

1AH TUBE TEST SET

	<u>CONTENTS</u>	<u>PAGE</u>
1.	GENERAL	1
2.	DESCRIPTION OF SET AND CIRCUIT DETAILS	2
	(A) Panel Layout and Controls	2
	(B) Test Connections and Power Supply	2
	(C) Grid Test Signal and Peak Volt- meter Circuit	2
	(D) Transconductance (G_m) Measuring Circuit	3
	(E) Filament Activity Circuit	5
	(F) $\% \Delta G_m$ Circuit Details	5
	(G) Peak Plate and D-c Plate Current Measurement	5
	(H) Grid Current Test	5
	(I) Power Output Test of a 374A Tube	6
3.	METHOD OF OPERATION	6
	(A) Sensitivity Calibration	6
	(B) Calibration of $\% \Delta G_m$ Scale	6
	(C) Measurement of Transconductance (G_m)	7
	(D) Measurement of Filament Activity	7
	(E) Measurement of Peak Plate Current	7
	(F) Measurement of D-c Plate Current	8
	(G) Measurement of Grid Current	8
	(H) Measurement of 374A Power Output	8
4.	MAINTENANCE	8
5.	DRAWINGS	8

1. GENERAL

1.01 This section contains the description and methods of operation of the 1AH (J64001AH) tube test set, a portable device which is used for testing 373A and 374A tubes. Tubes are tested with this set on an out-of-socket basis.

1.02 This issue replaces Issue 2, dated October, 1942 which was rated Provisional and given limited distribution for field trial and training purposes.

1.03 The 1AH tube test set measures transconductance and plate current. Transconductance is also called "Mutual Conductance." Transconductance may be defined as the ratio of the value of a-c plate current to the value of a-c grid signal producing it or $\Delta i_p / \Delta e_g$, at normal fixed tube operating potentials. It is usually expressed in terms of conductance and measured in micromhos. The per cent decrease in transconductance or plate current as observed for a 10% reduction in filament voltage, commonly known as a "filament activity" test is also measured in this set. These types of measurement are employed to evaluate tube performance with time and normal aging effects. Transconductance (G_m) the ratio of μ / R_p , provides a good indication of the amplifying properties of a tube, for example, its gain adequacy in a stage of a feedback amplifier. Filament activity when correlated with a G_m test provides an index of remaining useful tube life, sufficient usually to insure satisfactory service until the next normal testing interval occurs.

1.04 In addition to the G_m and d-c plate current tests, the set is capable of making the following tests:

- (a) Instantaneous peak plate current when the grid is driven to zero bias.
- (b) Grid current tested by the insertion of a suitable resistor in the grid circuit and measured by a d-c plate current increment under no signal conditions.
- (c) Power output of the 374A output tube under maximum amplifier load conditions, with a peak input voltage on the grid equivalent to normal C bias.

While all of these tests are described herein, only the specific tests called for in the current issue of the E3 series of Bell System practices covering the particular type of equipment need be made.

1.05 The test set accommodates two 373A tubes in sockets 1 and 2 and one 374A tube in socket 3 and all three tubes are tested under approximately normal amplifier operating conditions. Power supply arrangements to the set

require insertion of all three tubes to insure adequate load regulation irrespective of the number of tubes to be tested.

1.06 Mutual conductance (G_m) and peak plate current measurements are made by applying a calibrated 60-cycle signal to the grid of a tube and measuring the output voltage or current with a vacuum tube peak voltmeter circuit. The values of G_m are read directly on the scale of the microammeter in the peak voltmeter circuit. The peak (a-c) or d-c plate currents are interpreted from readings on the G_m scale. The micromho scale of the meter has a single range calibrated 0-2000, with 40 equal divisions, each division equal to 50 micromhos. The meters supplied in earlier model 1AH sets were provided with two calibrated G_m scales, 0-2000 micromhos in black, and 0-1000 micromhos in red.

1.07 The set is self-contained in a carrying case with handle for portable use. The outside dimensions of this case including removable cover are 12 by 11 inches, and approximately 6 inches deep, and the weight is about 25 lbs. Earlier models have identical control features but a different panel layout. A cord and plug permanently connected to the test set are provided to obtain external power for its operation.

2. DESCRIPTION OF SET AND CIRCUIT DETAILS

(A) Panel Layout and Controls

2.01 The location of the control equipment, vacuum tube sockets and G_m meter on the panel is shown in Fig. 1. The 4 gang 5 position vacuum tube selector and CAL switch is used to permit each of three tubes to be tested with appropriate manipulation of the six key switches.

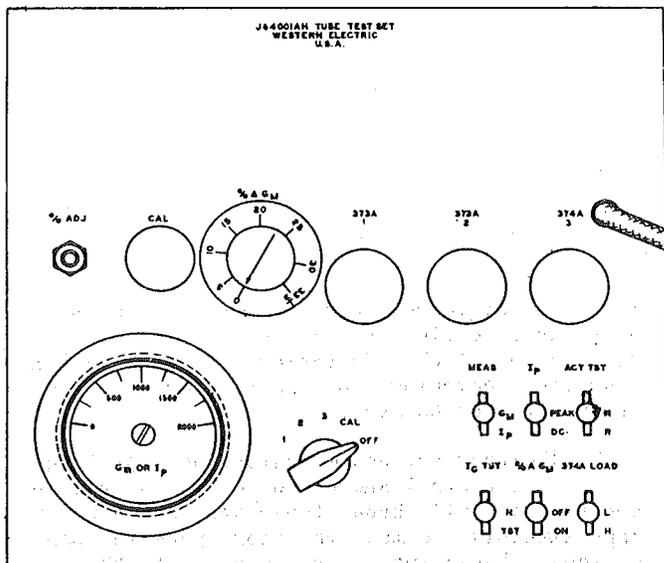


Fig. 1 - Face View of Set

2.02 The six key switches are listed below with indicated operating positions, together with reference to parts of this section which describe the circuit function of each:

- (a) MEAS. Key, G_m and I_p positions; Parts 2(D) and (G)
- (b) I_p Key, PEAK and DC positions; Part 2(G)
- (c) ACT TST Key, N and R positions; Part 2(E)
- (d) I_G TST Key, N and TST positions; Part 2(H)
- (e) $\% \Delta G_m$ Key, OFF and ON positions; Part 2(F)
- (f) 374A LOAD Key, L and H positions; Part 2(I)

(B) Test Connections and Power Supply

2.03 A block schematic is given in Fig. 2 to illustrate the principal functions of the set. Test connections to any particular socket are made by operating the selector switch to position 1, 2 or 3.

2.04 Power is obtained through cable and plug from the receptacle provided in a bay at or near the equipment being tested. This receptacle provides a regulated supply of 60 volts at 60 cycles for grid signal and filament voltage, office plate battery, and grid voltage for the 374A tube from the common office grid battery. The accuracy of test results will depend on the regulation of these power supplies. Tests of these voltages may be made with a suitable volt-ohmmeter at the power receptacle terminals, with the test set connected and a tube in each socket.

(C) Grid Test Signal and Peak Voltmeter Circuit

2.05 The 60 volt 60 cycle filament supply which is normally regulated to $\pm 1\%$ for voltage provides grid test signals for G_m and peak plate current measurements. A schematic of the voltage divider circuit appears in Fig. 3, which provides four taps, 1 volt and 5 volts for 373A and 374A tube G_m tests, respectively, and 1.6 and 15 volts for the corresponding peak plate current tests. The 1 volt tap is also used to calibrate the peak voltmeter circuit.

2.06 The peak voltmeter circuit shown in Fig. 4 is for the G_m test. The a-c output voltage of a tube is amplified by a 6SJ7 tube and rectified with a 6H6 diode detector used as a half wave rectifier. The rectified current flows through a d-c microammeter calibrated to read micromhos. The input circuit to the peak voltmeter contains the CAL rheostat, the $\% \Delta G_m$ potentiometer, the $\% ADJ$ rheostat and

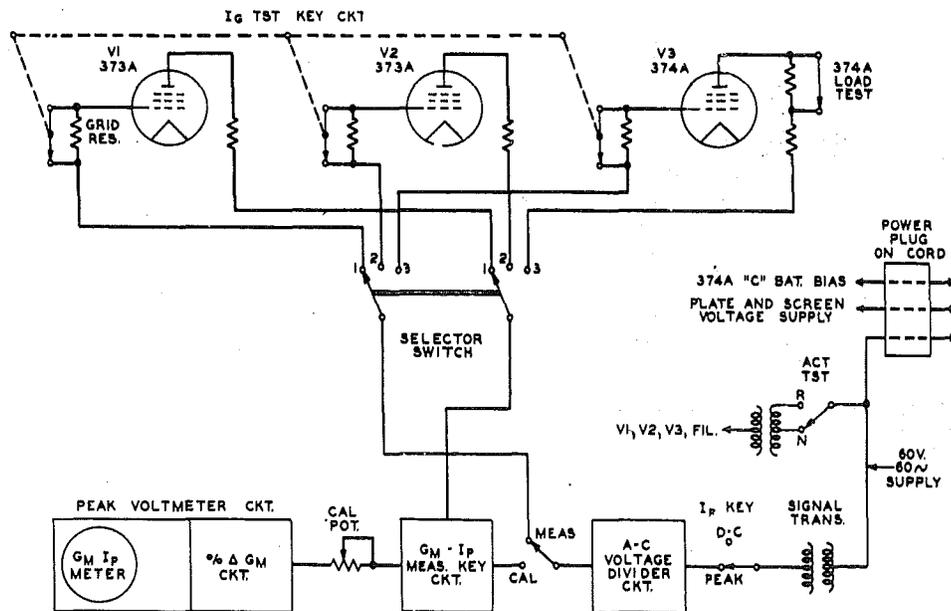


Fig. 2 - Circuit Arrangement of Test Set

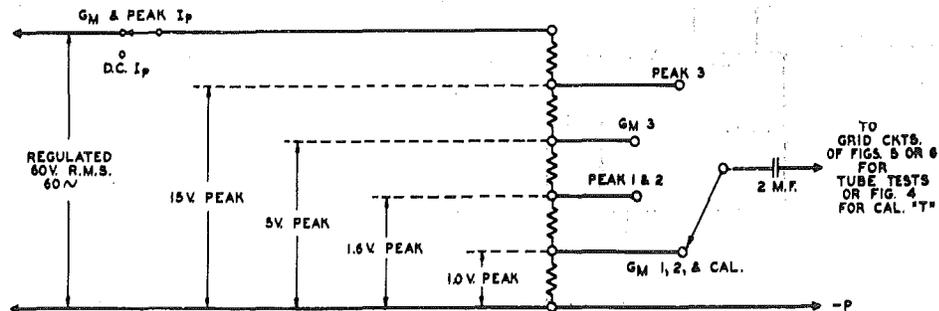


Fig. 3 - Signal Supply Circuit

the $\% \Delta G_m$ key. The CAL rheostat is used to introduce a variable series loss for calibrating the sensitivity of the voltmeter with a known value of input. In some sets the $\% \Delta G_m$ potentiometer and the $\% \text{ADJ}$ rheostats are not provided due to lack of material in manufacture. In this case suitable fixed resistances are substituted in this circuit. If the $\% \Delta G_m$ feature of the filament activity test circuit is not provided, the description in Part 2(F) does not apply. An alternative procedure may be used in this case as described under Part 3(C).

2.07 Sensitivity calibration of the G_m measuring circuit is accomplished by two basic adjustments of the peak voltmeter circuit. After a suitable tube heating interval, (2 to 5 minutes), a mechanical "zero" adjustment of the G_m meter pointer is made to reduce

any residual reading due to the contact potential of the diode rectifier tube. Secondly, a 1 volt signal obtained from the signal supply circuit is applied directly to the input of the peak voltmeter circuit. With the $\% \Delta G_m$ key in the OFF position the "CAL" dial is adjusted until a midscale (1000) reference reading is obtained.

(D) Transconductance (G_m) Measuring Circuit

2.08 The G_m of a 373A tube is measured by applying a 1 volt peak signal obtained from the signal supply circuit to the grid of the 373A tube in its test socket as shown in Fig. 5. The input of the peak voltmeter circuit is connected across the load resistance in the plate circuit consisting of the 800 ohm and the 200 ohm resistors. The meter will indicate the G_m directly on the 0-2000 micromho scale.

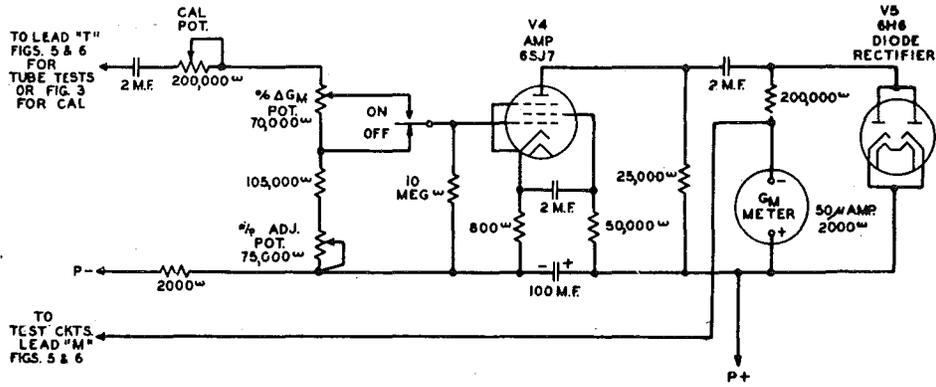


Fig. 4 - Peak Voltmeter Circuit

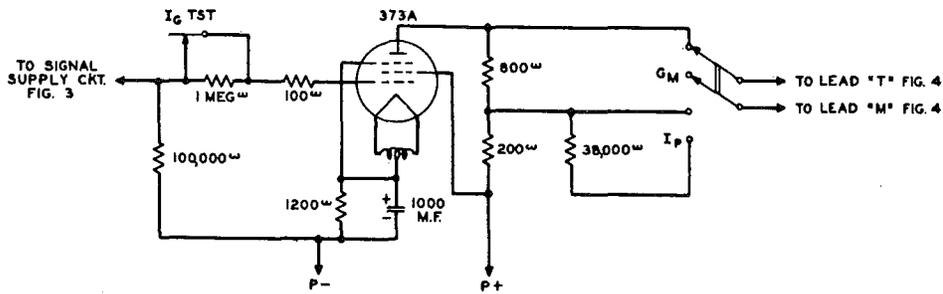


Fig. 5 - Test Circuit for 373A Tube

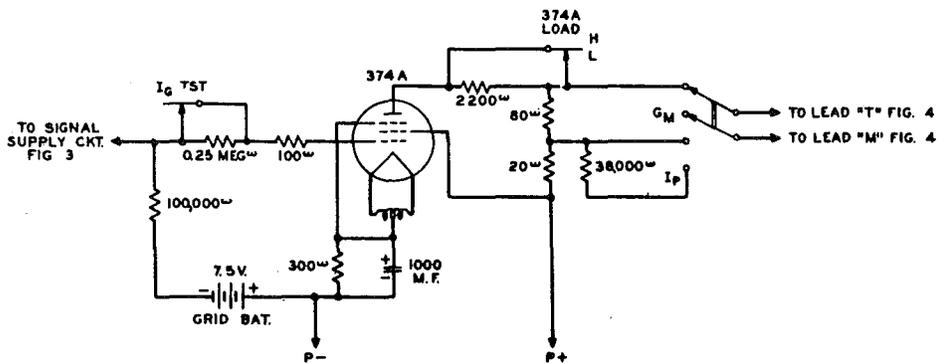


Fig. 6 - Test Circuit for 374A Tube

2.09 In a similar manner a 5 volt signal is applied to the grid of the 374A tube as shown in Fig. 6. The voltage across the plate load resistance consisting of the 80 ohm and the 20 ohm resistors is measured by the peak voltmeter. In this case the G_m reading on the 0-2000 scale must be multiplied by 2 to give the true value of G_m . That is, a full scale reading on the 0-2000 scale is equal to 4000 micromhos.

(E) Filament Activity Circuit

2.10 Filament activity of the tubes is tested by measuring the change in G_m when the filament voltage is reduced. By operating the ACT TST key to R the filament voltages on all three tubes are reduced 10%. In this condition G_m is measured again as in Paragraphs 2.08 and 2.09. With the $\% \Delta G_m$ key then operated to ON, the $\% \Delta G_m$ dial is adjusted until the same reading of the G_m meter is obtained as given in Paragraph 2.08 or 2.09. The calibration required for the $\% \Delta G_m$ circuit is described in Part 2(F) following. The readings on the $\% \Delta G_m$ dial will indicate directly the percentage reduction in G_m caused by reducing the filament voltage.

(F) $\% \Delta G_m$ Circuit Details

2.11 The $\% \Delta G_m$ measuring feature is part of the input circuit of the peak voltmeter circuit (Fig. 4) discussed under Part 2(C) but details are given here as a function of the filament activity test circuit. With the $\% \Delta G_m$ key in the normal OFF position the grid of the AMP tube is connected to the common point between the fixed resistance and the $\% \Delta G_m$ potentiometer. In this condition the portion of the voltage across the input leads "T" and "R" that is applied to the grid of the AMP tube is independent of the setting of the $\% \Delta G_m$ potentiometer. When the $\% \Delta G_m$ key is operated to the ON position the grid of the AMP tube is then connected to the arm of the potentiometer. By varying the potentiometer over its range the voltage applied to the grid of the AMP tube can be increased from normal to 50% above normal. These arrangements are used to measure the percentage change in G_m caused by reducing the filament voltage 10%. The G_m is first measured at normal filament voltage and measured again at reduced filament voltage. With the filament voltage still reduced, the $\% \Delta G_m$ potentiometer is adjusted until the meter reading is restored to the value obtained at normal filament voltage. The magnitude of the adjustment made with potentiometer is a direct measure of the percentage difference between the readings at normal and reduced filament voltage and by providing a calibrated scale on the potentiometer the per cent differences may be read directly. The per cent change in G_m caused by reducing the filament voltage is read on the calibrated scale (0 to 33-1/3%) which corresponds to a grid signal change from

normal to 50% above normal as required to increase the G_m reading at reduced filament voltage to the value previously obtained at normal voltage. The per cent indications on the scale are accurate when the total resistance of the $\% \Delta G_m$ potentiometer is equal to one-half the sum of the resistance of the fixed resistance and the adjusted value of the $\% \Delta G_m$ rheostat. The $\% \Delta G_m$ potentiometer is provided to establish this required resistance ratio and thus compensate for manufacturing variations and aging of the resistors.

(G) Peak Plate and D-c Plate Current Measurement

2.12 The peak plate current is tested by applying a signal to the grid of the tube large enough to drive the grid instantaneously to zero bias. The peak voltage developed across the plate load resistance is measured under this condition.

2.13 To measure the peak plate current I_p of a 373A tube a 1.6 volt peak signal is applied to the grid from the appropriate voltage divider tap and the peak voltmeter is connected across the 200 ohm portion of the plate load. The peak value of the a-c component of the voltage across the plate load is rectified by the voltmeter circuit and the rectified current applied to the meter. To this is added the d-c component of the plate current which is fed to the meter directly through the 38,000 ohm series resistance. The resistances are so proportioned that full scale on the G_m meter is equivalent to a current of 10 milliamperes. Thus a reading on the 0-2000 G_m scale divided by 200 will indicate the value of absolute peak plate current.

2.14 The d-c plate current is read by operating the I_p key to DC which opens the signal supply circuit. With no signal applied, the G_m meter indicates the d-c plate current with the same scale conversion as given in Paragraph 2.13.

2.15 The peak and d-c plate currents of a 374A tube are read in a similar manner. A 15 volt peak signal is applied to the grid of a 374A tube and the voltmeter circuit is connected across the 20 ohm portion of the plate load. The resistances are so proportioned that the full scale of the G_m meter is equivalent to 100 milliamperes. In order to obtain the absolute value of plate current, the meter reading should be divided by 20.

(H) Grid Current Test

2.16 The presence of grid current is tested by operating the I_G TST key to TST when a d-c plate current test is being made and observing any change in d-c I_p reading.

2.17 The operation of the I_G TST key to TST inserts a 1 megohm resistance in each

of the grid circuits of the 373A tubes and a .25 megohm resistance in the grid circuit of the 374A tube. If grid current is present the resulting change in grid bias caused by the grid current flowing through the high grid resistance will cause an increase in plate current. Tubes drawing excessive grid current are eliminated by placing limiting values on the amount of change in plate current.

(I) Power Output Test of a 374A Tube

2.18 In order to check the maximum power carrying capacity of a 374A tube it is necessary to measure the peak plate current when the plate voltage is driven to the minimum value. This simulates the condition of an amplifier delivering maximum output. The test is made by operating the 374A LOAD key to position H which provides a total plate load resistance of 2300 ohms. When the grid is driven to zero bias the peak plate current drives the plate voltage down to approximately 25 volts. The value of peak plate current obtained under this condition is a measure of the maximum power output capacity of the tube.

3. METHOD OF OPERATION

3.01 This part describes operating procedures for making transconductance, filament activity in terms of $\% \Delta G_m$, d-c and peak plate current, grid current and power output (374A tube only) tests.

3.02 Three tubes are tested at a time. When less than three tubes are to be tested, a spare tube of the proper type must be inserted in each idle socket of the test set.

3.03 Care should be taken to insure that the operating test voltages (a-c filament, d-c plate and 374A "C" bias) supplied to the test set through the power plug cord are within the limits for the equipment being tested, using a Weston KS-8295 volt-ohmmeter or equivalent at the terminals of the power receptacle. If test operating voltages exceed normal limits, unreliable tube test data are likely to result. Tube tests should, of course, not be made during periods of fluctuating supply voltages. It may be noted, however, that any noise existing in the 60 cycle supply voltage source will not always be entirely filtered out. This may result in transient "kicks" of the meter indicator during G_m or I_p measurements, and such readings will have to be averaged.

3.04 Usually, to expedite testing, each type of test may be made on all three tubes using a single test condition setup, by manipulation of the tube selector switch, before proceeding to the next test. However, it may sometimes be preferable to make all tests on the 374A tube at the same time when critical tests are being made at or very near rejection limits of G_m or I_p . This is to avoid unstable

or uncertain results in repeated measurements at reduced filament voltage for each type of test required.

3.05 The test set should be connected to the power supply through the receptacle provided in the bay at or near the equipment being tested. In order to avoid blowing a fuse due to momentary overload, the following caution should be observed.

Caution: Tubes to be tested should not be placed in the test sockets until after the power supply has been connected.

(A) Sensitivity Calibration

3.06 The sensitivity of the over-all G_m measuring circuit must be calibrated before any tube tests are made. A tube of the proper type should be inserted in each of the 3 test sockets.

3.07 Procedure:

- (1) With all keys normal, operate the selector switch to the CAL position.
- (2) Operate the I_p key to DC and adjust the "Zero" on the meter as required to bring the pointer to 0 indication on the scale. This zero adjustment is located in the center of the dial and operated with a screwdriver.
- (3) Restore the I_p key to normal and adjust the CAL dial to obtain a reading of 1000 on the meter scale.

(B) Calibration of $\% \Delta G_m$ Scale

3.08 This calibration does not apply to those sets which are not equipped with the $\% \Delta G_m$ and $\% \text{ADJ}$ potentiometers as covered in Paragraph 2.06.

3.09 Procedure:

- (1) Calibrate the sensitivity as described in Part 3(A).
- (2) Operate the $\% \Delta G_m$ key to ON.
- (3) Operate the $\% \Delta G_m$ dial from a reading of 0% to 33-1/3%.

Requirement: The meter reading should increase from 1000 to 1500.

- (4) If the meter reading at the 33-1/3% setting of the dial does not read 1500, adjust the CAL potentiometer to obtain a reading of 1500, or three-quarters of full scale.
- (5) Return the $\% \Delta G_m$ key to normal position and readjust the $\% \text{ADJ}$ potentiometer to obtain a reading of 1000.

- (6) Repeat Items (1) to (5) until the requirement is met.

(C) Measurement of Transconductance (G_m)

- (1) If the test set has not already been calibrated, proceed as described in Part 3(A).
- (2) With the tubes to be tested in the test sockets and all keys in their normal position, operate the selector switch to position 1, 2 or 3 to select the tube to be tested.
- (3) Read G_m on the scale of the meter. For 373A tubes this reading is the transconductance. However for 374A tubes the meter reading (0-2000 scale) must be multiplied by 2 to obtain the transconductance. Requirements are generally expressed in terms of meter readings to avoid this computation.
- (4) For sets not equipped with the $\% \Delta G_m$ and accessory $\% ADJ$ potentiometers as mentioned in Paragraph 2.06, note the initial G_m reading at normal filament voltage. This value of G_m is used in connection with Table I Part 3(D) for determining the per cent filament activity.

(D) Measurement of Filament Activity

- (1) With all keys normal operate the ACT TST key to R.
- (2) Measure the G_m as described in Part 3(C), allowing about 10 seconds for the tubes to stabilize at the reduced filament voltage.
- (3) Operate the $\% \Delta G_m$ key to ON and adjust the $\% \Delta G_m$ dial until the meter reads the value obtained in Part 3(C) Item (3).
- (4) The per cent change in G_m is indicated directly on the $\% \Delta G_m$ dial.
- (5) Where the $\% \Delta G_m$ dial feature is not included (see Paragraph 2.06) note the G_m reading for reduced filament voltage.
- (6) The value read in Item (5) should not be below the minimum G_m limit listed in Column (2) or (3) for the nearest normal value of G_m given in Column (1) Table I. This refers to the G_m value previously obtained in Part 3(C), at normal filament voltage. Table I lists normal G_m values as reference for a range of 500 to 2000 micromhos. This range will cover the 374A as well as the 373A tubes since it is not necessary to multiply by 2 the G_m readings for the 374A tubes to determine the per cent reductions in G_m .

TABLE I

% FILAMENT ACTIVITY LIMITS
IN
MICROMHOS-TRANSCONDUCTANCE (G_m)

Normal G_m Normal Filament Current (1)	Minimum G_m Limits	
	Reduced Filament Current	
	FIL ACT 25% (2)	FIL ACT 30% (3)
500	375	350
550	412	375
600	450	420
650	488	455
700	525	490
750	562	525
800	600	560
850	638	595
900	675	630
950	712	665
1000	750	700
1050	788	735
1100	825	770
1150	862	805
1200	900	840
1250	938	875
1300	975	910
1350	1012	945
1400	1050	980
1450	1088	1015
1500	1125	1050
1550	1162	1085
1600	1200	1120
1650	1238	1155
1700	1275	1190
1750	1312	1225
1800	1350	1260
1850	1390	1295
1900	1425	1330
1950	1462	1365
2000	1500	1400

(E) Measurement of Peak Plate Current

- (1) With all keys normal, operate the selector switch to position 1, 2 or 3 to select the tube to be tested.
- (2) Operate the MEAS key to I_p and read the meter on the 0-2000 scale. Requirements are generally given in terms of meter reading.
- (3) If it is desired to obtain the plate current value in milliamperes, the meter reading should be divided by 200 for 373A tubes and by 20 for 374A tubes.
- (4) When the test requirements so specify, the peak plate current at reduced filament current is obtained by operating the ACT TST key to R and repeating Item (2) for each tube, allowing about 10 seconds for the tubes to stabilize. Note the reduced meter reading in each case.

(F) Measurement of D-c Plate Current

- (1) With all keys normal, operate the selector switch to 1, 2 or 3 to select the tube to be tested.
- (2) Operate the MEAS key to I_p , the I_p key to DC and read the meter. Requirements are generally given in terms of meter reading.
- (3) If it is desired to obtain the d-c plate current in milliamperes the meter reading should be divided by 200 for 373A tubes and by 20 for 374A tubes.
- (4) When the test requirements so specify, the d-c plate current at reduced filament current is obtained by operating the ACT TST key to R and repeating Items (1) to (3).

(G) Measurement of Grid Current

- (1) With all keys normal, operate the selector switch to 1, 2 or 3 to select the tube to be tested.
- (2) Operate the MEAS key to I_p , the I_p key to DC and read the meter.
- (3) Operate the I_g TST key to TST and again read the meter noting any change in reading from Item (2).

(H) Measurement of 374A Power Output

- (1) With all keys normal and the selector switch set at 3, operate the MEAS key to I_p and the 374A LOAD key to position H.
- (2) Read the meter.

4. MAINTENANCE

4.01 The principal maintenance items which may require periodic attention are the vacuum tubes employed in the peak voltmeter circuit. If difficulty is noted in establishing satisfactory operating stability in the calibration of the peak voltmeter circuit, and variations are not due to power supply fluctuation, the 6SJ7 and 6H6 tubes should be removed for test. Minor fluctuations in the order of one meter scale division due to noise transients in the power supply, however, cannot always be entirely eliminated. Satisfactory tube check tests may be made with the Hickok model 530B tube tester, as indicated in Paragraph 4.02 following.

4.02 With all other test settings for the 6SJ7 tube as obtained from the Hickok set ROLL chart, and an L Potentiometer setting of 60, the normal G_m of the 6SJ7 should be about 1575 micromhos. At normal heater voltage a minimum requirement of 1100 micromhos in conjunction with a filament activity limit of 25% is suggested. The twin diode 6H6 is tested as prescribed on the Hickok ROLL chart for each diode current only, observing the "Diode OK" calibration line limit on the Hickok G_m meter without a filament activity test. For replacement purposes, the glass type 6SJ7-GT and 6H6-G tubes are suitable instead of the all-metal 6SJ7 and 6H6 tubes.

5. DRAWINGS

Drawings for Reference Not Attached
SD-59036-011
ED-59036-011