Calibration Testing of the Hickok Model 539C Mutual Conductance Tube Tester

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Use this procedure to test and calibrate the Hickok Model 539C mutual conductance (AKA transconductance) tube tester. Except as noted, all of the readings are taken with a 1000 ohms per volt meter. If an accurate 1000 ohms per volt meter is not available a modern high impedance analog or digital voltmeter can be used with appropriate shunt resistors in parallel with the input to simulate proper loading. The following resistor values should be used: 10 volt scale use 10K, 50 volt scale use 51K, 250 volt scale use 250K. All resistors are 1/2 watt 5% carbon composition. Calibration will be easier if you supply AC power through a constant voltage regulation type transformer to do the tests, but this is not essential. Recalibrate the tester any time either rectifier tube is replaced. The correct type #81 fuse lamp must be installed in the tester or false readings can result.

For the identification and location of adjustments refer to the ADJUSTMENT CHART and UNDERSIDE VIEW at the end of this document. Because Hickok made production changes to the 539 series of testers through the manufacturing lifetime of the model, the illustration of the location of the adjustment controls may vary from your tester.

It is assumed that the person performing the testing and adjustment is knowledgeable in electronic service and aware of the dangers in working on equipment using high voltages. Do not attempt to service equipment if you are not experienced in such work. Serious shock or death could result in improper action or procedure.

PREPARATION

Remove the screw from the bottom of the case. Remove all of the screws around the outside of the panel that hold the tester to the case. Remove the tester from the case and set it up on spacers so that the front panel is facing up in the normal operating position. Before applying power adjust the mechanical zero on the meters that have that capability to set the pointers exactly at the zero line on the scale.

LINE ADJUST METER

1. Plug in the AC power cord and turn the POWER switch on. Connect an AC voltmeter across the AC supply and read the voltage. Push button P7 LINE TEST and verify that the AC panel meter, just above the power switch, reads the correct AC line supply voltage. It is important that this meter reads correctly or the calibration procedure will be erroneous. When the panel meter is verified to be correct release the P7 button. Rotate the POWER ADJUST control until the AC panel meter needle is exactly over the red line. Remove the external AC voltmeter from the AC supply. See also ADJUSTMENT CHART number 10 at the end of this procedure.

SHUNT POSITION

2. Rotate the SHUNT control fully counter clockwise and verify that the pointer lines up with the 0 mark on the scale.

SHORTS TEST

3. Set the SHORTS switch to the TUBE TEST position and the SHORT TEST switch to the OTHER TUBES position. Set both the CATHODE and the SUPPRESSOR switches to the number 1 position. Rotate the SHORTS switch counter clockwise. The SHORTS lamp should light in all positions except number 1. Repeat the procedure setting both the CATHODE and SUPPRESSOR switches simultaneously in positions 2 through Z. Return the SHORTS switch to the TUBE TEST position.

SHORTS LIGHT SENSITIVITY

4. Set the CATHODE SWITCH to position 8 and the PLATE switch to position 3. Connect a 300K, 1/2 WATT, 5% resistor between pins 8 and 3 of the octal socket. Rotate the SHORTS switch counter clockwise to position 4. The SHORTS lamp should be glowing or flickering dimly. Rotate the SHORTS switch to the TUBE TEST position and disconnect the 300K resistor.

LEAKAGE RESISTANCE METER TEST

5. Connect a 1MEG, 1/2 WATT, 5% resistor between pins 8 and 3 of the octal socket. Rotate the SHORTS switch clockwise to position D. The main meter should be reading approximately 1MEG ohms on the resistance scale. Rotate the SHORTS switch back to the TUBE TEST position and disconnect the 1MEG resistor.

Set up the tester for the remainder of the tests by setting the switches to the following positions:

NORMAL/SELF BIAS= NORMAL
VR VOLTS & MILS CONTROL=COUNTERCLOCKWISE
BIAS RANGE= 50V
BIAS VOLTS/VR VOLTS & MILS (toggle switch)= BIAS VOLTS
BIAS VOLTS CONTROL=COUNTERCLOCKWISE (Zero volts)
METER= NORMAL

SELECTORS:

FILAMENT= H	SCREEN= 4
FILAMENT= S	CATHODE= 8
GRID= 5	SUPPRESSOR= 1
PLATE= 3	

SHORT TEST= OTHER TUBES
SHORTS= TUBE TEST
CATH. ACT.= NORMAL
SHUNT= 0
FILAMENT= 6.3
PLATE VOLTS= NORMAL
FUNCTION SWITCH= C (15,000)

FILAMENT VOLTAGE TEST

6. Connect an AC voltmeter to pins 2 and 7 of the octal socket. While observing the reading on the meter, rotate the FILAMENT switch from the minimum through the maximum voltage positions and verify that the voltage agrees with the setting. The readings should be within +-10% of nominal.

Set the FILAMENT switch to the 10 volt position. Set the CATHODE ACTIVITY switch to the TEST position. The filament voltage should drop by about 10%. Return the CATHODE ACTIVITY switch to the NORMAL position and set the FILAMENT switch to the 6.3 volt position.

PLATE VOLTAGE TEST

7. Connect the negative lead of a DC voltmeter to pin 8 of the octal socket. Connect the positive lead to pin 3. Push the P4 GM button and read the voltage. Normal plate voltage is 150 volts plus or minus 5 volts. Release P4. Set the PLATE VOLTS switch to the LOW position and press P4. The reading should be 65 volts plus or minus 3 volts. Release P4 and return the PLATE VOLTS switch to the NORMAL position.

SCREEN VOLTAGE TEST

8. Move the positive lead of the DC voltmeter to pin 4 of the octal socket. Push P4 and read the screen voltage. Normal is 130 plus or minus 5 volts. Hold P4 and press P1. The reading should drop to 56 volts plus or minus 3 volts. Release P1 and P4.

BIAS VOLTAGE RANGE AND VOLTMETER TEST

9. Connect the negative lead of a high impedance DC voltmeter to pin 8. Connect the positive lead to pin 5. Do not use a compensating shunt resistor for this test. Set the BIAS RANGE switch to the 50V position. Adjust the BIAS VOLTS control fully clockwise. Verify that the maximum voltage is -40 volts. Return the BIAS VOLTS control to the counter clockwise, zero volts, position. Set the BIAS RANGE switch to the 10V position. Adjust the BIAS VOLTS to -5.00 volts as read on the DC voltmeter. Verify that the tester meter reads 5.0 volts. Change the BIAS RANGE switch to the 50V position. Adjust the BIAS VOLTS to -25.00 volts as read on the DC voltmeter. Verify that the tester meter reads 25.0 volts.

GRID SIGNAL VOLTAGE TEST

10. Set the BIAS VOLTS control to zero. Connect a high impedance AC voltmeter to pins 8 and 5 of the octal socket. Do not use a compensating shunt resistor for this test. Set the FUNCTION switch to positions A (60,000) through F (600) and verify that the voltages are:
A=.25, B=.25, C=.25, D=.50, E=2.5, F=1.0 volts AC.

V.R. VOLTMETER TEST

11. Set the FUNCTION switch to the H (V.R. TEST) position. Connect the negative lead of a DC voltmeter to pin 8 of the octal socket. Connect the positive lead to pin 3. Push P4 and read the voltage. Adjust the V.R. VOLTS & MILS control for a reading of 150 volts. Verify that the main panel meter reads 150 volts. Release P4. Set the V.R. VOLTS & MILS control to zero.

V.R. MILLIAMPERE METER TEST

12. Set the BIAS VOLTS/VR VOLTS & MILS (toggle switch) to the VR VOLTS & MILS position. Connect a 2000 ohm, 5 watt, 1% resistor across the DC voltmeter used in the last test. Push P4 and adjust the V.R. VOLTS & MILS control for a reading of 100 volts. Verify that the V.R. VOLTS & MILS meter is reading 50 milliamperes. Release P4, disconnect the DC voltmeter and remove the 2000 ohm resistor. Return the BIAS VOLTS/VR VOLTS & MILS (toggle switch) to the BIAS VOLTS position. Set the VR VOLTS & MILS control fully counterclockwise.

POWER SUPPLY BALANCE CALIBRATION

13A. Set the FUNCTION switch to the G (diode rectifier) position. Connect a DC coupled oscilloscope to pin 3 of the octal socket. Use pin 8 as a common for the scope. Press P4 (locked). Observe the plate voltage and obtain a display on the scope that shows the rounded positive peaks of the 120Hz pulsating DC with as high a gain as possible. Set the vertical position on the scope to move the trace downward as you adjust the gain upward to maintain the top of the trace on the screen. Adjust R8 for peaks of equal amplitude. Release P4.

13B. Connect the scope to pin 4 of the octal socket. Press P4 (locked). Adjust the scope as before to display the 120Hz peaks, and observe the screen bias voltage. Adjust R15 for equal peaks of the 120Hz pulsating DC. Release P4 and disconnect the scope.

METER BRIDGE BALANCE

14. Set the FUNCTION switch to the C (15,000) position. Connect a 10K 1% 10 watt resistor between pins 3 and 8 of the octal socket. Press P4 (locked) and observe that the meter reads zero. Adjust R8 to trim out small errors. Release P4 and remove the resistor.

MUTUAL CONDUCTANCE READING TEST

15. Verify that the panel switches are set up to the conditions as given in the list immediately following step 5. (HS 5348-1) FILAMENT at 6.3 volts.

For the following mutual conductance tests you will need to set up an isolated current limited source of AC voltage. Use the setup drawing in figure 1 to connect the equipment to the tester. Be careful because improper connection can cause serious damage. Connect the source to pins 8 and 3 of the octal socket. If the main meter deflects downward instead of up when you perform the test, swap the connections to pins 8 and 3. All voltages are measured directly across the secondary of the isolation transformer.

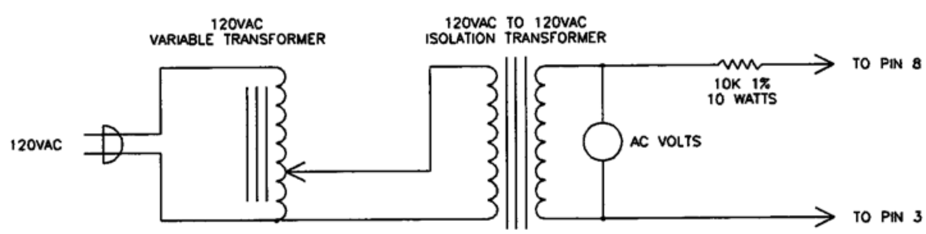

FIGURE 1

Set the FUNCTION switch to each of the positions shown in the chart below. Push P4 and adjust the voltage source as indicated in the chart. Observe the reading on the main meter and verify that the reading matches the value given in the chart. After each reading set the voltage back to zero, release P4 and go to the next setting.

FUNCTION	VOLTAGE	METER READING
A	50.0VAC	1000 on 3000 scale
B	25.0	1000 on 3000 scale
C	12.5	1000 on 3000 scale
D	10.0	1000 on 3000 scale
E	25.0	1000 on 3000 scale

F	6.00	Full Scale (600)

MUTUAL CONDUCTANCE CALIBRATION
USING A CALIBRATION TUBE

16. Set the FUNCTION switch to the C (15,000) position. Set the BIAS RANGE switch to the 10 volt position. Complete the usual setup for a type 6L6 tube setting the bias adjustment for 3.00 volts. Insert a calibrated 6L6 tube into the octal socket and allow it to warm up for a minimum of five minutes. Push P4 (locked). Readjust the AC line voltage to the red line on the meter and BIAS VOLTS control to 3.0 volts while the P4 button is depressed. Observe the mutual conductance reading. If the reading is more than one division high or low of the calibration value of the tube, the grid signal must be adjusted to make the reading correct. Be sure that the tester is blocked up and resting in its normal operating position or the meter calibration may be inaccurate. Release P4 and remove the 6L6 from the octal socket.

If a calibrated 6L6 is not available a reasonable calibration will be done by performing steps 10 and 14 above. The calibration tube test will verify that all adjustments have been successful.

DIODE/RECTIFIER TESTS:

17A. Verify that the panel switches are set up to the conditions as given above immediately following test 5. (HS 5348-1) FILAMENT at 6.3 volts. Set the BIAS and the ENGLISH controls to zero. Connect a 1K 1% 10 watt resistor to the anode lead of a 1N4005 silicon rectifier. Connect the cathode of the rectifier to pin 8 of the octal socket. Connect the other lead of the resistor to pin 3 of the octal socket. Adjust the SHUNT control to 24. Press the P1 DIODE test button. Verify that the meter reads at or slightly above the DIODES OK line on the meter. Release P1.

17B. Adjust the ENGLISH control to 83. Press the P3 RECTIFIER test button. Verify that the meter reads at or slightly above the DIODES OK line on the meter. Note: for actual rectifier tube tests the REPLACE ? GOOD scale is read for the test results. Release P3.

17C. Replace the 1K resistor with a 10K 1% 10 watt resistor. Adjust the ENGLISH control to 79. Press the P2 0Z4 test button. Verify that the meter reads at or slightly above the DIODES OK line on the meter. Note: for actual 0Z4 rectifier tube tests the REPLACE ? GOOD scale is read for the test results. Release P2.

GAS TEST

18. Obtain a 6L6 tube that is known to be free of gas. Put the tube in the tester and set it up for the standard 6L6 test. Set the BIAS VOLTMETER switch to the 50 volt position. Set the FUNCTION switch to the D position. Press P5, the gas 1 test button. Adjust the BIAS control for a reading of 500 on the 3000 scale. Hold P5 and press P6, the gas 2 test button and verify that the reading moves up by less than one small division. Release P6 and P5. Connect a 10Meg resistor between pin 5 and pin 8 of the nine pin miniature socket. Press P5, the gas 1 test button. Adjust the BIAS control for a reading of 500 on the 3000 scale. Hold P5 and press P6. This time verify that the reading goes up by 3 to 4 small divisions on the meter. Release P6 and P5. Switch off the AC power to the tester and disconnect the power cord. Reinstall the tester in the cabinet.

ADJUSTMENT CHART

1. LINE ADJUST METER: No adjustment possible. High readings can be brought into calibration by the addition of an appropriate value resistor placed in series with the meter. Low readings cannot be raised without disassembly of the meter and replacing the internal calibration resistor with a slightly smaller value.

2. SHUNT POSITION: Loosen the set screw on the knob and reposition the knob to the correct location. Retighten the set screw.

3. SHORTS TEST: No adjustment. Failure to read a short on any switch position means the switch contacts are dirty or damaged. Cleaning and de-tarnishing the contacts may help.

4. SHORTS LIGHT SENSITIVITY: If the lamp fails to light, replace the lamp and/or perform the test again and adjust R45 until the SHORTS light just comes on.

5. LEAKAGE RESISTANCE METER TEST: No adjustment. If the reading is wrong check resistors R46 / 1Meg, R47 / 36K and R48 / 330K. Also check the main meter movement sensitivity as described in step 15 below.

6. FILAMENT VOLTAGE TEST: No adjustment. This voltage is entirely dependent on the power transformer and the AC line setting. Some voltages may read slightly higher due to the lack of loading on the transformer.

7. PLATE VOLTAGE TEST: No adjustment. This voltage is entirely dependent on the power transformer and the AC line setting. If the voltage is low, check and/or replace the type 83 rectifier tube.

8. SCREEN VOLTAGE TEST: No adjustment. This voltage is entirely dependent on the power transformer and the AC line setting. If the voltage is low, check and/or replace the type 5Y3 rectifier tube. For the 539C the P1 low screen voltage is not adjustable.

9. BIAS VOLTAGE RANGE AND VOLTMETER TEST: If necessary, adjust the maximum bias voltage by loosening the screw on the sliding tap of R18 / 8.5K tapped power resistor and sliding it to the position which gives the correct reading. This is the tap with the jumper wire to the end tab of the resistor. Gently hold the tap with insulated pliers and slide the tap until the voltage is as close to -40 volts as you can get it. This adjustment may also affect the screen voltage that was tested in the previous step. The screen voltage should be retested if an adjustment is made. If the bias volts meter calibration is off check resistors R49 / 40K, R50 / 9.9K and R51 / 200 ohms.

10. GRID SIGNAL VOLTAGE TEST: The grid signal is provided from a 5.0 volt winding on the power transformer. If the voltages are incorrect measure the 5.0 volts across taps R and S on the power transformer to verify it is correct. Individual grid signal voltages are obtained by fixed divider resistors R52 / 500 ohms, R9 / 300 ohms, R10 / 100 ohms, R11 / 50 ohms and R12 / 50. Check these resistors for proper value. If the 5.0 volts is incorrect, this voltage is directly affected by the POWER ADJUST control. Carefully check the LINE ADJUST METER for inaccuracy and

correct it as necessary. If however, all other operating voltages are correct and only the 5 VAC grid winding is wrong, replace the grid signal divider resistor R52 with an appropriate new value to correct the error and bring the grid signal voltages to the specified values.

11. V.R. VOLTMETER TEST: Check resistors R20 / 1K, R21 / 1K, R22 / 600 ohms and R23 / 470K. Also check the main meter sensitivity as described in step 14 below.

12. V.R. MILLIAMPERE METER TEST: Check resistors R43 / 198 ohms and R44 / 2 ohms.

13. POWER SUPPLY BALANCE CALIBRATION: If balance is not obtainable replace the 83 and/or 5Y3 tube.

14. METER BRIDGE BALANCE: If balance is not correct check the bridge resistors R37 / 500 ohms, R38 / 60 ohms, R39 / 40 ohms, R40 / 40 ohms, R41 / 60 ohms and R42 / 500 ohms for proper value. Note that resistors of equal value in this series should be matched closely in value for good bridge balance. Also confirm that the plate power supply is correctly balanced as tested in step 13.

15. MUTUAL CONDUCTANCE READING TEST: If readings are not correct, repeat steps 13 and 14 and check the bridge resistors R37 / 500 ohms, R38 / 60 ohms, R39 / 40 ohms, R40 / 40 ohms, R41 / 60 ohms and R42 / 500 ohms for proper value. Note that resistors of equal value in this series should be matched closely in value for good bridge balance. Also check the main meter movement and verify that it indicates full scale when exactly 115 microamps are passed through it. The metal plate mounted on the side of the meter is a factory applied magnetic shunt. By loosening the mounting screw and sliding the plate back and forth, small adjustments can be made to the full scale deflection of the meter. If the meter reads too high with 115 microamps, adding a large value resistor across the meter terminals can shunt some of the current around the meter allowing it to read correctly. The value of the resistor can be calculated or found by trial and error. If the meter reads too low with 115 microamps it requires taking the meter apart and making major repairs far in excess of the scope of this document. Bear in mind that changing the meter range will also affect the readings of the other functions it performs so rule out everything else before adjusting the meter.

16. DIODE/RECTIFIER TESTS: The diode and rectifier tests measure the voltage drop across the rectifier by applying a fixed voltage with a series limiting resistor and measuring the available plate current. If the readings are not correct for any of the P1, P2 or P3 tests check resistors R1 / 150 ohms, R6 / 1.2K, R7 / 1.8K. The sensitivity of the meter and the accuracy of the transconductance circuits also affect this test.

17. GAS TEST: The gas testing circuits depend on the meter bridge circuit and several resistor values. If the mutual conductance tests are functioning properly, check for bad switches or dirty contacts on P5 and P6. Also check R2 / 470K and R53 / 220K resistors. R2 is placed in series with the grid for the gas test when P6 is pressed. Any grid current due to gas will cause a voltage drop across R2. The plate current goes up as the grid bias drops indicating gas in the tube.

Transconductance Calibration Notes:

Hickok calibration is always an inexact science. Hickok tended to change production details on an individual basis and tweak individual testers as they were assembled to cover irregularities. The test procedure outlined above is to be used as a guideline for the calibration of the typical tester. Individual testers may vary from the design norm. Keep this in mind if certain details in your tester do not match the information given here. It would take a custom test procedure written for each tester in order to be absolutely accurate in every detail.

The sensitivity of the transconductance readout circuit is essentially fixed by the hardware of the tester, the meter, power transformer and the various fixed resistors in the metering circuit. The transconductance circuit is in the form of a bridge that is sensitive to the relative amplitude of the alternate peaks of the full wave rectified 120Hz pulsating DC plate current. Any difference in the amplitude of the peaks is read as an indication of transconductance. This is why it is important to adjust out any difference in the voltage of the alternate peaks of the unfiltered plate voltage. If the alternate peak voltages differ constant errors will be added to the transconductance readings.

An unfiltered pulsating 120Hz DC bias with an added AC signal is applied to the control grid of the tube. For each peak of plate voltage the plate current is alternately higher than or lower than the average by the amount of the AC grid signal times the transconductance of the tube. The measurement circuit senses this difference and reads it out as a value of micromhos of transconductance. The greater the difference there is in the amplitude of the peaks because of the transconductance of the tube, the higher the reading.

Hickok determined a nominal grid signal value and displayed the AC plate current as a transconductance reading assuming the grid signal value is the design value. The 539C has no means of measuring the actual AC grid signal applied to the tube nor does it regulate that voltage in any way so that it is always correct. The tester simply calculates the transconductance of the tube under test assuming a correct grid signal voltage. Therefore if the AC grid signal is something different than the intended value, say for example because the AC line meter is inaccurate, the readings will be off by the amount that the grid signal differs from what it is intended to be. Calibration using the standard 6L6 calibration tube attempts to adjust out any residual error by adjusting the AC signal to the control grid in order to bring the reading to normal.

The zero transconductance reading, that is the meter reading at which the tube plate current has no AC component whatsoever due to transconductance, is trimmed by balancing the plate power supply in step 13A. Any error in this calibration is called “offset” since it offsets the actual readings by a fixed amount from zero. An error in this adjustment shows up as a constant number added to the measured transconductance.

R8 is a balance control that adjusts the relative amplitude of the plate supply rectified 120Hz pulsating DC peaks. Adjusting the balance of the peaks directly affects the balance of the plate current measurement bridge and thus the zero point of the readings displayed, sort of the electrical equivalent of zeroing the meter so that all of the readings won’t have a constant value added. The actual sensitivity or slope of the calibration line is fixed by the hardware and can only be changed by replacing the scaling resistors in the meter circuit.

R15 adjusts the balance of the amplitude of the peaks of the DC grid bias and screen voltages. Any difference in amplitude of the peaks in alternate pulses of unfiltered DC bias is exactly the same as adding an AC voltage to the bias. This directly affects the apparent AC signal on the grid so it must be balanced or additional signal will appear on the grid along with the intended signal. The amount of any additional AC signal added to the grid by an imbalance in peak voltages of the DC bias is directly proportional to the DC bias setting used. A setting of -3 volts will add only half of what a setting of -6 volts will. For this reason it is very important that the grid bias supply be closely balanced in order not to add any AC signal to the grid.

The common Hickok calibration procedure for the 539C used the calibration tube test to adjust R15 in order to trim out any residual unbalance and bring the readings to the nominal value of the calibration tube. The assumption being that everything else is good and adjusting R15 will set the true balance by default. This is a poor method because it opens the possibility that the DC bias is not actually balanced but only compensating for errors in grid signal and metering accuracy. It would have been better to split the function of bias balancing and calibration adjustment by adding another potentiometer to the grid signal divider resistors. Doing so would have added additional cost and complexity to the tester. Probably the problem was dealt with at the factory by selection of resistors in certain areas of the circuit to get close enough or it was not considered a particular problem since service type test equipment does not need laboratory grade accuracy.

Testing with a calibrated tube to match the readings to an actual known value as in step 15 acts as a final test of overall calibration. If the readings do not measure correctly after the tester has passed all of the other tests there is little else but to try and adjust the grid signal by replacement of the fixed grid bias divider resistors to make it comply. If a calibration tube is not available, following the balance adjustment step 13 then adjusting the AC grid signal voltage to the design values as in Adjustment Chart step 10 can do a reasonable calibration.

Notes on using the Calibrated 6L6, Hickok part number 20877-1:

The calibration tube is intended to be used as a tool to compare and adjust the final overall accuracy of any 539C tester against a factory standard 539C tester in order that your tester will give comparable results to the factory standard and comply with the roll chart results. It should be noted that this value is not necessarily the actual "book value" transconductance of the tube measured on precision test equipment according to tube manufacturers standard procedures but a representation of the transconductance that a factory calibrated Hickok 539C should measure.

Even though the mutual conductance calibration tests performed with the simulated test circuit show the correct readings, other factors and irregularities will noticeably affect the final readings. Power supply loading, small imbalances in screen voltage, plate voltage, mismatches between the two halves of the 83 and 5Y3 rectifiers, resistor values and other things all add up to affect the readings. Even using the wrong type of fuse lamp can substantially change the calibration of the tester.

The tube is not intended to be used to adjust out significant problems or faults in the operation of the 539C. It is only to be used to match the reading of a properly functioning tester to that of the factory standard. If significant errors in operating voltages are found at the time of calibration, first determine that the rectifier tubes are working properly and have substantially equal output from each half of the tube. A good test is to substitute known good replacement rectifier tubes and see if the problem resolves. Replacement of a rectifier tube will always require a recalibration of the tester. Verify that all of the test voltages are correct and that the fixed resistor values have not shifted with age or by electrical damage.

It should be noted that even calibration by this method will never guarantee perfect accuracy. A different calibration tube will seldom read the exact calibration value on any given 539 calibrated with another tube. They will be very close but the tester is simply not capable of that kind of repeatable accuracy from sample to sample. Slight differences in component tolerances, calibration tubes and mostly the lack of regulation of operating voltages due to loading, meter reading inaccuracy and the coarse adjustment capability of the line adjust control will cause a discrepancy in test results.

While Hickok designed the 539C to be a better than average tube tester it is still not a laboratory grade instrument. Some deviation from perfect accuracy must be expected. The calibration tube is carefully tested and specified for use with the Hickok 539C only. Because other Hickok model testers and other manufacturers testers use different voltages for testing than the 539C they may, but more likely will not, read the same value of mutual conductance for the calibration tube. Only a perfect tube would test out to the same mutual conductance value for every tester and every set of operating voltages applied to it. Since there is no perfect tube this should not be expected.

Never place the tube in emission type testers or testers of other brands because of the possibility of permanent changes in calibration value. Because it was specifically calibrated for the 539C circuit using 539C operating conditions its value for checking other testers using different test conditions is marginal at best

Notes on Making an Accurate 539C Calibration Tube:

Calibration tubes for the 539C must be measured at the specific conditions and voltages that the 539C testers subject the tubes to. According to Hickok documents, a calibration tube must be produced by measuring a sample candidate tube on a Hickok factory prototype instrument known to be in proper calibration. This sets up a kind of chicken-egg situation in which a calibration tube is required to calibrate a tester and a calibrated tester is required to create a calibration tube. Hickok never revealed how the factory prototype tester was calibrated in the first place before calibration tubes were available.

Hickok factory calibration tubes were probably not available to anyone other than internal factory personnel. None have ever been seen even by Hickok authorized repair stations outside the factory. To obtain an accurate calibration tube one must be either made by testing on a known accurate 539C tester or bought from someone who has such a tester and offers the tubes for sale. An individual cannot test one on his own using lab equipment and certify it. As stated above in the notes on using the calibrated 6L6, 539C testers do not represent the actual book value transconductance of a particular tube. They only determine the Hickok derived representation of it for comparison to the 539C roll chart to indicate the tube's worth. Certifying a tube using any other means than a calibrated 539C tester will not provide the same values.

A used tube with good transconductance is likely to be more stable than a new tube due to the need for a certain amount of initial break-in. Test candidate tubes in the usual way for transconductance, leakage and gas. Candidates for calibration tubes must be stable and have no heater hum. It may take a dozen samples to find a suitable tube for a calibration standard. Metal shell tubes tend to be less prone to heater hum but this is not always the case.

Heater hum affects the transconductance reading of the tube by artificially adding a 60Hz signal to the plate current causing the reading to be either abnormally high or low depending on the phase of the added hum with respect to the grid signal. To determine if a tube has hum, set up a candidate 6L6 on a 539C and test it in the usual way. Note the transconductance reading. Change the filament switches from the H S setting to C X and repeat the test. If the reading is different by even one small division reject the tube and try another one.

If the tube passes the hum test the stability should be checked. The quick easy way is to set up a normal tube test on a 539C tester for the candidate tube. Take the reading and write it down. Shut off the tester and repeat the test an hour later. Several repeated cold/warm cycles should be tried to verify that the candidate tube would reliably read the same every time. If not then you cannot depend on it to be used as a calibration standard that is repeatable.

A better verification is to set up the tube on stable laboratory equipment for a DC grid shift test. Use the manufacturers design center book values of 250 volts for the plate, 250 volts for the screen and a nominal –16 volts for the control grid.

Do a grid shift of 2.0 volts around nominal (-17 to -15 volts) and verify that the DC plate current does not take an inordinate amount of time to stabilize and remains stationary at the new value after either the shift up or down. The plate current should also return to close to the same measured lower or higher value with every up or down shift. Plate current stability over time and repeatability are essential. Tubes that tend to wander or take a long time to settle are not acceptable. Perfection is not necessary but the best sample you can find will help assure the best results in the long run.