Calibration Testing of the Hickok Model 800/800A Tube Testers

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Use this procedure to test and calibrate the Hickok Model 800/800A mutual conductance (AKA transconductance) tube testers. 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 and for troubleshooting refer to the ADJUSTMENT CHART immediately following the test sequence.

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 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 meter to set the pointer exactly at the zero line on the scale.

Turn on the tester and allow it to warm up for 5 minutes. Set the tester programming switches to these settings: 6.3 JR-5347-2 0 0. Set the SHORTS switch to the TUBE TEST position. Do not insert any tubes in the test sockets.

LINE ADJUST

1. Push switch P7 and rotate the LINE ADJUST until the meter points directly to the LINE TEST mark in the center of the meter scale. Release P7.

ENGLISH POSITION

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

BIAS POSITION

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

SHORTS TEST

4. Connect a 1 megohm resistor between pins 8 and 1 on the octal socket. Rotate the SHORTS switch to positions 1 through 5 and observe that the meter reads about 1 megohm in all short test positions. Return the SHORTS switch to the tube test position.

FILAMENT VOLTAGE TEST

5. 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 plus or minus 10% of nominal. Return the FILAMENT switch to the 6.3 volt position.

PLATE VOLTAGE TEST

6. 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.

SCREEN VOLTAGE TEST

7. 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 volts plus or minus 5 volts. Release P4.

REDUCED SCREEN VOLTAGE TEST

8. Hold P4 and press P1. The reading should drop to 56 volts plus or minus 3 volts. Release P1 and P4.

GRID BIAS VOLTAGE
9. Remove the type 49 bias fuse lamp and verify that it is of the correct type and it is good. Put a good type 49 lamp back into the tester. 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. Adjust the BIAS control fully clockwise. Verify that the maximum voltage is -39 volts plus or minus 1 volt. Set the BIAS control to 22. Verify that the reading is -3 volts plus or minus .2 volt.

GRID SIGNAL VOLTAGE TEST
10. Set the BIAS control to zero. Connect a high impedance AC voltmeter to pins 8 and 5 and measure the grid signal voltage. Do not use a compensating shunt resistor for this test. The AC grid signal voltage should be 2.5 volts AC plus or minus .125 volts.

PLATE SUPPLY BALANCE TEST
11. Connect a DC coupled oscilloscope to pin 3 of the octal socket. Use pin 8 as a common for the scope. Press P4. Observe the plate voltage and obtain a display on the scope that shows the rounded 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. Verify that the alternating peaks of 120Hz DC are of equal amplitude. Release P4.

SCREEN SUPPLY BALANCE TEST
12. Remove AC power from the tester. Connect the scope probe ground lead to pin N, the center tap of the power transformer winding for the 5Y3 plates. Connect the scope probe to pin K, the center tap of the power transformer winding for the 5Y3 rectifier filament and reapply AC power. Adjust the scope as before to display the 120Hz peaks, and observe the screen bias voltage. Verify that the alternating peaks of 120Hz DC are of equal amplitude. Remove AC power and disconnect the scope. Reapply AC power for the next test.

METER BRIDGE BALANCE
13. Connect a 10K 10 watt 1% resistor between pins 3 and 8 of the octal socket. Set the ENGLISH control to zero then rotate it clockwise to the orange dot near number 73, which is the 3000 micromho scale setting. Press P4 and observe the meter reading. Verify that the meter reads zero or no more than one small division high or low. Rotate the control from end to end to see if the balance changes positive and/or negative with control rotation. Release P4 and remove the resistor.

MUTUAL CONDUCTANCE READING TEST
14. Verify that the panel switches are set up to the conditions as given in PREPARATION at the beginning of this section, (JR 5347-2) FILAMENT at 6.3 volts. Set the BIAS and the ENGLISH controls to zero. Rotate the ENGLISH control clockwise to the orange dot near number 73.

For the following mutual conductance test 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. Measure the voltage source directly across the secondary of the isolation transformer. Do not use a shunt resistor across the meter.

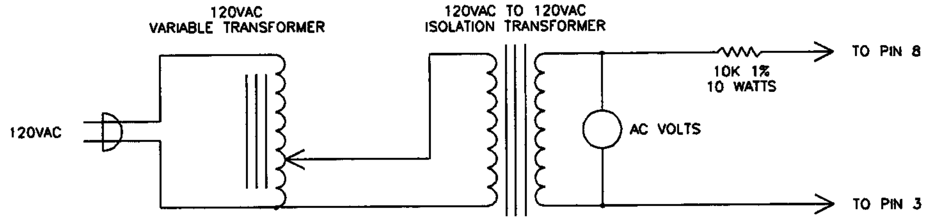

FIGURE 1

Push P4 and slowly adjust the voltage source up to exactly 50.0 volts. Observe the reading on the tester meter. The correct reading is 2000 micromhos plus or minus one small division on the 3000 scale. It may be slightly worse depending on the quality of the ENGLISH control. After taking the reading set the voltage back to zero and release P4.

DIODE/RECTIFIER TESTS:

15A. Verify that the panel switches are set up to the conditions as given in PREPARATION at the beginning of this section, (JR 5347-2) 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 ENGLISH control to 86. Press the P1 DIODE test button. Verify that the meter reads at or slightly above the DIODES OK line on the meter. Release P1.
15B. Adjust the ENGLISH control to 53. 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.
15C. Replace the 1K resistor with a 10K 1% 10 watt resistor. Adjust the ENGLISH control to 46. 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
16. 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 ENGLISH control to 73. Press P5, the gas 1 test button. Adjust the BIAS control for a reading of 100 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 1Meg resistor between pin 5 and pin 7 of the nine pin miniature socket. Repeat the test. This time verify that the reading goes up by 4 to 5 small divisions on the meter when the P6 button is pushed. Release P6 and P5.

This completes the testing and calibration procedure. For adjustments and problem resolution refer to the ADJUSTMENT CHART section below.

ADJUSTMENT CHART
1. LINE ADJUST: The 150 volt plate supply is used as the reference when setting the AC line voltage adjustment. The AC line control is adjusted until the plate voltage is 150 volts as read on the meter. All of the other operating voltages follow along and are assumed to be correct. If the plate supply is abnormally high or low then adjusting it to the nominal 150 volts with the line test will cause all of the other operating voltages to be shifted. This is because the line adjust will be compensating for an abnormal plate supply and also affecting every other operating voltage.

If the plate supply voltage is normal and all of the other voltages are wrong by the same percentage, look at the plate supply for problems. If the AC line test circuit itself is bad the plate and other voltages will all be wrong. Earlier versions of the 800/800A had a fixed resistor in the AC line voltage metering circuit. This was a 215K fixed resistor mounted on the terminal side of the pushbutton switch deck. In that case check the 215K resistor for proper value and replace it if necessary in order for the meter to read the line test correctly when the plate voltage is 150 volts.

Later versions of the 800A had a calibration adjustment for the AC line test. Adjustable resistor R24 / 100K is used for that. If the plate and other voltages are not correct after setting the AC line adjustment, perform the PLATE VOLTAGE TEST 6 and adjust the LINE ADJUST control for a reading of 150 volts. Follow this with the LINE ADJUST test but do not change the LINE ADJUST control. Adjust R24 instead of the LINE ADJUST until the meter points to the LINE TEST mark in the center of the meter.

Also check the meter movement and verify that it indicates full scale when passing the nominal full scale current of 500 microamps and has a movement resistance of 233 ohms. Other values may have been used as production changes were made through the years. 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. Bear in mind though that changing the meter adjustment will effect the mutual conductance reading too so rule out everything else before adjusting the meter.

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

3.BIAS POSITION: Loosen the set screw on the knob and reposition the knob to the correct location. Retighten the set screw.

4. SHORTS TEST: There is no adjustment for this function. Check the meter movement accuracy, R11 / 112K resistor and the 56 volts low screen voltage as measured in SCREEN VOLTAGE TEST 7.

5. FILAMENT VOLTAGE TEST: No adjustment. This voltage is entirely dependent on the power transformer and the AC line setting. See also ADJUSTMENT CHART 1, LINE ADJUST above. Some voltages may be slightly higher due to the transformer having no load.

6. PLATE VOLTAGE TEST: No adjustment. This voltage is entirely dependent on the power transformer and the AC line setting. See also ADJUSTMENT CHART 1, LINE ADJUST above. If the AC line test circuit is reading correctly, check and/or replace the type 83 rectifier tube.

7. SCREEN VOLTAGE TEST: No adjustment. This voltage is entirely dependent on the power transformer and the AC line setting. See also ADJUSTMENT CHART 1, LINE ADJUST above. If the AC line test circuit is reading correctly, check and/or replace the type 5Y3 rectifier tube.

8. REDUCED SCREEN AND GRID BIAS VOLTAGE ADJUSTMENTS: The 56 volt reduced (P4 and P1 pushed) screen grid voltage measured in step 8 and the –39 volt control grid bias voltage measured in step 9 is set by adjustment of the two taps on R15 / 8.5K. If adjustments are necessary to either the reduced screen voltage or the grid bias voltage, adjust the control grid voltage first because that affects the reduced screen grid voltage also. Before doing any adjustments always verify that the screen supply voltage is 130 volts. Adjust the AC line control until it is.

In both versions of the 800/800A the grid bias is controlled by the series combination of R15 a tapped power resistor, and R16 the front panel BIAS adjust control. Remove the tester from the case and prop it up on a work surface face down such that you can reach and push the control panel buttons P4 and P1. Set it up with the top edge of the control panel facing you and the panel meter to the right.

To set the grid bias voltage, adjust the BIAS control fully clockwise. Loosen the clamp screw of the sliding tap on resistor R15. This is the tap with the jumper wire to the end tab on R15. Gently hold the tap with insulated pliers and slide the tap until the voltage is as close to –39 volts as you can get it. Tighten the screw to secure the tap in place. Don't over tighten the screw. Only enough pressure to keep the tap from sliding is sufficient.

To set the reduced screen voltage perform test 8. Loosen the clamp screw of the second sliding tap on resistor R15. This is the tap that is not connected to the end tab of R16. Gently hold the tap with insulated pliers and slide the tap until the voltage is as close to 56 volts as you can get it. Tighten the screw to secure the tap in place.

There is some interaction between the two adjustments so repeat tests 8 and 9 and adjust as necessary to get both voltages within the limits.

9. GRID BIAS VOLTAGE: See step 8 above. A burned out bias fuse lamp will cause the bias voltage to be low.

10. GRID SIGNAL VOLTAGE TEST: No adjustment is possible for this voltage. The voltage is entirely dependent on the power transformer and the AC line setting. Make sure that the AC line setting is correct and that the AC line set function is working properly. A burned out bias voltage fuse lamp can cause the grid signal to be low.

11. PLATE SUPPLY BALANCE TEST: This is entirely dependent on the power transformer and the rectifier tubes. If balance is incorrect replace the 83 tube.

12. SCREEN SUPPLY BALANCE TEST: This is entirely dependent on the power transformer and the rectifier tubes. If balance is incorrect replace the 5Y3 tube.

13. METER BRIDGE BALANCE: The meter bridge balance is determined by the relative positions of the upper and lower halves of the ENGLISH control. The ENGLISH control is designed so that the two halves form the two legs of a balanced bridge circuit. As the control is turned clockwise the two halves decrease in resistance by the same amount thereby decreasing the sensitivity of the bridge so that higher transconductance readings are displayed without over scaling the meter. The resistance of both halves of the control must track each other as they are rotated or the bridge will become unbalanced, adding or subtracting a constant number from the correct reading. If the power supply is properly balanced and the meter does not read zero or close to it with this test, the ENGLISH control is not balanced. If the control becomes dirty and intermittent the resistance will change abruptly and deviate from normal as it is rotated causing the zero to fluctuate or jump adding error. Because these are not high precision controls some fluctuation is always going to be seen as they are moved through the full span of rotation, especially at the end points and sometimes when the direction of rotation is changed. If the total fluctuation is on the order of four or more small divisions on the meter and cleaning doesn't help, the only solution is to replace the control. To clean a dirty control, follow the Control Cleaning instructions given below.

If the ENGLISH control is not balanced it will have to be adjusted. While proper balance is vital to the accuracy of measurement, calibration is done by adjustment of the control under Control Alignment described below in the MUTUAL CONDUCTANCE CALIBRATION section.

Control Cleaning:

If the ENGLISH control is dirty or intermittent it is best to remove it from the tester to clean both sections. If you are not experienced in taking apart controls do not use this as a learning opportunity. It is fairly easy to ruin one and there are no replacements other than salvage from a junk tester. Set the control to the center of rotation before working on it. Do not rotate the shaft more than a short distance while the halves are separated. On older controls that do not completely separate, if you rotate past the stop you can drop the front wiper into the slot between the ends of the element and it will be difficult to get it back out.

The back cover is press fit onto the end of the back section shell and can be removed by prying it off. On the older controls you cannot completely separate the front section from the back. To separate them enough for cleaning, remove the retaining ring around the shaft where it enters the front section then melt the solder spot and gently pull the shell apart only far enough to keep the solder from holding the two halves together when it cools and no farther. Once the shell sections are separated remove the solder from the surfaces. Gently separate the front section shell from the cover just enough to provide an opening to infuse an appropriate cleaning solution. A couple of toothpicks placed in the gap will hold the halves separated for cleaning. Never attempt to pull them farther apart as this will bend and destroy the front section wiper components.

On newer controls the front section comes completely apart by removing the retaining ring from the shaft and sliding the shaft out the back of the shell after it has been separated. The wiper and center tab can be removed and cleaned. The back section cannot be disassembled as the front section but there is enough exposed to do a cleaning.

The main problem is not the wirewound element or the slider on the wiper but the sliding contact between the wiper and the center lug of the control. Old dried out grease, dust and tarnish on the contacts that connect the center tab to the wiper are the main problems. A good cleaning method is to immerse the control in an ultrasonic cleaner for a few minutes using a detergent solution in water. Afterward, give it a good rinse with clean water and then a second rinse with a mild water soluble solvent such as isopropyl alcohol to purge the water. Follow up with an air dry. After cleaning reassemble the control but do not reapply the solder to the shell. Do a control alignment as described below in the Control Alignment section under MUTUAL CONDUCTANCE CALIBRATION.

14. MUTUAL CONDUCTANCE CALIBRATION: The mutual conductance reading in this test is controlled by the setting of the ENGLISH control and the accuracy of the meter. Check the meter accuracy as described above in ADJUSTMENT CHART step 1. A bad or dirty ENGLISH control will cause the readings to be wrong. If necessary, cleaning the ENGLISH control as described above in Control Cleaning should always be done before adjusting the mutual conductance calibration. If the readings are incorrect follow the Control Alignment procedure below to adjust the control to the proper calibration.

A difference of one or two small divisions might be seen if you rotate the control and set it to the orange dot by rotating it counterclockwise instead of clockwise. This is because the ENGLISH control is not a precision device nor was it ever intended to be. It has a certain amount of inaccuracy in the resistance and instability in the mechanical motion. This is about the best you can do with an instrument of this age and caliber.

Control Alignment:

Remove the tester from the case. Remove the ENGLISH control from the tester. Note the small spot of solder on the side of the shell of the ENGLISH control. Remove the solder so that the shell of the back resistor section can rotate with respect to the front section. Block the tester up on a level surface with the front panel facing up. The top edge of the control panel should be facing you so that you can see the meter and push the buttons.

Temporarily connect the ENGLISH control to the tester with clip leads and place it in a convenient position such that you can hold it and adjust it. Verify that the AC line adjustment is correct. Rotate the ENGLISH control fully counterclockwise. Put the ENGLISH knob on the control and rotate the knob without rotating the shaft to align the zero setting to some convenient landmark. Tighten the set screw on the knob and, using the landmark, rotate the control to the orange dot near number 73. Connect the calibration test circuit and perform the mutual conductance reading test. Secure switch P4 down and while holding the back section of the control stationary, rotate the shell of the front section until the meter reads 2000 on the 3000 scale. Once that is achieved, remove power and carefully tape the shell to prevent it from rotating. Perform the test once more and verify that the knob didn't move and the shell didn't slip before it was secured with the tape. Reapply just a little solder spot to the shell to permanently secure the shell in place and re-install the control in the tester. After reassembly do a final re-test. Be careful when you do this adjustment because of the dangerous voltages in close proximity. Wear insulated gloves and understand exactly what you are going to do before you start.

15. DIODE/RECTIFIER TESTS: The diode and rectifier tests assess 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 R4 / 12 ohms, R5 / 1.2K, R6 / 1.8K, R22 / 200 ohms. The sensitivity of the meter and the accuracy of the ENGLISH control also affect this test.

16. GAS TEST: The gas testing circuits depend on the meter bridge, ENGLISH and BIAS controls. If the mutual conductance tests are functioning properly, check for bad switches or dirty contacts on P5 and P6. Also check R17 / 180K resistor. This resistor 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 R17. The plate current goes up as the grid bias drops indicating gas in the tube.

NOTES

Always test the two rectifier tubes first if trouble is suspected. Check for out of tolerance resistors, inaccurate meter movements, dirty switch contacts, dirty ENGLISH control or a bad transformer. The type of measuring instruments used or other factors not related to the tester itself can give readings that appear to be a little out of specification. Some of the important factors are the DC operating voltages, power supply balance and the AC grid signal voltage.

The mutual conductance measurement circuit assumes a correct AC grid signal voltage. If the AC grid signal voltage is wrong, the displayed mutual conductance reading will be wrong by the same amount of error even though the DC voltages and mutual conductance measurement circuit are calibrated correctly. Hickok did not provide a means for adjusting or regulating this voltage, relying on the transformer winding to be pretty close to the right value. The AC signal voltage will change depending on things like the setting of the bias control, heater load and plate current but, for the purpose the tester was intended, this is good enough. Hickok knew these things and compensated the roll chart numbers to provide adequate test results. The cutoff point where a tube is judged good or bad is rather arbitrary and subjective depending on the application so some error is not all that important. Hickok testers are not designed to measure the absolute quality of a tube but to discern the probable good from the probable bad in connection with service work.

There are several points to consider on the replacement of the vacuum tube rectifiers with solid state devices or other design changes. Hickok made a lot of assumptions and clever design tradeoffs to manufacture an instrument that worked well but was not overly complicated or expensive. Calibration constants of the tester are very much dependent on certain conditions remaining in place such as voltage drops due to the rectifier heater current consumption and the effect of plate resistance voltage drops in the rectifiers. Any circuit modifications including substitution of the rectifiers with anything but the original types will compromise the accuracy and should be avoided.

The component designation numbers given refer to the parts listed in the Hickok schematic diagram included with the operators manual for the model 800A. Hickok revised and changed the 800 and 800A several times during the manufacturing life of the instrument. Some deviation is to be expected from unit to unit depending on the year of manufacture. These calibration guidelines serve as a model for a general outline on calibration. Individual testers may vary as to the physical layout or other details. All of the Hickok mutual conductance testers use the same basic circuit with small variations. Many of the other models, especially the small service type testers can be checked using the same voltage specifications. Significant variations in the AC grid signal voltage might be found in earlier testers. Earlier testers used 5.0 volts AC rather than the 2.5 volts used later. Other model testers used a selection of AC grid signal voltages depending on the meter range selected.