precise

construction book

MODEL 111

GM & EM TUBE TESTER

PRECISE DEVELOPMENT CORPORATION
OCEANSIDE, NEW YORK

PRECISE DEVELOPMENT CORP.

Oceanside, New York
ROckville Centre 6-0171-2

Dear Customer:

Now that you have purchased a PRECISE INSTRUMENT, we would like you to feel that the PRECISE DEVELOPMENT CORP. is available to you at all times. We consider your purchase to be the beginning of our responsibility toward you, our customer. If a question should arise, please feel free to contact us at our factory, or through your distributor.

Very truly yours,

PRECISE DEVELOPMENT CORP.

Melville Byron

Melville Byron
Chief Engineer

MB/bam

INTRODUCTION

The Model III Gm and Em Tube Tester introduced to the electronics industry the most complete tube evaluation available, other than by expensive and complicated laboratory Bridge Systems.
The Model III makes the following general tests:
1) Gm -- Mutual Plate Transconductance.
2) Em -- Plate Emission.
3) Filament Current.
4) Leakage and Shorts.
5) Gas.
6) Noise.
7) Life.

1- Gm

Gm (Mutual Plate Transconductance) is the ability of the grid of the tube to control its plate current. Mathematically it is a small change in plate current divided by the change in grid voltage required to make the plate current change. The plate voltage is kept constant. From this it can be seen that the Gm is a most important measurement - especially in video, I.F. and power amplifiers.
The Gm test is made by applying pulsating DC voltages as follows:- Positive to the plate and screen; negative to the grid. An AC signal voltage is also fed to the grid which causes an AC increment to appear in the plate current. It is the measurement of this increment which ascertains the Gm of the tube. These are actual average Gm measurements and are not hypothesized.

2- Em

Em (Plate current measurement) of a tube is, as the name implies, measurement of the tube plate current. Although the voltages applied to the plate are swept, the measurement is still primarily static. It is an indication of the cathode current (which, of course, controls self bias) and also the plate resistance, etc. In this test separate voltages are again fed to the plate, screen and grid of the tube. The voltages are AC, the current is DC since the tube rectifies it.

SELECTING THE PROPER TEST

It may be said that the more tests made, the more correct the analysis of the condition of a tube. It is necessary, however, to occasionally look for a faster means. With this idea in mind, PRECISE has * (Asterisked) the most important single test for each tube or section thereof. If you do not wish to make both the Gm and Em tests, we recommend that you select the one with the * in back of its listing on the roll chart.

TESTING A TUBE FOR Gm

1- Select the tube type under the heading marked 'TYPE' above the Roll Chart. Gm tests are indicated by 'Gm' in the 'NOTE' column.

2- Set the FILAMENT Switch to the same value as shown under the heading 'FIL'. The top value listed is the Filament voltage. The value directly beneath it is the Filament current. Measuring the current is discussed in a later section.

3- Control A is set to the 1st; B to the 2nd; C to the 3rd; D to the 4th and E to the 5th letter or number as shown under the heading marked 'A-E'. As an example, if the letters were BGGG(0) then Control A goes to B; Control R goes to G; Control C goes to G; Control D goes to G; Potentiometer E goes to 0.

4- Controls F, G, H, I and J are set to the numbers under the heading F-J.

5- Similarily controls K, L, M, N and O are set to the numbers under the heading K-O.

6- The tube is inserted into its appropriate socket; the OFF LIFE ON Switch set to ON; the SHORT Switch rotated through all its positions and then back to TEST (NOR). The Neon Bulb SHORT Indicator should only light for those numbers designated in the SHORT Column of the Roll Chart. If the bulb stays lit for any other setting, other than those listed in the SHORT column of the Roll Chart, the test should be stopped and the tube discarded since further tests could injure the tester. The neon bulb may light for an instant in other positions, but should not stay lit nor blink continuously except as designated.

7- Rotate the METER switch to the LINE position. Rotate the TEST switch to the HOLD position. Adjust the LINE ADJUST Rheostat until the Meter reads exactly center scale (the center of the question mark). The NOR.-REV. Meter Slide Switch should be in the NOR. (NORMAL) position.

8- Rotate the METER switch to the BIAS position. There are two BIAS scales on the meter; a ten and fifty volt full scale. If the value listed in the BIAS column of the Roll Chart is 10 or less volts, set BIAS slide switch to the 10 position and adjust the BIAS potentiometer for the proper voltage (that shown on Roll Chart) on the 10 volt Bias Scale of the Meter. If the value listed under the BIAS Column of the Roll Chart is greater than 10 volts, set the BIAS Slide Switch to the 50 position and adjust the BIAS potentiometer for the proper reading on the 50 volt BIAS scale of the Meter. Since the adjustment of the Bias will change the loading on the instrument, it is usually desirable to go back to the LINE setting of the METER switch and readjust the LINE ADJUST Rheostat. Greater accuracy may likewise be achieved by switching the METER switch back to BIAS and readjusting the BIAS potentiometer.

9- Rotate the METER switch to TEST and read the Gm value on the appropriate scale of the Meter. There are 5 Gm scales as explained below. The Gm VALUE ON THE ROLL CHART IS A MINIMUM VALUE AND TUBES BELOW IT SHOULD BE REJECTED. Switch A (the PLATE SHUNT switch) indicates the proper scale:- The 30K and 3K are read on the 0-3 scale of the meter; the 20K is read on the 20 scale; the 8K is read on the 8 scale; the 6K is read on the 6 scale. All readings are in thousands of micromhos. As an example, a reading of 4 on the 0-6 scale would be 4,000 micromhos; a reading of 2 on the 0-3 scale would either be 2,000 or 20,000 micromhos depending upon the PLATE SHUNT switch being set to the 3K or 30K range respectively. NOTE: THE "REPLACE ? GOOD" SCALE IS NEVER USED ON Gm MEASUREMENTS.

TESTING A TUBE FOR EMISSION

1- If this test follows the Gm test the tube need not be removed but the TEST switch must be in the OFF position. Repeat steps 2 through 7 of "Testing A Tube For Gm" except that the section marked EM in Note Column of the Roll Chart is used for setting switches and Step 6 may be omitted if done in Gm Test.

2- Set the BIAS potentiometer to the number indicated in the BIAS column of the Em test on the Roll Chart. The Bias voltages are not indicated on the meter in the Em test, but are set up by using the 0-50 scale around the BIAS potentiometer.

3- Rotate the METER switch to TEST, TEST switch to TEST and note the value of tube on the REPLACE ? GOOD scale of the meter.

SUMMARY

You have now completed the Gm, Em and Short checks on your tester. Let us summarize the procedure.

Gm

FILAMENT Switch to Filament Voltage.
Switches A through E set by letters and numbers on roll chart.
" F " J " " " " " " "
" K " O " " " " " " "
Insert tube and make SHORT CHECK by rotating SHORT switch. TEST switch to HOLD.
METER Switch to LINE and adjust meter pointer to center scale.
METER Switch to BIAS - BIAS potentiometer and BIAS Slide Switch used to set proper Bias on Meter Bias scales. In Gm position BIAS is measured on meter. In Em it is set by scale around BIAS potentiometer.

Em

TEST Switch to OFF.
FILAMENT Switch to Filament Voltage.
Switches A through E set by letters and numbers on roll chart.
" F " J " " " " " " "
" K " O " " " " " " "
Insert tube and make SHORT check by rotating SHORT Switch.
BIAS Potentiometer to number on roll chart under BIAS Column.
TEST Switch to HOLD.
METER Switch to LINE and ADJUST line.
METER Switch to TEST.
Read on REPLACE - ? - GOOD Scale.

TESTING THE FILAMENT CURRENT OF A TUBE

This is an extremely simple test. Once the instrument is set for either Gm or Em rotate the METER Switch to either the 3AMP (3 Ampere filaments)or .3AMP (300 milliampere filaments) ranges. The actual filament current is read on the bottom Meter scale. The filament current that should be flowing is listed on the roll chart under the Filament Voltage. A deviation of greater than 20% in current should be carefully observed as a possible source of trouble--this is particularly true of tubes in a series string. Note: It is possible to injure the meter by using the wrong current range. CAUTION:- Always check the higher current range (3AMP) before shifting down to the lower range (.3AMP).

TESTING FOR LEAKAGE OR SHORTS

1- Once the switches are set for either Gm or Em, the tube may be tested for SHORTS by rotating the SHORT Switch through all its positions. The SHORT Neon Bulb should light in each position under the heading SHORT of the roll chart. This test checks all tube elements against each other element in the tube. In position #1, pins #2,3,4,5,6,7,8,9, 10 are checked against pin #1. (Position #10 is connected to the Plate Cap). If a short exists between pin #1 and any other pin, the Neon Bulb will light. In position #2 all the pins are checked against pin #2. Again if a Short exists between pin #2 and any other pin, the Neon Bulb will light. The same, of course, applies to each other pin as the SHORT Switch is rotated through all its positions. When testing a tube for Gm or Em, the SHORT switch must be in the TEST(NOR.) position. Most tubes since they have filaments will show a short between at least two of its elements and these numbers will be listed on the roll chart. When the tube is warm, the Neon Bulb will often flash and then go out when switched to a pin. This is the series internal condenser charging and no short exists unless the bulb remains lit or flashes on and off continuously. Tapping the tube gently in each position of the SHORT test will often show up the possibility of loose internal shorts.

TESTING FOR GAS CURRENT

Gas current is actually a reverse current through the tube. It is particularly noticeable when the grid of the tube is biased highly negatively. Gas ions then flow to the grid causing it to become less negative.

To check the average tube for Gas. set it for the Gm test and then proceed as follows: (only applies to grid controlled tubes).
1- Rotate the SCREEN VOLTAGE switch to A. This lowers the Screen Voltage.
2- Set the BIAS Slide Switch to 50: the METER Switch to TEST.
3- Adjust the BIAS Potentiometer until the meter just barely reads on the scale. About ¼ or ½ inch from the 0 is about right.
4- Push GAS Switch. If Meter moves more than about 1/16 inch upward, the tube has Gas present.
5- Since Gas, on occasion, is not detectable until the tube is well heated, it is suggested that suspected tubes be allowed to operate for several minutes before testing. Gas is particularly troublesome in high impedance amplifiers, AVC, AFC and television circuits.
Rotate Switch 'D' to 'B' if #3 above does not reduce to low enough reading.

TESTING FOR NOISE

This test need not be made on most tubes unless it is actually suspected of being the trouble. Sparking, intermittent shorts, etc. which constitute the creation of noise will readily show up during this test.

1 - Connect the antenna and ground terminals of a radio receiver to the top and bottom NOISE terminals respectively.

2 - Tune the receiver to any portion of the dial without a station. Gently tap the tube and note if noise is present as the SHORT switch is rotated through each of its positions.

TESTING THE LIFE

This test is made at the conclusion of a Gm or Em test without changing the dial settings. It consists of lowering the filament voltage by approximately 10% by moving the OFF-LIFE-ON slide switch to the LIFE position and noting the affect on the Gm or Em of the tube. Note: NO other voltages are changed. If a greater than 20% Gm or Em drop is noticed, it may be assumed that a large life reserve is not present. This tube may cause trouble in the near future. We caution you in this test, however, not to consider this as more than an educated guess since there is no true method of ascertaining the life expectancy of a specific tube. In high filament voltage rectifiers, it is suggested that the instrument be turned off for a minute or so to allow the filament to cool. It should then be placed into the LIFE test directly.

TESTING PILOT LIGHTS

Switch G is set to #5 and switch L is set to #6. This corresponds to pins 2 and 7. The correct voltage is set on the FILAMENT switch. The pilot light should then light when it is inserted into the middle of the large 7 pin socket.

SWITCHES AND POTENTIOMETERS

OFF-LIFE-ON Switch

OFF - Turns entire instrument off.
LIFE- Turns instrument on, but reduces filament voltages by approximately 10%.
ON- Turns instrument on.

FILAMENT Switch

0 - Represents 0 Filament Voltage.
B - Represents Ballast position.
All other positions feed filament voltages as indicated.

BIAS Potentiometer

In the Gm position of the Gm-Em Switch a negative DC Bias is adjusted by this potentiometer. It is either from 0-10 or 0-50 volts depending on the setting of the BIAS Slide Switch.
In the Em position of the Gm-Em Switch an AC signal is adjusted by this potentiometer up to a maximum of 50 volts. The BIAS Slide Switch has no effect.

SHORT SWITCH

This switch progressively checks each pin against all the remaining pins for the possibility of a short circuit or leakage path. In Position #1 it checks all the pins for a short to pin #1. When the switch is rotated to position #2 it checks all pins to #2, etc. A short shows by the Neon SHORT Bulb lighting. In the TEST(NOR.) position, the short section is disconnected and the tube may be tested as desired. Note:- All pin connections are removed from the sockets to the various test - ing voltages when the SHORT Switch is in any position other than the TEST(NOR.). i.e. No tube test except for SHORTS can be made unless switch is in TEST(NOR.) position.

METER SWITCH

LINE- Measures the Line Voltage on the Meter. Proper setting is the Question Mark in the center of the top Meter scale. Thus voltage is adjusted by the LINE ADJUST Rheostat.
BIAS- Measures the DC Bias when the Gm-Em switch is in the Gm position. It does not indicate in the Em position. The Bias voltage is determined by the setting of the Bias Slide switch and the Bias Potentiometer.
TEST- Allows the meter to read either the Gm or Em of the tube.
3 AMP- Measures the filament current of the tube on the 3 Ampere range of the meter.
.3 AMP- Same as 3 AMP, above, except that it measures on the .3 Ampere range.

LINE ADJUST RHEOSTAT

When the METER switch is in the LINE position, this rheostat allows the line voltage to be adjusted to the proper value. Correct setting is the Question Mark in the center of the top scale

TEST SWITCH

TEST- is the momentary contact which applies all voltages, except filaments which are already applied, to the tube under test. When released it automatically returns to OFF.
OFF- No voltages, other than filaments, are applied to the tube in this position.
HOLD- Same as TEST except that the switch will stay in its position when released. This is used for prolonged tests.

BIAS SLIDE SWITCH

10 - Applies a 10 volt Bias to the BIAS potentiometer. See section on BIAS Potentiometer.
50 - Applies a 50 volt Bias to the BIAS potentiometer. See section on BIAS Potentiometer.

METER SLIDE SWITCH

NOR - This is the normal position of the meter.
REV - This meter is reversed for special tubes.

GAS SWITCH

Used in conjunction with various other switches in testing for Gas. The switch is of the momentary type and automatically returns to normal operation when released. See section on 'TESTING FOR GAS CURRENT'.

A -- PLATE SHUNT SWITCH

This switch is used for two different purposes: In the Em position, it changes the series loading resistors and meter shunts; In the Gm position it changes the meter shunts and also the AC Grid driving signals from a minimum of approximately ½ volt to a maximum of about 3 volts. The seven Em positions are designated by letters A through G; the 5 Gm are designated by numbers followed by the letter K which means 1,000. Gm is measured in micromhos. i.e. 30K means 30,000 micromhos.

B -- Gm-Em SWITCH

Gm - This position is used in Gm tests.
Em - This position is used in Em tests.

C -- SCREEN VOLTAGE SWITCH

G - Used normally in the Gm tests. Supplies approximately 140 volts of pulsating DC to the screen. May also be used for certain other tests where DC is desired.
A - Supplies approximately 60 volts of DC to the screen. Used on some Gm and GAS tests.
B - Supplies about 50 volts of AC to the screen. Used mostly in Em tests.

D -- PLATE VOLTAGE SWITCH

G - Supplies 160 volts, pulsating DC to the plate. This section is primarily used with Gm.
A - Supplies 20 volts AC to the plate -- used primarily with Em.
B - Supplies 50 volts AC to the plate -- used primarily with Em.
C - Supplies 160 volts AC to the plate - used primarily with Em.
D - Supplies 160 volts AC to the plate - used primarily with Em.
E - Supplies 300 volts AC to the plate - used primarily with Em.

E -- Em SHUNT POTENTIOMETER

Rotor of Switch F goes to Pin 1 of each tube socket; G goes to Pin 2; H goes to Pin 3; I goes to Pin 4; J goes to Pin 5; K goes to Pin 6; L goes to Pin 7; M goes to Pin 8; N goes to Pin 9 and also to Grid Pin Jack Connection and O goes to Plate Pin Jack Connection.

0 of each Switch F-0 goes to NO CONNECTION.
1 of each Switch F-0 goes to the GRID SUPPLY CIRCUIT.
2 of each Switch F-0 goes to the CATHODE SUPPLY CIRCUIT.
3 of each Switch F-0 goes to the SCREEN SUPPLY CIRCUIT.
4 of each Switch F-0 goes to the PLATE SUPPLY CIRCUIT.
5 of each Switch F-0 goes to the FILAMENT SUPPLY #1.
6 of each Switch F-0 goes to the FILAMENT SUPPLY #2.
7 of each Switch F-0 goes to the FILAMENT SUPPLY #3. SEE NOTE BELOW.
8 of each Switch F-0 goes to a CONNECTING LINE. SEE NOTE BELOW.

NOTE: FILAMENT #3 is connected to FILAMENT #2 through a 330 ohm resistor. This protects filament arrangements where a tap is brought out for a pilot light. Consider a tube, such as a 35Z5, with filaments on 2 and 7 and the tap between 2 and 3. Pin #7 of the tube should be connected to FILAMENT #1. Pin #2 should be connected to FILAMENT #2 and pin #3 (the tap) should be connected to FILAMENT #3. This places the 300 ohm resistor between taps 2 and 3 and reduces the current through the tap. The use of the CONNECTING LINE is explained in another section of this book.

FUSE LAMP

This automobile type bulb is in series with the 110 volt line and serves as a fuse for over-loads. On certain tubes it may glow dimly, but under no circumstances should it glow brightly. If it does, turn instrument off at once and recheck all switch settings.

SHORT LAMP

This is a Neon Bulb which acts as a SHORT indicator. A Short is present when the bulb glows or flickers continuously.

PLATE CAP

This cap is connected to Switch O. It is used for the cap connection on a tube as indicated on the roll chart.

GRID CAP

This cap is connected to Switch N. It is used as indicated on the Roll Chart.

MEASURING ELEMENT CURRENT

It is quite simple to connect in series with the Plate, Grid, Screen or Filaments.
Select the proper pin switch (F is pin 1, G is pin 2, H is pin 3, etc.) and set that switch to position #8 (the Connecting Line). Connect Switch N also to #8. Since Switch N is connected to the GRID Pin Jack, this brings the desired pin to the GRID Pin Jack through the Connecting Line. Rotate Switch O to the proper function (#1 is Grid; #2 is Cathode; #3 is Screen; #4 is plate; #5 is Filament 1; #6 is Filament 2; #7 is Filament 3). By connecting any device between the PLATE and Grid Pin Jacks, we have effectively connected it in series.
As an example consider the 6L6 tube: If we desired to measure the plate current this would be accomplished as follows: Switch H would be rotated to its #8 position (the plate of the tube is connected to the Connecting Line). Switch N is also connected to #8. (This connects the Plate of the 6L6 to the GRID Pin Jack). Switch O is now switched to the Plate Feed circuit which is #4. Switch O is also internally connected to the PLATE Pin Jack. If a milliammeter is now placed between the PLATE and GRID Pin Jacks, the plate current of the 6L6 may be read directly.
The above system may only be used through eight pin tubes. If 9 pin tubes are to be similarly checked, we suggest inserting another Pin Jack into the front panel and connecting it to the Connecting Line. The Connecting Line may be located by rotating switch O to position #8 on the front panel. When Switch O is viewed from the rear, the small protuberance on its rotor is connected to the Connecting Line.

Measurements are now made between the new Connecting Line Pin Jack and the PLATE Pin Jack. It is only necessary to switch Pin Q to the proper function. Switch N may be ignored.

SELF BIASING

Self Biasing is achieved in the same manner as MEASURING ELEMENT CURRENT. The cathode of the tube is switched to the Connecting Line by rotating its switch to position #8. The Cathode is determined from a tube manual. (Remember that Switch F is the same as Pin #1, Switch G the same as Pin #2, etc.) Switch Q is then rotated to #8. A resistor is then placed between the PLATE Pin Jack and the Ground Pin Jack (LOWER NOISE Terminal). A Cathode by-pass condenser (about 500 ufd at least) is placed across the resistor. (The negative side to Ground). The BIAS Potentiometer is rotated to zero and the Gm measured as it would normally.

VIEWING THE TUBE CHARACTERISTIC CURVE ON AN OSCILLOSCOPE

The simplest way of observing the characteristic curve is to set up a tube for Self Bias as described above, except that the resistor used is of a very low value(usually less than 100 ohms)and no by-pass condenser is used. The Vertical Input terminals of an oscilloscope are then connected across the resistor. The ground lead of the oscilloscope goes to the Ground Pin Jack while the high lead goes to the PLATE Pin Jack. If a 60 cycle signal is now fed into the Horizontal Input of the oscilloscope, the Characteristic curve can be seen. The curve will show two separate curves, one on the right hand side of the screen and the other on the left side of the screen. One curve will be higher than the other due to the fact that a Grid Signal is present. On one side it will be in phase and on the other side it will be out of phase. If some of the Plate Voltage is fed into the Horizontal Input of the oscilloscope instead of a 60 cycle signal, this will present both patterns on the same side. Plate Voltage may be obtained by rotating Switch N to position #4; this connects Plate Voltage to the GRID Pin Jack. This voltage is now fed to the Horizontal Input. Varying the Grid BIAS Potentiometer will change the shape of the Characteristic curve. The amount of Grid Signal may be changed by changing the setting of the PLATE SHUNT Switch. The signal voltage is progressively reduced as the Gm value increases. More signal is used for the 3K than the 30K. (Approximately 1/10th the signal is on the Grid when the 30K range is used.

NEW TUBES Gm TEST

The Gm setting can normally be made directly from the tube manual without special tests.

1 - Look up the base connections in the tube manual. Switches F through Q should be set to the proper numbers. (See section on Switches F through Q). Remember that Switch F connects to pin 1 of the tube; Switch G connects to pin 2, etc. Q on the Switches F through Q is no connection. 1 is the Grid connection; 2 is the cathode and suppressor connections; 3 is the screen connection; 4 is the plate connection; 5 is Filament #1 (one side of the Filament); 6 is the other side of the Filament; 7 and 8 may normally be omitted.

2 - Set the FILAMENT Switch to the proper voltage.

3 - Set the PLATE SHUNT Switch to a Gm range which is higher than that listed in the tube manual.

4 - Set the Gm-Em Switch to Gm.

5 - Set the SCREEN VOLTAGE Switch to G.

6 - Set the PLATE VOLTAGE Switch to G.

7 - Set the METER Switch to LINE and adjust LINE voltage.

8 - Set the METER Switch to BIAS and adjust the Bias to approximately that given under the heading of average operating conditions in the tube manual.

9 - Insert the tube and make the SHORT check. The tube should show a short on any pin which is connected to another.

10- Rotate the TEST Switch to HOLD and readjust BIAS. The LINE might also need adjustment.

11- Rotate the METER Switch to TEST and read Gm. The rejection Gm reading is normally about 40% lower than that listed in the tube manual. If you are to use the reading as a standard, it is suggested that you take the average of several new tubes - preferably of different manufacturers.

12- Once you have the new data, list it in your instruction manual or onto the roll chart.

13- A number of tubes being designed today are the same as those listed on the roll chart except for a change in Filament Voltage. This is particularly true of series string tubes. In this case you need only change the Filament Voltage, all other settings will be the same as the original tube.

NEW TUBES Em TEST

The Em test is more experimental than the Gm. The basic procedure is similar to the Gm.

1 - Repeat steps 1 and 2 of the Gm.

2 - Set the PLATE SHUNT to A.

3 - Set the Gm-Em Switch to Em.

4 - Set the SCREEN VOLTAGE Switch to B.

5 - Set the PLATE VOLTAGE Switch to A.

6 - Set the METER Switch to LINE and adjust LINE Voltage.

7 - Set the Em SHUNT Switch to 0. Set the BIAS Potentiometer to 0.

8 - Repeat step 9 of Gm.

9 - Rotate the TEST Switch to HOLD and the METER Switch to TEST.

10- If meter does not read to at least 25% of full scale, raise PLATE VOLTAGE Switch to a higher letter (from A to B to C to D -- do not use range E except for High Voltage Rectifiers).

11- Adjust the Em SHUNT Potentiometer until the meter reads about 50%. Raise the BIAS Potentiometer until the meter reads about 75%. Record readings for future use. It is again better to use an average of about 5 or 6 tubes for establishing new settings.

Supplementary information and new roll charts will periodically be made available to all purchasers of the Model 111. When requesting supplementary data, please send self addressed stamped envelope. If no additional information is ready, the envelope will be retained until new data becomes available. New roll charts will be made available at additional charge.

MATCHING TUBES

The requirement for matched tubes is increasing with the advent of Hi Fi and other advances in electronics. The Model III is particularly suited for this purpose since it can be used for matching at both the Gm and Em levels. This matches the tube for Gm (dynamic conditions) and Plate current which also controls bias and other static conditions.

BALLAST TUBES

These tubes may readily be checked by consulting the manufacturers diagrams and/or specifications. Test as follows:

1 - Keep TEST Switch in the OFF Position in all Ballast tests.

2 - Rotate the FILAMENT Switch to B.

3 - Plug Ballast into the appropriate socket.

4 - As SHORT Switch is rotated, it should show connections on each terminal being used. i.e. If a connection exists between terminals 3,4 and 5, the Neon SHORT Lamp will light when the SHORT Switch is at points 3,4 and 5. If the SHORT Lamp does not light at a particular pin, there is no connection to that pin.

TRUE BALLAST TEST

This test, an exclusive with PRECISE, actually tests Ballast tubes as they should be tested - under load and for current flow.

Consult manufacturers specification for Voltage and Current for each section of the Ballast. Set the FILAMENT Switch to the proper voltage for a particular section. Remembering that F is the same as pin 1, G is the same as Pin 2, H is the same as pin 3, etc. of each socket, connect one of the pins of that section to #5 and the other to #6 of switches F through O. Rotate METER Switch to proper Filament current range and observe current. It should, of course, be the same as recommended by the manufacturer. In the above test, the SHORT Switch should be in the TEST(NOR.) Position. NOTE: Only one section should be tested at a time and no filament voltage should be applied across jumper connections since it could damage the meter or transformer.

ACORN TUBES

The Acorn socket is not normally supplied, but data for Acorn tubes is listed on the roll chart. An acorn socket may be added to the panel by using the four pilot indicator circles in the center of the socket arrangement. The three outside holes are to be drilled with a 9/64th inch drill. The inside hole, in the center of the three mounting holes, should be made 1¼ inches in diameter- a socket punch should be used for adding this hole. The Acorn socket may be purchased directly from your local jobber.

CATHODE RAY TUBES

Cathode Ray Tubes may be checked by using the adapter Model CRIIIA.

IN-LINE

IN-LINE sub-miniature tubes are inserted with the red dot closest to the small dot on the socket or toward center of panel.

You have now completed the wiring of your Model 111. A few more tests and adjustments and the instrument may become part of your laboratory.

WIRING CHECK A separate chart lists the number of wires and parts going to each switch and tube socket. Experience has shown that miswiring is the most common cause of trouble. By checking over the chart, a reasonable chance exists for showing up a wiring mistake. We do not recommend by-passing this step since it could very well be the difference between waiting for a replacement power transformer and/or other major critical items. Make certain you check each connection for proper soldering.

OPERATIONAL PROCEDURE When you have completed the various checks and are certain that all wiring is proper, proceed as follows: All internal controls on the power supply chassis should be set to their maximum clockwise position. Shaft type controls are viewed from shaft side. Screwdriver controls or rheostats (those without shafts) are viewed from the side showing the entire control. Set all front panel controls and switches as follows:

1 - Controls A through O, BIAS, FILAMENT & METER TO THEIR EXTREME COUNTER-CLOCKWISE POSITION.
2 - TEST Switch to HOLD. LINE Pot to mid rotation (approximately).
3 - SHORT Switch to TEST (NOR.).
4 - Meter Slide Switch to NOR.
5 - Bias Slide Switch to 10V.
6 - OFF LIFE ON Slide Switch to OFF.
7 - Check the resistance from terminal #16 of PT4 to Ground. This should be at least 50,000 ohms. If a lower resistance is read, check wiring of H1, S6 and S2.
8 - Check the resistance to ground from pin #7 of the 7 Pin Miniature Socket (H61 on the Power Supply Chassis). This should be approximately 8,000 ohms. If a lower resistance is read, check wiring of H61, S5, S9, S12 and S2.
9 - Connect an AC Voltmeter from ground to terminal #14 of PT4. Use a range of at least 10 volts.
10- Plug the line cord into any 110 volt, 50 or 60 cycle outlet and push Power Slide Switch to ON. The Pilot Light should light immediately. If it does not, turn set off at once and check Pilot Light and Filament transformer wiring.
11- Set LINE ADJUST CONTROL on front panel, for a 5 volt AC reading.
12- Without changing any of the above settings, adjust the internal line potentiometer (P9), located on the Power Supply Chassis, for a center scale reading on the tube tester meter (center of Question Mark).
13- Without changing any settings, connect an AC Voltmeter (VTVM) between chassis ground and terminal #2 (center arm) of P5. Adjust for 2.6 volts AC. If an AC VTVM is not available, an ohmmeter may be used as follows: a) Remove power by disconnecting line Cord b) Temporarily remove the lead to P5#1. Connect an ohmmeter from P5#2 to P5#3 and Adjust P5 for a reading of 560 ohms. Remove ohmmeter and reconnect lead to P5#1.(A more accurate adjustment would be to first measure the total resistance of P5 and multiply it by .56 for the ohmmeter setting. P5, of course, should be measured with the lead to P5#1 removed). A conventional "1,000 ohm/Voltmeter" is not recommended since it will load the potentiometer P5. Remove VTVM when finished.
14- PLATE BRIDGE BALANCE. Turn Power off. Make certain the Switch S5, PLATE SHUNT, is in position A, 30K. Temporarily attach a 2K, 10 Watt resistor from ground to S2#11 (The TEST SWITCH). If you do not have a 2K, 10 Watt resistor, you may disconnect R10 and use it. Make certain all controls are as follows:
a) Controls A through O, BIAS & FILAMENT at maximum counter-clockwise.
b) METER Switch to LINE.
c) SHORT Switch in TEST NOR.
d) METER Slide Switch to NOR.
e) BIAS Slide Switch to 10V.
f) TEST Switch to OFF.
g) Insert Line Cord and push OFF LIFE ON Switch to ON. Adjust LINE ADJUST panel control to center scale reading on the meter.
h) Switch meter switch to TEST.
i) Rotate Test Switch to TEST and note if meter deflects off zero. If it does deflect, try adjusting potentiometer P4, located on the power Supply Chassis, for practically no deflection when the TEST Switch is rotated to the TEST position. If the adjustment of P4 makes the condition worse, then P4 is the wrong lea. In the latter case, proceed as follows:
1 - Disconnect Blue wire from H1#3 to P4#2. Remove on the H1#3 side only.
2 - Disconnect Blue wire from H1#4 to P4#1. Remove on the H1#4 side only.
3 - Solder a piece of wire from H1#3 to H1#4.
4 - Remove wire from H1#5 to H1#6.
5 - Solder Blue wire, which was left on P4#1 in Step 2 above, to H1#6.
6 - Solder Blue wire, which was left on P4#2 in Step 1 above, to H1#5.
j) Repeat step i above.
k) Turn power off and remove 2K 10 Watt resistor which was attached in Step 14, above. Replace resistor into original location.
15- On ADJUSTMENT. Set front panel controls for 6Q4 as shown in Diagram A below. Insert 6Q4 tube. Turn power on.

DIAGRAM A

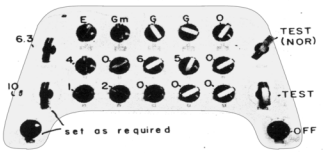
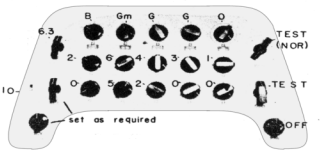


DIAGRAM B



a) Rotate SHORT Test Switch through all its positions and return to the TEST(NOR.) position. The SHORT Neon Bulb should only light in 1, 3, 7.

b) Rotate the TEST Switch to HOLD.

c) Rotate the METER Switch to LINE and adjust LINE ADJUST control, on front panel, for center scale reading.

d) Rotate the METER Switch to BIAS and BIAS Slide Switch to 10. Adjust BIAS Potentiometer, on front panel, to 5 volts on 10 volt BIAS SCALE of Meter.

e) Repeat sections c and d above.

f) Rotate METER Switch to TEST and note reading on the 3,000 Ωm scale. This is the 0 to 3 scale of the Meter.

g) Without changing any settings, what-so-ever, rotate PLATE SHUNT Switch to "D" "6K". This changes the instrument to the 6,000 Ωm scale. Adjust Potentiometer, P5A, on Power Supply Chassis, for the same reading on the 6,000 range as was observed on the 3,000 range. If the Meter indicated 2,000 on the 3,000 range. it should read 2,000 on the 6,000 range.

h) Repeat g above except that the PLATE SHUNT Switch is rotated to the 'C' '8K' range. Adjust potentiometer, P5, for the same reading on the 8K as was observed on the 3K and 6K ranges.

i) Ωm SCREEN BALANCE & VOLTAGE ADJUSTMENT. Remove 6L6, rotate switch "C" to "A" and rotate Switch 'Q' to position #3. Connect a DC Voltmeter from the PLATE Jack to Chassis Ground (use a range of at least 100 volts). Rotate the BIAS Potentiometer to 0 and the BIAS Slide Switch to 50. Turn the instrument on. Rotate the METER Switch to LINE and adjust the LINE ADJUST Control for center scale. Adjust P1A for 60 volts on the DC Voltmeter. Adjust the front panel controls for a 6L6 tube as shown in Diagram B. Remove leads from previous step.

Repeat section 15(a), above, except that #2 and #7 are the only ones that should light. Repeat sections 15(b), 15(c), 15(d)and 15(e). Return TEST Switch to OFF and METER Switch to TEST. Without changing any of the settings, turn instrument off. Remove the lead to Lug #10 of PT4 and connect it to Lug #13 of PT4.

j) Turn set on and allow a warm-up period of about 30 seconds. Rotate TEST Switch to TEST. If meter deflects from zero, adjust screw-driver potentiometer, P3, on Power Supply Chassis, until no deflection is noted when TEST Switch is rotated.

k) If adjustment of P3 cannot bring meter to zero, turn instrument off and reverse leads going to Lugs #3 and #5 on PT4. Repeat step j.

l) Replace lead moved to Lug #13 of PT4 in step i.

m) Rotate PLATE SHUNT Switch to 'C' '8K' and repeat steps b, c and d. Rotate METER Switch to TEST and note Ωm reading on 8K scale.

n) Rotate PLATE SHUNT Switch to 'B' '20K' and repeat steps b, c and d.

o) Rotate METER Switch to TEST and adjust potentiometer, P7, on Power Supply Chassis, for the same reading on the 20K Ωm scale as was observed in step m. If the reading was 5,000 on the 8K range it should read approximately the same on the 20K range.

p) Rotate PLATE SHUNT Switch to 'A' '30K' and repeat steps b, c and d.

q) Rotate METER Switch to TEST and adjust potentiometer, P6, on Power Supply Chassis, for the same readings on the 30K Ωm scale as was observed in step m. You have now completed the calibration of the Ωm section of your instrument.

r) EMISSION CALIBRATION. Turn instrument off and set up for Em check of 6L6 as shown below. Connect a milliammeter (DC) from the GRID to the PLATE Jacks on the front panel. Use a meter with a full scale reading of at least 50ma. Connect the negative side of the milliammeter to the PLATE Jack. (Note:- Steps r, s and t may be omitted by rotating potentiometer, P11, to approximately seven ohms when the wires going to it are disconnected. This is not as accurate a method as listed in steps r, s and t, but it is quite sufficient for most cases. Reconnect wires to P11 after adjustment is made). Insert 6L6.

s) Turn instrument on and allow a thirty second warm-up period. Adjust BIAS Potentiometer for 20 milliamperes of Plate current on the DC milliammeter.

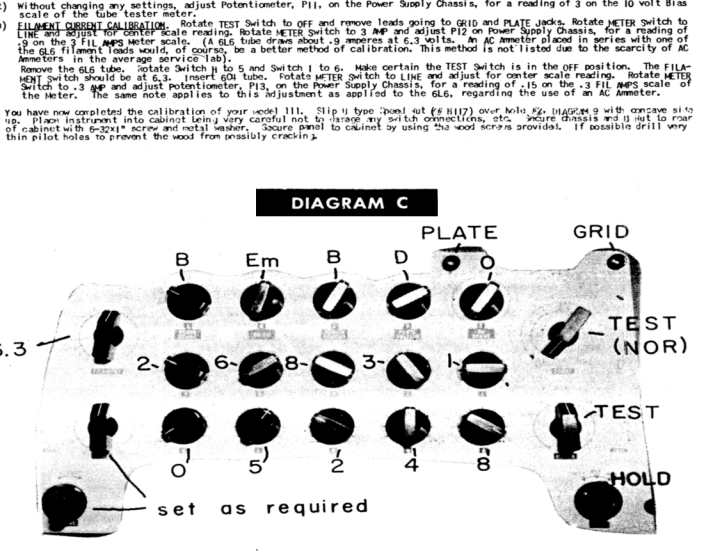
t) Without changing any settings, adjust Potentiometer, P11, on the Power Supply Chassis, for a reading of 3 on the 10 volt Bias scale of the tube tester meter.

u) FILAMENT CURRENT CALIBRATION. Rotate TEST Switch to OFF and remove leads going to GRID and PLATE Jacks. Rotate METER Switch to LINE and adjust for center scale reading. Rotate METER Switch to 3 AMP and adjust P12 on Power Supply Chassis, for a reading of .9 on the 3 FIL AMPS Meter scale. A 6L6 tube draws about .9 amperes at 6.3 volts. An AC Ammeter placed in series with one of the 6L6 filament leads would, of course, be a better method of calibration. This method is not listed due to the scarcity of AC Ammeters in the average service lab).

Remove the 6L6 tube. Rotate Switch H to 5 and Switch I to 6. Make certain the TEST Switch is in the OFF position. The FILAMENT Switch should be at 6.3. Insert 6D1 tube. Rotate METER Switch to LINE and adjust for center scale reading. Rotate METER Switch to .3 AMP and adjust potentiometer, P13, on the Power Supply Chassis, for a reading of .15 on the .3 FIL AMPS scale of the Meter. The same note applies to this adjustment as applied to the 6L6, regarding the use of an AC Ammeter.

You have now completed the calibration of your model 111. Slip 11 type Panel Nut (# 8117) over hole #2 DIAGRAM B with concave side up. Place instrument into cabinet being very careful not to damage any switch connections, etc. Secure chassis and 11 nut to rear of cabinet with 6-32x1" screw and metal washer. Secure panel to cabinet by using the wood screws provided. If possible drill very thin pilot holes to prevent the wood from possibly cracking.

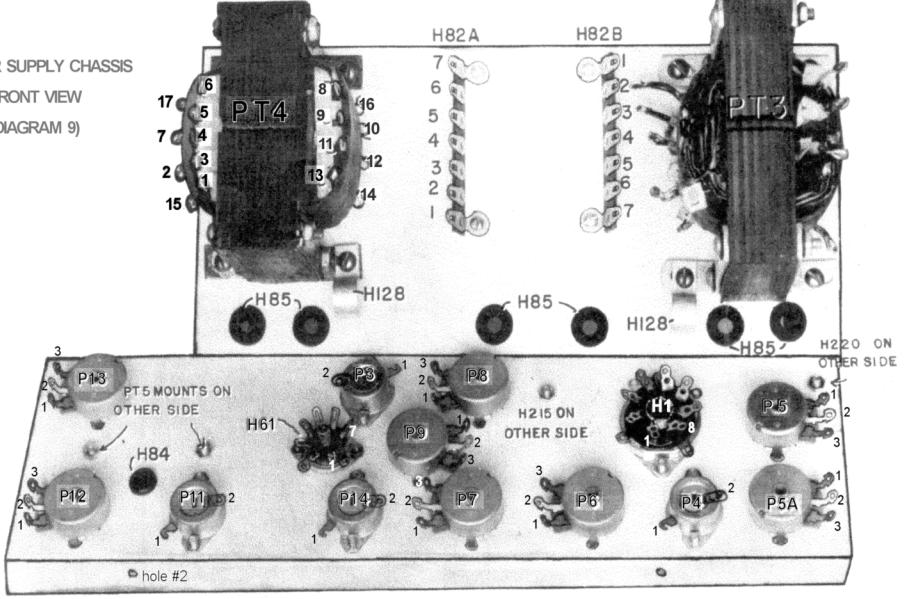
DIAGRAM C

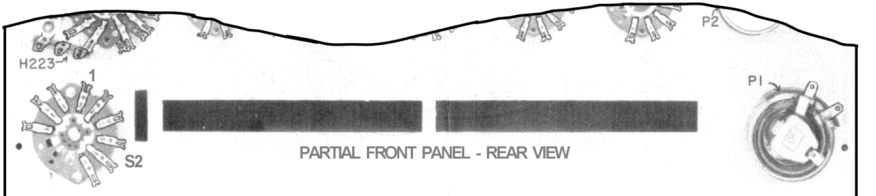


POWER SUPPLY CHASSIS

FRONT VIEW

(DIAGRAM 9)





Calibration Instructions – Preliminary Tests and Plate Bridge Balance

You have now completed the wiring of your Model 111. A few more tests and adjustments and the instrument may become part of your laboratory.

WIRING CHECK A separate chart lists the number of wires and parts going to each switch and tube socket. Experience has shown that miswiring is the most common cause of trouble. By checking over the chart, a reasonable chance exists for showing up a wiring mistake. We do not recommend bypassing this step since it could very well be the difference between waiting for a replacement power transformer and / or other major critical items. Make certain you check each connection for proper soldering.

OPERATIONAL PROCEDURE When you have completed the various checks and are certain that all wiring is proper, proceed as follows: All internal controls on the power supply chassis should be set to their maximum clockwise position. Shaft type controls are viewed from the shaft side. Screwdriver controls or rheostats (those without shafts) are viewed from the side showing the entire control. Set all front panel controls and switches as follows:

1 - Controls A through 0, BIAS, FILAMENT & METER TO THEIR EXTREME COUNTER-CLOCKWISE POSITION.
2 - TEST switch to HOLD, LINE pot to mid rotation (approximately).
3 - SHORT switch to TEST (NOR.).
4 - Meter Slide Switch to NOR.
5 - Bias Slide Switch to 10V.
6 - OFF LIFE ON Slide Switch to OFF.
7 - Check the resistance from terminal #16 of PT4 to Ground. This should be at least 50,000 ohms. If a lower resistance is read, check wiring of H1, S6 and S2.
8 - Check the resistance to Ground from pin #7 of the 7 pin Miniature Socket (H61 on the Power Supply Chassis). This should be approximately 8,000 ohms. If a lower resistance is read, check wiring of H61, S3, S9, S12 and S2.
9 - Connect an AC Voltmeter from ground to terminal #14 of PT4. Use a range of at least 10 volts.
10 - Plug the line cord into any 110 volt, 50 or 60 cycle outlet and push Power Slide Switch to ON. The Pilot Light should light immediately. If it does not, turn set off at once and check Pilot Light and Filament transformer wiring.
11 - Set LINE ADJUST CONTROL, on front panel, for a 5 volt AC reading.
12 - Without changing any of the above settings, adjust the internal line potentiometer (P9), located on the Power Supply Chassis, for a center scale reading on the tube tester meter (center of Question Mark).
13 - Without changing any settings, connect an AC Voltmeter (VTVM) between chassis ground and terminal #2 (center arm) of P5. Adjust for 2.8 volts AC. If an AC VTVM is not available, an ohmmeter may be used as follows: a) Remove power by disconnecting Line Cord. b) Temporarily remove the lead to P5#1. Connect an ohmmeter from P5#2 to P5#3 and adjust P5 for a reading of 560 ohms. Remove ohmmeter and reconnect lead to P5#1. (A more accurate adjustment would be to first measure the total resistance of P5 and multiply it by .56 for the ohmmeter setting. P5, of course, should be measured with the lead to P5#1 removed). A conventional "1000 ohm / Voltmeter" is not recommended since it will load the potentiometer P5. Remove VTVM when finished.
14 - **PLATE BRIDGE BALANCE** Turn Power off. Make certain the switch S5, PLATE SHUNT, is in position A, 30K. Temporarily attach a 2K, 10 Watt resistor from ground to S2#1 (the TEST SWITCH). If you do not have a 2K, 10 Watt resistor, you may disconnect R10 and use it. Make certain all controls are as follows:
   a) Controls A through O, BIAS & FILAMENT at maximum counter-clockwise.
   b) METER Switch to LINE.
   c) SHORT Switch to TEST NOR.
   d) METER Slide Switch to NOR.
   e) BIAS Slide Switch to 10V.
   f) TEST Switch to OFF.
   g) Insert Line Cord and push OFF LIFE ON Switch to ON. Adjust LINE ADJUST panel control to center scale reading on the meter.
   h) Switch the METER Switch to TEST.
   i) Rotate Test Switch to TEST and note if meter deflects off zero. If it does deflect, try adjusting potentiometer P4, located on the Power Supply Chassis, for practically no deflection when the TEST Switch is rotated to the TEST position. If the adjustment of P4 makes the condition worse, then P4 is the wrong leg. In the latter case, proceed as follows:
      1 – Disconnect Blue wire from H1#3 to P4#2. Remove the H1#3 side only.
      2 – Disconnect Blue wire from H1#4 to P4#1. Remove the H1#4 side only.
      3 – Solder a piece of wire from H1#3 to H1#4.
      4 – Remove wire from H1#5 to H1#6.
      5 – Solder Blue wire, which was left on P4#1 in step 2 above, to H1#6.
      6 – Solder Blue wire, which was left on P4#2 in step 2 above, to H1#5.
   j) Repeat step i above.
   k) Turn power off and remove 2K, 10 Watt resistor which was attached in Step 14 above. Replace resistor into original location.
15 - **Gm ADJUSTMENT** Set front panel controls for 6C4 as shown in Diagram A below. Insert 6C4 tube. Turn power on.

Calibration Instructions – Gm, Screen Balance, Emission & Filament Current

a) Rotate SHORT Test Switch through all its positions and return to the TEST (NOR.) position. The SHORT Neon Bulb should only light in 1, 3, 4 and 5.
b) Rotate the TEST Switch to HOLD.
c) Rotate the METER Switch to LINE and adjust LINE control, on front panel, for center scale reading.
d) Rotate the METER Switch to BIAS and BIAS Slide Switch to 10. Adjust BIAS Potentiometer, on front panel, to 5 volts on 10 volt BIAS SCALE of Meter.
e) Repeat sections C and D above.
f) Rotate METER switch to TEST and note reading on the 3,000 Gm scale. This is the 0 to 3 scale of the meter.
g) Without changing any settings, what-so-ever, rotate PLATE SHUNT Switch to "D", "6K". This changes the instrument to the 6,000 Gm scale. Adjust Potentiometer, P5A, on the Power Supply Chassis for the same reading on the 6,000 range as was observed on the 3,000 range (i.e., if the meter indicated 2,000 on the 3,000 range, it should read 2,000 on the 6,000 range).
h) Repeat step g above except that the PLATE SHUNT Switch is rotated to the "C", "8K" range. Adjust potentiometer P6 for the same reading on the 8K as was observed on the 3K and 6K ranges. Turn off the instrument.
i) **Gm SCREEN BALANCE & VOLTAGE ADJUSTMENT** Remove 6C4, rotate switch "C" to "A" and rotate Switch "0" to position #3. Connect a DC voltmeter from the PLATE Jack to Chassis Ground (use a range of at least 100 volts). Rotate the BIAS Potentiometer to 0 and the BIAS Slide Switch to 50. Turn the instrument on. Rotate the METER Switch to LINE and adjust the LINE ADJUST control for center scale. Adjust P14 for 60 volts on the DC voltmeter. Adjust the front panel controls for a 6L6 tube as shown in Diagram B. Remove leads from previous step.

   Repeat section 15(a) above, except that #2 and #7 are the only ones that should light. Repeat section 15(b), 15(c), 15(d) and 15(e). Return TEST Switch to OFF and METER Switch to TEST. Without changing any settings, turn instrument off. Remove the lead to Lug #14 of PT4 and connect it to Lug #13 of PT4.
j) Turn set on and allow a warm-up period of about 30 seconds. Rotate TEST Switch to TEST. If meter deflects from zero, adjust screw-driver potentiometer P3, on Power Supply Chassis, until no deflection is noted when TEST Switch is rotated.
k) If adjustment of P3 cannot bring Meter to zero, turn instrument off and reverse leads going to Lugs #3 and #5 on PT4. Repeat step j.
l) Replace lead moved to Lug #13 of PT4 in step i.
m) Rotate PLATE SHUNT Switch to "C" "8K" and repeat steps b, c and d. Rotate METER Switch to TEST and note Gm reading on 8K scale.
n) Rotate PLATE SHUNT Switch to "B" "20K" and repeat steps b, c and d.
o) Rotate METER Switch to TEST and adjust potentiometer P7, on Power Supply Chassis, for the same reading on the 20K Gm scale as was observed in step m. If the reading was 5,000 on the 8K range it should read approximately the same on the 20K range.
p) Rotate PLATE SHUNT Switch to "A" "30K" and repeat steps b, c and d.
q) Rotate METER Switch to TEST and adjust potentiometer P8, on Power Supply Chassis, for the same readings on the 30K Gm scale as was observed in step m. You have now completed the calibration of the Gm section of your instrument.
r) **EMISSION CALIBRATION** Turn the instrument off and set up for Em check of 6L6 as shown below. Connect a milliammeter (DC) from GRID to PLATE jacks on the front panel. Use a meter with a full scale reading of at least 50mA. Connect the negative side of the milliammeter to the PLATE jack. (Note: Steps r, s and t may be omitted by rotating potentiometer P11 to approximately seven ohms when the wires going to it are disconnected. This is not as accurate a method as listed in steps r, s and t, but it is quite sufficient for most cases. Reconnect wires to P11 after adjustment is made). Insert 6L6.
s) Turn instrument on and allow a thirty second warm-up period. Adjust BIAS potentiometer for 20 milliamperes of Plate current on the DC milliammeter.
t) Without changing any settings, adjust potentiometer P11, on the Power Supply Chassis, for a reading of 3 on the 10 volt Bias scale of the tube tester meter.
u) **FILAMENT CURRENT CALIBRATION** Rotate TEST Switch to OFF and remove leads going to GRID and PLATE jacks. Rotate METER Switch to LINE and adjust for center scale reading. Rotate METER Switch to 3 AMP and adjust P12, on Power Supply Chassis, for a reading of .9 on the 3 FIL AMPS scale. (A 6L6 tube draws about .9 amperes at 6.3 volts. An AC Ammeter placed in series with one of the 6L6 filament leads would, of course, be a better method of calibration. This method is not listed due to the scarcity of AC Ammeters in the average service lab).

   Remove the 6L6 tube. Rotate Switch H to 5 and Switch I to 6. Make certain the TEST Switch is in the OFF position. The FILAMENT Switch should be at 6.3. Insert 6C4 tube. Rotate METER Switch to LINE and adjust for center scale reading. Rotate METER Switch to .3 AMP and adjust potentiometer P13, on the Power Supply Chassis, for a reading of .15 on the .3 FIL AMPS scale of the meter. The same note applies to this adjustment as applied to the 6L6, regarding the use of an AC Ammeter.

You have now completed the calibration of your Model 111. Slip U type Speed Nut (#117) over hole #2, DIAGRAM 9, with concave side up. Place instrument into cabinet being very careful not to damage any switch connections, etc. Secure chassis and U Nut to rear of cabinet with 6-32 x 1" screw and metal washer. Secure panel to cabinet by using the wood screws provided. If possible, drill very thin pilot holes to prevent the wood from possibly cracking.

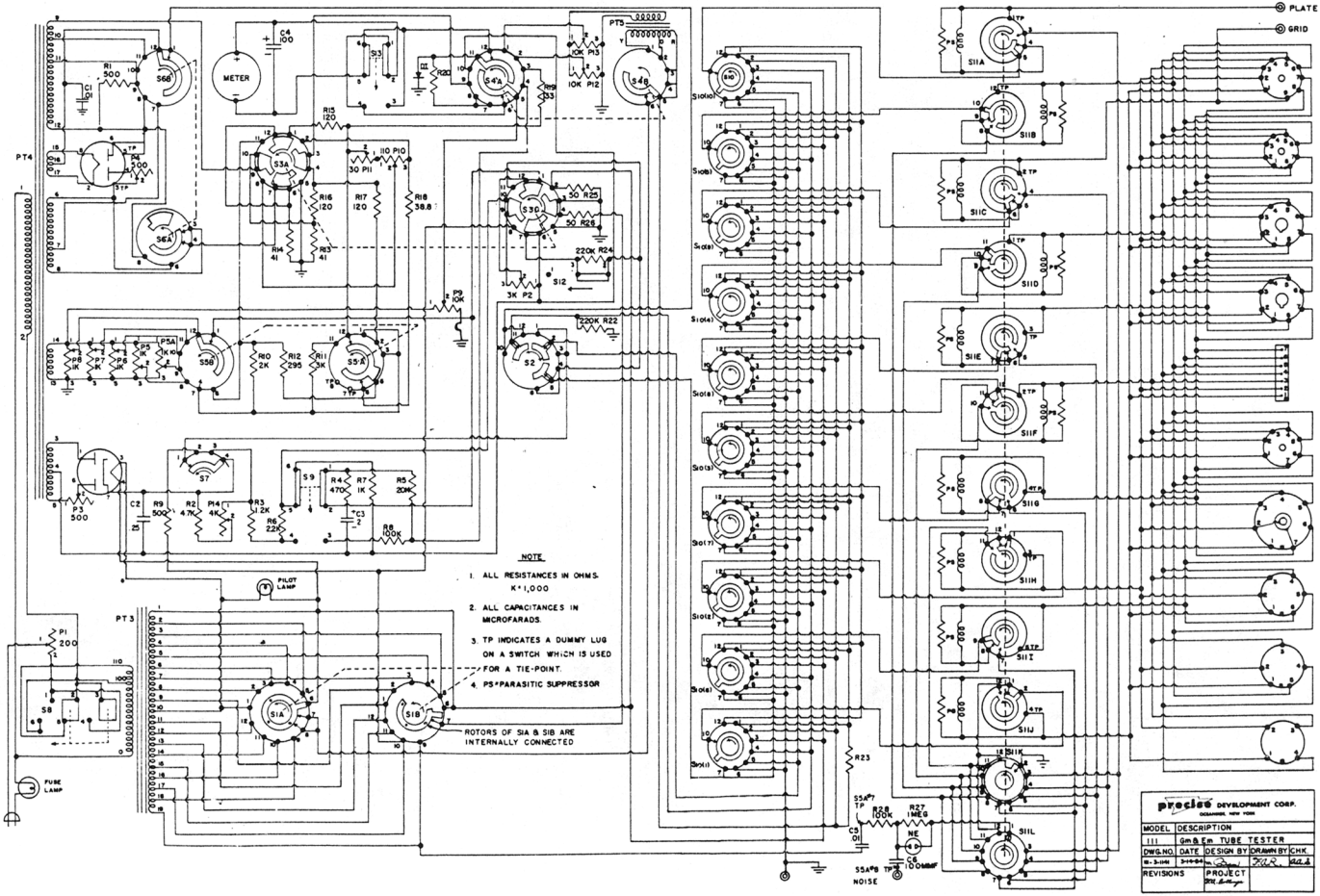


PLATE
GRID
METER
PT1
PT2
PT3
PT4
PT5
S1(a)
S1(b)
S1(c)
S1(d)
S1(e)
S1(f)
S1(g)
S1(h)
S1(i)
S1(j)
S1(k)
S1(l)
S1A
S1B
S2
S3A
S3B
S4A
S4B
S5A
S5B
S6A
S6B
S7
S8
S9
S10
S11A
S11B
S11C
S11D
S11E
S11F
S11G
S11H
S11I
S11J
S11K
S11L
PILOT LAMP
FUSE LAMP
NOTE
1. ALL RESISTANCES IN OHMS. K=1,000
2. ALL CAPACITANCES IN MICROFARADS.
3. TP INDICATES A DUMMY LUG ON A SWITCH WHICH IS USED FOR A TIE-POINT.
4. PS=PARASITIC SUPPRESSOR
ROTORS OF S1A & S1B ARE INTERNALLY CONNECTED
precise DEVELOPMENT CORP.
MODEL 111
DESCRIPTION GM & Em TUBE TESTER
DWG.NO. 111-1-1
DATE 3-10-54
DESIGN BY
DRAWN BY CHK
REVISIONS
PROJECT

K4XL's  BAMA

This manual is provided FREE OF CHARGE from the "BoatAnchor Manual Archive" as a service to the Boatanchor community.

It was uploaded by someone who wanted to help you repair and maintain your equipment.

If you paid anyone other than BAMA for this manual, you paid someone who is making a profit from the free labor of others without asking their permission.

You may pass on copies of this manual to anyone who needs it. But do it without charge.

Thousands of files are available without charge from BAMA. Visit us at http://bama.sbc.edu