INSTRUCTIONS

FOR

WESTON

MODEL 686

True Mutual Conductance Vacuum Tube Analyzer

WESTON ELECTRICAL INSTRUMENT CORPORATION
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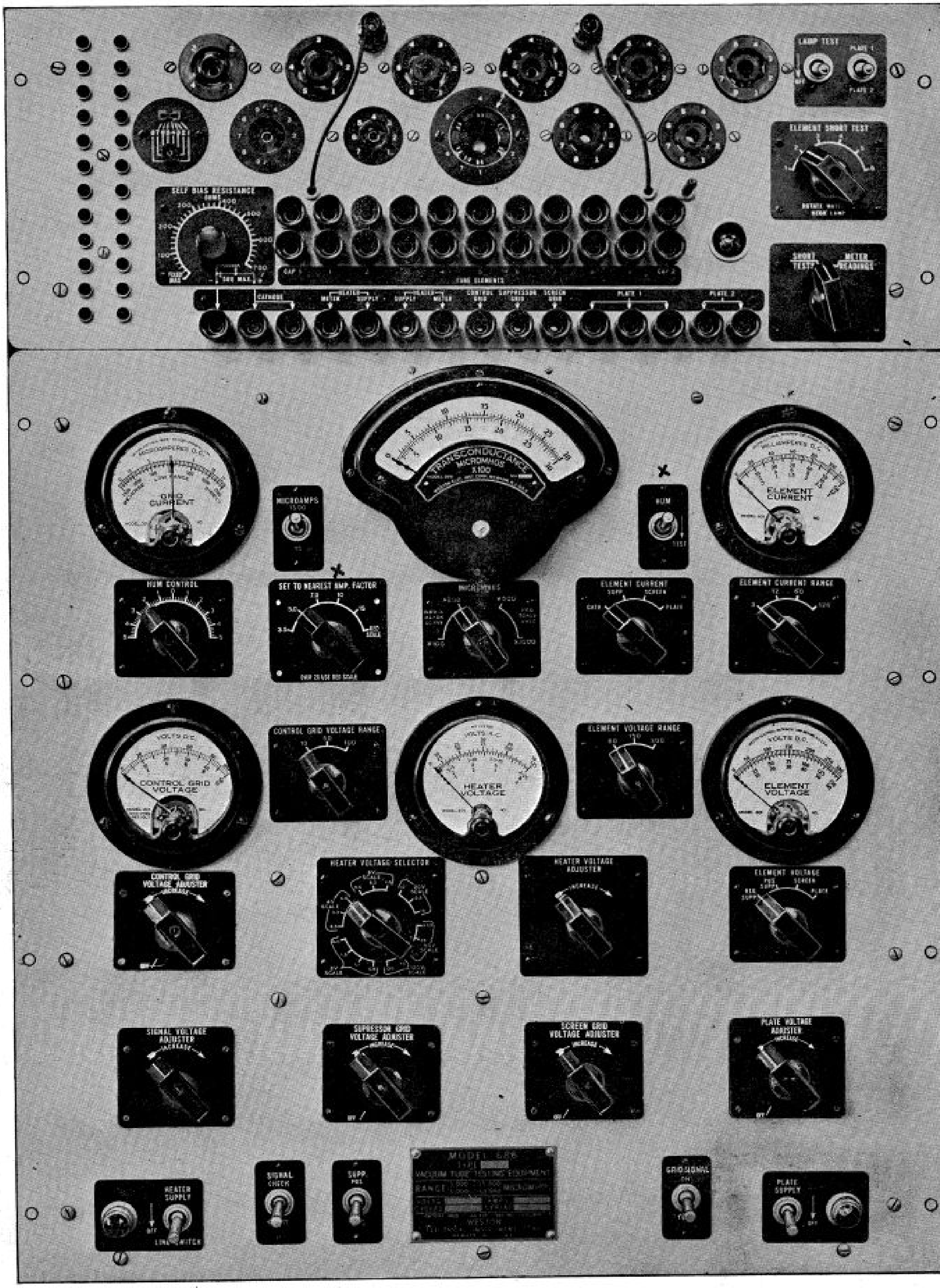


Front Panel View Of Model 686

INSTRUCTIONS FOR MODEL 686

TRUE MUTUAL CONDUCTANCE VACUUM TUBE ANALYZER

GENERAL DESCRIPTION

The Model 686 is a complete direct reading True Mutual Conductance Vacuum Tube Analyzer designed to operate from any 105 to 125 or 230 volt 50-60 cycle outlet. It has four mutual conductance ranges with full scale readings of 3,000, 6,000, 15,000 and 30,000 micromhos. Instruments are provided for accurately measuring all electrode voltages and for reading electrode currents including low order grid currents.

Internal power supplies and a signal source provide all necessary potentials to panel controls, wherein adjustments can be made in accordance with meter readings. Tube sockets for all commercial type receiving tubes are mounted on a removable socket panel across the top front section of the equipment. These in turn connect through short-test switches to patch cord jacks which are marked with R.M.A. pin numbers and are used with patch cords for any or all electrode connections. Thus with complete connector flexibility and complete voltage control, all kinds of static characteristics can be plotted, in addition to the measurement of G_m under any or all applied potential conditions.

DETAILED DESCRIPTION OF EQUIPMENT

THE G_m METER: The fan shaped instrument in the top center of the main panel is the G_m meter. The scale is calibrated in two arcs each reading zero to thirty. These arcs indicate 0 to 3,000 or *Micromhos* x 100 as noted on the small plate just below the scale glass. The top scale arc is printed with black lines and figures, while the lower arc is printed in red. The top or black arc is used for G_m readings on all tubes with an amplification factor (μ) up to and including 19. The red scale is used in measuring G_m on all types with amplification factors of 20 or over.

This meter operates with a multiplier switch marked *Micromhos* directly below it, and a compensator switch directly to the left marked *Set To Nearest Amp Factor* (Refer to Fig. 1).

On low mu tubes with low plate resistance, the meter resistance is a reasonable part of the total tube and tube tester plate circuit impedance; measurements on these tubes would be in error unless this was taken into consideration. The compensator switch, therefore, must be set to the nearest amplification factor up to a value of 19 and readings should be taken on the black scale.

The extreme right hand position on the compensator switch is marked *Red Scale*. On tube types with an amp factor of 20 or over, the *"Red Scale"* switch position is always used because on these types the instrument resistance is a negligible part of the tube plate resistance. On this switch position, all G_m readings are taken on the *Red Scale* arc.

The *Micromhos* switch is used for selecting the 3,000, 6,000, 15,000 or 30,000 micromhos range as required. Since the arcs on the G_m meter are calibrated 0 to 30, the G_m meter readings should be multiplied by 100 for the 3,000 range, 200 for the 6,000 range, 500 for the 15,000 range, and 1,000 for the 30,000 range. This switch does not change the meter sensitivity on *"Red Scale"* setting of the compensator switch but selects 4 different signal voltages. These are 1 volt r.m.s. for the 3,000 range, 0.5 volts r.m.s. for the 6,000 range, 0.2 volts r.m.s. for the 15,000 range, and 0.1 volts r.m.s. for the 30,000 range. This

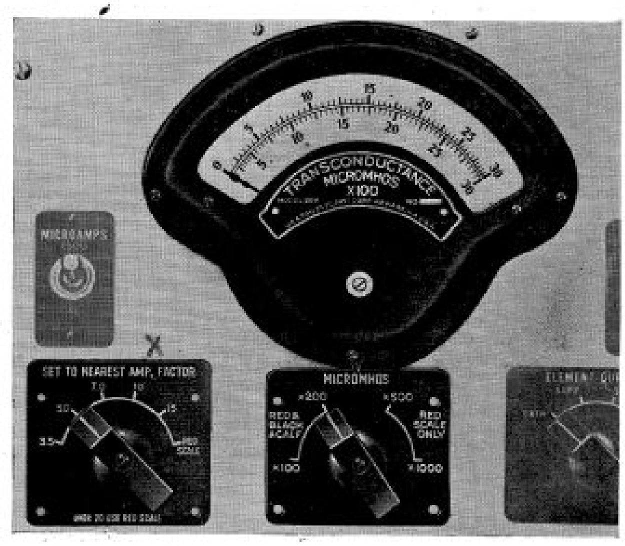


FIG. 1

method has a definite advantage over a system wherein the G_m meter is shunted for the various ranges and the signal voltage maintained constant. The low signal voltages available on the two higher ranges make it possible to maintain peak signal potentials well within the grid bias voltage on high mu triodes and other types where bias voltages in the region from 0.8 to 3 volts are specified. The above is necessary in the case of all low bias tubes operated and tested as Class A amplifiers. If too great a signal amplitude is used, the tube may operate in the grid current region during a part of the signal voltage cycle. In such a case the tube being tested is not operating under true class A conditions, and G_m readings will not agree with the tube manufacturer's listings.

It is advisable for the operator to select the highest G_m range that will render reasonable pointer deflection when testing all **low bias high mu tubes**.

Since low mu tubes do not have G_m ratings over 6,000 micromhos, the 15,000 and 30,000 micromhos ranges are used only with *Red Scale* readings. It will be noted that the *Micromhos* switch plate is marked *"Red Scale Only"* on these ranges.

The a-c grid signal voltage is also measured on the G_m meter to eliminate possible errors due to temperature. If the instrument is reading the a-c plate current component 2% low because of temperature effects, it will likewise require a signal voltage 2% higher in value to bring the meter to top mark on *Signal Check*. Since the signal voltage is higher the G_m indication will also be higher and hence a very good compensation is obtained.

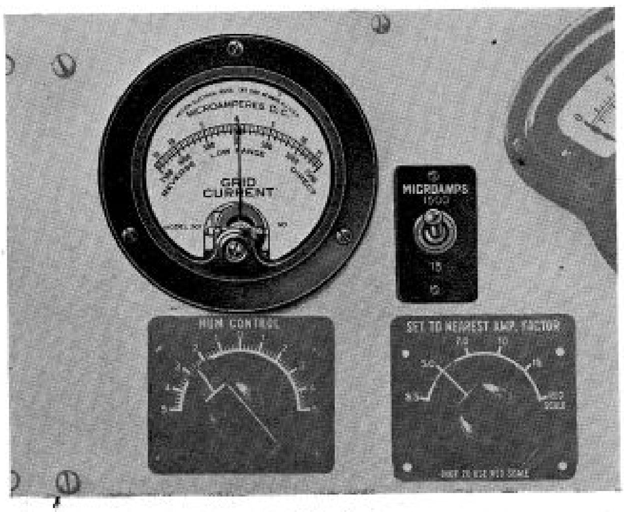


FIG. 2

GRID CURRENT METER: A two range microammeter for grid current readings is mounted to the left of the G_m meter. This instrument has a range of 15-0-15 microamperes. Readings down to and including one-half microampere are easily read. The meter is normally shunted to 1500-0-1500 microamperes and is switched to the low range by manipulation of a momentary toggle switch located to the right of the meter (Refer to Fig. 2).

The meter is a zero center instrument to indicate any or all components of grid current resulting from gas, leakage resistance, or secondary emission. Grid current readings are especially important in segregating defective power tubes such as the type 6L6 where a limit of 3 microamperes is specified.

In taking grid current readings, the operator will note that there is a red line on each side of the center scale zero mark. This red line indicates 15 microamperes on the 1500 microampere range. If the pointer does not deflect beyond the red line after the tube is heated, then the *Microamperes* switch can be shifted to the 15 microampere position, and readings taken on this low range. The instrument is in series with the control grid patch cord jack at all times and, therefore, will indicate grid current under all operating conditions.

ELEMENT CURRENT METER: A four range d-c milliammeter used to measure cathode, suppressor, screen, or plate current (Refer to Fig. 3). The *Milliamperes* switch below the instrument serves to select either the 3, 12, 60 or 120 milliampere range.[1] The element *Milliamperes* switch directly to the left of the range switch selects the electrode in which the current is to be measured.

The *Element Current* meter picks up the millivolt drop across low resistance shunts in the 4 different electrode circuits. Since any resistance in the cathode circuit will cause degeneration, the switch is designed so that the shunt used for cathode current readings is short-circuited on all other positions. It is advisable to have this switch indexed to one of the other three positions when taking G_m readings. Cathode current may be measured before or after taking the actual micromhos indications.

CONTROL GRID VOLTMETER: Measurements of grid bias potential are made on the *Control Grid Voltage* meter (Refer to Fig. 4). The switch to the right of the meter selects either the 10, 50 or 100 volt range[2] as required. Be sure to note the position of this switch when unexpected plate current exists in the tube under check.

This switch also changes the bias network, decreasing the drop across the control grid potentiometer on the 10 volt range, providing better voltage control when adjusting low bias potentials.

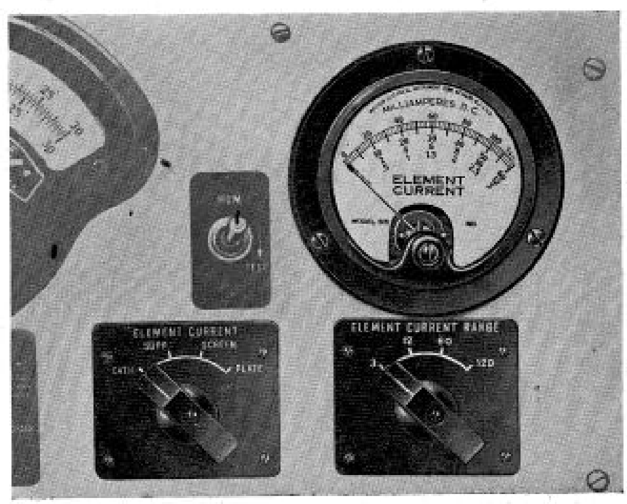


FIG. 3

HEATER VOLTMETER: Filament potentials from 0.6 to 120 volts[3] may be selected by means of a rotary switch and potentiometer. These potentials are measured on a multirange a-c voltmeter (Refer to Fig. 5).

1. Type 9B has ranges of 5, 10, 50 and 100.
2. Type 9B has ranges of 10 and 50 only.
3. Type 9B has range of 1 to 120 volts.

Note that the *Heater Voltage* switch is used to select the nominal voltage, and exact adjustment is made by rotating the *Heater Voltage Adjuster* which controls the primary potential on the filament transformer. An interlock circuit is used on the rotary switch to automatically shift ranges on the filament voltmeter as the switch is rotated. Thus the operator

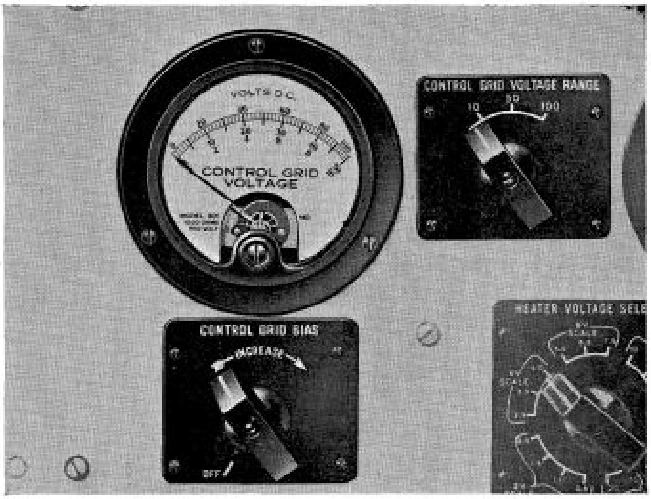


FIG. 4

always has this meter on the correct range, and the possibility of instrument overload is eliminated. The particular range connected into the circuit is marked for each group of potentials on the *Heater Voltage* switch plate. The voltmeter connections are brought back through separate leads directly from the tube socket thus providing a more accurate reading of filament potential at the tube pins. Thus any voltage drop in the leads from the filament transformer to the tube socket will not be in the meter circuit.

ELEMENT VOLTMETER: Electrode potentials are measured on the two range *Element Voltage* instrument mounted below the *Element Current* meter. Plate, screen, positive suppressor grid, or negative suppressor grid potentials can be selected by using the rotary switch below the meter (Refer to Fig. 6).

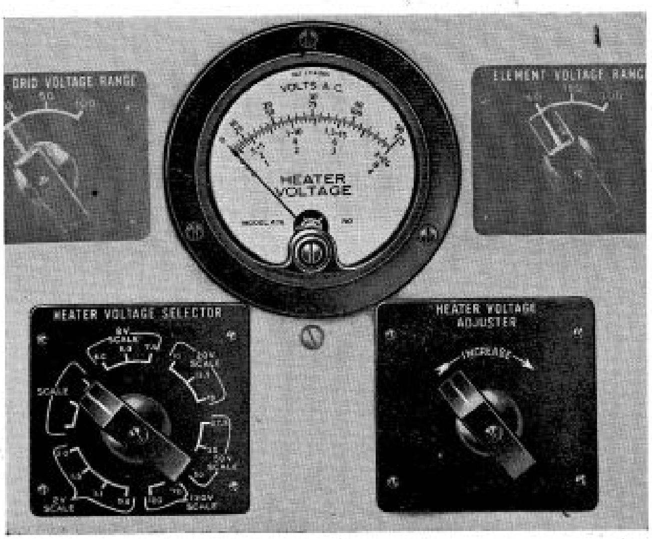


FIG. 5

When selecting either *Pos Supp* or *Neg Supp* volts position on the rotary *Elements* volt switch, choose the position indicated by the *Supp-Pos-Neg* toggle switch located just to the left of the Model 686 name plate. If the rotary switch is indexed to the wrong position with respect to the positioning of the toggle switch mentioned above, the *Element Voltage* meter will read down scale. No damage will be done to the voltmeter if a down scale reading should occur.

It must be remembered that when checking any one tube, either a negative suppressor volts or a positive suppressor volts (used for second anode voltage purposes) can be selected, but not both for the same tube test.

The *Volts* switch directly to the left of the meter selects the *Element Voltage* meter range of 60, 150 or 300 volts.[1]

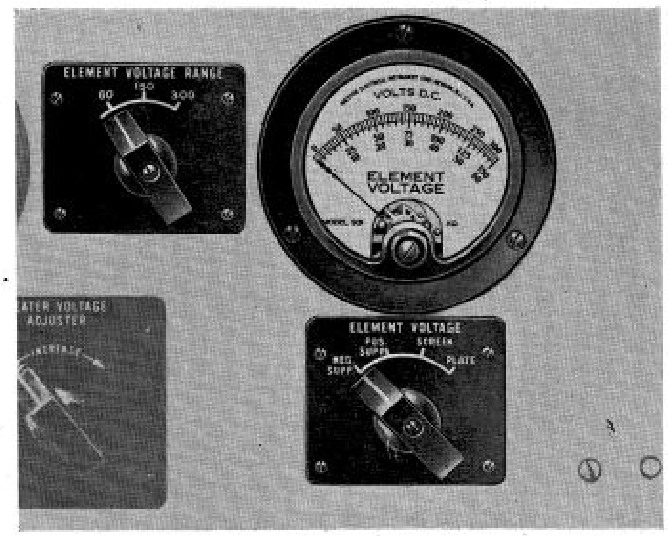


FIG. 6

D-C POWER SUPPLY CONTROLS: Individual control grid, suppressor grid, screen grid, and plate adjusters are mounted in line across the lower section of the Model 686 panel. These are 150 watt or 100 watt vitreous type potentiometers connected in the d-c supply circuit. While these high wattage ratings are not required, controls of this size provide a long peripheral length of contact travel, thus giving accurate potential settings on the tube electrodes. The element voltages should be adjusted in the following order to prevent damage to the screen and cathode due to excessive currents: (1) control grid (2) plate (3) screen. All electrode potentials can then be re-

1. Type 9B has ranges of 150 and 300 only. A red arc on the scale plate indicates true voltmeter current which can be subtracted from low range milliammeter readings where this current may be an appreciable part of the total element current. In other words the Element Current meter reads true element current plus voltmeter current when the voltmeter and milliammeter are switched to the same electrode position.

adjusted and any changes due to tube loading of the power supply can be corrected. The accuracy of the mutual conductance readings depend to a great extent on the accuracy of these electrode potential adjustments.

SIGNAL VOLTAGE ADJUSTER: By effectively changing the turns ratio of the signal voltage transformer, this potentiometer is used to compensate for different line voltages. The signal voltage is checked at full scale on the G_m meter and any necessary correction is then made with this control.

To correct for different line voltages the *Signal* switch should be placed on the *"Check"* position and the *Signal Voltage Adjuster* rotated to obtain full scale deflection on the G_m meter.

HUM CONTROL: Filamentary tube types require an accurate electrical center tap on the filament for correct G_m readings, and it is the purpose of this control to provide such an adjustment. On heater voltage switch positions 12.5 volts and above, the *Hum Control* is disconnected to prevent excessive heat dissipation.

After the tube is in position and all electrode potentials have been adjusted to the specified values, the *Hum* toggle switch to the right of the G_m meter should be operated and the *Hum Control* set for a minimum or zero reading on the G_m meter. ***(Serious errors in mutual conductance readings can be expected if this operation is not performed carefully.)***

SELF BIAS RESISTANCE CONTROL: The Model 686 is equipped with a *Self Bias Resistance* control mounted on the left side of the top panel section. This control provides for checking certain tube types such as the 6J4, 6J6 and 1231 where self bias is definitely specified by the manufacturer. These tubes tend to draw grid current or are unstable under equivalent fixed bias conditions, thus causing errors in G_m readings.

The control may be varied from 0 to 700 ohms,[1] and to prevent degeneration the unit is by-passed by a 1,000 m.f., 50 volt condenser. When checking the normal fixed bias types this control must be set to zero (0) but on those types requiring self bias the *Control Grid Voltage Adjuster* must be set in the most counter-clockwise position. This procedure is necessary to prevent fixed bias from being applied in addition to the self bias.

To prevent damage to the 1,000 microfarad condenser, a simple calculation should be made to see that the product of the expected cathode current, and the resistance in the self bias circuit does not exceed 50 volts: $V = I \times R \times .001$

Where V = Voltage appearing across 1,000 microfarad condenser.

I = Expected cathode current in milliamperes.

R = Resistance selected by *Self Bias* switch position.

1. Type 9B has a range of 0 to 500 ohms.

SHORT TEST-METER READING AND ELEMENT SHORT TEST SWITCHES: The *Short Test-Meter Reading* and *Element Short Test* switches mounted on the right side of the top panel section provide the necessary means for short checking tubes with a d-c potential. Tubes, having a filament or heater, may be short checked, either hot or cold. The *Short Test-Meter Reading* switch disconnects the d-c potential and meters from the tube elements and connects a small d-c power supply and a neon lamp into a group of circuits controlled by the *Element Short Test* switch. This switch segregates the element to be short checked, leaving all the other elements tied together.

The filament or heaters should be at normal operating temperature when hot short checking, and the *Short Test-Meter Reading* switch should be indexed to *"Short Test"* position. The *Element Short Test* switch is then rotated through its six positions, stopping at each position to tap the tube.

If the patch cords have been connected so as to use both P_1 and P_2, index the $P_1 - P_2$ toggle switch located on the upper right top panel section to its other position and rotate the *Element Short Test* switch through its six positions again. A slight flicker of the neon lamp between positions on the *Element Short Test* switch does not indicate a short in the tube.

HEATER SUPPLY TOGGLE SWITCH: Located at the bottom left side of the panel with its associated green jewel pilot lamp, this toggle switch disconnects the device completely from the line supply when indexed to the *"Off"* position. When in the *"On"* position, the heater transformer is energized and the line supply voltage is delivered to the *Plate Supply Toggle Switch.* After making the heater connections, the tube can be warming up while the operator is completing the patching operation by indexing the Heater Supply toggle switch to the *"On"* position.

The "Plate Supply" toggle is shorted out on 230 volt service to prevent possible damage to the equipment or tubes being checked. Therefore, use the "Line Switch" as the "On-Off" switch for the entire device.

PLATE SUPPLY TOGGLE SWITCH: This switch operates all of the internal d-c power sources and is inoperative if the *Heater Supply* toggle is in the *"Off"* position. The *Plate Supply* toggle should always be in the "Off" position when the operator is changing or removing patch cords.

SIGNAL CHECK TOGGLE SWITCH: To the right of the *Heater Supply* toggle is a momentary type *Signal Check* toggle switch. A change in power line voltage, of course, will affect the grid signal and hence it becomes necessary to check this potential just before taking G_m readings. Indexing the *Signal Check* toggle to the *"Check"* position places a definite portion of the grid signal directly across the G_m meter. Regardless of G_m range selected, the G_m meter must indicate top mark on this test. If it does not, the

Signal Voltage Adjuster should be rotated until top mark is obtained.

GRID SIGNAL TOGGLE SWITCH: This switch is located to the left of the *Plate Supply* switch and is of the momentary type. It is used to apply the signal voltage when the operator is ready to take a G_m reading. No signal is applied to the tube until this switch is indexed to the "On" position.

SUPPRESSOR POS NEG TOGGLE SWITCH: The purpose of this toggle is to allow the operator to select either a negative potential for suppressor, or a positive potential for tubes requiring a second anode voltage such as the oscillator plate in a pentagrid converter. It must be kept in mind that while checking a given tube only one or the other potential may be used. No occasion will arise requiring both a negative suppressor potential and a second anode positive potential, because in such cases, the suppressor of the tube is always connected directly to cathode.

To obtain negative suppressor volts index this toggle, located just to the left of the name plate at the bottom of the panel, to the NEG position. To measure the negative potential rotate the element *Volts* switch to the *"Neg Supp"* position.

LAMP TEST TOGGLE SWITCH: Located to the left of the rotary *Element Short Test* switch, this toggle provides a ready means for checking the neon lamp. If a tube shows no short and there is some doubt as to the condition of the neon lamp, lift the toggle to its upper position and if it does not glow replace with a new lamp.

OPERATION

STEP-BY-STEP TESTING PROCEDURE

GENERAL: Read the paper tag on the front panel of the instrument. Remove the back cover and insert the 5U4-G rectifier in the octal socket. Ascertain whether the 3A4 tube is in place by removing the shield from the miniature socket. Screw the neon lamp in the socket located above the *Lamp Test* toggle switch. The line cord can then be brought to the outside of the case and the back cover replaced.

A toggle switch has been incorporated in the 686-9B beginning with serial #398 to facilitate change over from 115 volt to 230 volt a-c operation.

This switch is located on the shelf inside the device between the 8 mfd. condenser and the small signal-short check transformer.

The toggle is set for 115 volt operation when its lever points toward the front panel and for 230 volt operation when its lever points away from the front panel.

The "Plate Supply" toggle is shorted out on 230 volt service to prevent possible damage to the equipment or tubes being checked. Therefore, use the "Line Switch" as the "On-Off" switch for the entire device.

The instrument is now ready for use and the *Step-by-Step Procedure* outlined below should be read carefully before attempting to check any tubes. It is suggested that a type 76 or any indirectly heated triode be used to acquaint the operator of this device with the various controls and their functions.

AMPLIFIER TUBES:

1. Plug the line cord into a power source having a frequency of 50-60 cycles and voltage between 105-125. Refer to preceding paragraph for 230 volt lines.

2. Place *Heater Supply and Plate Supply* toggle switches in *"Off"* position.

3. Patch the jumper leads in accordance with the tube base diagram of the tube to be checked following the specific procedures for Cathode, Heater and Suppressor connections as follows:

A—CATHODE

I—Connect cathode of the tube to any of the three *Cathode* jacks in the bottom row when the *Self Bias Resistance* control is set to *"Fixed Bias."*

II—Connect the tube cathode to the second or third *Cathode* jack if *Self Bias Resistance* control is set to any value above zero ohms.

B—HEATERS

I—Connect the heater or filament of the tube to the *Heater Supply* jacks.

II—Duplicate the connections from the heater of the tube and connect to the *Heater Meter* jacks.

C—SUPPRESSOR

I—Connect suppressor to *Suppressor Grid* jack except for the following two conditions.

(a) When other tube elements require a positive voltage from the *Suppressor Grid* jack follow steps II or III outlined below.

(b) When *Self Bias Resistance* control is set to or any value above zero ohms, step III outlined below must be followed.

II—Connect suppressor of tube to any of the three *Cathode* jacks in the bottom row when the *Self Bias Resistance* control is set to *"Fixed Bias"* or zero ohms.

III—Connect suppressor of tube to the second or third *Cathode* jack when the *Self Bias Resistance* control to set to any value above zero ohms.

4. Rotate *Short Test - Meter Reading* switch to *"Short Test"* position.

5. Select the required heater voltage by setting the *Heater Voltage* switch.

6. Insert tube in a socket corresponding to the pin arrangement of the tube to be checked.

7. Place the *Heater Supply* toggle in the "On" position. For those instruments connected for 230 volt line service see "Note" under paragraph headed "HEATER SUPPLY TOGGLE SWITCH", on page 6.

8. Rotate *Heater Voltage Adjuster* to correct heater voltage indicated on *Heater Voltage* meter.

9. Rotate *Element Short Test* switch through its six positions, stopping at each position to tap the tube.

10. A lighed neon lamp indicates a short in the tube and no further tests should be conducted. A lighted neon lamp on Position (1) indicates heater to cathode leakage.

11. From time to time check neon lamp by placing *Lamp Test* toggle in the upper position.

12. Set the *Self Bias Resistance* control to *"Fixed Bias"* or zero ohms position. *Note:* If manufacturer's rating specifically calls for *self bias*, set the control to the proper value.

13. Rotate the *Control Grid, Suppressor Grid, Screen Grid* and *Plate Voltage* adjusters to the extreme counter-clockwise position.

14. Index *Short Test - Meter Reading* switch to *"Meter Reading"* position.

15. Place *Plate Supply* toggle switch in the *"On"* position.

16. Index *Set To Nearest Amp Factor* switch to a position corresponding to the nearest amp factor value specified in manufacturer's rating. If tube is a screen grid, pentode, or beam power type or has an amp factor of *20 or over*, use *"Red Scale"* position.

17. Index *Micromhos* switch to a range consistent with the expected mutual conductance. This is the value listed by the manufacturer.

18. Index element *Milliamperes* switch located below the *Hum* toggle switch to the *"Plate"* position.

19. Index range *Milliamperes* switch located below the *Element Current* meter to a position higher than the expected plate current specified by manufacturer.

20. Rotate the *Control Grid Voltage Adjuster* until the *Control Grid Voltmeter* indicates the value specified by manufacturer. If over 10 volts, index *Control Grid* switch to *"50 Volts"* position. Rotate to extreme counter-clockwise position if *Self Bias Resistance* control is set to any position other than *"Fixed Bias"* or zero ohms.

21. Index the element *Volts* switch located under the *Element Voltage* meter to the *"Plate"* position.

22. Advance the *Plate Voltage Adjuster* until the *Element Voltage* meter indicates the plate potential specified by manufacturer. If over 150 volts, index *Volts* switch to "300" volts position.

23. Index element *Volts* switch to *"Screen"* position.

24. Advance *Screen Grid Voltage Adjuster* until the *Element Voltage* meter indicates the screen potential specified by manufacturer. If over 150 volts, index *Volts* toggle switch to "300" volts position. *Important Note:* To prevent excessive screen dissipation keep the plate potential the same as or higher than the screen potential.

25. Recheck the plate, screen and control grid voltages.

26. Plate, screen, suppressor or cathode currents can be readily checked by rotating the element *Milliamperes* switch through its four positions noting the current on the *Element Current* meter. It may be necessary in doing this to change range on the *Element Current* meter by rotating the range *Milliamperes* switch to one of the other positions.

27. If the tube is a filamentary type, hold the *Hum* toggle switch down in the *"Test"* position and rotate the *Hum Control* to give minimum reading on the fan-shaped *Micromhos* meter. *Note:* Serious errors in mutual conductance readings can be expected if this operation is not performed carefully on filament types.

28. Pull the *Microamperes* toggle switch to the "15" position. Read microampere grid current directly on 15 scale. Refer to *"Grid Current"* under Helpful Suggestions In Tube Testing on page 12.

29. Lift the *Signal* toggle switch to the *"Check"* position and rotate the *Signal Voltage Adjuster* to bring the *Micromhos* meter to exactly top mark.

30. Release *Signal* toggle switch.

31. To take the G_m reading, position the *Grid Signal* toggle switch to the *"On"* position, read the *Micromhos* meter, and multiply by the factor shown on the *Micromhos* switch. Read 3,000 micromhos full scale when the *Micromhos* switch is set to *"X 100."* The black scale arc on the *Micromhos* meter should be used if the *Set To Nearest Amp Factor* switch is set to an amp factor of 15 or lower, otherwise read on the red scale arc. *Note:* Refer to pages 11 & 12 for rejection limits.

RECTIFIER TUBES:

32. Patch jumper leads as in steps "3 and 3-(B)." If rectifier has double plates, patch one of the plates to the *Plate 1* jack and the other to *Plate 2* jack.

33. Follow steps 4-10 inclusive. If double rectifier plates have been patched as above, short check the tube as in step 9 indexing the *Plate* toggle switch to both *"Plate 1"* and *"Plate 2"* positions.

34. Follow steps 12-15 inclusive.

35. Set *Amp Factor* switch to "3.5."

36. Set *Micromhos* range switch to *"X 500." Note:* If steps 35 and 36 are not followed, the emission measurements will not be in error. However, follow-

ing these two steps reduces the plate circuit impedance and short circuits the G_m meter.

37. Index element *Milliamperes* switch to *"Plate"* position.

38. Index range *Milliamperes* switch to "120" position.[1]

39. Index *Volts* toggle switch to "60."[2]

40. Place *Plate Supply* toggle switch in the *"On"* position.

41. Advance the *Plate Voltage Adjuster* carefully until the *Element Current* meter indicates the current listed in the Tube Data Chart supplied separately.

42. Reject the tube as bad if the plate voltage required to give the specified current is greater than that shown in the Tube Data Chart supplied separately.

43. Repeat the emission check on the second plate in the same manner indexing the *Plate* toggle to its other position.

44. If the two plates have materially different emission readings the tube should be rejected.

DIODE DETECTORS:

45. Patch jumpers as in step 32 and in addition connect all other elements to cathode.

46. Follow steps 33-44 inclusive, except that in step 38 the range *Milliamperes* switch should be indexed to the "3" position.[3] *Note:* The 0.8 MA. limit at 10 volts maximum is usually considered satisfactory, however, diodes normally pass considerably greater current, some going as high as 2 or 3 MA.

CONVERTER AND MIXER-OSCILLATOR TYPES:

47. Patch the jumper leads in accordance with the information in Tube Data Chart supplied separately.

A—The figure in parenthesis in the Tube Data Charts refers to the pin connection. Example: A type 1A7-GT shows the figure (3) and (6) in parenthesis in the column headed *Plate Volts.* Hence pins 3 and 6 are connected together and patched to the *Plate 1* jack by means of the jumper leads.

B—The letter (C) in parenthesis denotes *Grid Cap.* Example: A type 1A7-GT shows the figure (5) and the letter (C) in parenthesis in the column headed Control Grid Volts. Hence pin 5 and the tube's grid cap are connected together and patched to the *Control Grid* jack by means of the jumper leads.

48. Follow steps 4 through 31 omitting any remarks concerning "manufacturer's specifications" and substituting "value specified in the Tube Data Chart supplied separately.

49. Reject tube when the mutual conductance indication is below that value specified in the column headed "Life End."

1. For Type 9B, use 100 milliampere range.
2. For Type 9B, use 150 volt range.
3. For Type 9B, use 5 milliampere range.

THYRATRON TUBES:

Thyratrons such as the 2050 and 2051 can be checked in any type Model 686. The step-by-step procedure given below is for the tube type 2050. Checking other thyratrons involves the same procedure but it must be kept in mind that the tubes should be of a type similar to the 2050 and 2051.

1. Make connections by use of patch cords in accordance with the base diagram except that a 100,000 ohm 1/2 watt resistor should be inserted in the grid lead to pin 5. Number 2 grid should be connected directly to cathode.
2. Set *Amp Factor* switch to *"Red Scale".*
3. Set *Micromhos* switch to "15,000" range.
4. Set range *Milliampere* switch to "120" milliamperes.[1]
5. Set element *Milliampere* switch to *"Plate"* position.
6. Before inserting the tube apply the following element voltages:

   Filament 6.3
   Control Grid .... — 10 volts d-c
   Plate .... + 212 volts d-c

7. Insert tube, readjust filament voltage and allow to heat for at least 30 seconds.
8. Reduce the grid bias carefully until the thyratron fires.
9. LIMITS: If the tube fires between —3 and —1 volts on the grid, the tube is within manufacturing limits for both end point and variation in new tubes.

   Note: Once the tube fires, the grid loses control. If it should be necessary to repeat the test, increase the grid bias to —10 volts and decrease the plate voltage to zero, and then reset it to 212 volts and repeat the above procedure.

   The plate current for tubes 2050 and 2051 should not exceed 100 milliamperes and 75 milliamperes respectively. If it does, reduce the plate voltage slightly to bring it within these values.

   Note also that when the thyratron fires the plate voltage will drop to about 7-1/2 volts. This is normal.

VOLTAGE REGULATORS:

Any type Model 686 can check voltage regulator tubes similar to the 874 and VR-150-30 types. The procedure outlined below is for checking the 874 type.

1. Make connections by use of patch cords in accordance with the base diagram. In the case of the 874, Pin 1 is the cathode and Pin 3 is the anode or plate.

2. Set *Amp Factor* switch to *"Red Scale"*.
3. Set *Micromhos* switch to "15,000" range.
4. Set range *Milliampere* switch to "100" milliamperes.
5. Set element *Milliampere* switch to *"Plate"* position.
6. Increase the plate voltage until conduction begins. This should be at approximately 115 volts for the type 874. (For other voltage regulators refer to manufacturer's ratings).
7. To check the regulating characteristics vary the plate voltage to produce anode currents between 10 and 50 milliamperes maximum. (For other voltage regulators see manufacturer's ratings.)

   Note: The voltage applied to produce currents between 10 and 50 milliamperes should be within the limits indicated by the manufacturer's ratings. In the case of the 874 the voltage after conduction should not vary more than 7 when the current is varied from 10 to 50 milliamperes.

THEORY OF OPERATION

Reference to the Simplified Block Diagram shown below will aid the reader in understanding the functioning of the various controls and parts of this equipment. Only those parts having important functions in the measuring of G_m have been included in this diagram so that the theory may be more readily understood.

Essentially the Model 686 is a low impedance power supply metered for potentials and currents and provided with a means of introducing an a-c signal into the grid bias line and measuring the a-c component in the plate circuit.

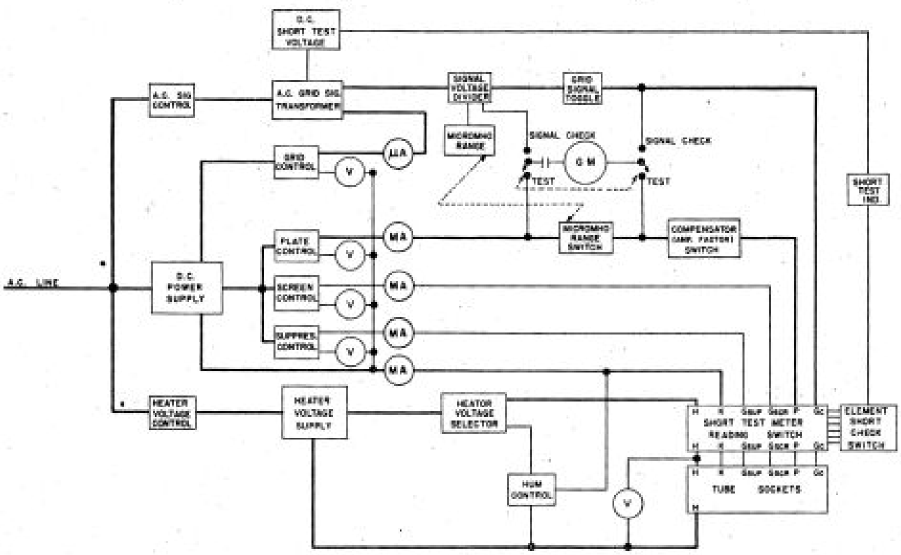
The incoming a-c line energizes the d-c power supply, the heater voltage supply and the a-c grid signal transformer. The filament and grid signal transformers have their controls located in the primary leads thus providing proper adjustment to take care of varying line voltage conditions. A rotary switch selects secondary taps to give the necessary heater voltages for all tubes.

The d-c power supply delivers potentials to the plate, screen and suppressor controls. Following these controls the potentials are metered and the circuit is so arranged that the element milliammeter can be placed in each of the lines. A resistance in the low side of the power supply develops the voltage for grid bias. This potential is likewise controlled by a potentiometer. A separate voltmeter is used to measure this potential and a microammeter is placed in the circuit to detect the presence of grid current.

The a-c grid signal winding together with a signal voltage divider is placed in series with the control grid circuit to the tube. The proper signal voltages are selected by one section of the *Micromhos* switch which is connected to the signal voltage divider. The injection of the a-c grid signal into the grid bias circuit is a function performed by the *Grid Signal* toggle switch.

The G_m meter is a rectifier type a-c instrument which is switched into the plate circuit for measuring the a-c component of plate current or into the signal circuit for measuring signal voltage. The *Micromhos* range switch selects the proper shunt for the G_m meter or the proper signal voltage in the case of high mu tubes.

A compensator network supplies the necessary correction in the plate circuit to give a true G_m indication. The introduction of an instrument into the plate circuit increases the plate circuit resistance to a point wherein it becomes an appreciable part of the tube plate resistance on low amp factor tubes. Hence a compensating resistance network based on



Simplified Block Diagram Of Model 686

sound mathematical calculations is necessary to provide accurate mutual conductance indications.

The element potentials are fed to a multi-circuit *Short Test-Meter Reading* switch. This switch provides the necessary circuit connections so that tube elements may be either short checked by means of the *Element Short Test* switch or energized by the potentials from the power supply.

The a-c grid signal transformer has a separate winding feeding a type 3A4 tube which supplies the necessary d-c voltage for high sensitivity short check.

The *Hum Control* is simply a potentiometer placed across the filament winding to provide the necessary balance on the filament return when checking these types. This is to prevent an additional signal (which may either add to or subtract from the true grid signal) from appearing in the grid circuit causing a modification in the a-c plate current component. The *Hum Control* is switched out of the circuit on heater voltages above 10.

In checking a tube, the d-c potentials are applied to the tube through the various controls. The a-c grid signal is applied in series with the grid bias voltage, and is measured by switching the G_m meter to *"Signal Check"* and held to a fixed value by rotating the *Signal Voltage Adjuster.* To measure a-c component of plate current, the compensator switch is set to the proper Amp Factor position and the G_m meter switched to the *Test* position. Inasmuch as the value of the grid signal and the a-c component of plate current are known, the mutual conductance is the ratio of the two. Since the ratio $\frac{\Delta I_p}{\Delta E_g} = G_m$ consists of one known value and one measured quantity, the scale can be calibrated directly in micromhos.

GENERAL INFORMATION

INSTRUCTION BOOK: This edition of the instruction book has been kept general in scope so that it will apply to all Model 686 Analyzers beginning with type 9. If any paragraph should obviously not apply to the particular model in question, that bit of information should be deleted.

For example, the Model 686 types 9 and 9A do not have a 30,000 G_m range, negative suppressor potentials, or a universal power transformer for operation on 230 volt lines. Hence, any reference to these features should be deleted when the text is applied to these types.

The wiring diagrams on pages 14 and 15 are for Model 686 Types 9B and 9C. When the diagram is to be used for repair purposes and the type number is other than 9B, *always refer to the diagram on the inside back cover of the instrument.*

Any questions concerning a special application, the use, maintenance or repair of these models should be addressed to Weston Electrical Instrument Corporation, giving all the information listed on page 13 under paragraph ORDERING INFORMATION.

TUBE MANUALS: It is advisable for the operator of this device to have at his disposal a tube manual which can be obtained from any of the tube manufacturers. A manual facilitates the measurements of tubes at potentials not normally listed in the manufacturer's specifications.

For example, if the mutual conductance of the 6C8 were to be measured at 150 volts and $-1\frac{1}{2}$ volts bias a glance at the E_p—I_p curves would show that on the vertical line corresponding to 150 volts a change in plate current of 1.6 milliamperes would result with a grid bias change of -1 to -2 volts. The expected mutual conductance, therefore would be approximately 1600 micromhos, this value being obtained by dividing plate current change in milliamperes by the grid bias change in volts and multiplying by 1,000. Computing the approximate G_m to be expected as explained above sometimes eliminates an incorrect reading due to improper testing of the tube.

TUBE DATA CHARTS: Tube Data Charts, supplied separately, list the manufacturer's nominal ratings for the element potentials, mutual conductance, amplification factor, and the tube base diagram number. These charts will in most cases handle all of the tubes that will be checked, and should be used as a quick reference supplement to the tube manual. Tubes not listed in the charts can be checked if the basing, element potentials and amplification factor of the tube are known.

REJECT LIMITS: The reject limits listed should be considered as nominal limits only. It is possible that in certain special applications it will be necessary to reject a tube when its G_m has fallen to possibly only 75 or 80% of its nominal value. In other cases a reduction of 60% in the G_m would have no adverse effect on the operation of the circuit. If an end point figure or an end point range is specified by the tube manufacturer, the operator should be guided accordingly.

If it is not known what reduction in G_m is allowable, the limits in percent of normal listed below are suggested as the proper end points for use in general electronic equipment:

RF, IF, and Pentode Voltage Amplifiers....65%
General Purpose and high mu Triodes......50%
Power Output Types 50%
Converters and Mixers
(Refer to Tube Data Chart)
Rectifiers (Refer to Tube Data Chart)
Diode Detectors (Refer to page 9, Step 46.)

D-C FILAMENT SUPPLY: In certain applications it may be desirable to measure the mutual conductance of a filamentary type using d-c voltage instead of an a-c source to energize the filmaent. In such cases index the *Heater Voltage* switch to zero position, run jumper leads from the d-c filament supply source to the proper numbered pin jacks in the top two rows. Connect an additional lead from the negative filament supply to the second or third *Cathode* pin jack. A separate d-c instrument will be required to measure the filament voltage and should be connected into the two pin jacks in the top two rows corresponding to the filament connections.

HELPFUL SUGGESTIONS IN TUBE TESTING

GRID CURRENT: In using the Model 686 care should be exercised to see that the grid current in microamperes indicated on the *Grid Current* meter does not exceed three to four microamperes. This value changes somewhat between tube types, but the above value can be assumed in general, to be satisfactory. Excessive grid current will cause an error in the G_m readings and it is advisable that a limit of 4 microamperes be strictly adhered to and that some means of eliminating this condition should be tried as outlined below.

If the *Grid Current* meter deflects to the left of zero the tube is either gassy or the element potentials applied are not correct. Check the manufacturer's specification and note whether the proper potentials have been applied. If the potentials are correct and the meter indicates 4 microamperes or more to the left of zero the tube should be rejected.

If the *Grid Current* meter indicates to the right of the zero with the correct potentials applied, the tube is oscillating. This condition must be eliminated before accurate G_m indications can be obtained. Usually a 15 to 20 ohm resistor placed in some one of the electrode leads, except filament or cathode, will eliminate the tendency to oscillate.

There are some tubes requiring low bias and if the signal voltage applied is too high, grid rectification will cause the *Grid Current* meter to indicate to the right of zero. This condition can be readily detected by noting the increase in *Grid Current* meter deflection when the *Grid Signal* toggle switch is indexed to the *"On"* position and the *Microamperes* toggle switch is indexed to the "15" position. To correct this on tubes having Amp Factor of 20 or higher, select the next higher G_m range, as this will reduce the grid signal.

Any attempt to check certain tubes under *Fixed Bias* conditions that should be checked under *Self-Bias* conditions, usually results in tube oscillation or instability.

The *Grid Current* meter will also indicate to the right of zero when the plate supply and grid bias potentials are extremely low or zero.

INCONSISTENT G_m READINGS ON FILAMENTARY TYPE TUBES: Inconsistent G_m readings on filamentary type tubes is caused by improper setting of the *Hum Control* when the *Hum* toggle switch is indexed to *"Test"* position. It is recommended that Step 27 in the *Step-by-Step Procedure* on page 8 be performed more carefully. The operator might find it helpful to temporarily set the *Micromhos* range switch to the X 100 position to obtain the maximum sensitivity when performing this operation.

VERY LOW OR NO G_m READING: Assuming the electrode potentials to be correctly applied and adjusted the operator may find that the G_m reading is zero. This is caused by indexing the *Set To Nearest Amp Factor* switch to one of the black scale positions and indexing the *Micromhos* range switch to "15,000" or "30,000". Under this condition the G_m meter is purposely shorted out so that the operator cannot obtain incorrect measurements. *Always keep in mind that the 15,000 and 30,000 micromhos ranges are not available on the black scale positions (amp factor setting of 15 or lower).*

If the *Self Bias Resistance* control is set a value higher than zero ohms and the grid bias voltmeter control has not been returned to the extreme counterclockwise position, the total grid bias applied to the tube will be that indicated by the *Control Grid Voltmeter* plus the bias developed in the self bias resistor. This condition would cause the plate current to be very low and the G_m to be either very low or zero.

Other factors causing low G_m readings are described in the section on *Maintenance* on page 13.

PRECAUTIONS

Don't Attempt to Test a tube unless it has been found cleared in the short test.

Don't attempt to patch the circuit unless the *Plate Supply* toggle switch is in the *"Off"* position.

Don't Insert a Tube until you are certain that the *Heater Voltage* switch is set to the correct value for that tube. Check with the Tube Data Chart.

Don't Insert a Tube in the Test Circuit Unless All Voltage Adjusters Are Rotated to the "Off" Position. This may be waived if testing a group of identical tubes.

Don't Test Rectifiers beyond their maximum current carrying capacity.

Don't apply more than 10 volts to diode detectors or their emission may be lost.

Don't Fail to *Bring Up the Grid Voltage First,* the *Plate Voltage Second* and the *Screen Voltage Third,* otherwise the cathode or the screen may be damaged.

Don't fail to set the *Amp Factor* switch at the nominal value for the tube under test in order to get an accurate reading.

Don't fail to completely *Shut Off* the device when testing is completed.

MAINTENANCE

RECTIFIER TUBES: It is recommended that the several components in the device be checked at two year intervals so that the equipment is maintained in a completely satisfactory operating condition.

If the power supply will not deliver 300 volts at 100 milliamperes at a measured line voltage of 120, the 5U4-G rectifier is failing and should be replaced. A 6L6 or a type 2A3 tube may be used as a load by applying 300 volts to the plate and lowering the grid bias from the specified value until the element current meter indicates 100 milliamperes. This will provide a convenient load for the power supply for checking the rectifier.

The small miniature type 3A4 can be checked by removing it from its socket and testing in the Model 686. If the plate current is considerably below that specified by the manufacturer (50%) this tube should be replaced.

For Type 9C the 6 X 4 rectifier and the 0B2 regulator tubes may be removed and tested in the Model 686.

ELECTROLYTIC CONDENSERS: Every two to three years three electrolytic condensers in the Model 686 should be checked with a capacity analyzer to determine whether they are in a satisfactory condition. It is necessary to remove the back cover to check these condensers.

The low voltage 1,000 microfarad condenser is located in a clip near the lower right hand section of the top panel when looking at the instrument from the back. The capacitance of this unit should not be allowed to fall below 500 microfarads.

Two 40 microfarad 450 W.V. electrolytic condensers are located in clips under the shelf at the left side when looking at the back of the instrument. These two condensers should not be allowed to fall to a value below 30 microfarads.[1]

Low G_m indications can be expected on high plate current tubes when the capacity of the 40 microfarad condensers fall below 30 microfarads. A decrease in the capacitance of the 1,000 microfarad unit will have no effect on the G_m indications when the tubes are being checked under fixed bias conditions, but will cause G_m indications to be very low under self bias conditions.

ORDERING INFORMATION

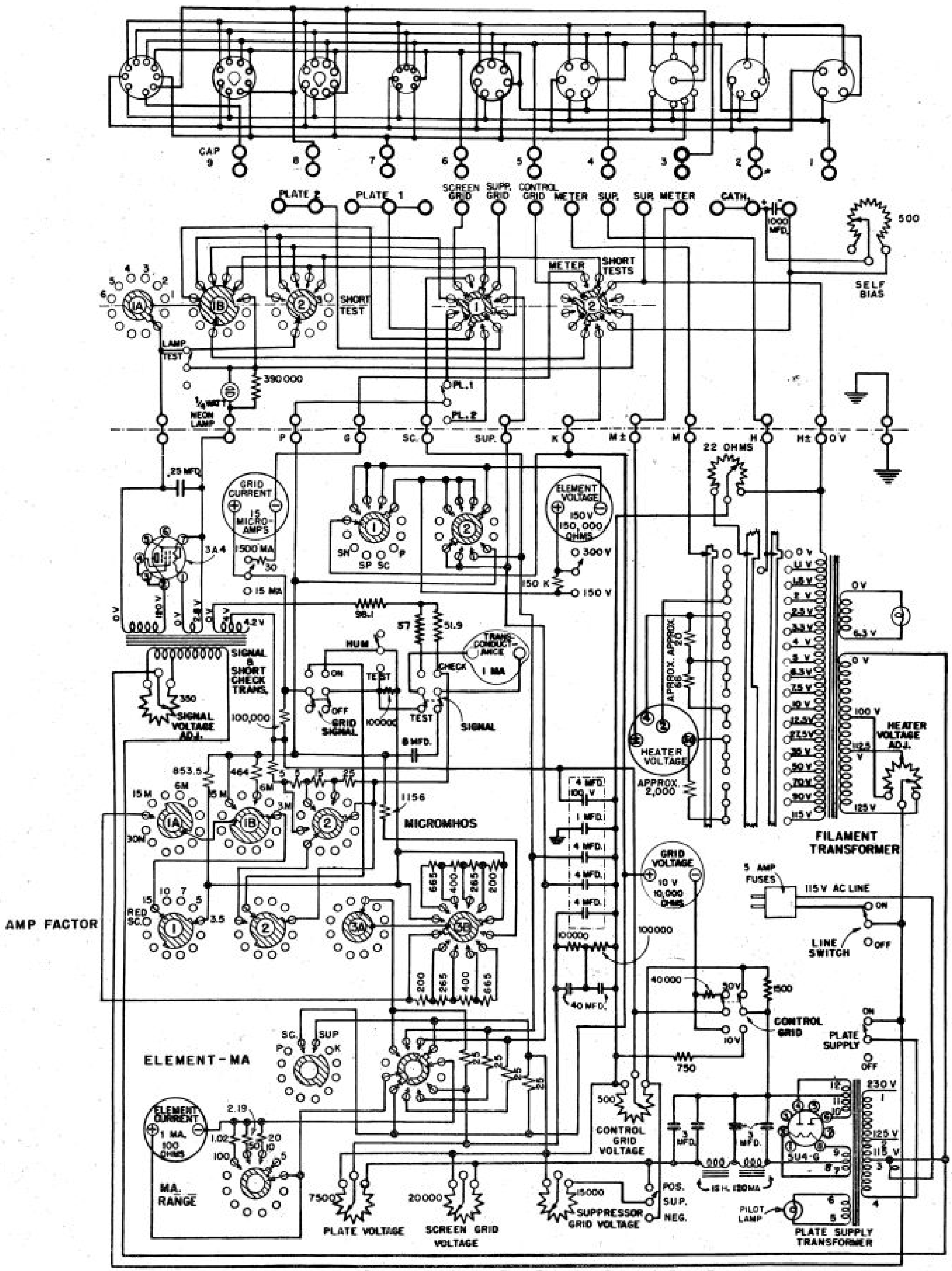
If an occasion should ever arise requiring the ordering of parts, *be sure to give the Model Number, Type Number, Serial Number, Voltage and Frequency Ratings.*

A description and location of the part in the equipment should be as complete as possible.

Address all inquiries to Weston Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

1. For Type 9B keep in mind when replacing these units that they are connected in series and that proper polarity must be observed. The 100,000 ohm ½ watt resistors should be replaced at the same time. These connect directly across each of the condensers and failure to replace them will cause either one or both of the condensers to become damaged.

WIRING DIAGRAM OF MODEL 686 TYPE 9B



SWITCHES ARE VIEWED FROM REAR AND SHOWN IN FIRST POSITION
SWITCH DECK NUMBERS INCREASE AWAY FROM PANEL

WIRING DIAGRAM OF MODEL 686 TYPE 9C