OPERATING INSTRUCTIONS

FOR

HICKOK

RADIO TEST EQUIPMENT

MODEL 155

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
CLEVELAND, OHIO U. S. A.

OPERATING INSTRUCTIONS MODEL 155
TRACEOMETER.

Accompany your Model 155 Indicating Traceometer is to be the following accessories:

Operating Instruction Manual No. 155.

4 Shielded Output Cables as follows:

1 Metal Lead - I.F. - R.F. probe.

1 Black Lead - Oscillator probe.

1 Red Lead - Audio Frequency Probe.

1 Blue Lead - D.C. voltmeter sectinn probe.

1 Chassis Connector - Unshielded Black lead.

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PRECAUTIONS TO BE OBSERVED IN OPERATION OF TRACEOMETER.

External overload of any of the four voltmeters is very unlikely to cause any damage.

Wattmeter section is protected by means of a 5 amp fuse which will normally blow before serious damage will occur to wattmeter. It is advisable, however, to be sure that any appliance plugged to the wattmeter section is not directly short circuited before actually making this connection.

Do not leave oscillator voltage range switch in Monitor Position except when using monitor.

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CIRCUITS AND OPERATION:

Putting the Model 155 into Operation:

1. Connect the line plug to suitable source of 110 volts, 50-60 cycles A.C. supply. If the unit is wired for 220 volt operation or for 25 cycle operation, suitable designation tag will be placed on the front panel indicating the primary voltage on which it is to be operated.

2. Turn the power supply switch on. When it is turned on the pilot light should indicate that the equipment is in operation and almost immediately after the switch has been turned on, the three meters, namely, the R.F. - I.F. meter, the Oscillator Meter, and the A.F. Voltmeter will come up to over full scale. As the tubes warm up these three meters should come down to zero and approximately the same time the D.C. voltmeter should come up to the zero point at mid-scale.

3. After allowing the Traceometer to warm up for several minutes, adjust the 4 balance controls until all four meters indicate zero. Further adjustment of these controls should not be necessary as long as the equipment is left in continuous operation.

4. FUSE PROTECTION: Should the 5 ampere fuse be blown, it may be readily removed by unscrewing with a screw driver the red plug at the end of the fuse clip holder labeled "Fuse" and replacing the fuse with standard cartridge type of <u>not over 5 amperes.</u>

5. CHASSIS CONNECTOR: Before making any other connection to a receiver chassis under test, connect the black chassis connector lead from one of the ground binding posts on the front of the panel to the chassis of the receiver under test. In the case of A.C. D.C. sets where the chassis is not connected to any part of the power supply, the chassis connector clip should preferably be connected to the "B" negative side of the power supply.

6. POSSIBILITY OF DAMAGING THE METER: The Vacuum Tube Voltmeter circuits are so constructed that regardless of what voltage is applied to any range, it is only possible to obtain a current through the meter which is approximately 20% greater than the current required to bring the meter to full scale. For example, it requires .8 of 1 mil to bring any one of the four voltmeters to full scale. The maximum current which could possibly flow thru any of these meters, barring a circuit breakdown internally in the Traceometer, is approximately 1 milliampere. <u>Do not be worried if the meter goes past the end of the scale, as the meter is capable of withstanding many times this small overload.</u>

7. D.C. VOLTMETER SECTION: Comprising the D.C. voltmeter section is the D.C. voltmeter located in the upper left hand corner of the panel. The D.C. voltmeter balance control and the range control. The D.C. voltmeter calbe as outlined in page one of the operating

instructions is the cable with the blue plug. This cable has at the end of a test probe a 1 megohm resistor for decoupling and reduction of capacity effects. This cable could be plugged into the input jacks found on the D.C. voltmeter panel.

8. If the D.C. voltage being measured is positive with respect to ground the meter will indicate towards the right on the scale, whereas if the voltage is negative with respect to ground it will read in the reverse direction. The input impedance for this section is approximately 18 megohms and therefore will cause no serious loading on any circuits into which it might be normally connected. Since it is practically impossible to damage the meter due to overload, it is not necessary to start with the range switch on the highest range, but it may be started on any range and adjusted until suitable reading is obtained on the scale without fear of damaging the meter.

9. AUDIO FREQUENCY VOLTMETER SECTION: The Audio Frequency Voltmeter Section consists in the audio frequency voltmeter, found in the upper right hand corner of the Traceometer, of a balance control for zero adjust on the meter, an 8 position switch, the input jack and the minitor jack.

10. The proper cable to use in the audio frequency section is the cable with the red plug. This is a shielded cable and has no isolating or decoupling resistors or condensers at the end of the test probe and works into approximately 2 megohm input impedance. This test probe can be connected in at any place in the audio frequency system without disturbing the operation of that system.

WATTMETER SECTION: Plug the receiver under test into the wattmeter service outlet on the front panel of the Traceometer and the wattmeter will give a continuous automatic indication of the wattage being drawn by the receiver so connected.

Do not use the wattmeter for checking devices which draw over 300 watts. Such equipment as electric irons, washing machines, etc. will generally draw over this wattage and the result will invariably be that a fuse will be blown.

R.F. - I.F. SECTION: The R.F. - I.F. section consists basically of a tuned voltmeter, the frequency range of which is selected by the three position frequency range switch and the R.F.-I.F. calibrated frequency scale. To use this section, use the R.F.-I.F. probe in the input jack and make connections with probe end to the signal to be measured. The frequency being measured will be indicated by the calibrated frequency scale and the magnitude of the voltage can be directly read on the R.F.-I.F. voltmeter.

OSCILLATOR HIGH FREQUENCY SECTION: The oscillator section consists of a tuned voltmeter with frequency selected by means of the frequency range and calibrated frequency scale and voltage indicated on the oscillator output voltmeter. The input to the oscillator section should be connected to the input jack and the voltage section should be connected to the input jack and the voltage range adjusted until the meter reads on scale.

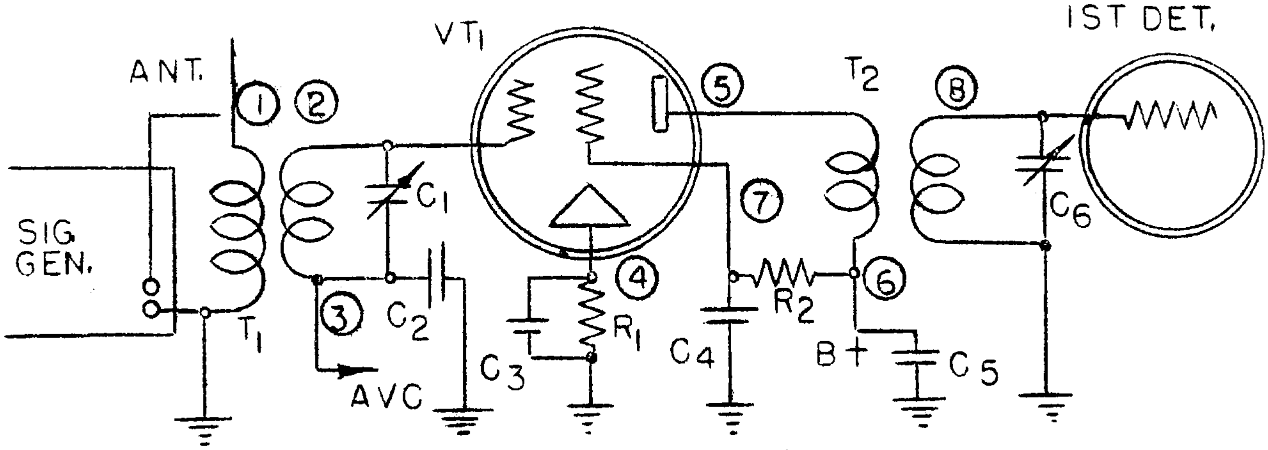
SPEAKER MONITORING: Coming out through the bottom of the case will be found a cord with conventional phone plug on the end. This is the connection to the voice coil of the speaker. For speaker monitoring of either the R.F.-I.F. or audio frequency section, this plug should be inserted in the monitor jack on the audio frequency section. When the speaker is being used for monitoring, the audio frequency voltmeter, as well as the oscillator high frequency voltmeter will be disconnected.

In monitoring the audio frequency section, set the oscillator frequency range switch to the monitor position as well as the voltage range switch of the oscillator section to the monitor position.

Turn the AF voltmeter range switch to .1 volt or 1 volt, depending upon the intensity desired from the speaker. As the range switch is turned towards the higher voltage ranges the signal coming from the speaker will decrease.

To monitor the R.F. - I.F. section, merely turn the audio frequency range switch to the monitor R.F.-I.F. position and the speaker will automatically monitor any signal being picked up at the R.F.-I.F. section.

R. F. AMPLIFIER



ONE STAGE OF R. F. AMP.

R.F. AMPLIFIER: The signal generator is connected in at antenna post 1 and ground.

POINT 1.

Measure microvolts delivered to antenna post and adjust signal generator to some definite voltage, for example, approximately 5000 microvolts. The signal generator output could be adjusted to any other specific value than 5000 microvolts if so desired.

POINT 2.

Connect the R.F. I.F. section to point 2 and tune the Traceometer for the frequency being delivered by the signal generator. If the input transformer C1 is operating normally, it is probable that the voltage at point 2 will be found to be practically the same as that at point 1, or approximately 5000 microvolts. When making this check it is also well to tune the main tuning condenser on the receiver and see that maximum voltage is obtained when the main tuning dial on the receiver corresponds to frequency being delivered by the signal generator and indicator on the Traceometer. With the signal generator tuned for say 1000 KC and the Traceometer also tuned for this resonance frequency if maximum voltage is obtained the main tuning dial on the receiver indicates below or above this value, it is an indication that this R.F. section is not tracking properly. Should the resonance occur at considerably lower value on the dial of the receiver than 1000 KC for example, as low as 700 or 800 KC, this would probably be an indication of a shorted turn on the secondary winding of the transformer T1.

At point 2 it is also possible by means of the D.C. voltmeter section to measure the AVC bias voltage being applied to the grid of the tube VT1.

POINT 3.

At point 3 AVC voltage can be checked by means of the D.C. voltmeter section and grid correspond directly to the same D.C. voltage as measured at point 2. Should there be any difference in voltage between these two points it is an indication that there is something wrong with the secondary of transformer T1. Bypass condenser C2 can be checked by using the R.F. I.F. channel properly tuned and connected to point 3. If C2 were opened up an R.F. voltage would appear between point 3 and ground which could be measured by the R.F. I.F. section. If condenser C2 were shorted out, zero AVC bias voltage would, of course, appear between this point and ground.

POINT 4.

At point 4 it is possible by means of the D.C. section to check the proper cathode bias voltage as a result of the IF drop through cathode biasing resistor R1. If zero bias voltage is obtained between the cathode and ground it would be an indication that condener C3 had shorted out. By using the RF-IF section and checking between point 4 and ground an opening up of condenser C3 would evidence itself by an indication of RF voltage from cathode to ground.

POINT 7.

A check at point 7 by means of the D.C. voltmeter section would determine whether or not the screen were operating at the proper voltage. Should zero voltage be found between the screen and ground it would be an indication that either R2 had opened up or C4 shorted out.

Should bypass condenser C4 be opened up, or of insufficient value for use with R.F. - I.F. section at point 7, it would indicate a voltage between the screen and ground.

POINT 5.

Point 5 is checked with the R.F. I.F. section and indicates considerable gain over the voltage as observed at point 2. Under ordinary conditions a gain of approximately 10 might be expected in this stage or approximately 50,000 microvolts at the plate of VT1. Of course, the type of tube being used and type of input and output transformer would largely determine the actual voltage gain of this tube and figures given are not to be considered absolute for all receivers.

At point 5 the use of the D.C. section can also be employed to determine whether or not the plate is receiving the proper D.C. voltage supply.

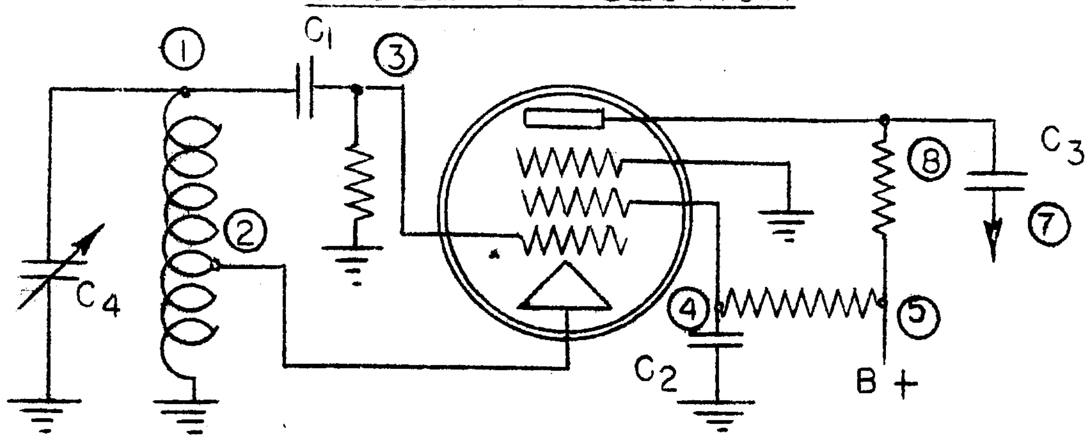
POINT 6.

A check with the D.C. voltage will determine whether or not the proper B-plus supply is connected to this source.

POINT 8.

By connecting the R.F. I.F. probe to point 8, check on the R.F. transformer T2 should indicate approximately the same voltage at point 8 as is found at point 5. The tracking of this condenser can also be checked by adjusting the main tuning dial on the receiver and noting if a maximum indication of voltage at point 8 is obtained when the main tuning dial on the receiver indicates the same frequency as supplied by the signal generator. If there is a tendency for a double peak, that is,maximum indication on the I.F. R.F. channel meter at two points it would be well to feed the signal from the signal generator in at point 2 rather than point 1. In doing this the selector tuning effect of the first transformer and condenser combination T1 and C1 would be eliminated and the actual tracking of condenser C5 checked.

OSCILLATOR SECTION



OSCILLATOR SECTION:

POINT 1.

At this point it is possible to check the voltage and frequency being generated by the oscillator section. As previously noted the oscillator frequency should be numerically equal to the intermediate frequency of the receiver plus the frequency as indicated on the main tuning dial of the receiver. The magnitude of the voltage at point 1 will be determined, of course, upon the circuit design of the oscillator section. In general, oscillator sections are found to deliver voltages between 50 and 120 volts at this point. No appreciable D.C. voltage should be found at point 1.

POINT 2.

At point 2 the frequency as measured by the oscillator section should be identical to that measured at point 1, but the voltage will probably be somewhat lower. In general, approximately 1/2 the voltage is found at point 1.

POINT 3.

The magnitude of the radio frequency voltage as measured by the oscillator section at point 3 should be approximately identical to that measured at point 1. It is possible, however, to use the D.C. section at point 3 to determine whether or not the oscillator is operating properly. When doing this, of course, it is not necessary to tune the Traceometer to the frequency being received. A negative voltage on the control grid of the oscillator section indicates that the oscillator is operating normally. The magnitude of this voltage might be expected to be something over 1 volt.

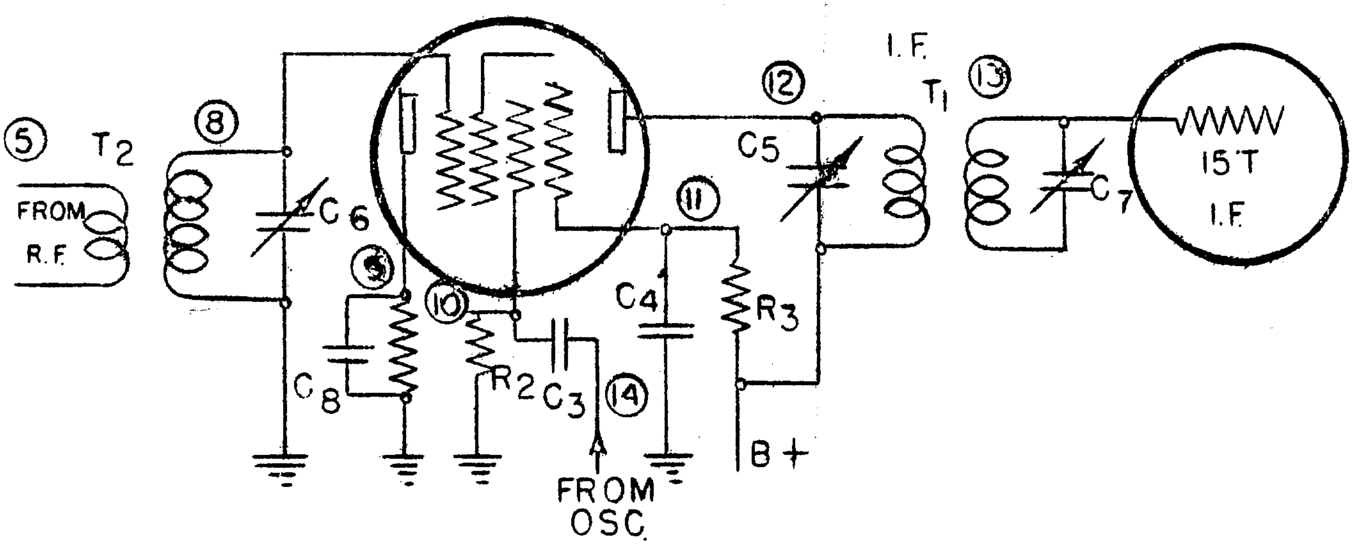
POINT 4.

The D.C. voltage applied to the screen of the oscillator tube can be measured with the D.C. section. Bypass condenser C2 can be checked for open by measuring the radio frequency voltage appearing at this point. If the condenser is operating normally very little radio frequency voltage should be between point 4 and ground. At point 6 the B-plus voltage can be measured by the D.C. section and also the radio frequency voltage measured by the oscillator section voltmeter. The magnitude of this voltage, of course, depends upon the circuit design and in general will be over 1 or 2 volts, but probably not anywhere near as high as the voltage found at point 1 or 2.

POINT 7.

The oscillator voltage at this point will be approximately the same as the voltage at point 6.

1 ST. DETECTOR



FIRST DETECTOR SECTION:

POINT 8.

Voltages and frequencies at point 8 were previously described. For further explanation we will assume that 50,000 microvolts were found applied to the grid of the first detector.

POINT 9.

Check the cathode bypass condenser C1 and cathode bypass resistor R1. This can be done in the same manner as outlined for checking cathode bypass condenser C3 and cathode bias resistor R1 under the R.F. amplifier section.

POINT 10.

The oscillator section of the model 155 should be used in checking the voltage being delivered to the injector grid by the oscillator section of the receiver. If we assume that the main tuning dial of the receiver has been tuned to 1000 KC the oscillator should be delivering a voltage which has a frequency numerically equal to 1000 KC plus the intermediate frequency. If the intermediate frequencies are 456 KC the frequency at point 10 should be 1456 KC. The magnitude of the voltage at this point will depend largely upon the first detector and oscillator section design. At least several volts should be delivered at this point. At point 10 it is also possible to check the D.C. voltage of the injector grid about ground. When the oscillator operates normally it should be found that this injector grid is operating at positive potential with respect to ground. The magnitude of this voltage will depend, of course, upon the design of the circuit, but in general, should be over one volt. Since the voltage from the oscillator section is quite often taken from the plate side thru the blocking condenser C3, if a rather high D.C. voltage such as 15 or 20 volts is found at point 10 it will probably be be an indication that condenser C3 were leaking thereby permitting the injector grid of the first detector tube to operate at a high positive potential with respect to ground.

POINT 14.

When using the oscillator section in the model 155 the voltage and frequency delivered at point 14 should be measured. The voltage will probably be found to be somewhat higher than the voltage measured at point 10. However, the frequency should be identical.

POINT 11.

At this point it is possible to check the D.C. voltage appearing at the screen and also the condition of capacity C4 as outlined for screen dropping resistor and bypass condenser under the RF amplifier section.

POINT 12.

At point 12 several different voltages and frequencies will be found. The frequencies at this point will be as follows: First, the 1000 KC signal which is injected at the control grid of the first detector. The magnitude of this voltage will probably be almost the same as the voltage appearing at the grid (Point 8). The reason for no amplification in this voltage at this stage is that the plate is not tuned to 1000 KC but tuned to the intermediate frequency of 465 KC. At point 12 will also be found the frequency from the local receiver oscillator, namely, 1456 KC. The magnitude of this voltage will probably be somewhat comparable to the voltage appearing at the injector grid of the first detector tube. Since the plate circuit is not tuned to the frequency of the oscillator no amplification will normally be experienced in this stage.

At point 12 will also be found the intermediate frequency of 456 KC. The magnitude of this voltage will, of course, depend entirely upon the type of tube and circuit being used, but in general, it will probably be found to be quite high, perhaps on the order of 1 volt or more. This is due, of course, to the fact that the plate circuit is tuned to resonate at 456 KC.

At this point also would be found the sum of the oscillator frequency of 1456 and the R.F. frequency of 1000 KC or 2456 KC. In general, this voltage will be very low since it is so widely separated from the tuned frequency of 456 KC.

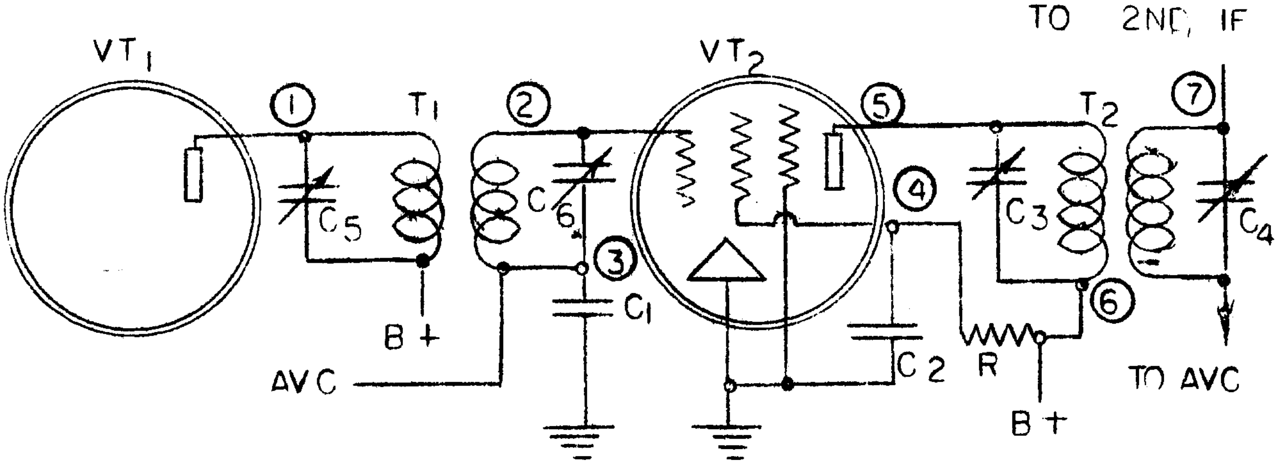
POINT 13.

Point 13, a voltage delivered to the grid of the first intermediate amplifier tube will probably be found to be somewhat the same as the voltage found at the plate of the first detector. Adjustment of the first IF transformer and trimming condenser C5 or C7 may be checked to determine whether or not the circuit is correctly resonated at the proper intermediate frequency.

POINT 13 CONT.

If a serious loss of voltage is experienced at point 13 it is an indication that probably the first I.F. transformer is defective. The actual resonance frequency of this transformer, should it be defective, could be determined by feeding the signal generator in at the control grid of the first detector and noting the voltage obtained at the grid of the first I.F. tube then shift the signal generator either higher in frequency or lower in frequency and at the same time shifting the input circuit of the Traceometer to a corresponding frequency and note whether or not the voltage delivered to the grid or the voltage appearing at the plate, point 12, is increased or decreased. By following this procedure through and increasing the frequency or decreasing the frequency of the signal generator it will probably be noted that at some frequency an extremely high voltage gain is obtained. If this frequency were found to be something other than the proper I.F. frequency, it would indicate that transformer R3 were defective and would not resonate at the proper intermediate frequency.

I. F. SECTION



FREQUENCY MODULATED RECEIVERS: In frequency modulated receivers the intermediate frequencies are generally above 2 megacycles, therefore, it will be necessary to use the oscillator or high frequency section of the #155 for measuring the intermediate frequency voltages in these receivers.

INTERMEDIATE FREQUENCY SECTION: If VT1 corresponds to the first detector and T1 is the first intermediate frequency transformer by reference to the chapter on the first detector, the test made at Point 1 and Point 2 can be determined. These consist of checking the voltage gain of the transformer and the signal delivered at the grid of the first intermediate frequency amplifier tube as well as the measurement of the automatic volume control voltage at Point 3 and Point 2.

Assume that the measured voltage at Point 2 is found to be 5000 microvolts.

POINT 5.

Measure the I.F. voltage at point 5 and if the I.F. stage is operating normally a gain of approximately 40 may be expected or in other words, .2 of a volt at the plate of the first intermediate frequency amplifier tube. At point 5 the D.C. voltage at the plate of the tube can be measured at the D.C. section.

CHECKING PRIMARY OF TRANSFORMER T2: With the R.F.-I.F. probe connected at Point 5, adjustment of trimmer condenser C3 should be made to determine whether or not the primary of the second intermediate frequency transformer T2 were operating properly. As the trimmer condenser C3 is adjusted back and forth a very definite increase and decrease in voltage delivered at the point 5 should be obtained. If it is found that with condenser C3 tuned to its extreme minimum capacity the voltage is still increasing, this will be an indication of a defective primary transformer T2, likewise, with the condenser C3 at its extreme maximum capacity and the voltage is still increasing this would likewise be an indication of defective primary transformer T2.

POINT 4.

At point 4 the bypass condenser C2 could be checked by the R.F. I.F. section as practically no intermediate frequency voltage should appear at this point if condenser C2 were operating normally as a bypass condenser. An indication of intermediate frequency voltage at this point would be a definite indication that C2 were open, thereby allowing a high potential to be built up between point 4 and ground.

If condenser C2 were shorted out, of course, this would result in zero voltage at the screen of the tube. Likewise, if resistance were opened up, this would also result in no voltage appearing between point 4 and ground.

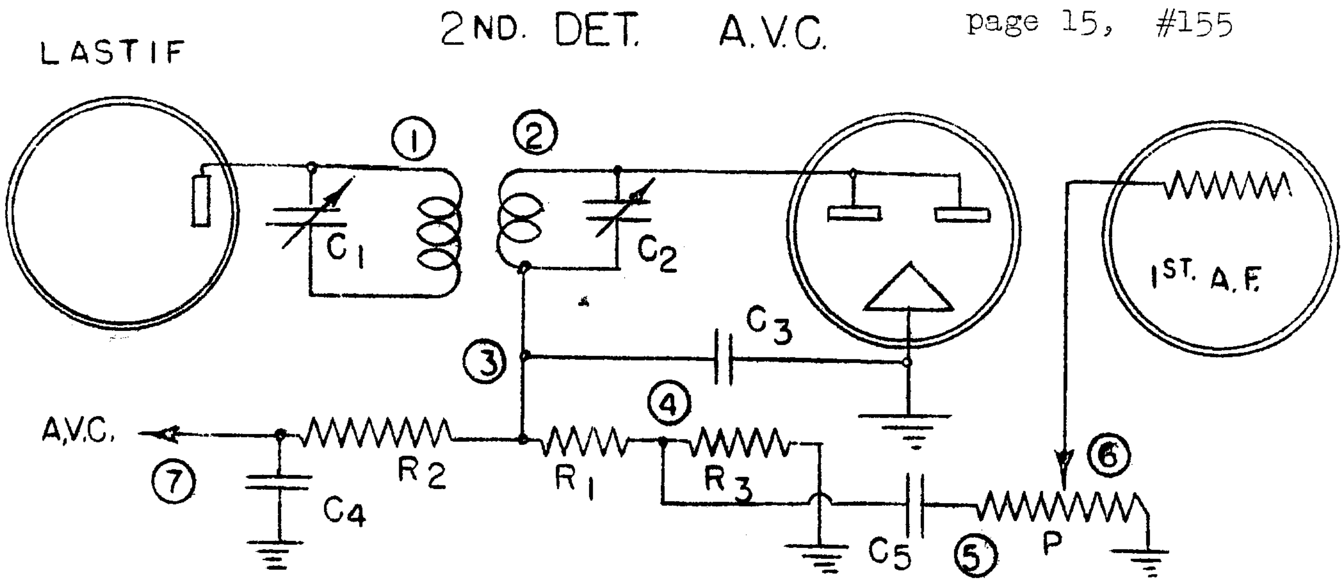
POINT 6.

At this point the B-plus voltage can be checked with the D.C. voltmeter section.

POINT 7.

If the intermediate frequency voltage is measured with the R.F. and I.F. section at point 7 it should be approximately the same as that measured at point 5.

When connecting at point 7 it is possible to check the secondary of transformer T2 by adjusting condenser C4. It should be possible to adjust C4 someplace between minimum and maximum capacity where a very definite increase or peak in the voltage being measured is observed. If adjustment of C4 either to its maximum or minimum capacity shows continued increase in voltage at point 7 this would be a definite indication that transformer T2 were defective and should be examined.



SECOND DETECTOR AND AVC:

POINT 1.

Voltages in the plate of the last intermediate frequency transformer have been previously discussed in the intermediate frequency section.

POINT 2.

Checking of the intermediate frequency voltage at point 2 of the last intermediate frequency transformer would be identical to the procedure in checking for intermediate frequency voltages at the secondary of any intermediate transformer and check should be made for voltage transfer from point 1 to point 2 and also for the possibility of defective intermediate frequency transformer.

POINT 3.

Due to the fact that bypass condenser C3 is generally of a fairly low value and will not bypass all of the I.F. signal a small amount of intermediate frequency voltage should be found at point 3. This would generally be considerably less than .1 of the intermediate frequency voltage as measured at point 2.

Due to the rectifying action of the second detector tube, a D.C. voltage will be built up at point 3 which is in proportion to the radio frequency voltage delivered to the second detector. This D.C. voltage should be measured, of course, by the D.C. voltmeter section and the meter should indicate the voltage as being negative with respect to ground.

POINT 13 CONT.

Superimposed upon the D.C. voltage generated at point 3, which is used for automatic volume control, will be the modulated component of the R.F. signal. If the test oscillator is supplying a signal modulated at 400 cycles, the 400 cycle audio frequency will also be found at point 3. This makes three different voltages at point 3. One, the intermediate frequency voltage which is measured by the R.F. I.F. section, second, the D.C. voltage which can be measured by the D.C. section, and also a 400 cycle audio frequency voltage which can be measured by the audio frequency section.

The operation of condenser C3 can also be checked. If C3 is shorted out no radio frequency voltage of course will be built up at point 3, nor will any D.C. or audio voltage be built up at this point. If condenser C3 is opened up a relatively high intermediate frequency voltage will be found at 3.

POINT 4.

At point 4 the intermediate frequency voltage should be filtered out and a check at this point with the R.F. I.F. section would indicate zero voltage at the intermediate frequency. At point 4 D.C. voltage should be found which will be less than the D.C. voltage found at point 3, depending on the ratios of resistance R1 to resistance R3. At point 4 an audio frequency voltage should also be found which will also be somewhat less than the audio frequency voltage found at point 3.

POINT 5.

At point 5, the D.C. voltage will not be found, but the audio frequency voltage should be found to be almost identical to the A.F. voltage found in point 4.

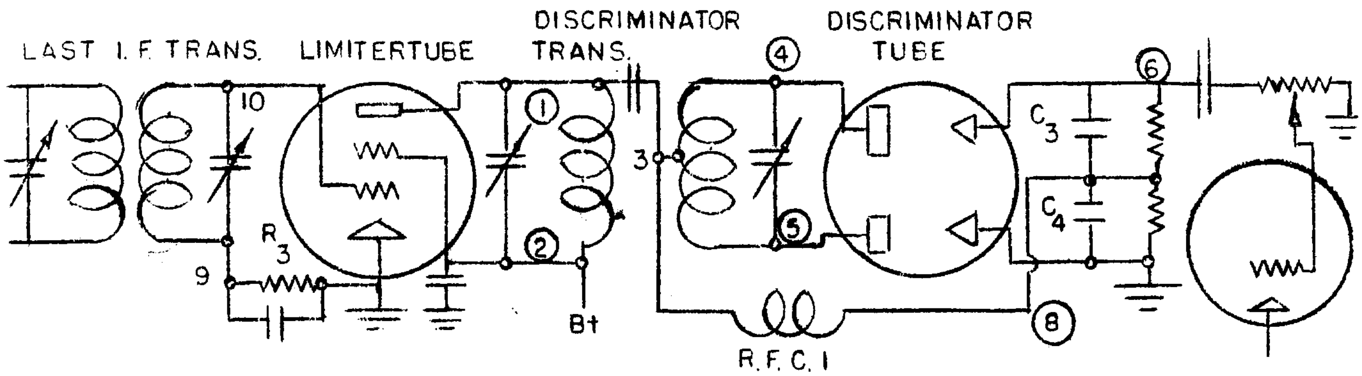
POINT 6.

A test at point 6 in the audio frequency section will indicate the action of the volume control C1. As the volume control is advanced towards maximum the voltage at point 6 should approach the voltage found at point 5, and as the volume control is retarded towards the minimum position the voltage at point 6 should be reduced to zero.

POINT 7.

At point 7 the only voltage appearing should be the automatic volume control bias voltage. The value of this D.C. voltage should be numerically equal to the D.C. voltage as found in point 3. Should this voltage be zero at point 7 it would be an indication that condenser C4 had shorted out. It might be noted that in general, resistance 2 is of relatively high value, generally over 1 megohm, and consequently C4 could be shorted out without seriously reducing the D.C. voltage of point 3.

The voltage found at point 7 should also be numerically equal to the voltages found at the grids of the tube which is controlled by the automatic volume control bias.



SECOND DETECTOR OF FREQUENCY MODULATED RECEIVERS: It will be noted that the second detector of frequency modulated receivers correspond almost identically to the circuit used for obtaining automatic frequency control voltage in amplitude modulated receivers, the exception being that the output of the discriminator tube at Point 6 instead of going directly to the grid of the control tube goes through a condenser and then to the first audio frequency amplifier.

The theory of operation of the second detector of a frequency modulated receiver is that when an intermediate frequency,unmodulated, of the correct value is being delivered from a discriminator transformer to the discriminator tube, that there will be no D.C. or A.F. voltage appearing between Point 6 and ground. When the oncoming signal, however, is frequency modulated, and is varied above and below frequency at some definite audio rate, the A.F. voltage appearing between Point 6 and ground will follow the audio frequency rate at which the signal is being modulated. Hickok Model 177X or 188X signal generators are capable of supplying this frequency modulated signal properly modulated at 400 or 60 cycles, or it can be modulated from any external audio frequency source. This demodulated signal is then fed to the grid of the first audio frequency amplifier tube and followed by conventional audio frequency amplifiers. Measurements at Point 6 can then be made by the audio frequency section of the Model 155 in the same manner that measurements were made at the second detector load in the case of conventional amplitude modulated receivers, or in addition to this, of course, D.C. voltage measurements can be made between Point 6 and ground if the signal being supplied from the intermediate stages is not frequency modulated, but is not of the correct intermediate frequency.

POINT 1.

At Point 1 the high frequency oscillator section can be used to measure the voltage being delivered by the discriminator tube. If the discriminator tube is operating properly this RF voltage as measured at this point should remain essentially constant regardless of the input voltage to the intermediate frequency stages above the threshhold or point where limiter section takes place. Of course, the D.C. voltage supplied to the plate of the discriminator tube could also be measured by the D.C. voltmeter section.

POINT 2

At Point 2 there should be no intermediate frequency voltage as measured by the high frequency section, of course, there should be a D.C. voltage as measured by the D.C. voltmeter section.

POINT 3.

The high frequency oscillator section can be used to measure the high frequency R.F. voltage at this point and should be found to be approximately identical to the voltage as measured at Point 1. If the voltage is found to be considerably lower at Point 3 than at Point 1, it will be an indication that coupling condenser C5 was open. If D.C. voltage is found at point 3 it will be an indication that coupling condenser C5 was shorted out or leaky.

POINT 4 - POINT 5

At these points an R.F. voltage should be found which corresponds approximately to the voltages found at Point 3, however, in all cases the voltage at Point 4 or Point 5 should be approximately equal.

POINT 6.

At this point should be found zero D.C. voltage with respect to ground if the discriminator transformer is properly aligned. At this point, of course, should be found an audio frequency voltage if the signal being supplied were frequency modulated.

POINT 8.

At this point there should be very little high frequency voltage due to the choke action of RFC1.

POINT 9.

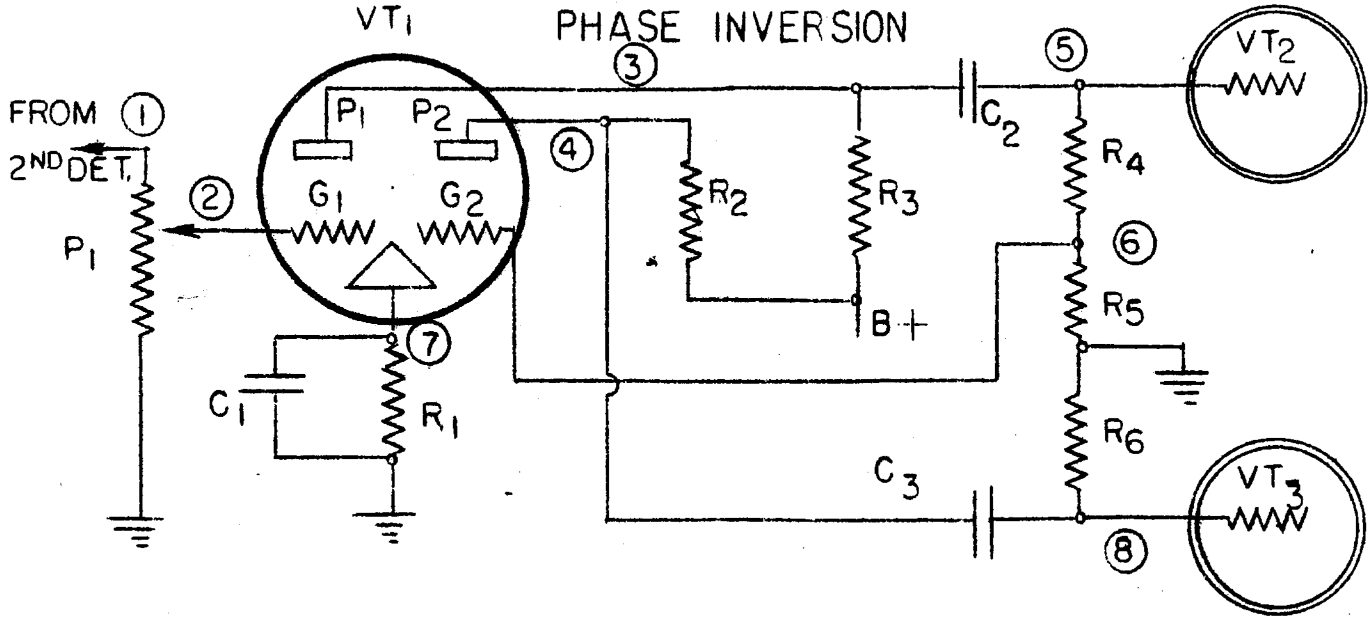
At point 9 will be found some high frequency RF voltage, but very little due to bypassing action of condenser C7. At this point should be found the D.C. voltage which is negative with respect to ground, the magnitude of which will depend upon the amount of signal being supplied from a signal to the intermediate frequency stages. With the D.C. voltmeter connected at Point 9, it is possible to align the intermediate frequency stages for maximum deflection of the D.C. voltmeter. In general, however, manufacturers recommend that the actual alignment of intermediate frequency stages be made with an oscillograph with the vertical plates connected at point 9.

POINT 10.

At point 10 should be found a high frequency I.F. voltage being delivered by the secondary of the last intermediate frequency transformer.

1ST. A.F. RESISTANCE COUPLED

PHASE INVERSION



FIRST AUDIO FREQUENCY AMPLIFIER STAGE INVERTED: The signal supplied to the first audio frequency amplifier can either be fed directly in as audio frequency at point 1, which is the high end of the volume control, or can be fed in thru the antenna in the conventional manner with the 400 cycle modulated RF signal and the receiver tuned for the proper frequency being generated by the signal generator.

Assume that volume control potentiometer C1 is so adjusted that maximum voltage delivered from the second detector or signal generator is applied directly to the grid 1 of VT1.

Assume that the signal voltage supplied to grid 1 is measured and found to be one-half volt.

POINT 3.

In using the audio frequency section the voltage found at point 3, which is plate 1, should be the voltage gain of the tube times the voltage supplied to the grid or if 1/2 volt is supplied to the grid the voltage at plate 1 or point 1 should be 10 volts if the gain of the tube were 20.

At point three the D.C. voltage at the plate of VT1 can also be checked with a D.C. voltmeter section.

POINT 5.

The same audio frequency voltage should be found at point 5 as is found at point 3. If this voltage should be found to be considerably lower than the voltage found at point 3, it would be an indication that condenser C2 was probably of too low a value or had opened up in service.

At point 5, the D.C. voltage on the grid of the following tube can also be measured, and in the circuit as outlined a voltage should be zero with respect to ground. If it is found to be a positive voltage of the grid of VT2 it would be an indication that the grid was being overdriven and was swinging positive with respect to ground. Unless the tube was being operated as a class AB or class B amplifier the grid should not be operated positive.

POINT 6.

Since the voltage delivered by plate 2 of VT1 to the grid of VT3 should be equal to the voltage delivered by the plate 1 of VT1 to the grid of VT2, the voltage applied to grid 2 of VT1 should also be equal to the voltage applied to grid 1 of VT1. It is the purpose of the voltage dividing network of R4 and R5 to supply the correct voltage to grid 2 of VT1. Thus, when R4 and R5 are of the correct values the voltage measured at point 6 or the grid 2 of VT1 should be equal to the voltage as measured at point 2 or the grid 1 of VT1.

Having voltages at point 2 and point 6 equal with respect to ground the voltages at point 4 should also be equal to the voltage of point 3.

POINT 8.

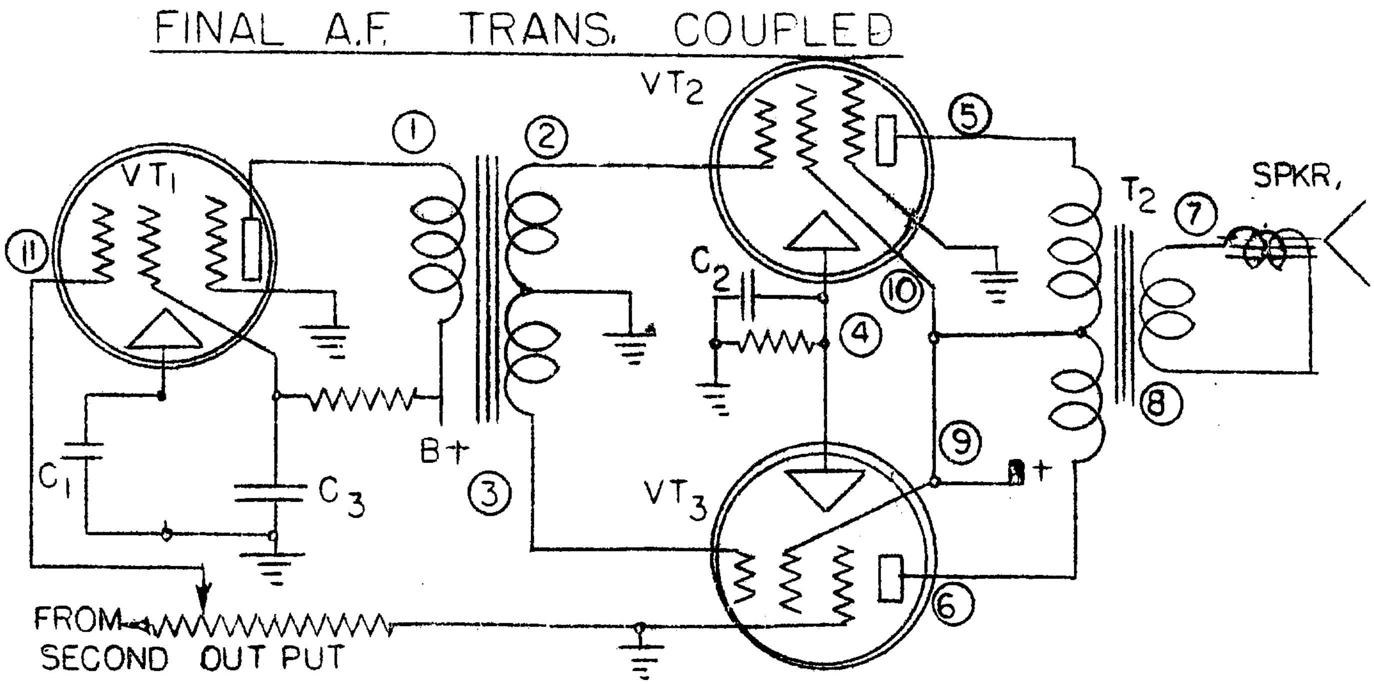
The voltage measured at point 8 should be numerically equal to the voltage at point 4. Should this voltage be found to be lower than the voltage measured at point 5, but still the voltage at point 4 equal to voltage at point 3, it would be an indication that condenser C3 had opened up or was of too low a value. This might also be an indication that resistor R6 was not equal to the combined resistance of R4 plus R5. If the voltage at either point 5 or point 8 were found to be positive with respect to ground it might also be an indication that either condenser C2 or condenser C3 were leaking allowing some of the B-plus voltage from the plates of VT1 to be fed across to the grids of VT2 or VT3. The D.C. voltages measured at point 3 or 4 should be equal.

POINT 7.

If condenser C1 were operating normally and had the proper capacity very little audio frequency voltage should appear at point 7. By using the D.C. voltmeter section measuring the D.C. voltage at point 7 it should be found to correspond to manufacturers specifications relative to proper bias applied to the particular tube being used in this circuit. If the D.C. voltage at point 7 with respect to ground were found to be zero it would be an indication that condenser C1 had shorted out or resistance R1 were shorted out.

MEASUREMENTS OF A.F. VOLTAGES AT THE PLATES OF TUBES:

Sometimes when tracing signals especially with the audio frequency voltmeter section at the plate of an audio amplifier tube there will be a small amount of 60 cycle or 120 cycle ripple from the power supply found at the plate of this tube which will show up as a voltage on the audio frequency meter. If small condenser of approximately .001 to .005 is connected between the audio frequency test probe and the plate of the tube at which the voltage is to be measured it will greatly reduce the amount of indications of the 60 or 120 cycle ripple without seriously impairing the sensitivity of the AF section at 400 cycles or some higher audio frequency. When doing this, of course, keep in mind that the voltage as measured will be somewhat less than the actual voltage at the plate of the tube. At 400 cycles a .005 condenser will reduce the reading by approximately 5%.



FINAL AUDIO FREQUENCY AMPLIFIER:

In this case we have considered the case of a transformer coupled amplifier rather than phase inversion type as previously outlined under first audio frequency amplifier section.

POINT 1.

The D.C. voltage delivered to plate of T1 can be measured with D.C. voltmeter section.

The audio frequency delivered by the plate of C1 can be measured in the audio frequency section.

In case VT1 is of the pentode type, the voltage gain as measured on point 10 to point 1 might be over 100. If C1 is triode, the voltage gain as measured in point 11 to point 1 of the first audio amplifier stage will probably be under 50.

The transformer ratio of input transformer T1 will be determined entirely by the tubes in circuits being used.

POINT 2 - 3.

The audio frequency voltage when measured at point 2 or 3 should be equal numerically and in general probably not much below the value of the audio frequency voltage measured at point 1. If the voltage at either point 2 or point 3 were found to be zero it would be a definite indication that either the grids of VT2 or VT3 were shorted to ground or that transformer T2 had a defective secondary winding.

POINT 4.

Using the audio frequency section at point 4, no audio frequency voltage should be found between cathode and ground. If it is found that there is audio frequency voltage at this point it would be well to check bypass condenser C2 as this has probably opened up or is defective. At point 4 the D.C. bias voltage can also be measured by the D.C. section.

POINT 9 - 10

The voltage of the screens of the fianl amplifier tube can be measured by the D.C. voltmeter section and in the case illustrated will be found to be equal and approximately the same as the B-plus supply voltage of the receiver under test.

POINT 5 - 6.

The voltage gain of the tube can be calculated from the ratio of the voltage at point 5 to the voltage at point 2 and also the ratio of voltage at point 6 to voltage at point 3. The voltage gain on this tube will depend entirely upon the tube being used and will probably be found to vary between 15 and 20 in triodes or in the case of high gain pentodes, as high as 100 to 150.

The voltages as found at point 5 and point 6 should be identical numerically. If these voltages are not found to be the same it will be an indication that either the VT2 or VT3 were not operating properly, or that there was a defective primary in transformer T2.

POINT 7 - 8.

In order to measure the voltage of secondary of transformer C2, it becomes necessary to connect the chassis connector clip instead of to the chassis to point 7 ot 8. If, however, it is necessary to leave the chassis connected to the chassis, point 7 or 8 could be grounded for the voltage measurements.

A voltage delivered to the speaker between point 7 and point 8 will always be less than the voltage as found between point 5 or 6 and ground. This is due, of course, to the fact that a step down transformer is necessary to match the low impedance of the voice coil to the relatively high plate impedance of the output tubes.

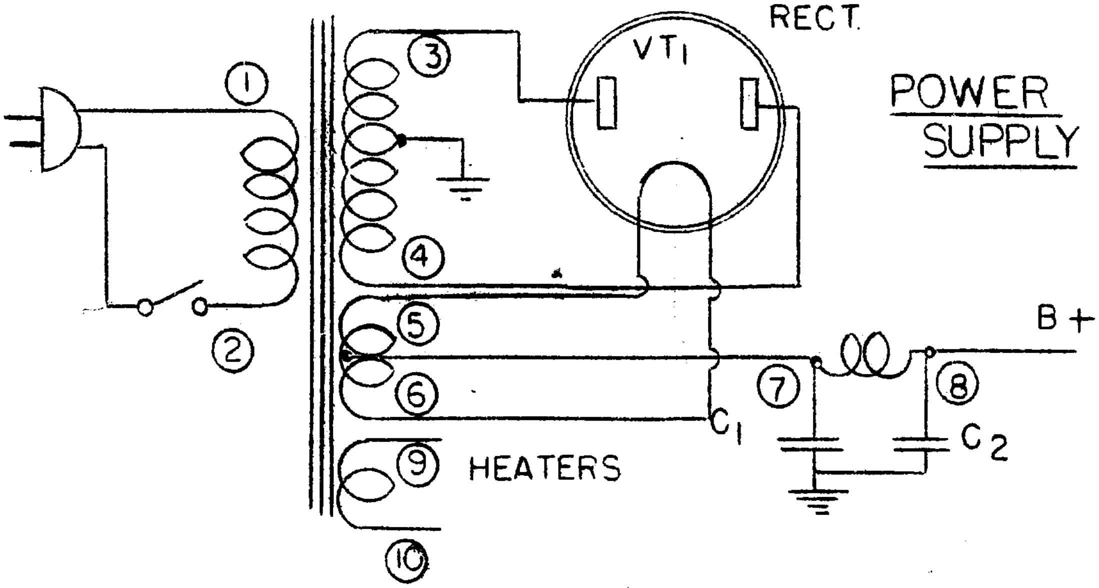
It is difficult to give any exact figure as to what voltage might be expected at the voice coil due to the extreme wide variance in voice coil design. The approximate voltage at the voice coil might be calculated from the formula: $\frac{E^2}{R}$ = WATTS if the impedance of the voice coil were known.

If we assume that the receiver is capable of delivering five watts and the voice impedance is known to be 10 ohms, the voltage delivered at full output would then be:

$$\frac{E^2}{(R = 10} = 5 \text{ Watts}$$

$$E^2 = (5)\ (10) - 50$$

$$E - \sqrt{50} = \text{approx. } 7 \text{ volts}$$



POWER SUPPLY SECTION: Since the audio frequency section has a blocking condenser in its input it will neglect any D.C. voltage and therefore it can be used to measure A.C. voltage irrespective of whether or not they have a D.C. component superimposed upon the A.C.

POINT 1 - 2

The A.F. voltage can be used to measure the primary voltage at the transformer between point 1 and point 2, but the following precaution must be observed:

Be sure that the chassis connector clip is not connected to the chassis of the receiver under test, but connected to one side of the power supply. Also, be sure that the chassis of the receiver under test is not connected to an earth ground. The A.F. test probe can then be connected to the other side of the power supply line at the primary of the transformer and the power supply voltage measured.

POINT 3 - 4

In the rectifier section the A.C. voltages delivered to the plate of the rectifier tube at point 3 and 4 can be measured and should be found to be identical. In this measurement the chassis connector is connected to B-negative which in most cases is the chassis.

POINT 5 - 6

In measuring the voltage supply to the filament of the rectifier tube it is essential that the chassis connector clip is not connected to the chassis of the receiver but connected to either point 5 or 6. The audio frequency probe can then be connected to the other point and the filament supply voltage to the rectifier tube measured.

POINT 7 - 8

By using the audio frequency voltmeter section in a normal manner the hum voltage at point 7 and point 8 can be measured. At point 7 the hum voltage will be found to be relatively high, generally in the neighborhood of 15 or 20 volts. At point 8, however, this ripple voltage should drop down and be only a fraction of one volt, if the system is operating normally. By using the D.C. section the voltage at point 7 and point 8 can be measured and in general, be found that the voltage at point 7 is somewhat higher than the voltage at point 8.

POINT 9 - 10

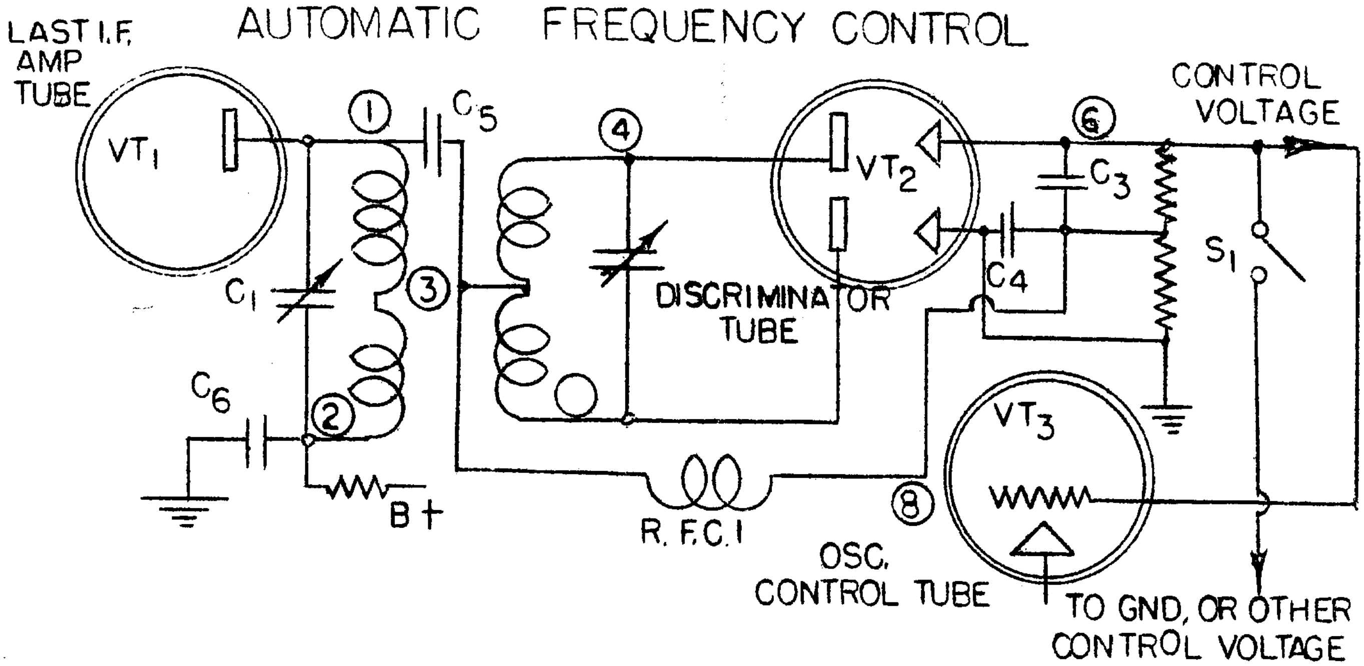
If one side of the heater voltage supply is grounded it is possible to measure the heater voltage directly with the audio frequency probe by measuring to the ungrounded side. If, however, the heaters are not grounded it becomes necessary to connect the chassis connector clip to one side of the heater and using the audio frequency voltmeter probe and connect to the other side to measure heater voltage.

If the heaters are center tapped to ground a reading from ground to either side should be identical.

WATTMETER SECTION: Most receivers, especially of the more expensive type, have on the nameplate the correct rating in watts for the particular receiver.

If the wattage as indicated by the wattmer section of the Traceometer indicates the wattage to be in excess of the rated value for the particular receiver under test,it would be well to check for possibility of defective power supply transformer or short circuit in the receiver itself.

If there is no wattage rating plate of the receiver under test a very rough estimate of the proper wattage consumption may be made by assuming 20 watts plus 5 watts per tube. Of course, this will vary greatly with the extremely small and extremely large receivers.



AUTOMATIC FREQUENCY CONTROL:

POINT 6.

The theory of operation of the automatic frequency control principle is that when the proper intermediate frequency is being delivered to the discriminator tube this tube developes a control voltage at point 6 which is equal to a predetermined voltage at which the oscillator control tube has the effect of neither increasing nor decreasing the frequency of the oscillator tube. In the case illustrated this predetermined voltage would be zero with the correct intermediate frequency if switch S1 shorts the control circuit at point 6 to ground in order to eliminate the automatic frequency control feature.

In some makes of receivers this voltage may not be zero, but some other value plus or minus. This could be very readily checked, however, by turning the automatic frequency control switch to the "Off" position and measuring the control voltage at point 6 with the D.C. voltmeter section.

POINT 1.

At point 1 the R.F. I.F. section should indicate a voltage, the frequency of which is that of the intermediate frequency amplifiers. The actual value of this voltage, of course, will be determined by the number of stages of intermediate frequency amplification and the signal being fed to the receiver under test.

POINT 3.

The readings at point 3 should be practically identical to readings at point 1. Should this voltage be found to be very much lower than the voltage measured at point 1 it would be an indication of defective coupling condenser C5.

POINT 4 - 5

The intermediate frequency voltages measured at point 4 and point 5 should be at least as much as the voltage measured at point 3, but in any event, the voltage should be the same at point 4 as it is at point 5.

POINT 8.

Very little intermediate frequency voltage would be found at point 8 due to the filtering effect of the radio frequency choke.

ALIGNMENT OF AUTOMATIC FREQUENCY CONTROL: In aligning automatic frequency control circuits the automatic frequency control cut-off switch S1 should be shorted out, disconnecting the automatic frequency control feature. With the proper frequency flowing thru the intermediate frequency stages, condenser C1 should be adjusted for maximum R.F. voltage delivered to points 3, 4, or 5. In case the audio frequency section of the model 155 is being used as an output meter at the output stage or speaker, condenser C1 should be adjusted for maximum voltage at this point.

POINT 6.

Connect D.C. voltmeter to point 6 and note the voltage at that point.

If the voltage at point 6 is found to be zero with the automatic frequency control switch in the "out" position, open up the automatic volume control switch, allowing the AFC circuit to come into operation, and adjust trimmer condenser C2 until voltage at point 6 is zero.

It is found that voltage at point 6, which is the control grid of the control tube, has some other value than zero, for example, plus 5 volts with the automatic frequency control circuit inoperative, the trimmer condenser C2 should be adjusted until 5 volts are obtained when the AFC switch is turned to the "on" position.

After the trimmer condenser C2 has been properly adjusted the opening and closing of S1 should make no difference in the voltage at the grid of the control tube.

MAINTENANCE AND USEFUL INFORMATION ON MODEL 155

R.F. - I.F. - OSCILLATOR AND AUDIO FREQUENCY VACUUM TUBE VOLTMETERS.

If either one of these meters should suddenly go over to full scale and cannot be brought back by the balance adjustment, check the 6SQ7 tube operating this meter. (See Fig. 4). This tube may be replaced with any good type 6SQ7 without in any way effecting the calibration. The 6SQ7 tubes used in these circuits are matched at the factory so that all three balance controls will be approximately in the same position when zero balance is obtained. In replacing one of these tubes, it may be found that the balance control for this particular tube has to be advanced or retarded with respect to the other controls in order to obtain a correct balance. This is in no way detrimental to the operation of the unit, but it is considered advisable to try and select a type 6SQ7 which more nearly matches the other tubes in the Traceometer.

LINE VOLTAGE: Before leaving the factory the circuit for the vacuum tube voltmeter is so adjusted that zero balance can be obtained by the balance control from line voltages of approximately 95 to 130. If a condition is encountered where the line voltage supply is below 95 volts or above 130 volts, it might be found impossible to bring all the vacuum tube voltmeters to zero balance. If this condition is encountered, it will be necessary to adjust the voltage balance control which will be found on the rear of the chassis and accessible through a hole provided in the rear of the case. Adjust the control with a screw driver until zero balance can be obtained.

USING PHONES FOR MONITORING: If it is desired to use a pair of phones rather than speaker for monitoring, the phones may be connected directly into the monitoring jack on the audio frequency section. There is no D.C. in this jack and therefore crystal type of phones could be used without fear of damage.

BROADCAST INTERFERENCE: If you are working with a very low signal level from the signal generator, especially when working on R.F. stages where little amplification is found, it is quite possible in tuning the R.F. I.F. section of the Traceometer that a reading on the meter due to local broadcast station would be obtained. It should be kept in mind that presence of a signal of only 1000 microvolts is sufficient to give readable deflection and with local broadcast stations, especially of the more powerful types operating in the vicinity, a signal of over 1000 microvolts can very easily be picked up by the test probe. If there is any question in your mind as to whether the signal being indicated on the meter is coming from a local broadcast station or from the signal generator it can be readily checked in two ways. First, use a pair of phones for monitoring the signal and determine whether it is from the broadcast station or from your own oscillator, or secondly, by turning the oscillator back and forth if a signal is being picked up from the oscillator. Of course, the meter will indicate a maximum when the oscillator is tuned to resonance with the circuit, whereas if the signal is being picked up from a broadcast station the tuning of a local service oscillator would in no way influence the reading.

CHECKING THE CABLES: Audio Frequency Test Cable:

An Ohmmeter to be used in checking the oscillator cable as follows:

Connect one side of the ohmmeter to the tip end of the phone plug and with the other side of the ohmmeter probe check the sleeve or ground side of the phone plug. No reading should be obtained between these two points. If the ohmmeter shows zero ohms between these two points it is a definite indication that in some manner or other the cable has become shorted out. If an inspection of the cable will not reveal a short a replacement cable may be ordered from the factory.

Test #2 of the audio frequency probe is connecting one side of the ohmmeter to the tip end of the phone plug as previously outlined and connecting the other end of the ohmmeter to the tip of the test probe. The ohmmeter should show zero ohms or correct continuity between these two points. No reading should be obtained between the tip end of the phone plug and the tip end of the test probe.

If any of the cables should become defective in service they can be replaced directly from the factory without the necessity of returning the Model 155 for recalibration if the serial number of the unit is given.

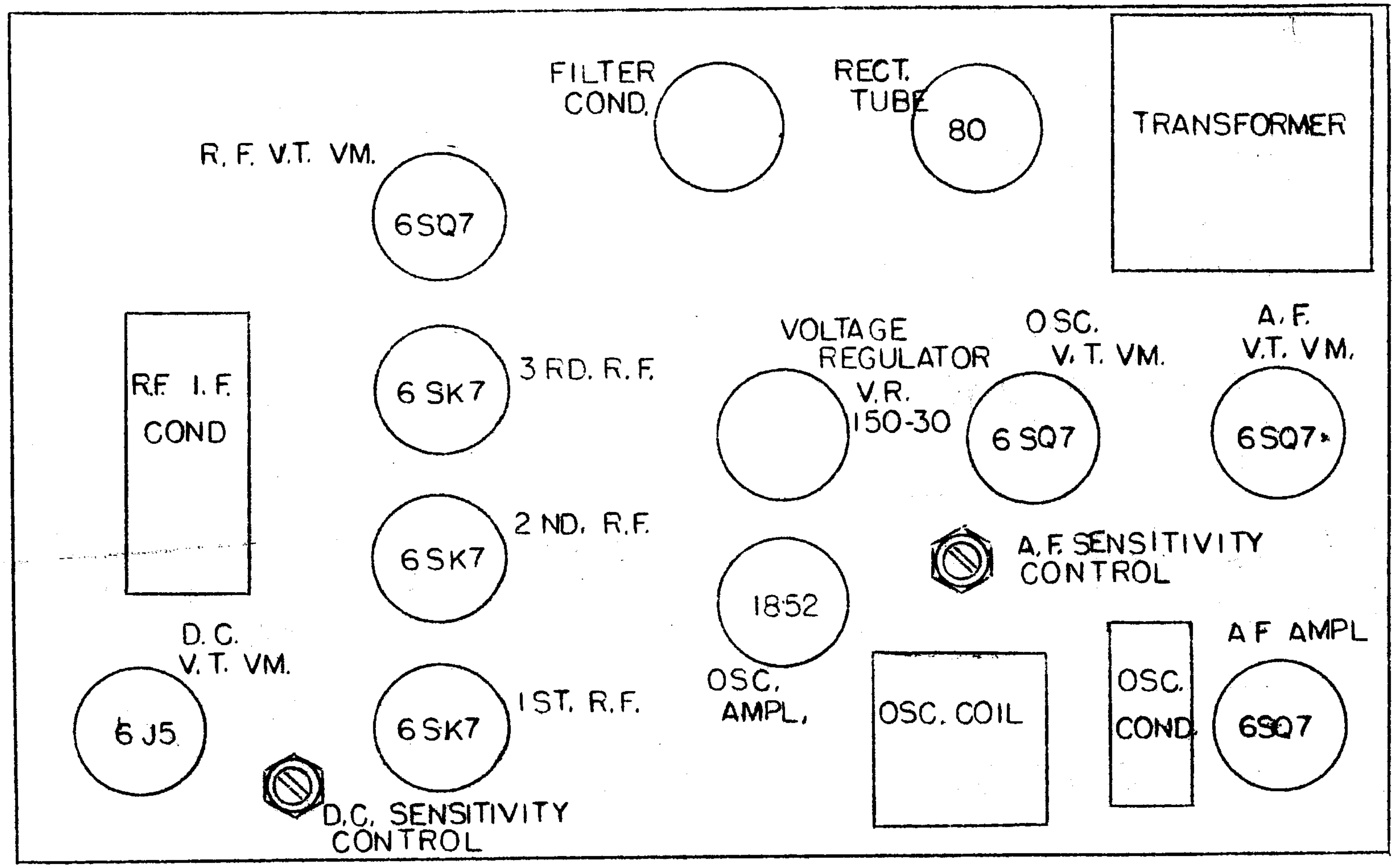
D.C. VACUUM TUBE VOLTMETER: Check of the D.C. probe, which is the probe with the blue tip, for shorts should be made in the same manner as outlined for checking the audio frequency probe. There should be no continuity between the tip and the sleeve connections on the phone plug.

By connecting the ohmmeter between the tip end of the plug and the tip of the test probe, the ohmmeter should show a resistance of approximately 1 megohm.

R.F. I.F. PROBE - OSCILLATOR PROBE: Check for shorting of R.F. I.F. or oscillator probe is similar to the manner outlined for the audio frequency probe by connecting between the tip end of the phone plug and ground or sleeve end of the phone plug. No continuity should be found between these two points. Connect the ohmmeter from the tip end of the phone plug and to the tip end of the test probe and in neither the R.F. I.F. or oscillator test probe should any reading be obtained. There is capacity coupling at the end of the probe which amounts to about .85 micro-micro-farads for the R.F. I.F. probe, and approximately 1.2 micro-micro-farads for the oscillator probe and if suitable capacity measurement equipment is available this could be measured.

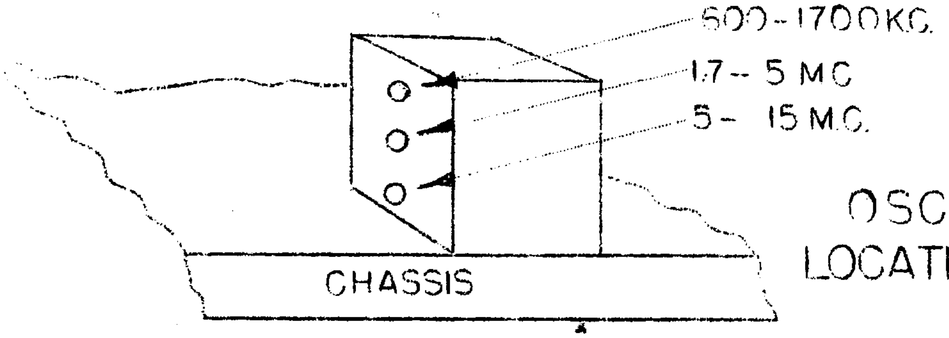
WATTMETER CONNECTION: The wattmeter is so connected that it is in the circuit at all times irrespective of whether the power supply switch in the Traceometer is turned on or off.

CALIBRATION CHECK: In normal service the calibration of the R.F.I.F. section and also the oscillator section remain permanently accurate for many years of service. Should it ever become advisable to check or realign either one of these sections the location of the trimming condensers for these sections are given in the figure illustrated on following pages.



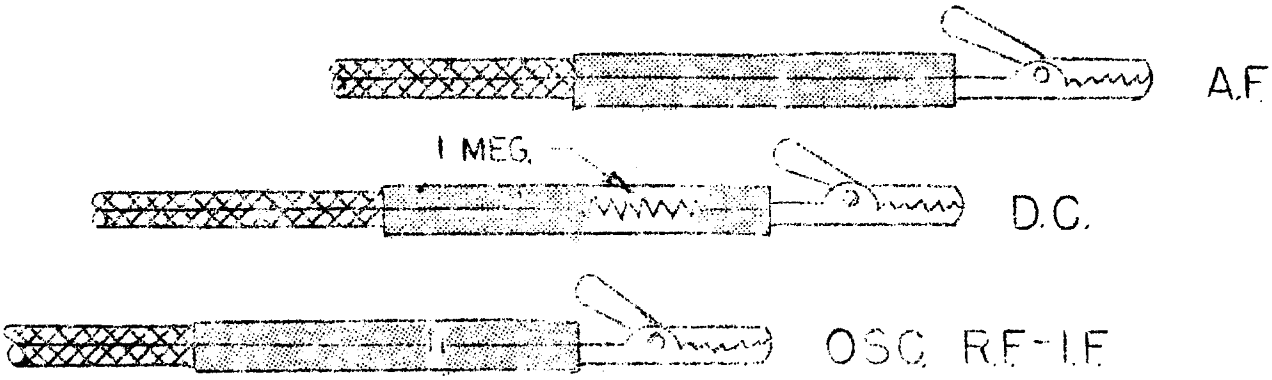
FRONT

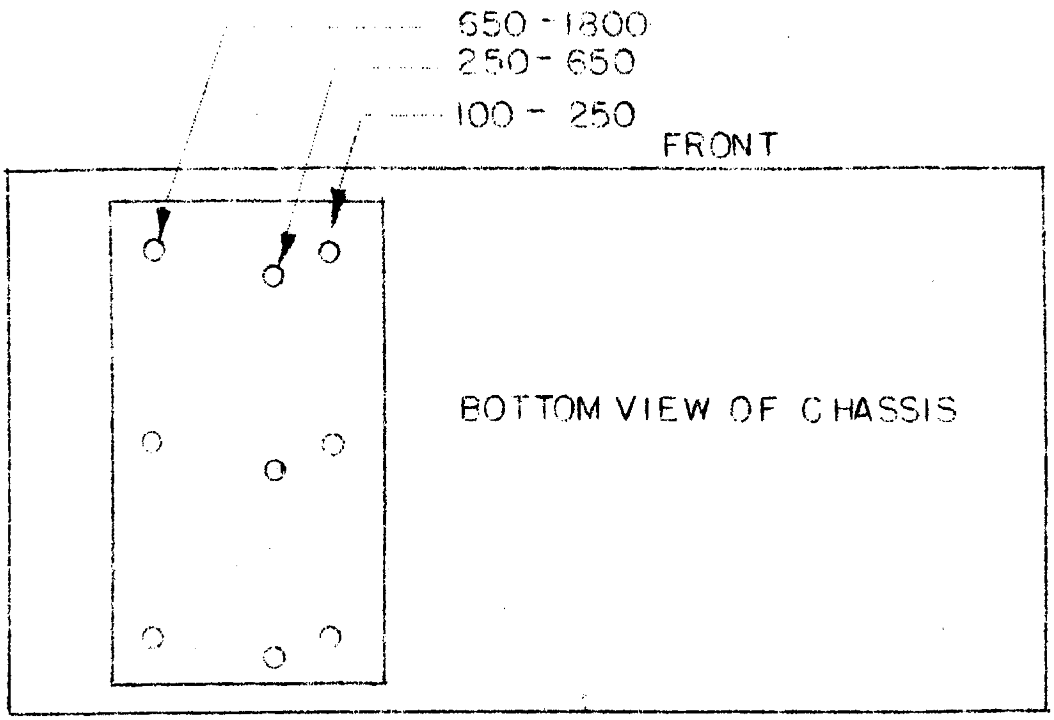
TOP VIEW OF MODEL 155 TRACEOMETER CHASSIS



OSC. COIL TRIMMER LOCATION.

CABLES





R. F. I. F. TRIMMER LOCATION

MODEL 155 TRACEOMETER

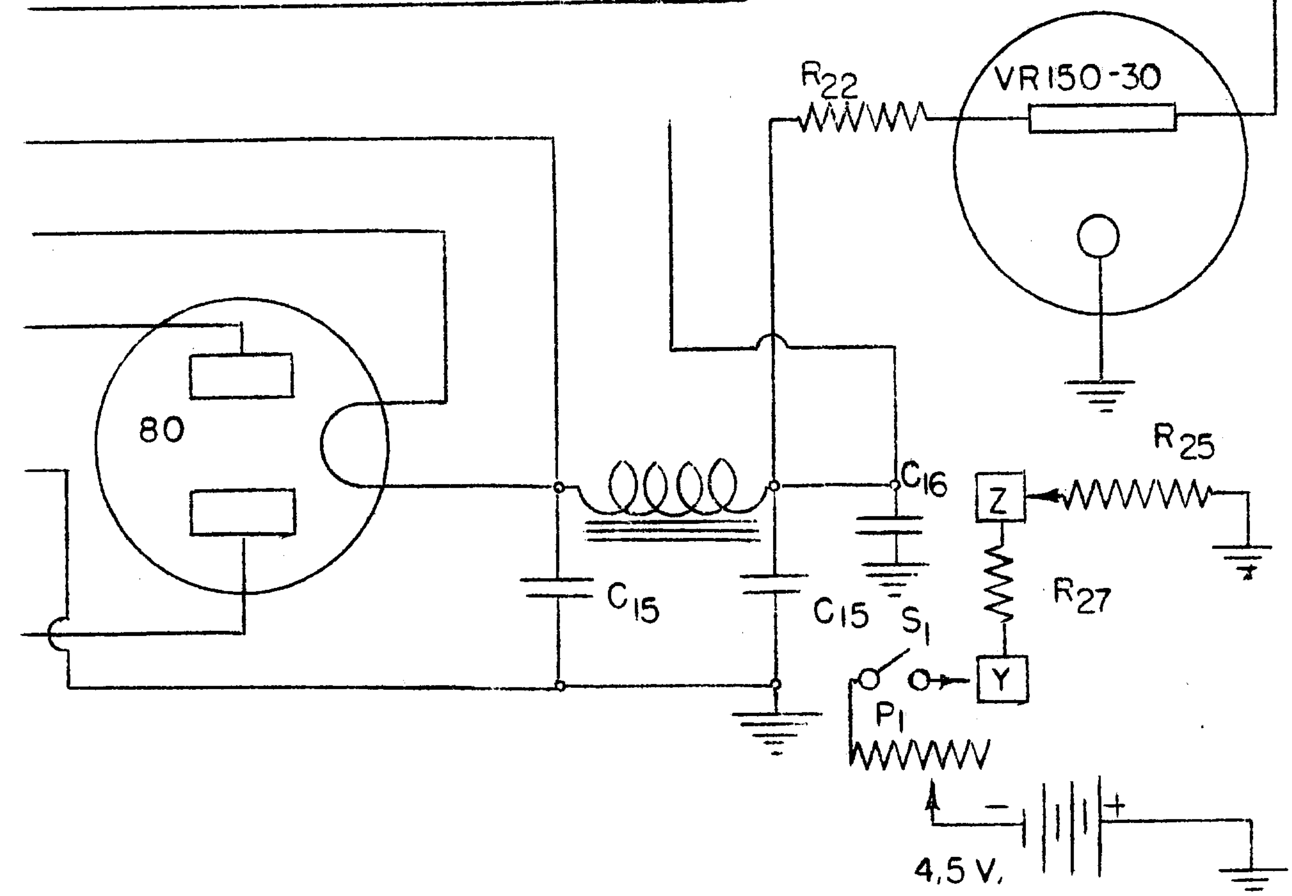
IMPORTANT

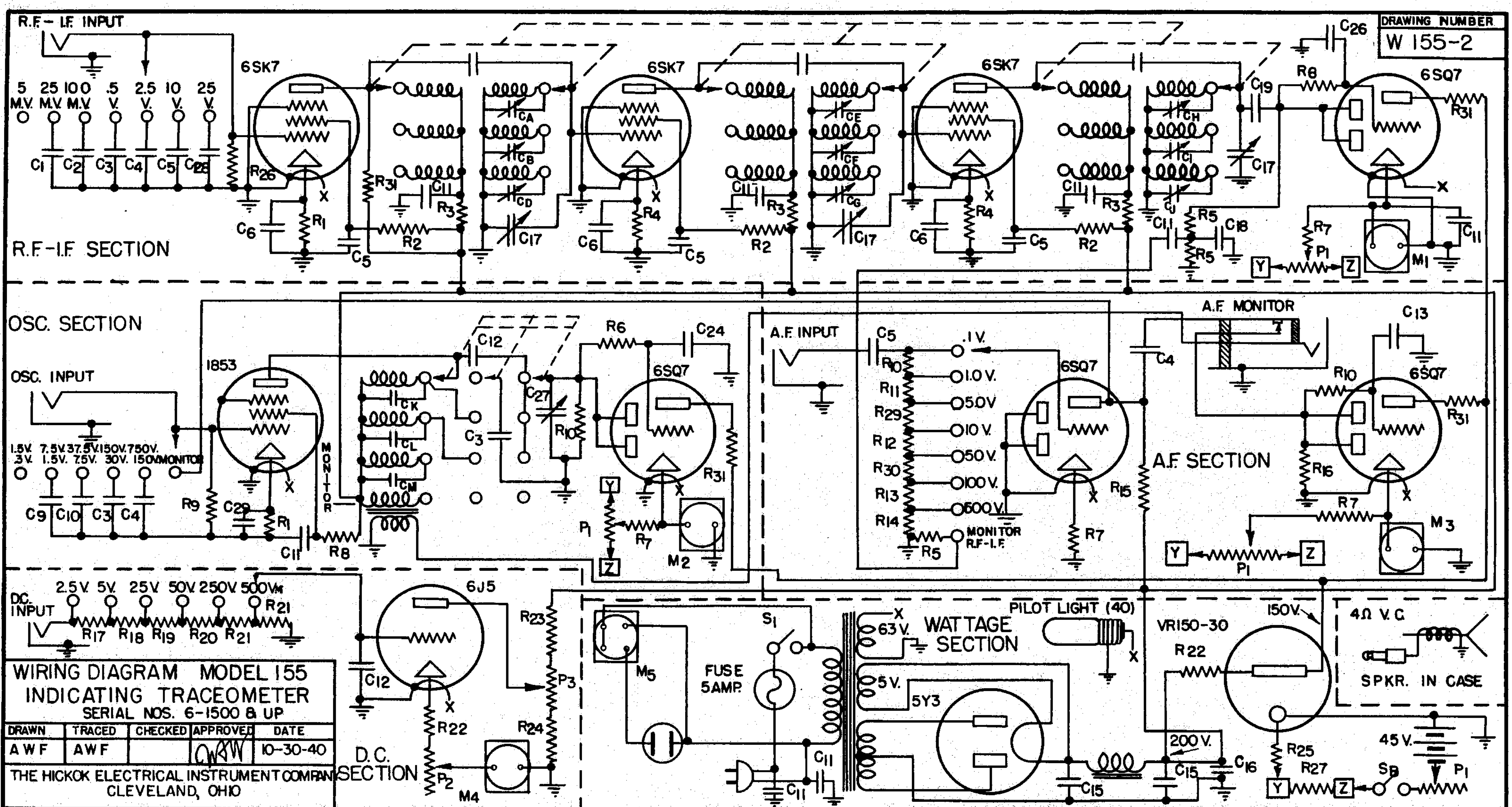
The high degree of stabilization and the complete freedom from voltage fluctuation is obtained by means of two regulated voltages in the model 155. One of these regulated voltages is obtained by means of the type VR-150-30 voltage regulator tube which is connected from B plus to ground. The other stabilized voltage is obtained by means of the three large type 1½ volt flashlight batteries. The stablilized voltage required in the low voltage circuit is approximately 3 volts. The three dry cells are capable of producing 4½ volts. A rheostat is connected in series with the 4½ volt to drop this voltage to 3 volts when the batteries are new. This rheostat is accessible through the back of the case and can be adjusted by means of a screw driver. When originally shipped from the factory, this rheostat is adjusted at its maximum resistance position and zero balance for all meters can be obtained by means of the balance control on the front of the panel.

After approximately 200 hours of service it will probably be necessary to adjust this rheostat in order to make the balance control bring the meters to zero. At the end of another 200 hours of service it may again be necessary to readjust the rheostat. After approximately 1000 hours of service it may be necessary to replace the three 1½ volt dry cells. These dry cells can be easily replaced by removing the small escutcheon plate on the rear of the case and removing the batteries and inserting new ones. Below is a circuit diagram illustrating the revised circuit which has been adapted to this service.

TURN OFF TRACEOMETER BY LINE SWITCH—NOT BY PULLING LINE CORD FROM 110 VOLT SUPPLY.

REVISED CIRCUIT FOR DRWG.# W 155





WIRING DIAGRAM MODEL 155
INDICATING TRACEOMETER
SERIAL NOS. 6-1500 & UP

DRAWN	TRACED	CHECKED	APPROVED	DATE
AWF	AWF		[signature]	10-30-40

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
CLEVELAND, OHIO

R_1	350Ω	1/2 WATT
R_2	75KΩ	1/2 WATT
R_3	1500Ω	1/2 WATT
R_4	350Ω	1/2 WATT
R_5	.5MΩ	1/2 WATT
R_6	2 MΩ	1/2 WATT
R_7	2,000Ω	1/2 WATT
R_8	6KΩ	1 WATT
R_9	.3MΩ	1/2 WATT
R_{10}	1.125MΩ	1/2 WATT
R_{11}	.1MΩ	1/2 WATT
R_{12}	10KΩ	1/2 WATT
R_{13}	1KΩ	1/2 WATT
R_{14}	250Ω	1/2 WATT
R_{15}	.3MΩ	1 WATT
R_{16}	.25MΩ	1/2 WATT
R_{17}	7.5MΩ	1/2 WATT
R_{18}	6 MΩ	1/2 WATT
R_{19}	75 MΩ	1/2 WATT
R_{20}	.6MΩ	1/2 WATT
R_{21}	75 KΩ	1/2 WATT
R_{22}	3 KΩ	3 WATT
R_{23}	30 KΩ	1 WATT
R_{24}	50 KΩ	1/2 WATT
R_{25}	350Ω	1/2 WATT
R_{26}	.2 MΩ	1/2 WATT
R_{27}	150Ω	1/2 WATT
R_{28}	100KΩ	1/2 WATT
R_{29}	12.5KΩ	1/2 WATT
R_{30}	1,250Ω	1/2 WATT
R_{31}	7.5KΩ	1/2 WATT

S_1	LINE SWITCH
S_B	BATT. SWITCH
P_1	200Ω
P_2	3KΩ
P_3	10KΩ
M_1	MICROVOLTS
M_2	OSC. VOLTMETER
M_3	A.F. VOLTMETER
M_4	D.C. VOLTMETER
M_5	WATTMETER

C_1	.00025 M.F.	400 V.
C_2	.001 M.F.	400 V.
C_3	.005 M.F.	400 V.
C_4	.025 M.F.	400 V.
C_5	.1 M.F.	400 V.
C_6	.025MF	200 V.
C_9	.0005 M.F.	400 V.
C_{10}	.0025MF	400 V.
C_{11}	.05M.F.	400 V.
C_{12}	.01M.F.	400 V.
C_{13}	.025 M.F.	200 V.
C_{14}	.15 M.F.	200 V.
C_{15}	15 M.F.	350 V.
C_{16}	.1 M.F.	600 V.
C_{17}	.410 MMF	VARIABLE
C_{18}	.0001 MF	200 V.
C_{19}	.00025 M.F.	200V.
C_{20}	.002 M.F.	400V.
C_{24}	.001 M.F.	200 V.
C_{26}	.01 M.F.	200V.
C_{27}	.365 MMF	VARIABLE
C_{28}	.25 M.F.	400V.
C_{29}	20 M.F.	25 V.

BOTTOM VIEW OF TUBE BASES