COMPLIMENTARY R. M. S. LESSON
TO BE GIVEN TO SERVICEMEN ATTENDING
1934 RADIO MANUFACTURERS SERVICE MEETINGS

Philco Model 200-X

Circuit Description and Adjusting Instructions

Getting the Most Out of Your Test Equipment

RADIO MANUFACTURERS SERVICE

Your Guarantee of Best Radio Service

A PHILCO SERVICE PLAN

Philco Radio & Television Corporation

TORONTO — PHILADELPHIA — LONDON

CIRCUIT DESCRIPTION OF THE

Model 200-X

The new PHILCO High Fidelity Receiver, Model 200-X, is considerably different in its circuit arrangement from any previous receiver, and the description which follows will enable servicemen to have a better understanding of this latest development in radio.

Referring to Fig. 1, the incoming radio signal is first impressed through the antenna terminal of the chassis on the primary of the antenna coil ② in the wiring diagram. The coupling between the primary and the secondary is fairly loose, and for this reason, the receiver is independent of antenna length. The antenna stage is tuned by a variable condenser. The signals are transferred through coil ⑤ , which is likewise tuned by a variable condenser. This tuned circuit is connected directly to the control grid of the type 78 R. F. tube. The design of these circuits is such that a large gain is obtained while cross molulation is avoided. The output from the R. F. tube is next coupled through R. F. transformer ⑫ to the control grid circuit of the 6A7 detector-oscillator tube. This input circuit is tuned with a third variable condenser. The 10-ohm resistor ⑬ in the grid circuit of the 6A7 broadens the selectivity of this circuit in such a way as to afford 15 K. C. selectivity at this point.

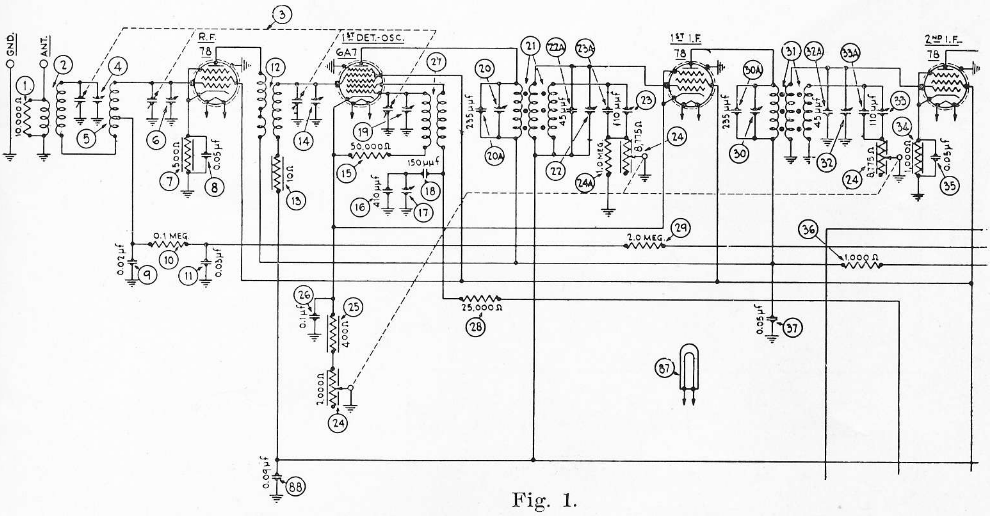


Fig. 1.

Referring to the various grids in the 6A7 tube, we shall designate these, in the customary way as Nos. 1, 2, 3, 4, and 5; No. 1 being nearest the cathode. No. 1 is the oscillator control grid and No. 2 is the anode-grid of the oscillator circuit. If we consider only the filament, the cathode, and No. 1 and No. 2 grids of the 6A7 tube, it will be seen that we have a complete triode consisting of an indirectly heated cathode, a grid and an anode (plate). Feed-back through the oscillator coils from No. 2 grid (oscillator anode) circuit to No. 1 grid (oscillator grid) circuit produces oscillation through this portion of the tube circuit. The frequency at which this circuit oscillates is controlled by the oscillator tuning condenser. The oscillator circuit is so arranged that the oscillator signal will always be 175 K. C. higher than the incoming R. F. signal. The incoming R. F. signal is impressed upon the control grid No. 4 of the 6A7 tube and is mixed in this tube with the signal from the local oscillator circuit. The 175 K. C. I.F. signal is thus produced. The oscillator high-frequency compensating condenser connected across the oscillator tuning condenser is indicated at ⑲ in the diagram, and serves as an adjustment to keep the oscillator circuit aligned or tracking with the R. F. circuits at the high-frequency end of the dial. The low-frequency compensating condenser in the oscillator circuit is indicated at ⑰ in the diagram, and serves to keep the low-frequency range of the oscillator circuit aligned with the R. F. circuits.

From the output circuit of the 6A7 tube, the 175 K. C. signal next goes to the first I. F. transformer. It will be noted that this transformer has three windings — a primary, a secondary, and a tertiary or trap circuit. In the diagram, the secondary connects to the grid of the 78 tube, while the trap, which is coupled inductively to the primary and secondary, is connected to a variable resistor through a compensating condenser.

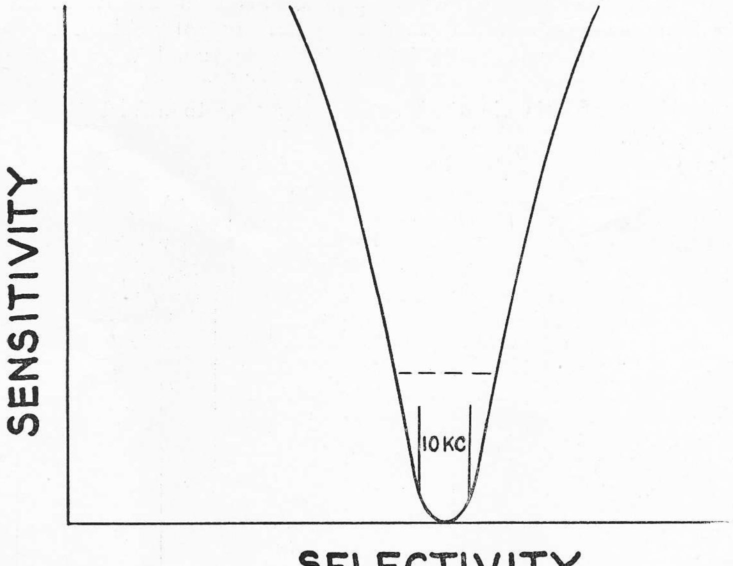


Fig. 2.

In a receiver equipped with ordinary I. F. circuits, the selectivity can be illustrated as shown in Figure 2. The horizontal section of this curve indicates kilocycles and the vertical section indicates any arbitrary figure of sensitivity. The curves in Figs. 2, 4 and 5 show peak sensitivity toward the bottom, corresponding with the standard engineering practice of indicating sensitivity in terms of microvolts input to the receiver. It will be seen that the sensitivity drops off sharply beyond the portion which corresponds to a 10 K. C. band. This 10 K. C. channel is the maximum transmission band width allowed by the Federal Radio Commission to most stations. This means that the maximum musical frequency which can be transmitted, in order to remain within the 10 K. C. band, is half this amount, or 5,000 cycles.

This fact is best explained by reference to Figure 3. Station WJZ operates on 760 K. C.; that is, the 760 K. C. carrier is modulated by audio frequencies up to 5,000 cycles. During the time that WJZ is modulated at 5,000 cycles, it actually transmits three waves — at 755 K. C, 760 K. C., and 765 K. C. This means that the band occupied by WJZ's transmission will be 10 K. C. wide during all the time that a 5,000 cycle note is being transmitted. When lower frequencies are being transmitted, the two side waves will naturally be closer to the carrier. The overall result is that the entire 10 K. C. is being used over a period of time during a program. Figure 2 shows the next adjacent stations, as WJR on 750 K. C., and WBBM on 770 K. C. As the figure shows, when these stations are transmitting 5000 cycle notes, one of the waves sent by WJR will be identical with the 755 K. C. wave of WJZ, and one of the waves sent by WBBM will be identical with the 765 K. C. wave of WJZ. This identity is complete, as it is impossible to discriminate between WJR's 755 K. C. wave and WJZ's 755 K. C. wave. As a consequence, existing radio receivers have generally been designed to reduce the response at frequencies approaching 5 K. C. away from the desired carrier. Additionally, it is unusual to have two stations transmitting waves corresponding to 5,000 cycles at the same instant, and the geographical spacing of stations is such that two stations on adjacent bands rarely have the same intensity at the receiver.

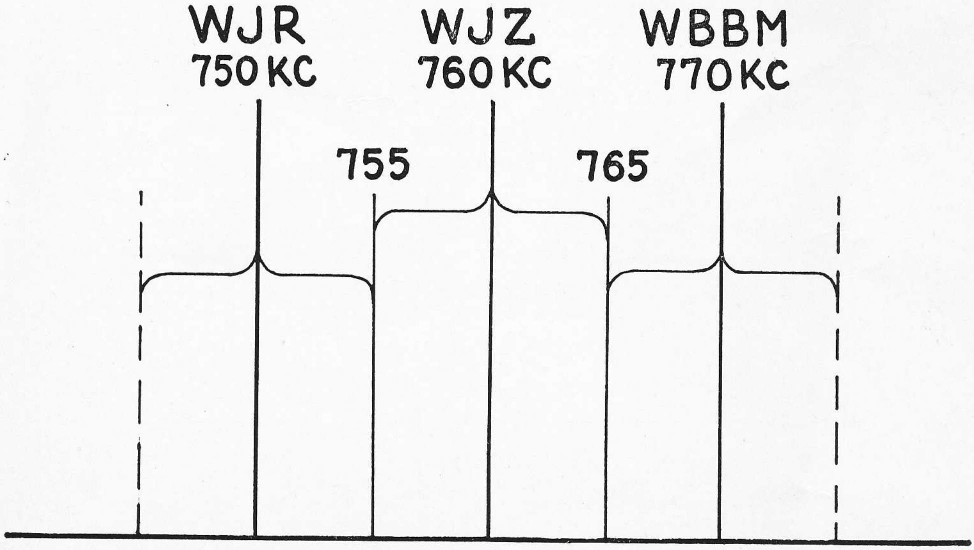


Fig. 3.

Although, in the past, stations have attempted to limit their highest frequencies to 5,000 cycles, certain stations are now sending out higher frequencies, particularly during the daytime. It is also possible to improve the response fidelity when receiving a station which transmits frequencies of 5,000 cycles or less as compared with the reception on earlier receivers. Figure 4 shows the selectivity curve of a modified receiver which is now responsive to 12 K. C. at its maximum sensitivity. It will be seen that there is substantially no loss of amplitude even at the band width of 15 K. C., as indicated at A, although the receiver cuts sharply beyond this point. This result has been accomplished by the use of the new PHILCO three winding transformers throughout the receiver. By comparing Figure 4 and Figure 2, it will be understood that audio frequencies up to 7500 cycles will be received with substantially full intensity. It is noted that a double peak is present in the curve of Figure 4, and that the sensitivity of the receiver using this circuit is reduced considerably from that of Figure 2. This action is due to the use of the trap circuit which, being tuned to the exact carrier frequency, absorbs energy at that frequency, but not at the frequencies corresponding to high audio notes. Further comparison with Figure 2 will show that the receiver of Figure 4 has substantially the same selectivity against stations several channels away from the tuned carrier. The received band corresponding to the desired signal is wider, but the selectivity approaches that of earlier receivers as the separation between stations is increased.

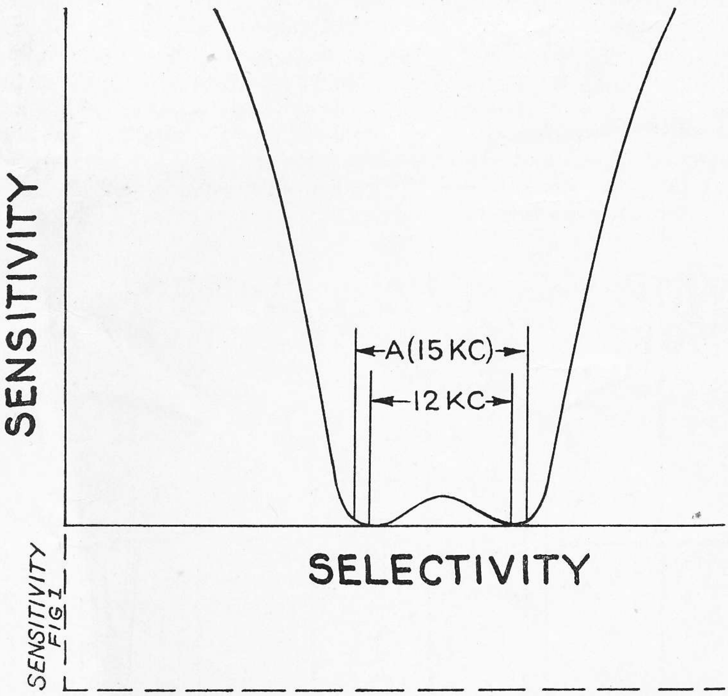


Fig. 4.

In the PHILCO Model 200 circuit, there has been made available a circuit with variable control of transfer between the primary and secondary of the I. F. transformers to afford variable control of selectivity. This change in selectivity is accomplished by introducing a tertiary or trap circuit in inductive relation to the primary and secondary circuits. Variable control of this circuit is accomplished by connecting a variable resistor in series with the tertiary winding to control the effectiveness of the circuit. Without any resistance in the circuit, the tertiary or trap winding acts as a heavy load across the secondary. This results in wide band reception with decreased sensitivity. Now, as we start adding resistance to the circuit, the effectiveness of the trap becomes less as the amount of resistance increases. Finally, when maximum resistance is in, the trap is least effective; the receiver thus becomes sharp, sensitivity being increased. It will be noted upon examining the second I. F. circuit that exactly the same arrangement exists as in the first I. F. and that the variable resistor in this circuit is mounted on the same shaft with the variable resistor in the first I. F. circuit, so that the two operate together.

In increasing the band width from 10 K. C., to 15 K. C., the sensitivity has gone down. It becomes necessary, therefore, to increase the sensitivity if a constant response in the circuit is to be maintained as the band control is changed. This increase in sensitivity is obtained by decreasing the amount of resistance in the cathode circuit of the 6A7 tube. It will be noted that the variable resistor is on the same shaft as the variable resistors in the two I. F. circuits. As the trap circuit resistance is decreased, the cathode resistance in the 6A7 circuit is decreased. This produces a lower negative grid bias on the 6A7 with resulting increased sensitivity. The overall result of the increased sensitivity and selectivity is indicated in the curve of Figure 5.

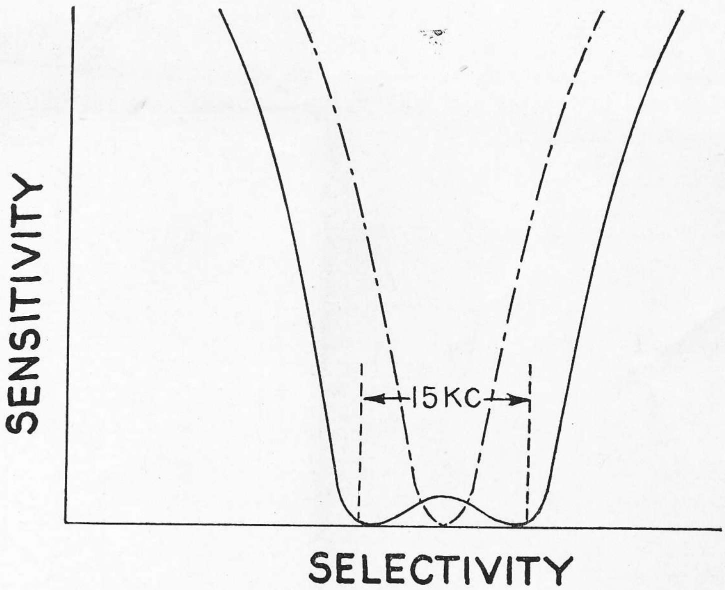


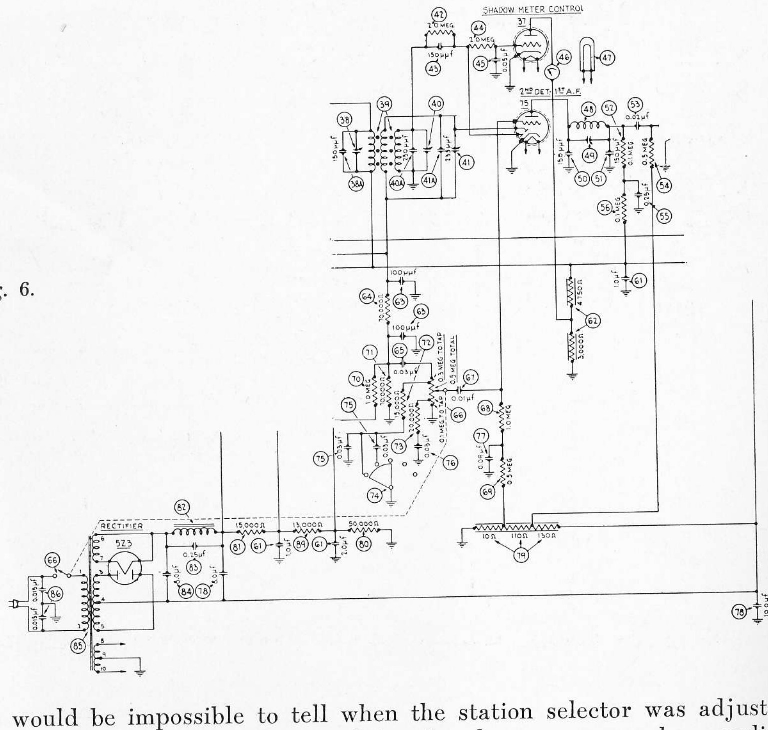
Fig. 5.

The dotted curve of Figure 5 shows the selectivity of the PHILCO Model 200 when the band control is adjusted for minimum band width. Comparison with Figure 2 shows that in this case the selectivity is substantially greater than that of the normal radio receiver. This allows the user to obtain improved results under conditions of the worst interference, although, of course, the musical quality of a program including high frequencies is impaired.

After the signal has passed through the first I. F. transformer it is amplified in the first I. F. tube, type 78, then passes through the second I. F. transformer, and is then amplified again in the second I. F. amplifier tube, type 78. From the output of the second I. F. tube, the signal passes through the third I. F. transformer which is a coupling to the second detector and shadow tuning circuits. It will be noted in Fig. 6 that the secondary of the third I. F. transformer connects to the detector section of the 75 tube. The pulsating D. C. voltage, which is produced by the rectifier action between the diode plate and the cathode, appears across the resistor circuit of the 70,000 ohm resistors (64) and (71). This D. C. voltage adds to the normal D. C. grid bias of the first detector and the first I. F. amplifier to produce automatic volume control. As the signal tends to increase, the voltage developed across the diode plate and the cathode increases. This negative voltage is added to the negative grid bias of the R. F., the first detector and first I. F. tubes, and thus tends to produce a decrease in volume, keeping the volume uniform. Conversely, as the signal decreases, the voltage which is developed between the diode plate and the cathode decreases and thus a lower negative grid bias is applied to these tubes, with a resulting equalizing in signal strength. The audio portion of the signal is coupled through the .03 mfd. condenser (65) to the volume control (66). From the variable point of the volume control, the signal is coupled through the .01 mfd. condenser (67) to the control grid of the 75 tube. This portion of the tube functions entirely as a first audio tube, and receives a constant bias through grid leak resistor (68).

Because of the wide band in the I. F. selectivity of the circuit and because of the double peak which is present in this circuit, it would be impossible to obtain an accurate shadow tuning indication if the shadow tuning meter were connected in the plate circuit of the I. F. tubes as is ordinarily

Fig. 6.



I.F.=175 KC.

done. It would be impossible to tell when the station selector was adjusted to the middle of the band. This condition has been overcome by coupling a highly selective trap circuit to the third I. F. transformer and utilizing the output of this selective circuit, rectified by one diode element of the 75 tube, to operate the 37 amplifier tube which in turn operates the shadow meter in its plate circuit. The voltage generated by this diode across the 2 meg. resistor (42) and 150 mmf. condenser (43) is filtered by a 2 meg. resistor (44) and .05 mfd. condenser (45) before being supplied to the grid of the 37 tube to prevent radio and audio frequencies from arriving in the plate and shadow meter circuit. The input of this tube is highly selective and is accurately tuned to 175 K. C. by means of the compensating condenser. The 37 tube does not serve any function so far as amplification of signal is concerned, but is used merely to afford a means of operating the shadow tuning indicator.

From the plate circuit of the 75 tube, the audio signal passes through a 10 K. C. low pass filter, which cuts off sharply. The purpose of this filter is to remove any side bands of a signal which may be coming through from an adjacent channel and to provide clear audio reception up to 10,000 cycles. This means that the audio portion at this point is responsive to frequencies up to 10,000 cycles. On the opposite side of the filter, the signal is coupled in the usual resistance coupled manner through a .02 mfd. condenser (53) to the control grid of the type 42 driver tube. The screen grid (see Fig. 7) of this tube is connected directly to the plate, so that the tube operates essentially as a triod affording high undistorted output power. The output from the plate of this tube is coupled to the Super Class A push-pull amplifier circuit through the audio transformer.

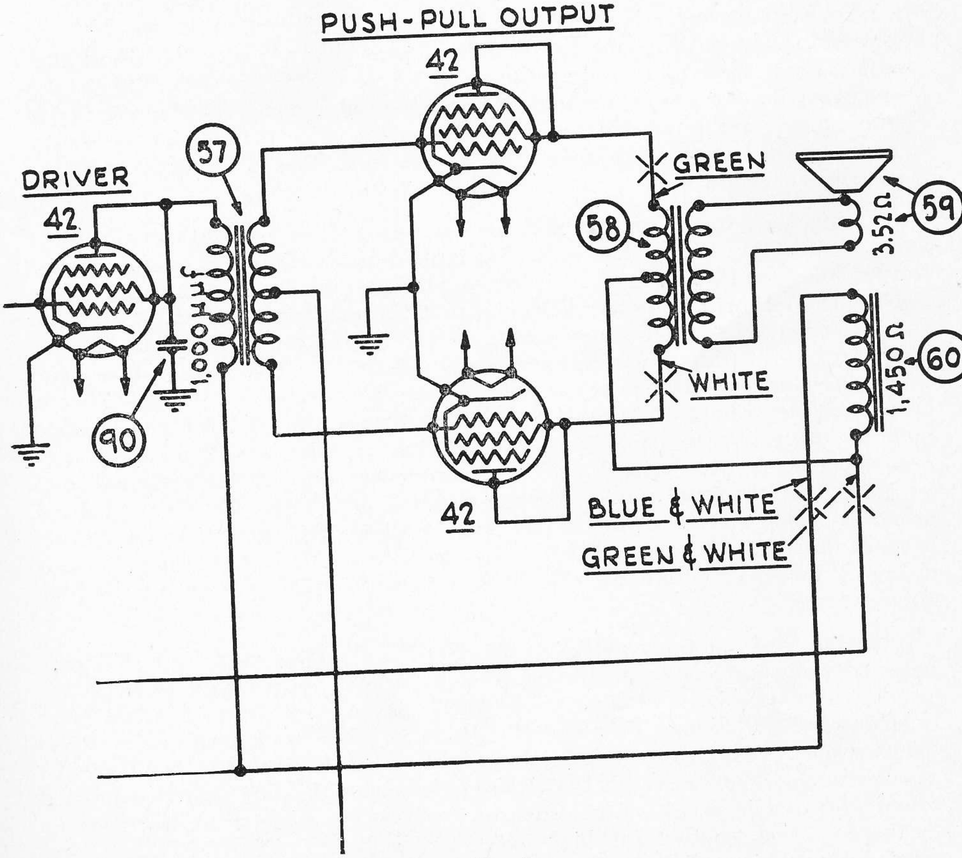


Fig. 7.

In the ordinary class A push-pull output circuit, the grids of the output tubes are biased with a comparatively high negative voltage. From the high impedance secondary winding of the input transformer, a high voltage is impressed upon the grids of these tubes. This change in grid voltage is reflected as a corresponding change in plate current with high amplification resulting. When the circuit is not overloaded the grid bias on the output tubes is always negative. When a heavier signal is impressed on the grids than that for which the circuit was designed, the grids are driven into the positive region of bias, because of the large added voltage of the signal itself. As soon as this occurs, grid current flows from the grid to the cathode and around through the secondary of the input transformer. This current flowing through the high resistance of the secondary causes a big voltage drop with resulting audio distortion.

Even if the resistance of the secondary winding were low, the small amplifier tubes normally used would not supply sufficient voltage to the grids of the push-pull tubes at the high current loads.

In the PHILCO output system, the resistance of the secondary of the input transformer is comparatively low. When a heavy signal is impressed on the grids of the tubes, the instantaneous bias may go into the positive region, and grid current will be drawn. The 42 driver tube is capable of supplying the necessary energy. Since the secondary resistance is low, there is no appreciable voltage drop due to the flow of grid current, with the result that power rather than mere voltage can be impressed upon these tubes and tremendous output power without distortion is obtained. The screen grids of these tubes are connected to the plates in the same manner as the driver tube to afford extremely high output power with the tubes functioning as three element tubes.

Going back to the volume and tone control circuit again, (see Fig. 6) it will be noted that the volume control is tapped at two different points. When the variable point of the control is nearest the grounded end, minimum volume is obtained. It will be noted, however, that the resistance tapped at this low end is connected to a 20,000 ohm resistor (73) and a fixed condenser of .03 mfd. (76). This circuit constitutes a fixed bass compensation circuit for low volume, and when the volume control is set at a low point, bass compensation will always be present regardless of the setting of the tone control. At the next tapped point on the volume control, it will be seen that a connection is made through a 15,000 ohm resistor (72) and a .03 mfd. condenser (75) to ground. It will also be noted that the tone control permits shorting out of the last-mentioned .03 mfd. condenser at one point of the tone control, and also permits cutting in an additional .03 mfd. condenser at another point of the control. This makes it possible to have variable bass compensation, if desired, at the high volume level.

In the external construction of the 200-X cabinet, a vast store of knowledge of acoustics has been applied. High musical notes travel much in the same manner as a beam of light. The higher the musical frequency, the more this beam effect becomes pronounced. In fact, when using frequencies above 4,000 cycles, this beam narrows down to a path directly in front of the speaker cone. For years, PHILCO has pointed out the fact that the inclined sounding board is necessary in order to transmit the beam from the floor up to the ear level, so that the high notes can be heard. Now, PHILCO has carried the design of its cabinet even further. In the Model 200-X, the speaker is mounted on the inclined sounding board, so that all of the high notes are heard. Due to the use of a high fidelity speaker especially designed for this cabnet the effect of these high notes is so pronounced that it is hard on the ears if the listener happens to be standing directly in the front of the beam.

In the beam, more high notes are heard in proportion to the remainder of the music than would be natural or normal in listening to the original music. Therefore, it is necessary to diffuse these high notes and spread them around the room, so that they take their proper proportion to lows and intermediate tones. PHILCO has accomplished this result in the design of the speaker and cabinet. Inside of this radio set, the inclined sounding board is set back beyond the grill cloth, and a sound diffuser is mounted directly in front of the speaker. This sound diffuser acts as an assembly of mirrors for the high notes, so that they are reflected and spread all around the front of the radio cabinet. The sound diffuser has no effect on the low or intermediate tones but does produce the desired diffusion with respect to the higher musical frequencies. The inclined sounding board raises the high notes to the ear level and the sound diffuser spreads the additional high notes all through the room so that no matter where the listener is sitting he gets the proper proportion of high, low and intermediate tones. The diffuser also includes a transverse mirror which acts to throw the proper proportion of high frequency notes to the ear of the person tuning the receiver. The effect is that the music is reproduced over a large area and is sent out from this large area in various directions. The result is natural tone and clear, original music reproduction.

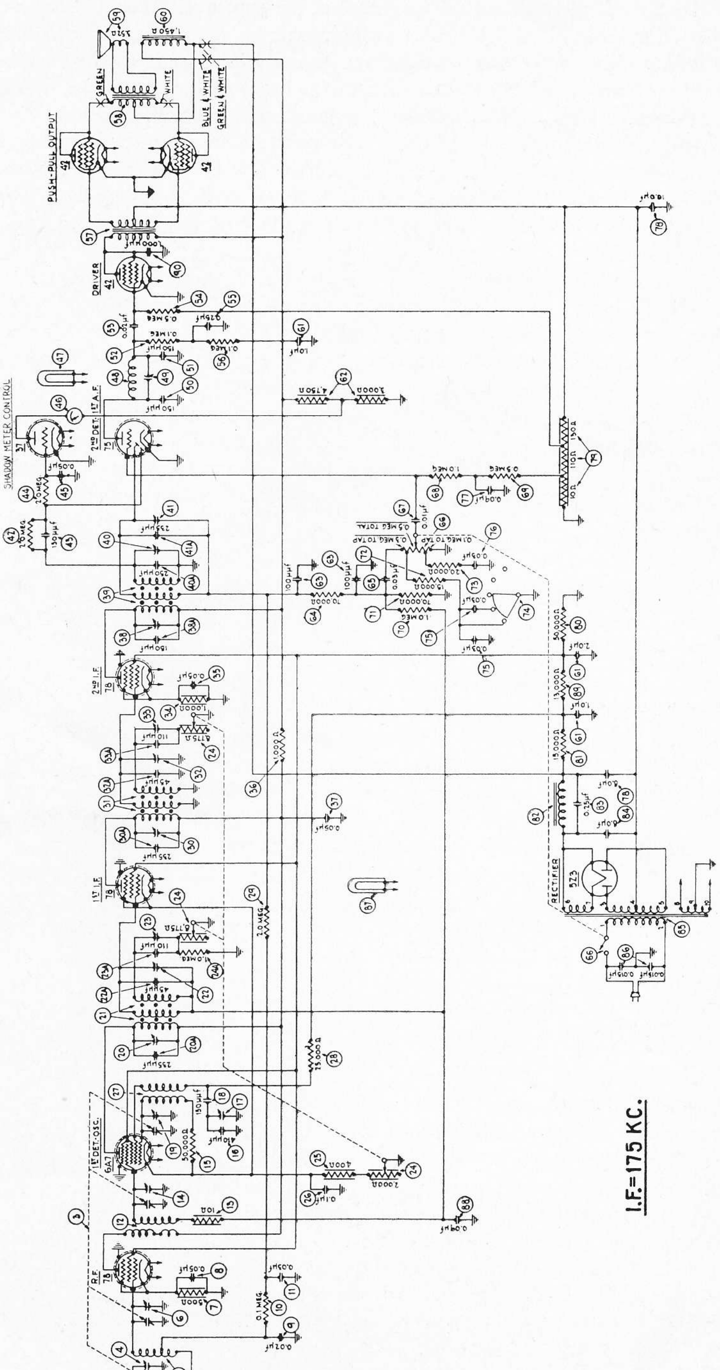


FIGURE 8. Wiring Diagram— Philco Model 200-X

ADJUSTING COMPENSATING CONDENSERS IN MODEL 200-X

The quality performance of this receiver depends to a great extent upon providing a wide channel through the R. F. and I. F. stages to permit the passage of a broadcast signal without cutting of the side bands.

In order to produce this wide tuning band, the set must be carefully and accurately adjusted. These adjustments will be more critical than in the conventional radio, and the padding procedure will be considerably more complicated.

In making the adjustments, it is necessary to use an unmodulated signal generator. The PHILCO Model 048 Set Tester or the Model 024 Signal Generator can be readily adapted for this purpose by the installation of a single-pole double-throw switch, and an additional grid leak resistor, as shown in Figure 9. This switch will adapt the signal generator for either a modulated or an unmodulated signal.

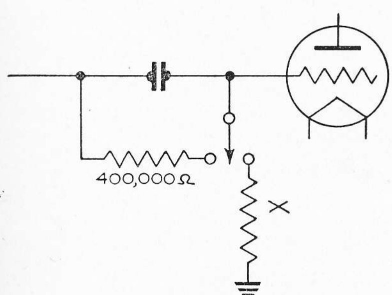


FIGURE 9

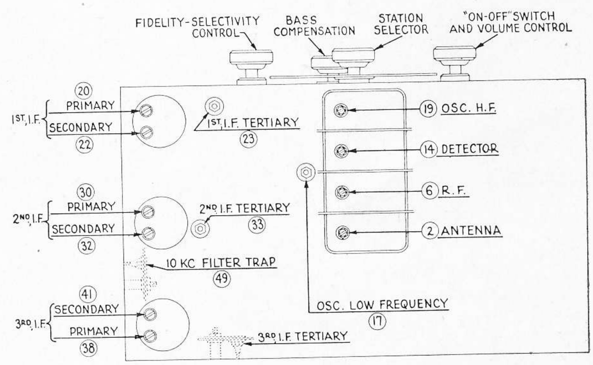


FIGURE 10

With an unmodulated signal, it is not possible to obtain an indication of output by means of the usual form of output meter. An indirect indication can be obtained, however, through the automatic volume control system by connecting a high resistance voltmeter having a scale reading of 0-5 or 0-10 volts across the R. F. cathode resistor ⑦, shown in the wiring diagram Fig. 8. This connection can be made conveniently through the use of leads equipped with test clips. With this arrangement, maximum output at the second detector will be indicated by a minimum reading of the meter, and vice versa. In other words, the action will be just the opposite of an output meter used to measure audio frequency voltage at the power output stage. With no signal applied to the receiver, the bias voltage indicated by the voltmeter, will be approximately 3 volts. This voltage will be reduced by the application of a signal to the R. F. or I. F. input circuits.

I. F. ADJUSTMENTS

After preparing the unmodulated signal generator and connecting the voltmeter as directed, proceed as follows:

1. Set the receiver tuning dial at its extreme low frequency position. Remove the grid clip from the cap of the 6-A-7 detector oscillator tube, and connect the signal generator antenna lead in its place. Connect the ground lead from the signal generator to the ground terminal of the chassis. Adjust the signal generator frequency to exactly 175 K. C. Turn the fidelity control of the receiver all the way to the left.

2. Adjust the 6 I. F. padding condensers ⑳, ㉒, ㉚, ㉜, ㊶ and ㊳ (see Fig. 10) in the tops of the 3 I. F. cans, for maximum output (minimum meter reading), starting with the padder at the front of the chassis, and continuing with the adjustments toward the rear of the set. During these adjustments, the output of the signal generator should be regulated to maintain a voltmeter reading of approximately 2 volts.

3. Connect a 250 Mmf. Condenser from the plate of the 2nd I. F. tube to ground. This will increase the voltmeter reading to approximately 2.5 volts.

4. Readjust the 3d I. F. secondary padder ㊶ for maximum output.

5. Readjust the 3d I. F. primary padder ㊳ for maximum output. Do not touch the grid padder ㊶ again.

6. Turn the fidelity selectivity control all the way to the right.

7. Adjust the 1st & 2nd I. F. tertiary padders ㉓ and ㉝ for MINIMUM output (maximum voltmeter reading).

8. Leaving the fidelity selectivity control in the right hand position, it will be found, upon varying the frequency of the signal generator, that two definite dips will appear in the voltmeter reading—one at 167 K. C. and another at 182 K. C. These dips in the voltmeter reading indicate peaks in the tuning curve. The amplitude of these peaks should be equal; that is, the same voltmeter reading should be obtained at both 167 K. C. and 182 K. C. Any variations in these two readings can be corrected by a *slight* readjustment of the 3rd I. F. primary padder ㊳ . If the peak at 167 K. C. is higher than the one at 182 K. C., the primary padder will have to be turned out. If the reverse is true, the capacity of this padder must be increased. In any case, the voltmeter readings must be made equal by dividing the differences through readjustment.

R. F. ADJUSTMENTS.

The R. F. portion of the receiver is adjusted as follows:

9. Replace the grid clip on the detector-oscillator tube and connect the antenna terminal of the signal generator to the antenna terminal of the chassis. Turn the fidelity selectivity control all the way to the left and set the receiver dial at 1,500 K. C. The same type of output indication is employed as in the I. F. adjustments.

10. Adjust the signal generator for a frequency of 1,500 K. C. Adjust the "oscillator" padding condenser ⑲ and the "detector" padding condenser ⑭ for maximum output and in the order mentioned. Regulate the signal generator output control to maintain a voltmeter reading of 2 volts as before.

11. Turn in padder ⑥ (R. F.) until the voltmeter reads 2.5 volts and then adjust padder ② (ANT.) for maximum output.

12. Readjust padder ⑥ for maximum output. Do not touch padder ② again.

13. Set the receiver dial and the signal generator at 600 K. C. Adjust the "oscillator low frequency" padder ⑰ for maximum output. As the R. F. tuning is rather broad, there will be a considerable range on the dial that will give about the same output when the oscillator L. F. padder is adjusted for maximum. The padder must be adjusted at the middle of this range. This point may be determined with accuracy in the following manner: Starting with the usual voltmeter reading of 2 volts, slowly turn the receiver dial toward the low frequency end and, at the same time, readjust the padder ⑰ for maximum output until a point is reached where the maximum output is indicated by a voltmeter reading of 2.5 volts. Note carefully the exact dial reading at this point. Follow the same procedure while turning the dial in the opposite direction until the output reading decreases to the same value. Set the dial at the exact center of these two points and readjust padder ⑰ , for maximum output.

14. Adjust the 3d I. F. tertiary padder ㊵ to give minimum width in the shadow tuning meter in the receiver. This padder is reached from rear of chassis.

ADJUSTMENT OF 10 K. C. FILTER

The 10 K. C. filter in the audio circuit will rarely require readjustment. As the proper adjustment of this padder (㊾ on diagram) requires an accurately calibrated audio oscillator, it should be reset only in the event that it has been tampered with or in cases where it has become necessary to replace one of the elements of this filter. An emergency adjustment of this filter can be made in the following manner:

15. Connect the signal generator to the control grid of the type 6-A-7 tube, leaving the grid clip in place.

16. Disconnect the voltmeter from resistor ⑦ and connect an output meter to the plates of the power output tubes in the usual way.

17. Set the receiver dial at 550 K. C. At this point, the oscillator in the receiver will be tuned to 725 K. C. The adjustment of the signal generator (switch in unmodulated position) to approximately this same frequency will cause an audible beat note to be heard in the speaker. By means of the signal generator tuning control, reduce the frequency of this beat note until zero beat is reached, at which point the output meter reading will decrease to 0. Turning the receiver dial in either direction will gradually increase the frequency of the audible note so that at 540 or 560 K. C. a 10,000 K. C. note will be heard. At either of these points, the padder ㊾ should be adjusted for minimum reading of the output meter.

GETTING THE MOST OUT OF YOUR TEST EQUIPMENT

One of the chief concerns of the radio serviceman is to provide himself with the kind of test equipment which, with a minimum investment, enables him to carry on his work in the most interesting and profitable way. In selecting his equipment a serviceman must compromise with several factors. The equipment must not be too expensive; it must be sufficiently complete to expedite trouble finding, but yet not so complicated as to divert his attention from the receiver under test to the test equipment itself. Above all, there must be some assurance that the instrument will not become obsolete with the advent of any new developments or radical change in radio receivers.

During the days of the battery type radio, trouble finding was an extremely simple procedure. It did not require much more than the testing of continuity of the filament, grid and plate circuits at each tube socket. At that time a plug-in tester was introduced which was adapted for the convenient measurement of these three voltages by simply inserting a plug in the tube socket. To some extent, this piece of apparatus compensated for a lack of training on the part of the serviceman and made it possible for almost any mechanic to locate trouble in a radio set, by following the directions supplied with the tester. As electrically operated sets were introduced, and receivers gradually became more complicated, this mechanical equipment soon passed out of existence together with the serviceman who had no other training than the instructions covering the use of a now obsolete tester.

At the Philco factory the component parts that go into the manufacture of a radio receiver are given an instantaneous yet very thorough test by means of highly complicated test fixtures. For each new part that is developed a testing unit is designed which will quickly measure the overall characteristics, usually by means of a single meter indication. The equipment is so complete, yet so simple to operate, that anyone — no matter how unskilled — can make a thorough test of the part for which the instrument was designed As developments and changes take place in design, this type of equipment is quickly rendered useless and must be rebuilt or replaced to take care of new production.

It is obvious that such elaborate equipment is not for the serviceman. His problem is the testing of an infinite variety of circuits, ranging from the newest to the oldest types. To successfuly carry on his work, his test equipment must be adaptable to any type of radio receiver. It must be basically simple and supplemented by his thorough understanding of the principles underlying radio receiving.

The location of trouble in a radio set often requires a certain amount of resourcefulness on the part of the serviceman and the use of common sense logic in analyzing symptoms of improper operation. There are, however, a great many ways of guiding the procedure to be followed in the usual forms of trouble. It is this type of information that the following instructions are intended to cover.

The Philco Model 048 All Purpose Set Tester is the most versatile and the most useful of all types of test equipment. It is quick to respond to any test that may be applied during the process of locating the trouble, and its accuracy leaves each final and unquestionable.

1. Location Of Trouble—Unless there is some outward indication of the failure of the voltage supply or some other part of the receiver, it is desirable to determine first in which part of the set to look for the trouble. The signal generator provides a short cut to the solution of this part of the problem. By connecting the output of the signal generator to the control grids of the various R. F. and I. F. tubes, the trouble can be quickly isolated to one particular section or stage. The antenna lead of the signal generator can be attached to the antenna terminal of the receiver and to the control grids of the R. F. and detector oscillator tubes to determine if a response can be obtained in the speaker from these points. In making these tests, the signal generator should be tuned to the frequency corresponding to the receiver dial setting.

Leaving the signal generator connected to the control grid of the detector oscillator, the operation of the I. F. amplifier and audio amplifier can be checked upon readjusting the signal generator frequency to the intermediate frequency used in the receiver. The audio system can be checked from the speaker back to the second detector through the use of the output meter.

As a condenser is connected in the output meter circuit, the output meter can be connected from the plate of any audio amplifier tube to ground. This will afford an indication of the audio frequency voltage appearing at these points without disturbing the D. C. potentials applied to the tubes in any way. It will be seen that the operation of each particular amplifier stage can be checked in this way with the second detector as a starting point. The output meter test lead is used to test amplifier continuity from this point through each succeeding A. F. stage and the speaker terminals, while the signal generator antenna lead will complete the procedure in the opposite direction from the last I. F. stage back to the antenna terminal.

When an output reading is obtained with the signal generator connected at one I. F. stage, but not at the preceding stage, it is advisable to check the I. F. transformer separately by connecting the signal generator to the primary of this transformer. The signal generator antenna lead can be applied to the plate of the I. F. tubes if a blocking condenser of .01 capacity is inserted between the ground lead of the signal generator and the receiver chassis. If a signal is obtained from this point, the I. F. transformer will be eliminated as a possible source of trouble.

2. Voltage Tests—Following the approximate location of trouble, it is usually desirable to check the operating voltages — more especially the plate voltages — at several points in the set. It is well to begin with the power output stage, as the plate voltage readings at the power output tubes will indicate the condition of the entire voltage supply unit. If any one plate voltage reading is found to be far below normal while the rectifier appears to be overloaded, a short circuit will be indicated and should be traced by locating the point at which zero voltage is obtained. The effect a short circuit at any point will have on voltages at other parts of the receiver will depend upon the amount of resistance in the circuit.

Voltage readings do not always indicate actual voltage. If the resistance between the voltage supply and the point at which the voltage is taken is greater than the resistance of the voltmeter, only a fraction of the actual voltage will be indicated. This factor must be taken into consideration as voltage is not reduced by a series resistance, unless current flows in the circuit. Screen grids and control grids are often fed with voltage through a high resistance and as they draw little or no current their operating voltages are essentially equal to the voltage at the opposite end of the series resistors. The error in obtaining voltage readings in such circuits is minimized when a high resistance voltmeter is used.

The usefulness of voltage readings can be greatly increased by a thorough understanding of the simple relationship expressed by Ohm's law. This formula simply means that the current flowing in the circuit is directly proportional to the voltage across that circuit and inversely proportional to the resistance in the circuit. If an abnormally high voltage appears across a speaker field or a choke coil, and it is known that the resistance of that element has not changed, it follows that an abnormally high current is flowing in the circuit. This indicates excessive current drain due to a short circuit at the low voltage side of the filter. It is possible in this way to estimate current flow without the cumbersome procedure of inserting a milliameter in the circuit and without danger of damaging such a meter. This method will apply to the testing of voltages throughout the receiver and will assist materially in locating the causes of low voltages.

In R. F. and I. F. tubes in which the voltage of the control grids is regulated by A. V. C. action, a true reading of grid voltage cannot be obtained by connecting a voltmeter directly to the control grids. An indirect reading of control grid voltage can be obtained by measuring the voltage across the bias resistor in the cathode circuit. The voltage at this point will decrease when a signal is applied to the A. V. C. tube, due to the decrease in plate current in the tubes controlled through the A. V. C. circuit.

Voltage readings should be applied whenever a faulty amplifier stage or an overload in the rectifier circuit is indicated. Operating voltages of the audio amplifier tubes should be checked when distortion is present as incorrect grid voltage is the usual cause of this condition. Low sensitivity will often be traced to incorrect voltages applied to R. F. and I. F. tubes resulting from faulty condensers or resistors in the voltage supply circuits and voltage readings will facilitate the location of such defects.

In making voltage measurements it is necessary to take into consideration the effect of supplying amplifier tubes with incorrect voltages. Excessive plate current in tubes having insufficient control grid voltage or insufficient screen grid voltage will often cause misleading effects in other parts of the receiver, due to excessively high voltage drop in various parts of the circuit. As a concrete example, the removal of grid bias from the power output tubes in the receiver will increase the plate current in these tubes to several times the normal value. As these tubes normally draw the major portion of the current supplied by the rectifier, all voltages in the receiver will be reduced as a result of the abnormally high current.

3. Resistance Measurements—Resistance readings are necessary in testing parts in which trouble is indicated by voltage measurements. Very often, however, the trouble can be cleared by the disconnection of a faulty part, such as a condenser causing a short circuit, making further resistance tests unnecessary. Resistance measurments are the most convenient and useful indications of the condition of individual parts. Many servicemen prefer to locate trouble entirely by the point-to-point resistance method.

When an abnormal voltage has been indicated at any point, the resistance measurements should first be directed to determining whether an open circuit or short circuit is the cause. In the absence of a plate voltage reading, a ground in the plate lead or a short circuit in a by-pass condenser can be located by measuring the resistance between plate and cathode. An open circuit in the voltage supply to the plate will be indicated by a continuity test between the plate of the amplifier tube and the filament of the rectifier tube.

Under certain conditions some types of carbon resistors will have a tendency to decrease their resistance when heated by the current they are required to carry. When a resistor has been continually overloaded this tendency will increase to such an extent that the resistance may decrease to a small fraction of the correct value when under load. Bleeder resistors will often develop this condition, yet will appear to have normal resistance after cooling. A resistor suspected of this condition must be connected to the ohmmeter the instant the current is turned off from the set.

There will be some cases where resistance measurements will be required to supplant voltage readings entirely. In the case of a short circuit at the output of the rectifier circuit it is not advisable to operate the receiver until the short has been removed. In this case resistance readings must be resorted to and will serve to quickly indicate the location of the short circuit.

4. Gain Measurements—Certain forms of trouble developed in a radio may be difficult to locate by the usual methods of testing. A high resistance short circuit in the windings of an I. F. Coil will make no appreciable difference in the resistance of the coil and may even permit an apparently normal adjustment to be obtained by the padding of the compensating condenser in the circuit. A defect of this nature will only be indicated by the absence of gain in that particular stage of amplification. The contribution of each amplifier stage to the total gain in the set can be determined by the methods outlined in Section No. 1. Upon moving the antenna lead of the signal generator to each preceding stage an increase in the output meter reading should be obtained. Any stage which is not performing at maximum efficiency will cause a lack of increase or even a decrease in the output indication. The increase observed under normal conditions cannot be taken as an exact measurement of amplification factor due to the differences in coupling required in the various circuits which it is not practicable to build into the conventional signal generator. The increase at each stage can be used only as a relative indication.

5. Adjustments—The importance of padding adjustments in a radio receiver is often overlooked in service work, yet these adjustments are very easy to make with the right kind of equipment. The adaptability to this requirement was one of the chief considerations in the design of the Philco Model 048 Set Tester, and both the signal generator coupling leads and the output meter leads have been so arranged as to afford a quick and convenient means of connecting the instrument to a radio receiver. The special clips on the output meter leads can be quickly slipped over the plate and cathode prongs of one of the power output tubes or the plate prongs of the speaker plug. The procedure for padding all types of radio receivers is covered in detail in R. M. S. Lesson No. 1.

The usual indications of the need for repadding are low sensitivity and selectivity, excessive tube hiss or background noise, or a decided error in calibration at various points on the tuning dial. In any general tune up of a receiver chassis, all padding adjustments should be carefully gone over, especially if the tubes have been replaced. It will be found that a receiver which has been treated in such a thorough manner will really do justice to the serviceman's efforts and will result in a greater degree of customer satisfaction.

Under certain conditions it will be found advisable to change the intermediate frequency in a receiver from the value originally specified by the manufacturer. In localities affected by interference from commercial transmitters operating at or near the intermediate frequency of a particular receiver, it will be advisable to readjust the intermediate frequency amplifier to a different frequency. This will be particularly true of superheterodyne sets using the higher intermediate frequencies, such as 460 K. C. which corresponds closely to the frequencies used by many naval and commercial transmitters. The change involves only the connection of the signal generator and output meter in the usual way and the readjustment of the I. F. amplifier to a slightly higher or lower frequency. If the set is equipped with a wave trap in the antenna circuit this should be retuned to the same frequency used in adjusting the I. F. padders. This I. F. change will cause an error in calibration at some part of the tuning range which will have to be compensated for by a readjustment of the R. F. and oscillator padders.

Padding adjustments will often be found useful in locating a defective coil in a tuned circuit. When one or more turns in an R. F. or I. F. coil become shorted there may be no appreciable change in a resistance reading of that particular winding, but such a fault would be certain to show up when the padding condenser in the circuit is adjusted. It will either be found that the padding adjustment will make no difference in the output indication or will be incapable of tuning the circuit to a definite peak.

6. Tube Testing—The testing of tubes in the customer's home, and at the same time proving to the customer that new tubes are required, has been up to this time an unsolved problem to the serviceman. Exhaustive tests in the Philco Research Laboratories have shown that the mutual conductance of an amplifier tube in a radio set will vary in almost direct proportion to its effect upon the total amplification in the set. In other words, if a signal generator is connected to the input circuit of a receiver and an output meter to the output circuit, a variation in the mutual conductance of any one amplifier tube will produce the same amount of variation in the output meter. By comparing the readings obtained with any one tube in the set with a new tube substituted in its place, the condition of the tube being tested can be definitely determined. Our tests have indicated that when the mutual conductance of a tube varies more than 35% from the normal value, it is no longer fit for service and should be replaced. As the output reading is directly proportional to this variation, the tube producing an output reading over 35% less than that obtained with a new tube should be rejected. Obviously, this method of testing tubes is equally suited to all amplifier tubes. In addition to the positive indication obtained by this method, the customer can be shown conclusively that the replacement of a tube will actually improve the performance of his set.

In testing rectifier tubes, an emission test will be satisfactory. It is not actually necessary to measure this current, as a plate voltage reading at one of the power output tube sockets will give just as satisfactory an indication.

II

The Philco Model 059 Cabinet Tester embodies all the equipment required for the convenient and thorough testing of a receiver chassis in the shop. This unit is provided not only with the equipment required to make a complete test of a radio receiver, but is also adapted for testing any type of radio chassis without the original speaker. In addition to saving bench space, this feature provides the serviceman with a better idea of the tone quality to be expected upon replacing the chassis in the customer's cabinet than is possible when the speaker is used for testing without a baffle. Even when it is desirable to bring the customer's speaker to the shop for test or repair, the speaker in the Cabinet Tester can be used as a basis of comparison or to locate the source of distortion by the process of elimination.

III

The Philco Model 024 Signal Generator and Model 025 Circuit Tester are separate units, which together are equivalent of the Model 048 Set Tester. The same instructions covering the use of this instrument apply also to the separate Signal Generator and Circuit Tester.

IV

The Philco Model 091 Crystal Controlled Short Wave Signal Generator is indispensable in the servicing of short wave and all wave receivers. As calibration of the short wave Signal Generator cannot be checked conveniently against short wave broadcasting stations as in the case of a signal generator adapted for the broadcast band only, the crystal controlled feature is an absolute necessity. The use of this instrument in padding all wave receivers is covered in R. M. S. Lesson No. 1. It is also indispensible in locating trouble in the R. F. portion of the all wave receiver. The procedures outlined in Section No. 1 and Section No. 4 will apply to the use of the Short Wave Signal Generator in checking the R. F. circuits.

V

The Philco Model 093 Condenser Test Box is intended for the testing of condensers by the substitution method. It is also useful in locating trouble in cases where an open condenser is the possible cause. Substituting a condenser of the proper capacity through the use of the Test Box will always be far more convenient than actual testing of the condenser which may be suspected.

When oscillation appears in the operation of a receiver, the possibility of an open condenser in the voltage supply circuits to the R. F. and I. F. tubes can be quickly checked by connecting the leads of the Test Box to the screen grids and to the control grid and plate voltage supply circuits for these tubes.