CHAPTER 13

IF AMPLIFIER STAGE

Quick Check.—If a modulated signal at the intermediate frequency is applied to the signal grid of the converter tube and the modulation note is heard in the speaker, the IF stage is probably functioning, and the serviceman proceeds to check the next stage.

Function of the IF Stage.—The input IF transformer couples the IF stage to the previous converter. The output IF transformer couples the IF stage to the succeeding detector stage. The signal at the input of the stage contains components at the oscillator frequency, the received signal frequency with its modulation, and sum and difference values of these two frequencies with the same modulation as the signal. The signal at the output of the stage should be at the difference or intermediate frequency and will also contain the modulation component of the original signal. The function of the IF stage, therefore, is to tune and amplify at the intermediate frequency.

THEORY OF OPERATION

Standard Circuit.—This is illustrated by Fig. 13–1.

Functions and Values of Component Parts.—The tuning function of the IF amplifier is accomplished by the action of the four tuned circuits of the input and output transformers: L-8 and C-8, L-9 and C-9, L-10 and C-10, and L-11 and C-11. All are tuned sharply to the intermediate frequency, and the four tuned circuits make possible the well-known selectivity of the superheterodyne receiver.

The amplification function of the IF amplifier is dependent on two factors: the design of the transformers T-4 and T-5, and the amplification of the tube. In a circuit of this type, the transformers are usually designed for high gain, and the voltage amplification of the 6K7 tube is roughly 100. A discussion of stage-gain measurements will be given in the section on the signal check.

Input IF Transformer.—Input IF transformer assembly T-4 includes the primary coil L-8 with its associated trimmer C-8, and the secondary coil L-9 with its trimmer C-9. This transformer is the coupling device between the converter and the IF stages. It is very
similar to the output IF transformer T-5 and, although there may be some design differences between them, the input and output transformers are usually a matched pair. Both transformers are tuned to the intermediate frequency of the receiver. The tuning arrangement is usually by means of trimmer condensers on either air or iron-core coils. In some cases, condensers C-8 and C-9 are of the fixed mica type, and tuning is accomplished by varying the permeability of the cores by a screw arrangement that withdraws or inserts the core plug.

We might at this time refer to the intermediate frequencies in common use. Older receivers operate at an intermediate frequency of 130 or 175 kc. Later receivers operate at some frequency be-

Fig. 13-1.—Typical circuit of an IF amplifier stage.

tween 450 and 480 kc, to minimize image-frequency interference (see Chap. 16 on the RF stage). An intermediate frequency often encountered is 260 kc. The trend in modern receivers is to standardize at 455 kc. In almost all cases, the intermediate frequency used in a particular receiver is indicated on the schematic wiring diagram of that receiver.

**IF Tube.**—The tube employed in the IF stage is usually the metal 6K7 supercontrol pentode. Sometimes the single-ended 6SK7 type of tube is used, the characteristics of which are quite similar to those of the 6K7. When glass tubes like the 6K7-G or 6K7-GT are used, they are almost always enclosed in a shield. Older receivers use the 6D6 or 78 type of tubes that have similar characteristics.

Where the IF amplifier tube is combined with a diode for detection purposes, the tube employed is the 6B8.
AC/DC receivers may use any of the above tubes in circuits where all the tubes draw 0.3 amp of filament circuit. Where the 0.15-amp filament tubes are used, the 12K7, 12K7-G or -GT, or 12SK7 tubes are found.

![IF Amplifier Diagram](image)

Fig. 13–2.—Self-bias in an IF amplifier without automatic volume control.

**Minimum-bias Circuit: R-23, C-23.**—Components R-23 and C-23 form a self-bias circuit, similar to that of R-13 and C-13 in the second AF stage (see page 101). To see the similarity more clearly, assume for the moment that the grid return goes to ground instead of the

![AVC Bus Diagram](image)

Fig. 13–3.—The grid bias applied to the IF tube is the sum of the self-bias and AVC voltages.

AVC bus, as in Fig. 13–2. Plate and screen currents flow through the cathode resistor R-23, making the cathode 3 volts positive with respect to ground. Since the grid is at ground potential, it is 3 volts negative with respect to cathode. This is the grid-bias voltage.

When the grid is returned to the AVC bus, as in Fig. 13–3, there is no AVC voltage when no signal is present, and the grid is therefore
at zero or ground potential. This makes the condition similar to that of a grounded grid return; that is, the grid is at ground potential, the cathode is at a potential of plus 3 volts due to the self-bias resistor R-23, and the grid is therefore 3 volts more negative than the cathode. When a signal is tuned in, it develops an AVC voltage, which is negative with respect to chassis, thereby making the grid negative with respect to chassis by an amount equal to the AVC voltage. The cathode is still positive with respect to chassis because of self-bias, and therefore the actual bias on the grid of the tube is the sum of the AVC and the cathode voltages. The weaker the signal, the lower the AVC voltage will be, and the less it will add to the minimum grid bias. However the grid-bias voltage cannot fall below the self-bias voltage, even when no signal is received. Since the self-bias circuit of R-23 and C-23 sets a minimum limit to the grid-bias voltage, it is called the "minimum-bias" circuit.

Cathode resistor R-23 is usually a ½-watt resistor, and its ohmic value is usually 300 to 400 ohms. A higher value would mean a higher minimum-bias voltage and less possible amplification for the stage.

Cathode condenser C-23 by-passes the signal from the self-bias resistor in the same way that C-13 by-passes the audio signal from R-13. However, in this case the signal is at the intermediate frequency, and a much smaller capacity will be effective. The usual capacity for C-23 is 0.1 mfd. The type of condenser most often used is the paper tubular type. Voltage rating is not important. A 200-volt value is satisfactory.

The AVC voltage is by-passed by condenser C-28, which is usually a 0.05-mfd/200-volt paper tubular condenser.

**Screen Voltage Supply:** C-24 and R-24.—Resistor R-24 drops the B voltage, from the usual 250 volts available at B plus, to approximately 100 volts at which the tube screen operates. It is usually a ½-watt, 80,000-ohm resistor. There is considerable variation in this value in different models of receivers. In general, a higher resistance will make for a lower screen voltage, and a lower value of resistance makes possible a higher screen voltage.

Screen resistor R-24 is sometimes omitted and the screen voltage is taken from the mid-point of the voltage divider R-15 and R-16 (see Fig. 8–14).

Condenser C-24, the by-pass for the screen voltage, helps to filter the screen supply. Its usual value is 0.1 mfd/400 volts. Its most important function, however, is to keep the screen of the tube at ground potential as far as the signal is concerned, since C-24 offers little impedance to IF signals. This effectively shields the control
grid from the plate, internally in the tube, and allows for stable amplification.

Sometimes screen condenser C-24 is not readily located in the receiver schematic diagram. This may be the case where the screens of other tubes are tied together with the IF screen for a common voltage supply. The screen by-pass condenser will then be found at one of the other screens. As a matter of fact, in some circuits, where an electrolytic filter condenser is used on the screen voltage supply, an additional paper screen by-pass condenser is often found in the RF or IF screen circuit, in parallel with the electrolytic condenser. This is to take advantage of the more effective RF filtering by the paper tubular condenser.

![Circuit Diagram](image)

**Fig. 13-4.**—Coupling in the plate circuit due to a common B power-supply component.

In AC/DC receivers, operating potentials for the IF tube are approximately 90 volts for both the plate and the screen. In this case, the dropping resistor R-24 is omitted and the screen is connected directly to B plus. Screen by-pass condenser C-24 may also be omitted, in which case its by-pass function is taken over by the output filter condenser C-16 in the power supply.

**Output IF Transformer T-5.**—Output IF transformer T-5 couples the output of the IF stage to the detector stage. Replacement notes for T-5 are found in Chap. 12, which describes the detector and AVC stage (see page 161).

**Decoupling Filters.**—Whenever two or more stages are operated from the same voltage supply, there is a possibility of coupling between the stages through the common power supply. This is illustrated in Fig. 13-4.
If we consider the signal voltage in the plate circuit as being from plate to cathode, the signal voltage of tube $V-1$ is across $L-4$, $C-16$ in the power supply, and $C-1$. The signal voltage of $V-2$ is across $L-8$, $C-16$ in the power supply, and $C-18$. The signal voltage of $V-3$ is across $L-10$, $C-16$ in the power supply, and $C-23$.

Let us consider the plate circuit of tube $V-1$. The greater part of the signal voltage will be where it is wanted—across the high impedance of $L-4$, where it will be transferred to $L-5$ and the grid circuit of the following tube. There will also be some signal voltage drop across the low impedance of $C-16$ in the power supply and $C-1$ in the cathode circuit.

![Fig. 13-5.—Decoupling filter in the plate circuit of tube $V-3$.](image)

Now let us consider the plate circuit of $V-2$. Again, the signal voltage will be mainly across $L-8$, but there will be some across $C-16$ and $C-18$. Note that the signal voltages of tubes $V-1$ and $V-2$ have a common circuit in $C-16$ in the power supply.

When we consider the plate circuit of $V-3$, again, most of the signal is across $L-10$, but a small part will be across $C-16$, which is common to all three plate circuits.

If the signals from any of the tubes are in phase, oscillation may result owing to regenerative feedback through the common coupling, $C-16$.

The coupling through the common power supply is usually avoided by the addition of a resistor and condenser known as a “decoupling filter” or isolation circuit, as shown in Fig. 13–5.

The decoupling filter consists of $R-25$ and $C-25$. Condenser $C-25$
offers a low opposition path to ground for the signal, and \( R-25 \) offers a high opposition path to the signal. The net result is to keep the signal voltage of \( V-3 \) out of the power supply, so that it cannot mix with the signal from any other tube. An RF choke is sometimes used instead of \( R-25 \). This also offers high opposition to the signal.

The decoupling filter may be applied in the plate circuit of tube \( V-1 \) instead of tube \( V-3 \), as shown in Fig. 13-6. The result would be the same, since in this case the signal voltage of \( V-1 \) would be kept out of the power supply and therefore would not react with the signal from any other tube.

![Diagram of decoupling filter in the plate circuit of tube \( V-1 \).](image)

In different receivers, there is considerable variation as to the placement of the decoupling filter. Sometimes it is in the plate circuit of \( V-1 \), sometimes in the plate circuit of \( V-3 \), sometimes in both. Also, the plate circuit of \( V-2 \) may be tied to either that of \( V-1 \) or \( V-3 \), or have its own filter. Since there is no standardization in the placement of the decoupling filters, a decision as to the placement in the standard receiver circuit (Fig. 1-1), which attempts to show the most commonly used practices, has to be reached. In the standard receiver circuit, a decoupling filter is placed in the plate circuit of each tube, and servicing procedures are dealt with so as to include the filter. From the above discussion, it is to be hoped that the serviceman will expect an individual receiver to differ somewhat from the standard in that one or more decoupling filters may be omitted.
By a similar line of reasoning, there could be undesirable regenerative coupling, if the cathodes of three stages were connected together and fed from a common cathode to ground resistor for equal self-bias voltages. The same thing could happen with the screen-voltage supply, or the grid returns through the AVC bus. Where we

Fig. 13-7.—Cathode circuits with individual self-bias resistors to avoid interstage coupling. have three stages operating at similar frequencies through a common coupling, decoupling filters will be found in at least one of these circuits.

In the standard circuit, the cathodes of the RF, converter, and IF tubes have individual self-bias resistors to avoid coupling, as shown

Fig. 13-8.—Decoupling filters in the screen circuit to avoid coupling in the common power supply.

in Fig. 13-7. It is fairly common practice, however, to find the cathode of V-2 joined to V-1, and R-18 and C-18 omitted.

In the screen circuit, coupling is avoided, as shown in Fig. 13-8, where screen by-pass condensers, in conjunction with screen resistors, are used. It is most common practice to obtain screen voltage for the IF tube V-3 from a separate dropping resistor R-24 connected
to $B$ plus. The screens of $V\text{-}1$ and $V\text{-}2$ may be tied together, with $R\text{-}14$ and $C\text{-}14$ omitted. Or all three screens may be tied together and fed from a common voltage source.

![Diagram](image)

**Fig. 13-9.**—Decoupling filters in the grid return circuit to avoid coupling in the common AVC voltage supply.

Decoupling filters in the grid returns of the RF and converter tubes are rarely omitted. In this case, the standard circuit is indeed standard. In Fig. 13–9, resistor $R\text{-}30$ and condenser $C\text{-}30$ make up

![Diagram](image)

**Fig. 13-10.**—Plate-circuit decoupling filter in the IF amplifier stage.

such a decoupling filter for tube $V\text{-}1$, while $R\text{-}29$ and $C\text{-}29$ make up a similar filter for tube $V\text{-}2$.

A great many receivers do not use an RF stage. In this case, since there are fewer stages with a common coupling component, the probability of regenerative feedback is lessened, and there is little necessity for decoupling filters.

To get back to the IF stage, the plate decoupling filter consists of
R-25 and C-25, as shown in Fig. 13–10. Resistor R-25 varies from 400 to 1,000 ohms in different receivers, and C-25 varies from 0.05 to 0.25 mfd. These values are not critical.

NORMAL TEST DATA FOR THE IF STAGE

Signal Check.—The test point for the signal check of the IF stage is the converter signal grid, as shown in Fig. 13–11. As was the case in the signal check for the detector stage, the input signal is applied to a previous tube, to avoid the detuning effect of the capacity in the signal generator. The converter-grid test point is readily available, either at the top contact of the 6A8 converter tube or at the stator-plates terminal of the converter tuning condenser, C-5. The output indication is the modulation note of the signal generator in the speaker, or its amplitude, as shown by the output meter. The output meter should be adjusted for a high-voltage range at the start of the signal check, since, from this test point, the amplification of the receiver is considerable. Until the signal generator's attenuator is adjusted, the output signal may be high enough to harm the meter, if it is at its usual 25- to 60-volt range for output measurements. The RF portion of the receiver is made inoperative by shorting the oscillator section of the gang tuning condenser, as explained on page 159.

The signal check consists in rotating the frequency control of the signal generator through the receiver's intermediate frequency, while listening for its modulation note in the speaker or observing the output meter reading. Unless the response is considerably stronger than that heard from the IF grid (quick check for the detector stage), the IF stage bears investigation for trouble. This is the quick check for the IF stage.
At the same time, the signal check may be used to check alignment, operation at the proper intermediate frequency, and the presence of oscillation. The presence of two peaks close together is not necessarily an indication of misalignment. This may be the normal response from an overcoupled IF transformer. This is explained in the variations section dealing with broad-band IF amplifiers.

When the modulated IF signal is applied to the converter grid and there is no response or abnormally low response, the trouble may be in the converter tube or its operating potentials. This can be checked by shifting the signal generator test lead to the converter plate. In this case, normal response is a somewhat stronger signal from the converter plate than was obtained from the IF grid (quick check of the detector stage). Trouble in the converter tube or its operating potentials is handled in Chap. 14, which deals with the converter. If there is no signal response from the converter plate, the trouble is definitely in the IF stage.

Normal Voltage Data.—Readings are taken from the chassis or common negative terminal to tube elements. The data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Tube elements</th>
<th>AC receivers, volts</th>
<th>6K7 pin No.</th>
<th>AC/DC receivers, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>250</td>
<td>3</td>
<td>90</td>
</tr>
<tr>
<td>Screen</td>
<td>100</td>
<td>4</td>
<td>90</td>
</tr>
<tr>
<td>Cathode</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

Normal Resistance Data.—These data are presented below.

<table>
<thead>
<tr>
<th>Resistance, ohms</th>
<th>Air core</th>
<th>Iron core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across L-8, primary of T-4</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Across L-9, secondary of T-4</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Across L-10, primary of T-5</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Across L-11, secondary of T-5</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Cathode to chassis</td>
<td>300–400</td>
<td>5–15</td>
</tr>
<tr>
<td>Control grid to chassis</td>
<td>1,500,000</td>
<td>5–15</td>
</tr>
<tr>
<td>Screen grid to chassis</td>
<td>140,000*</td>
<td>5–15</td>
</tr>
<tr>
<td>Screen grid to B plus</td>
<td>80,000*</td>
<td>5–15</td>
</tr>
<tr>
<td>Plate to B plus</td>
<td>640†</td>
<td>5–15</td>
</tr>
</tbody>
</table>

* These values are for the standard circuit. Owing to the wide divergence in methods of obtaining screen supply, these readings should be checked against the receiver schematic diagram.

† If there is no decoupling filter, this reading will be simply the DC resistance of L-10, the primary of the output IF transformer T-5.
A wide divergence is given for the coils \( L-8, L-9, L-10, \) and \( L-11, \) to allow for differences between receivers. In any one receiver, however, owing to the common use of matched transformers, these coils should all check very close to the same value within the limits given.

**IF Stage-gain Measurements.**—As was done for the previous stages, the serviceman should run some checks on receivers known to be good, so as to have a basis of comparative data as to the operation of his test equipment and the normal gain to be expected from the IF stage.

The receiver, test oscillator, and output meter are connected, as shown in Fig. 13–11. The receiver’s RF section is made inoperative by shorting the oscillator section of the gang tuning condenser. The receiver is set to the full volume and minimum bass positions. A selectivity control, if any, is set for the maximum selectivity position. The test oscillator is adjusted for modulated output on the IF band. The output meter is set at a high AC voltage range for safety’s sake, although the range will be reduced for the final check of the standard output voltage.

The signal generator is connected to the converter grid, and the frequency-control dial is rotated carefully through the receiver’s intermediate frequency for peak deflection on the output meter. At peak, the attenuator of the signal generator is adjusted to give the standard output of 50 mw in the speaker. Standard output corresponds to an output meter reading of 16 volts (see page 131).

The average IF signal input at the converter grid, necessary to give standard output, is 50 microvolts for a modern high-gain receiver. The attenuator setting just obtained, therefore, corresponds to 50 microvolts. After several good receivers have been checked by the above procedure and the results have been compared, a reference point, corresponding to 50 microvolts, has thus been established on the signal-generator attenuator dial.

In the detector stage, it was seen that the average IF signal input necessary to give standard output from the IF grid was 3,500 microvolts. From the converter signal grid, the average IF signal input necessary to give standard output is 50 microvolts. The average gain of a receiver between the two grids, therefore, is \( 3,500 / 50 = 70. \) Having established comparative data on good receivers, the serviceman is in a position to judge the gain characteristics of any IF amplifier.

**COMMON TROUBLES IN THE IF STAGE**

**Troubles Common to the Input IF Transformer.**—Replacement notes and troubles of the input IF transformer \( T-4 \) will be outlined briefly here. For a more detailed discussion, the replacement notes
on the similar output IF transformer are equally applicable (see page 161).

The IF transformers sometimes open. When this is the case, the receiver will not operate, and a signal check will indicate the defective stage. An ohmmeter check then shows the open transformer.

The IF transformers also cause noise. This condition is usually due to corrosion of the windings. It will be found by an ohmmeter check, since a corroded winding will check several hundred ohms instead of its normal value of 15 to 50 ohms.

If an exact replacement transformer is not available, the suggestions on page 163 should be helpful.

**Fig. 13-12.**—The input IF transformer and its position in the circuit.

**Input IF Transformer Color Code.**—The R.M.A. color code given below will help to identify the leads.

- Blue .................. Plate lead
- Red ........................ B plus lead
- Green .......................... Grid lead
- Black .......................... Grid return

When a new transformer is installed, grid and plate leads should be short and direct and away from each other and all other wiring.

**Troubles Common to the AVC By-pass Condenser.**—Replacement notes on the AVC by-pass condenser C-28 are found in the detector and AVC stage on page 165.

**Troubles Common to the Minimum-bias Resistor.**—The voltages and currents encountered in the cathode circuit of the IF tube are such that there is no overload on minimum-bias resistor R-23, and the resistor rarely gives trouble. If it should open, the stage will not operate and the condition would be found in a voltage check.
The cathode-to-ground voltage would check abnormally high, since the test voltmeter, with its high resistance, would bridge the open resistor in the circuit.

The original should be duplicated as to ohmage and wattage. If the exact ohmage value is not available, a considerable tolerance may be allowed, since the value is not critical and will cause little effect on the over-all performance of the receiver.

Troubles Common to Minimum-bias By-pass Condenser.—As with its associated resistor $R-23$, the low voltage encountered will rarely harm minimum-bias by-pass condenser $C-23$. Nor will leakage be overly important, since the condenser is in parallel with a low-ohmage resistor. Should the condenser open, however, there will be degeneration with a consequent loss in gain for the stage. If the open is intermittent, there will be intermittent loss in volume or fading. In either case, substituting a condenser known to be good and observing results is the best check. Sometimes wiggling the condenser leads will show up the intermittent open. When condenser $C-23$ is replaced, a large tolerance in capacity is allowable.

Troubles Common to the Screen By-pass Condenser.—In service, screen by-pass condenser $C-24$ sometimes opens and sometimes shorts. If it is open, the receiver will oscillate. Standard procedure for an oscillating receiver includes checking for open-screen by-pass condensers. Bridging the various screens to ground with a good 0.1-mfd condenser is the regular test.

If condenser $C-24$ is short-circuited, there will be no screen voltage and the receiver will not operate. The condition would be found in a voltage check and confirmed by a resistance check.

When a short-circuited $C-24$ is replaced, it would also be wise to replace the screen dropping resistor $R-24$, which may have been harmed by feeding heavy current to the short-circuited screen by-pass condenser.
The replacement condenser should not be smaller than the original as to the capacity and voltage rating. A higher capacity will do no harm. Although the screen operates at about 100 volts, the voltage rating of the condenser should be considerably higher. This is because the condenser is at the full $B$ plus voltage when the receiver is first turned on, owing to the dropping resistor circuit of $R-24$.

Troubles Common to the Screen-dropping Resistor.—Screen-dropping resistor $R-24$ may change in value or open. A change in value might not be noticed until checking the screen voltage, since the over-all operation of the receiver would not be affected too much, unless the change is very great. If the resistor is open, screen voltage is zero and the stage is inoperative.

Before resistor $R-24$ is replaced, screen by-pass condenser $C-24$ should be checked, since a shorted screen by-pass may have originally caused the resistor to open.

The ohmic value of $R-24$ is not critical, and a fairly wide tolerance may be allowed. The replacement, however, should be at least a $1/2$-watt size.

Troubles Common to the Plate Decoupling Filter.—If present, the decoupling filter may be a source of trouble. Condenser $C-25$ may short, with the result that there will be no plate voltage, the receiver will be inoperative, and resistor $R-25$ will probably burn. This condition would be found very early in the trouble-shooting procedure, since the $B$ plus voltage will be very low. To find the short, however, might be more difficult, since there are several circuits in parallel with the condenser. An overheating $R-25$ would be one indication. Another helpful device is to make a resistance check from all plates to ground. If condenser $C-25$ were shorted, the IF plate would check approximately 40 ohms to ground (the resistance of $L-10$), while all other plates would check their normal plate load plus the resistance of their decoupling filter, if any, plus the resistance of $R-25$.

It is not unusual to find only a by-pass condenser connected at $B$ plus of an RF or IF tube, even though no other form of decoupling filter is used. This condenser therefore is connected from $B$ plus to chassis and is in parallel with the power-supply filter condenser $C-16$. When this is the case, the ohmmeter check from each plate to ground would give no definite clue, since, with no decoupling resistors, all plate-to-ground readings would show their normal plate load. It would be necessary then to open the $B$ plus wiring, one circuit at a time, to find the short.

A decoupling filter condenser may also open. In this case, all voltages would show normal readings, but the receiver would have a
tendency toward oscillation. Since it is common practice, in trouble shooting for oscillation, to bridge all by-pass condensers with a good condenser, the open decoupling condenser would be found in this manner.

When replacing condenser C-25, voltage rating is important. A 600-volt rating is recommended for all replacements. The capacity is not critical, so that a wide tolerance may be allowed. If a shorted C-25 is being replaced, the resistor R-25 in the decoupling filter should also be replaced, since it has been damaged by feeding heavy current to the short. Unless C-25 has been shorted, R-25 will, of itself, cause no service trouble.

**Fig. 13-14.—The IF amplifier plate-decoupling filter.**

**Troubles Common to the IF Amplifier Tube.—**The amplifier tube is the most common cause of trouble in the stage. The best check, of course, is to compare operation with a similar tube known to be good.

Since there are many similar tubes that will operate in the IF stage, a previous tube replacement may have put a different tube in the IF socket, and the serviceman would do well to check the tube type for which the receiver was originally designed. For example, 6K7-G, 6K7-GT, and 6K7 are all pretty much alike, and any one of them might work in some circuits. They cannot be interchanged in all circuits, however, since they differ as to shielding and inter-electrode capacities. A receiver designed for a 6K7-G may not ground pin 1, and a 6K7 or 6K7-GT would show a tendency to oscillate in this receiver. Similarly, a 6K7-GT may oscillate in a receiver designed for a 6K7, unless equipped with a close-fitting shield in contact with the metal tube base. A 6K7-G would have to be shielded and the shield grounded.
CIRCUIT VARIATIONS OF THE IF STAGE

Minimum Bias from Delayed AVC.—The IF stage in a receiver, using fixed bias and receiving AVC voltage from a delayed AVC circuit, is similar to the standard circuit. It differs primarily in the manner of obtaining minimum bias for the IF tube. The cathode is grounded. Normal fixed-bias voltage for the IF tube, with no signal input, is obtained from the voltage drop across the C voltage divider $R_{-116}$, through the grid return. This minimum bias is also the delay voltage, since the same end of $R_{-116}$ is connected to the IF grid return and the delayed AVC diode plate, through resistor $R_{-128}$.

![IF Amplifier Diagram](image)

Fig. 13–15.—The IF amplifier stage in a receiver using a DAVC circuit.

When a strong station signal is received on the diode plate and it overrides the delay voltage, a voltage drop takes place across $R_{-128}$, which adds to the fixed minimum bias delivered to the IF grid. In this manner, station signals may increase the IF grid bias, but under no condition will the bias drop below the minimum bias furnished by the C voltage divider.

All service notes and tests for the standard IF stage apply here also, except for cathode-to-ground voltage. Owing to the high resistance of $R_{-28}$, a voltage check from grid to chassis may not show any indication with the usual voltmeter. This voltage, however, can be measured across $R_{-116}$.

Broad-band IF Amplifiers.—The IF transformers of receivers, like that of the standard, are designed for great selectivity and gain. Figure 13–16 shows the frequency-response curve for such trans-
formers. However, such a circuit has a defect in that it is too selective and attenuates the high-frequency audio signals. This defect is known as "side-band cutting." In high-fidelity reproduction, where

![Diagram of Frequency-response curve of the usual IF transformer.](image)

Fig. 13-16.—Frequency-response curve of the usual IF transformer.

the high-frequency audio notes are desired, it is necessary to broaden the response curve of the IF transformers to that shown in Fig. 13-17.

![Diagram of Frequency-response curve of a high-fidelity IF transformer.](image)

Fig. 13-17.—Frequency-response curve of a high-fidelity IF transformer.

In high-fidelity receivers, where the response curve of the IF amplifier is broadened, the amplification of the stage is reduced. Usually, a second broadly tuned stage is therefore added to make up for this loss. The over-all gain of the two-stage IF amplifier is somewhat greater than the gain of a single-stage amplifier, and the over-all selectivity is equally good owing to the extra tuning circuits of the added stage. Figure 13-18 is a graphic representation of the response curve of each stage of a two-stage IF amplifier and the over-all response of the amplifier.
Several methods are in common use to obtain the desired broadband response. One method is known as “overcoupled” transformers. In any IF transformer, the relative position of the primary and secondary windings to each other is called the “coupling.”

When the two windings are far apart, the energy transfer from primary to secondary is small, and the transformer will give low gain and good selectivity. As the two windings are brought closer together, the gain of the transformer increases and the selectivity becomes somewhat broader up to a critical point, after which the gain is reduced and the selectivity becomes considerably broader, owing to the appearance of two peaks, one on each side of the resonant frequency. When the primary and secondary windings are closer than this critical point, the transformer is said to be “overcoupled.” Figure 13-19 illustrates the effects of the coupling on the gain and selectivity of a transformer.

The design of the usual single-stage transformer makes some compromise as to coupling between the low and the critical points, so as to give high gain with good selectivity. Some receivers that feature
broad-band IF amplifiers make use of overcoupled IF transformers. Often the coupling is made variable by a mechanical arrangement that raises and lowers one winding by turning a knob on the front panel of the receiver. The position of minimum coupling is labeled **selectivity or sensitivity**, whereas the position of maximum coupling is labeled **fidelity or treble**. This control is called a "fidelity" control.

Another method of broadening the response of the IF amplifier is to load the tuned circuits with resistors, as shown in Fig. 13–20. The resistors may be placed across the primary winding, the second-

![A. SHUNT LOADING](image1)

![B. SERIES LOADING](image2)

**Fig. 13–20.**—Resistance loading to broaden response characteristic of an IF amplifier.

ary, or both; or they may be placed in series with the trimmer condenser. In any case, the introduction of resistance loads the tuned circuit and results in a decreased gain and a broader response curve. The amount of broadening is determined by the amount of loading; that is, the ohmic value of the resistor. The single-stage curve of Fig. 13–18 is typical for a resistance-loaded transformer.

A third method of broadening the response of the IF transformer is to use loosely coupled primary and secondary windings, and to introduce a third winding, known as a "tertiary" coil, closely coupled to the secondary winding. The tertiary is also tuned to the intermediate frequency and absorbs energy from the secondary winding, thereby acting as a load and broadening the response. A resistor, if used in the tertiary winding, increases the effect. Figure 13–21 shows a circuit for an IF transformer with a tertiary winding.

From the serviceman’s point of view, a two-stage IF amplifier presents few complications. The signal check is about the same as for a single-stage IF amplifier, since the gain per stage is considerably lower. It merely adds another grid from which to check. The presence of two peaks close together is to be expected, especially where overcoupling is employed. The IF transformers are subject to the same ills as with a single stage. They open and become noisy
because of corrosion; the same checks are applicable. However, when an IF transformer is replaced in a two-stage IF amplifier, it becomes more necessary to employ an exact replacement.

Because of an added stage, more decoupling filters will be used. However, the treatment of them will not vary from that given for our standard circuit.

The alignment of broad-band IF amplifiers can best be performed with an oscilloscope, but satisfactory alignment can be obtained with a standard signal generator and output meter. It is extremely important to follow the manufacturer's service instruction. Where such instructions are not obtainable, a generalized procedure may be followed. Set the receiver for maximum gain position (not high-fidelity); that is, minimum coupling where a coupling control is used (shunt resistors switched out where this is the method), and align for maximum response, as usual. Then switch to the high-fidelity position and rotate the signal generator about 10 kc on each side of the intermediate frequency, noting the output-meter deflection. If it remains fairly constant for about 5 kc on each side of the intermediate frequency, the alignment may be considered good. If the output meter fails to remain constant, alignment adjustments should be repeated.

Overcoupling and use of a tertiary coil may sometimes be used in a single-stage IF amplifier, where gain is sacrificed for fidelity of reproduction. The tertiary coil may be switched out here for greater gain at the expense of fidelity.

Broad-band IF amplifiers are not usually employed in AC/DC receivers, where emphasis is on simplicity, low cost, and maximum gain from the fewest tubes.

Fig. 13-21.—Tertiary winding to broaden response characteristic of an IF amplifier.
SUMMARY

Quick check.

Introduce a modulated signal at the intermediate frequency to the signal grid of the converter tube. When the IF stage is functioning properly, the modulation note will be heard in the speaker. The response will be much stronger than that heard when the detector stage is checked; that is, when the signal is applied to the IF grid.

Diagram of typical IF amplifier stage.

A diagram of the typical IF amplifier stage is given in the accompanying figure.

Voltage check;

Readings are taken from chassis or common negative terminal. Normal voltage data are given in the accompanying tables.

<table>
<thead>
<tr>
<th>Tube elements</th>
<th>AC receivers, volts</th>
<th>6K7 pin No.</th>
<th>AC/DC receivers, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>250</td>
<td>3</td>
<td>90</td>
</tr>
<tr>
<td>Screen</td>
<td>100</td>
<td>4</td>
<td>90</td>
</tr>
<tr>
<td>Cathode</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
Normal resistance data.

Normal resistance data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Resistance, ohms</th>
<th>Air core</th>
<th>Iron core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across L-8, primary of T-4</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Across L-9, secondary of T-4</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Across L-10, primary of T-5</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Across L-11, secondary of T-5</td>
<td>30–50</td>
<td>5–15</td>
</tr>
<tr>
<td>Cathode to chassis</td>
<td>300–400</td>
<td></td>
</tr>
<tr>
<td>Control grid to chassis</td>
<td>1,500,000</td>
<td></td>
</tr>
<tr>
<td>Screen grid to chassis</td>
<td>140,000*</td>
<td></td>
</tr>
<tr>
<td>Screen grid to B plus</td>
<td>80,000*</td>
<td></td>
</tr>
<tr>
<td>Plate to B plus</td>
<td>640†</td>
<td></td>
</tr>
</tbody>
</table>

* These values are for the standard circuit. Owing to the wide divergence in methods of obtaining screen supply, these readings should be checked against the receiver schematic diagram.

† If there is no decoupling filter, this reading will be simply the DC resistance of L-10, the primary of the output IF transformer T-5.

A wide divergence is given for the coils L-8, L-9, L-10, and L-11, to allow for differences between receivers. In any one receiver, owing to the common use of matched transformers, these coils should all check very close to the same value within the limits given.

Signal-substitution test procedure for an inoperative IF amplifier.

The test oscillator, receiver, and output meter are connected as shown in Fig. 13–22. The signal generator is adjusted for modulated output on the IF band. The receiver is adjusted for maximum volume, minimum bass response, and maximum selectivity (if there is such a control); the RF portion is made inoperative by shorting the oscillator section of the gang tuning condenser. Let us assume normal operation of the audio amplifier, as proved by a normal response when an audio test signal is applied to point ⑤, the input of the AF amplifier, and no response or weak response when a modulated signal at the intermediate frequency is applied to point ④, the converter signal grid.

Step 1. The test lead from the signal generator is moved to point ②, the converter plate.

1. If a normal response results, the trouble may be
   a. A shorted converted signal grid (most likely a short in the gang tuning condenser).
   b. A defective converter tube (substitute a good one).
   c. Open or shorted plate, screen, or cathode circuit in the converter tube (detected by voltmeter check).

2. If the signal does not come through or remains very weak, move on to step 2.

Step 2. The test lead from the signal generator is moved to point ③, the IF grid.

1. If a normal response (3,500 microvolts input for standard output) results, the trouble may be
   a. A defective input IF transformer (detected by ohmmeter check).
   b. An open AVC by-pass condenser C-28. (Bridge it with a good one and recheck from point ①.)
   c. Input IF transformer T-4 badly misaligned (check alignment).

2. If the signal does not come through or remains very weak, move on to step 8.
Fig. 13-22.—Signal check for locating trouble in an IF amplifier.
Step 3. The test lead from the signal generator is moved to point ①, the IF plate. The attenuator is advanced, and the frequency control is wobbled through the intermediate frequency.

1. If the signal comes through, the trouble may be
   a. A shorted IF grid. (Detected by ohmmeter check. The short would most likely be between the grid wire or trimmer and the IF shield can.)
   b. A defective IF tube (substitute a good one).
   c. Open or short in the plate, screen, or cathode circuits of the IF tube (detected by voltmeter check).

2. If the signal does not come through, check the detector stage (see Chap. 12).

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Abnormal reading</th>
<th>Look for</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reception</td>
<td>Plate voltage = 0</td>
<td>Open IF output transformer. Shorted plate by-pass condenser C-25. Open plate circuit decoupling resistor R-25. Plate-to-ground short in IF can</td>
</tr>
<tr>
<td></td>
<td>Screen voltage = 0</td>
<td>Shorted screen by-pass condenser C-24. Open screen voltage-dropping resistor R-24</td>
</tr>
<tr>
<td></td>
<td>High cathode voltage</td>
<td>Open minimum-bias resistor R-23</td>
</tr>
<tr>
<td></td>
<td>All voltage checks are normal</td>
<td>Dead IF tube V-3. Shorted trimmers in the IF cans. Open IF transformer secondaries. Open AVC by-pass condenser C-28</td>
</tr>
<tr>
<td>Weak signal</td>
<td>All voltage checks are normal</td>
<td>Weak IF tube V-3. Open AVC by-pass condenser C-28. Open cathode by-pass condenser C-23. Open plate circuit by-pass condenser C-25. Misalignment</td>
</tr>
<tr>
<td>Noise</td>
<td>All checks are normal</td>
<td>Noisy IF tube V-3. Corrosion in the IF transformer windings</td>
</tr>
<tr>
<td>Squeal or oscillation</td>
<td>All checks are normal</td>
<td>Open screen by-pass condenser C-24. Open ground connection to shielding. Incorrect IF tube V-3. Open AVC by-pass condenser C-28. Open plate circuit by-pass condenser C-25. Incorrect wire dress</td>
</tr>
</tbody>
</table>
QUESTIONS

1. A receiver does not play. Signal check shows normal operation when a test signal is applied to the IF plate; no response when the test signal is shifted to the IF grid. List the likely sources of trouble, and explain how you would check for each.

2. A receiver does not play. Signal check shows normal operation when the proper test signal is applied to the IF grid; no response when the test signal is shifted to the converter plate. List the likely sources of trouble, and explain how you would check for each.

3. The receiver of Fig. 12–17 is inoperative. A signal check shows that the trouble is in the IF stage. A voltage check gives normal readings for the stage. List the likely causes of the trouble, and explain how you would check for each.

4. A receiver gives the following voltage readings for the IF stage:
   Plate ........................................ 250 volts
   Screen ........................................ 130 volts
   Cathode ...................................... 50 volts

What is the probable trouble, and how would you check for it?

5. A receiver gives the following voltage readings for the IF stage:
   Plate ........................................ 0 volt
   Screen ........................................ 95 volts
   Cathode ...................................... 1 volt

What are the probable troubles? What should the next checks be?

6. An AC superheterodyne receiver oscillates badly. The oscillation continues when the converter tube is removed but stops when the IF tube is removed. This indicates that the cause of the trouble is probably in the IF stage. What checks and adjustments should be made to track down the trouble?

7. What factors in the IF stage can cause noisy reception? How would you check for each?
CHAPTER 14

CONVERTER: MIXER AND OSCILLATOR STAGES

After the IF check, the next area for investigation is the converter, which consists of two distinct stages: the mixer and the oscillator. Their functions are so closely interrelated that they are best handled as one unit—the converter. In most receivers, the two stages are combined in one pentagrid converter tube. Although some receivers use separate mixer and oscillator tubes, service analysis is similar for both types of receivers.

The modulated RF signal from the stage before the converter is fed to the mixer grid of the converter tube, where it is mixed with the unmodulated RF signal from the local oscillator stage. The signal on the mixer grid, regardless of frequency, is changed by the converter to a signal with the same frequency, the intermediate frequency of the receiver. The signal at the intermediate frequency retains the same audio modulation that is present in the RF signal fed to the mixer grid. The IF signal is then fed to the input of the IF amplifier.

Many superheterodyne receivers do not incorporate an RF stage. In receivers of this type, the antenna is coupled to the converter mixer grid. In the signal-substitution method of servicing, where the trouble shooter works from the speaker back to the antenna, the converter will be the last area of investigation for receivers of this type.

Quick Check for the Operation of the Oscillator Stage.—Tune the receiver to 600 kc. Connect the signal-generator output to the converter signal grid through a 0.1 mfd condenser, and rotate the signal-generator dial through 600 kc. If the signal-generator modulation note is heard in the speaker at or near 600 kc, the oscillator is functioning.

Quick Check for the Operation of the Mixer Stage.—Tune the receiver to 1,400 kc. Connect the signal-generator output to the RF grid (antenna if there is no RF stage) through a 0.00025-mfd condenser, and rotate the signal-generator dial through 1,400 kc. If the signal-generator modulation note is heard in the speaker at or near 1,400 kc, the mixer stage is functioning.
Function of the Converter.—The function of the converter is fourfold:

1. It tunes and amplifies the received signal.
2. It generates an unmodulated RF signal of its own at a frequency different from the received signal.
3. It mixes the locally generated signal with the received signal.
4. It maintains a constant frequency difference (the intermediate frequency) between the locally generated signal and any signal to which the receiver is tuned.

Standard Circuit of a Converter.—This circuit is shown in Fig. 14–1.

![Diagram of a pentagrid converter circuit]

Fig. 14–1.—Typical pentagrid converter circuit.

Theory of Operation of the Converter.—The theory of operation of the converter can be explained by elaborating the four functions listed above.

1. *It tunes and amplifies the received signal.* The input of the stage is RF transformer T-2, which couples the preceding RF stage or antenna to the converter tube. Tuning is accomplished by the circuit composed of L-5 and C-5, which feeds the signal to G-4, the signal grid of the converter tube. Grids G-3 and G-5 are tied together and act as a screen, so that this section of the converter tube plus cathode and plate is a tetrode amplifier. Condenser C-5 is one section of the ganged tuning condenser.
2. It generates an unmodulated RF signal of its own at a frequency different from the received signal. The cathode and grids G-1 and G-2 act as a triode oscillator. This can be more easily seen by re-drawing the oscillator stage of the converter, as shown in Fig. 14–2. Grid G-1 acts as the oscillator grid while grid G-2 acts as the oscillator plate or anode. Coil L-6 and its associated condenser C-6 are located in the oscillator grid circuit and make up the tuning section for the oscillator. Condenser C-6 is the oscillator section of the gang tuning condenser. Feedback from the plate circuit is obtained by coupling between L-6 and L-7, the latter coil being in the oscillator anode circuit. The feedback is in proper phase and of sufficient strength to maintain oscillation, the frequency of which is controlled by L-6, C-6, C-6A, and C-7. The function of condenser C-7 will be explained in more detail in the section on tracking.

3. The converter mixes the locally generated signal with the received signal. The electron stream coming from the cathode is caused to pulse by the oscillator action of grids G-1 and G-2, at a rate determined by the values of L-6, C-6, C-6A, and C-7. Since the oscillator anode is not a solid plate but a pair of rods, most of the pulsing electron stream will go right through the oscillator anode G-2 to the rest of the converter tube. The received signal is applied at G-4, where it contributes its own effect on the pulsing electron stream, thereby mixing the signal and oscillator output in the converter tube. Grid G-4 in the converter tube is sometimes called the “converter signal” grid, and sometimes called the “mixer” grid. The plate output circuit of the converter tube, therefore, will contain a signal with components at the received signal frequency, the oscillat-
tor frequency, the sum of these two frequencies and the difference of these frequencies. This type of mixing of two signals is known as "electron" mixing.

4. The locally generated signal must maintain a constant frequency difference (the intermediate frequency) with any signal to which the receiver may be tuned. Of all the signals present in the converter plate circuit, the IF amplifier accepts only the one to which it is tuned. This is the signal that is at the difference frequency between the received signal and the locally generated signal. The oscillator frequency is usually higher than the frequency of the received signal. A few examples may clear this up. The most commonly used intermediate frequency is 455 kc. This will be used in the examples. Let us assume that the wanted station signal is 1,000 kc, approximately in the center of the broadcast band. Then the signal tuning circuit \((L-5, C-5)\) will be at 1,000 kc. The frequency of the oscillator section, controlled by \(L-6, C-6, C-6A,\) and \(C-7,\) will be 455 kc higher, or 1,455 kc.

The converter plate circuit will contain various frequency components:

\[
\begin{align*}
1,000 \text{ kc} & \quad \text{Received signal} \\
1,455 \text{ kc} & \quad \text{Oscillator signal} \\
2,455 \text{ kc} & \quad \text{Sum of the above} \\
455 \text{ kc} & \quad \text{Difference between the first two}
\end{align*}
\]

The sharply tuned IF amplifier will accept the signal at 455 kc, amplify it, and pass it on to the detector.

If the desired signal is near the low-frequency end of the broadcast band at 600 kc, the signal input circuit \((L-5, C-5)\) will be tuned to 600 kc, and the oscillator tuning circuit composed of \(L-6, C-6, C-6A,\) and \(C-7\) will be tuned to 1,055 kc, making the difference frequency 455 kc.

At the high-frequency end of the broadcast band, the oscillator must be adjusted to 1,955 kc to receive a signal at 1,500 kc. The two signals are mixed in the converter tube, giving, among others, the same difference frequency of 455 kc.

From the above examples, it can be seen that the prime function of the converter is to change any received signal to a signal at 455 kc, the intermediate frequency. It follows as a corollary that the oscillator frequency must be greater by 455 kc, the intermediate frequency, than the desired station signal frequency.

An oscillator frequency 455 kc lower than the desired signal frequency could also be used. This is sometimes done in reception on the short-wave bands.
Tracking.—In a receiver operating on the broadcast band, condenser $C-5$ tunes coil $L-5$ from 550 to 1,600 kc in the received signal circuit (the mixer grid circuit). In the oscillator tuning circuit, condenser $C-6$ tunes coil $L-6$ from 550 plus 455, or 1,005 kc to 1,600 plus 455, or 2,055 kc, where the IF amplifier is tuned to 455 kc. Since condensers $C-5$ and $C-6$ are parts of the same tuning gang, there is considerable design work needed to make these two tuning circuits always 455 kc (or the intermediate frequency) apart. The ability of a receiver to perform equally well on all parts of the tuning range is dependent on this factor, which is known as "tracking." Alignment instructions often include tracking adjustments on both ends of the tuning range and a tracking check in the center. The usual check points on the broadcast band are 600 kc for the low-frequency end, 1,000 kc for the middle, and 1,400 or 1,500 kc for the high-frequency end.

Oscillator Tuning Circuit.—The RF tuning circuits have a tuning range for the broadcast band of 550 to 1,600 kc. The oscillator tuning circuit for the same band must have a tuning range of 1,005 to 2,055 kc. The two tuning circuits must, therefore, be considerably different.

The oscillator tuning circuit can perhaps be better understood if it is redrawn, as in Fig. 14–3. It can now be recognized as an $L$-$C$ circuit, the $L$ being the oscillator coil. The $C$ of the $L$-$C$ circuit is composed of the main tuning condenser $C-6$ with its shunt trimmer $C-6A$, both of which are in series with condenser $C-7$. The latter is an adjustable condenser of comparatively high capacity. Trimmer $C-6A$ is a low-capacity unit. Now we need only remember that the capacity of condensers in series is lower than the individual condensers, whereas the capacity of condensers in parallel is additive.
When tuning condenser C-6 is in a low-capacity position, the lumped C in the tuning circuit is small (series condensers). Trimmer condenser C-6A is an important cog at this position since its small capacity is added to the small capacity of the tuning condenser. The setting of trimmer condenser C-6A, therefore, controls the low-capacity (high-frequency) end of the tuning range. This trimmer is often called the "high-frequency oscillator aligner."

When tuning condenser C-6 is in a high-capacity position, the lumped C in the tuning circuit is high since it is composed of two comparatively large condensers in series. Trimmer condenser C-6A has little effect in this position since its small capacity is added to the large capacity of the tuning condenser. At this time, the setting of adjustable condenser C-7 becomes of greater importance, since its capacity, now of about the same order as that of the tuning condenser, will have a greater effect on the lumped C in the circuit. The setting of adjustable condenser C-7, therefore, controls the high-capacity (low-frequency) end of the tuning range. Since this adjustment is usually performed at 600 kc, condenser C-7 is often called the "600 padder."

Cut-plate Oscillator Tuning Condensers.—In some receivers oscillator tuning condenser C-6 has been designed to maintain the 455-kc difference without a low-frequency padder adjustment. In this case, the rotor plates of condenser C-6 are smaller and differently shaped than the rotor plates of the other condensers in the tuning gang, as shown in Fig. 14–4. When the oscillator rotor plates are shaped in this manner, the gang condenser is known as one having a "cut-plate oscillator" section. The shape of the cut plates is so designed that tracking is automatic, in that the capacity in the oscillator circuit maintains its frequency at a value 455 kc higher than the frequency of the received signal.

Functions and Values of Parts in the Converter.—From the above discussion, it can be seen that the values of the component parts in the tuning section of the receiver are an important part of the design of any receiver. The serviceman rarely, if ever, changes the values of any of these parts, since any such changes will seriously affect the operation of the receiver in selectivity, sensitivity, and dial calibration. Defective components in the tuning circuit usually require the serviceman to obtain the original manufacturer's replacement parts. As a result, values of parts need not be given, and it merely remains to state the functions of parts not yet mentioned.

The oscillator grid leak and condenser, R-19 and C-19, develop the oscillator grid-bias voltage. When a tube is in an oscillating condi-
tion, there is considerable grid current. This flows through $R-19$ and causes a voltage drop across it. The grid end of the resistor is negative, giving the bias voltage for the oscillator section of the tube.

The voltage developed across $R-19$ is also important from a service point of view, since it makes a good check as to whether the oscillator is operating.

Oscillator grid-leak resistor $R-19$ is usually a 50,000-ohm/½-watt resistor. Oscillator grid condenser $C-19$ is usually a 0.0001-mfd mica condenser. Occasionally, a paper tubular condenser is used for $C-19$.

![Diagram of condenser gangs with similar rotor plates and with a cut-plate oscillator section.](image)

Fig. 14-4.—Comparison between condenser gangs with similar rotor plates and with a cut-plate oscillator section.

Minimum-bias circuits were described in some detail in connection with $R-23$ and $C-23$ in the chapter dealing with the IF stage. Resistor $R-18$ and condenser $C-18$ form a similar circuit for establishing a minimum-bias voltage to be applied to the signal grid of the pentagrid converter, where AVC operation is used.

Resistor $R-18$ is usually a 300-ohm/½-watt resistor. In some circuits, $R-18$ is made somewhat larger, 500 to 600 ohms. In these circuits the tube is being operated at a higher minimum-bias voltage. The by-pass condenser $C-18$ is usually 0.05 to 0.1 mfd. The voltage rating of this condenser is unimportant since it is a low-voltage circuit. In some circuits, $C-18$ may be omitted to provide some degeneration in the converter.
Finally, both $R-18$ and $C-18$ may be omitted, and the cathode of the converter tube is tied to the cathode of either the RF or IF tube, resulting in a common minimum-bias voltage for both tubes.

The AVC decoupling filter ($R-29$ and $C-29$) has been described in the detector and AVC stage. Typical values are 100,000 ohms/$\frac{1}{2}$-watt for $R-29$, and 0.05 mfd/400 volts for $C-29$. When there is no RF stage, $R-29$ and $C-29$ are usually omitted, and the signal grid return of coil $L-5$ is connected directly to the AVC bus.

The tube used is the metal 6A8 pentagrid converter. The 6A8-G or 6A8-GT are also used in similar circuits. In the latter case, the tube is usually covered by a closely fitting metal shield. Receivers using loctal-type tubes use the 7B8 or 7B8-LM. An older variety of the same tube is the 6A7.

Another tube very commonly employed is the 6SA7 pentagrid converter. In this case the circuit is somewhat different. A circuit using the 6SA7 will be described in Chap. 15.

AC/DC receivers may use any of the above tubes in circuits where the filament drain is 0.3 amp. In circuits utilizing a 0.15-amp filament line, 12-volt/0.15-amp tubes like the 12A8, 12SA7, and 14Q7 pentagrid converters are used.

The oscillator anode filter circuit, $R-20$ and $C-20$, also acts as a voltage-dropping device for the oscillator anode. $R-20$ is usually a 20,000-ohm/$\frac{1}{2}$-watt resistor and $C-20$ is a 0.1-mfd/400-volt condenser. Where the total $B$ voltage of the receiver is 200 volts or less, $R-20$ and $C-20$ may be omitted.

The converter-plate-circuit decoupling filter consists of $R-22$ and $C-22$. Resistor $R-22$ is usually 400 to 1,000 ohms, while condenser $C-22$ is 0.05 to 0.1 mfd. Like all decoupling or isolating circuits, $R-22$ and $C-22$ may be omitted.

The input to the mixer stage of the converter is the RF transformer $T-2$. The primary $L-4$ is in the plate circuit of the RF tube, or antenna circuit where no RF stage is used. The secondary $L-5$, which is tuned by $C-5$ of the ganged variable condenser, feeds the signal to the signal grid of the pentagrid converter tube. In some receiver circuits, RF transformer $T-2$ is replaced by an untuned resistance-coupled stage.

In receivers that do not use an RF stage, RF transformer $T-2$ couples the antenna to the signal grid of the pentagrid converter tube. In this case, $L-4$ the primary of the transformer is connected to the antenna and ground. In loop-operated receivers that do not use an RF stage, RF transformer $T-2$ is replaced by the loop antenna. Coil $L-5$ is the main part of the loop, which is still tuned by condenser $C-5$ in the usual way. Primary coil $L-4$ consists of two or
three turns on the loop, which may be connected to an external antenna and ground when it is desired to obtain greater signal pickup. Figure 15-2 shows a loop-operated receiver of this type.

NORMAL TEST DATA FOR THE CONVERTER

Signal Check for Normal Operation of the Oscillator.—When the operation of the oscillator is checked, the test signal is applied to the converter mixer grid (sometimes called the "signal" grid). This is the same point that was used in checking the IF amplifier. Before the oscillator check is made, any short that had been placed on the oscillator tuning condenser for previous tests is removed. The receiver is tuned to 600 kc. The signal-generator dial had been set at 455 kc for checking the IF amplifier. At this position, the modulation note will still be heard in the speaker. The signal-generator dial is then rotated past 600 kc. As the dial leaves 455 kc, the modulation note should die out, and it should be heard again, at about the same volume as before, when the signal-generator dial pointer passes 600 kc. This is the signal check for normal operation of the oscillator portion of the converter.

If the modulation note is not heard, the oscillator section is inoperative. If the note is considerably weaker than the note at 455 kc, the converter tube is probably weak. If the note is heard when the signal-generator frequency control is at a considerable distance from 600 kc, the oscillator circuit is probably out of alignment.

This check could be performed at any position in the tuning range. However, it is recommended that the check be performed at 600 kc, since oscillator action is normally weaker at the low-frequency end of the tuning range.

Signal Check for Normal Operation of the Mixer.—When normal operation of the oscillator section has been found, the next step is to check for normal operation of the mixer portion of the converter. The test signal is applied through a 0.00025-mfd condenser to the control grid of the RF tube. Where there is no RF tube, the test signal is applied to the antenna lead of the receiver. The antenna lead is, of course, readily available. The same applies to the control grid of the RF tube in the case of a 6K7 where it is the top contact. Where a single-ended RF tube is employed, the test point is most easily available at the stator connection of the RF section of the gang tuning condenser.

The receiver dial is set to 1,400 kc. If an output meter is connected to the receiver, it should be switched to a high-voltage range. This is important since the amplification from the RF grid is very
high and even a moderate test-signal input may furnish sufficient output voltage to bend the output meter pointer.

The signal generator frequency control is rotated a few points each side of 1,400 kc. When the receiver is functioning normally, the signal generator modulation note should be heard in the speaker as its dial pointer passes 1,400 kc. It should be considerably louder than the last check (the oscillator section), where the test signal was applied to the mixer grid.

If the signal-generator note is not heard, the mixer section must be checked. The same applies if the check shows no gain over the check from the mixer grid. If the note appears at a considerable distance from 1,400 kc on the signal-generator dial, alignment is indicated.

Normal Voltage Data for the Converter.—Readings taken from indicated terminals to the chassis or common negative terminal of the receiver are given in the accompanying table.

<table>
<thead>
<tr>
<th>6A8 pin No.</th>
<th>AC receiver, volts</th>
<th>AC/DC receiver, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>3</td>
<td>250</td>
</tr>
<tr>
<td>Screen</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>Oscillator anode</td>
<td>6</td>
<td>200</td>
</tr>
<tr>
<td>Oscillator grid</td>
<td>5</td>
<td>-15</td>
</tr>
<tr>
<td>Cathode</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

Normal Resistance Data for the Converter.—Resistance data are given in the following table.

Across L-4, primary of the signal input transformer T-2 .... 40 ohms
Across L-5, secondary of the signal input transformer .... 5 ohms
Across L-6, grid coil of the oscillator transformer T-3 .... 5 ohms
Across L-7, feedback coil of the oscillator transformer .... 3 ohms
Cathode to chassis ........................................ 800 ohms*
Signal grid (G-4) to chassis ................................ 1,600,000 ohms
Screen grid (G-3 and G-5) to chassis .... 30,000 ohms*
Plate to B plus .......................................... 640 ohms*
Oscillator grid (G-1) to chassis .......... 50,000 ohms
Oscillator anode (G-2) to B plus .......... 20,000 ohms

*These readings are for the standard circuit and should be checked against service notes for any particular receiver.

In receivers where the signal input transformer T-2 is a loop antenna, the grid coil of the loop will measure 1 to 3 ohms. The antenna winding will measure less than 1 ohm.
Stage-gain Measurements for the Converter from the Converter Signal Grid.—The serviceman should run some checks on receivers known to be in perfect operating condition, so that he has a basis of comparative data on his bench test equipment, and normal gain data to be expected from the converter. In addition, he should tabulate his experience with each of the various types of converters.

There are two check points for the converter: the converter signal grid G-4, and the RF grid or antenna, if the receiver does not use an RF stage. The receiver, signal generator, and the output meter are connected, as shown in Fig. 14-5 to check from the converter signal grid. The receiver is adjusted as follows: The volume control is set to the maximum-volume position; the tone control to the minimum bass position; the selectivity control is set for the position of maximum selectivity; and the receiver dial is adjusted to 600 kc. Any short placed across the oscillator section of the tuning condenser gang for previous tests should be removed. The output meter is switched to a high-voltage range. The signal-generator output leads are connected shield to chassis, and the “hot” lead through a 0.1-mfd condenser to the converter signal grid. The signal generator is adjusted to give a modulated signal on the broadcast band. The attenuator setting is kept comparatively low, since approximately 50 microvolts will give standard output from the receiver.

The frequency-control dial on the signal generator is rotated through 600 kc for peak output from the receiver. When the peak position is found, the attenuator on the signal generator is adjusted to give the standard output of 50 mw from the receiver. When the output voltage is low enough, the range switch of the output meter is reduced so that the 16 volts which correspond to 50 mw can be read more accurately.

The average 600-kc signal strength necessary to give standard output from the converter signal grid is 50 microvolts. In making stage-gain checks for the IF amplifier (see page 197), it was seen that the average IF signal strength necessary to give standard output from the converter signal grid was also 50 microvolts. From the above it may be seen that the gain of the receiver from the converter signal grid should be approximately the same for a signal at the intermediate frequency as for the RF signal to which the receiver is tuned. Any great difference in signal input for standard output would indicate a defective converter tube.

Stage-gain Measurements for the Converter, Including the Tuned Signal Grid Input.—Since the capacity of the signal generator will define the converter signal grid circuit, measurements to include the tuned circuit must be made, as was done in all other checks,
Signal Generator Setting
- Modulation: On or Internal
- Range Switch: To Cover 600KC
- Frequency Control: Rotate through 600KC for peak indication
- Attenuator: Adjust for standard output, average setting = 50μV

Receiver Settings
- Volume Control: Maximum
- Tone Control: Maximum Hlghs
- Fidelity Control: Maximum Selectivity
- Dial: 600KC

Output Indication
- Standard output: 16 Volts or Specification

Fig. 14-5.—Stage-gain measurements from the mixer grid.
from a previous point in the receiver. Figure 14–6 shows the connections for a receiver with an RF stage. Note that the condenser in the "hot" lead of the signal generator is 0.00025 mfd. When the

receiver has no RF stage, measurements are made from the antenna terminal, as shown in Fig. 14–7. When the receiver has no RF stage and is loop-operated and there is no antenna terminal on the receiver, the signal generator is fed into a loop made up of a few turns of wire. This loop is then placed near the loop antenna of the receiver, as shown in Fig. 14–8. In all cases, the receiver is adjusted for maximum gain; that is, the volume control is set to the full on position, tone control to the minimum bass, and the selectivity-
fidelity control to the position of maximum selectivity. The receiver dial is turned to 1,500 kc. (If a station is received at this frequency, it will interfere with the check. When this is the case, the receiver is tuned to a quiet part of the dial between 1,400 and 1,600 kc.) The output meter is set for a high-voltage AC range. The signal generator is adjusted for a modulated output on the broadcast band.

The frequency-control dial on the signal generator is then carefully rotated through 1,400 to 1,600 kc for peak response from the receiver. When the peak position is found, the attenuator is adjusted to give the standard output of 50 mw in the speaker. When the standard output has been obtained, the signal-generator fre-

![Diagram](image)

**Fig. 14-8.**—Method of connecting a signal generator to a loop-operated receiver.

quency control is again adjusted for peak response on the output meter, and the attenuator readjusted if a response greater than 50 mw was obtained. This repetition is necessary because a high-level signal input would bring AVC action into play with a consequent broadening of the peak.

The average signal strength at 1,500 kc needed to give the standard output of 50 mw from the antenna of a receiver that does not use an RF stage is 20 microvolts. Since an average of 50 microvolts is required to produce the same effect from the converter signal grid, the apparent approximate gain between the antenna and the converter signal grid is $\frac{50}{20} = 2.5$.

When a receiver uses an RF tube, the average input signal (at 1,500 kc) applied to the RF grid is 5 microvolts for standard output from the receiver. In this case the apparent gain between the converter signal grid and the RF grid is $\frac{50}{5} = 10$. The added gain is due to the amplification of the RF tube.
Having established comparative gain data with several good receivers, the serviceman is in a position to judge the gain characteristics of any converter stage. He should remember, however, that these checks are approximate and that there will be considerable variation shown when different receivers are checked.

A signal of 5 microvolts is about the lower limit that can be expected from the average signal generator. Leakage in the attenuator circuits, insufficient shielding, and the increased noise level when working at lower signal levels make it extremely difficult to carry out even approximate stage-gain measurements. For this reason, gain data for the antenna circuit of a receiver that uses a tuned RF stage will not be given.

**COMMON TROUBLES IN THE CONVERTER**

**Troubles Common to the RF Input Transformer.**—The RF input transformer, T-2, is likely to be an interstage RF transformer coupling the RF stage to the converter, or an antenna coil coupling the antenna to the converter, or a coil loop acting as the antenna for the receiver, depending on the type of receiver. The three types of coupling units all have one common trouble—that is, the windings open—but they present different service problems and will be handled separately.

**Service Notes for an Interstage RF Transformer.**—An open secondary winding of an interstage RF transformer will be found on signal check. At such time, when a test signal, either at RF or IF, is fed into the converter signal grid, the signal will come through to the speaker, but the gain will probably be low. In addition, the modulation note of the signal generator will have a rough tone due to the open grid circuit. When the test signal is applied to the RF grid, the response will be very low. The condition is then confirmed with an ohmmeter check.

When the primary of the interstage RF transformer is open, the receiver will operate normally when the test signal is applied to the converter signal grid but will not operate at all when the test signal is shifted to the RF grid. A voltage check will then show no voltage at the RF plate, and a continuity check will confirm the trouble.

Before a defective interstage RF transformer is replaced, it would be wise to examine the coil, since the break is often at or near a terminal lug and is easily repaired. Even removing a turn to effect a repair is permissible.

An exact replacement of the RF interstage transformer is necessary, since tuning circuits will not bear wide tolerances. However,
at times, the coil is beyond repair, an original replacement cannot be obtained, and a general replacement transformer is the only alternative. In this case, the serviceman should choose the replacement transformer carefully, so that it matches the original as closely as possible in physical characteristics. The important points to keep in mind are the size of the shield, length and diameter of the coil form, and size and location of the windings.

![Diagram of RF transformer and oscillator](image)

**Fig. 14-9.—A typical interstage RF transformer and its position in the circuit.**

When the replacement transformer has coded leads, the color coding is the same as for an IF transformer.

- Blue wire: Plate
- Red wire: B plus
- Green wire: Grid
- Black wire: Grid return

The placing of the green grid lead can easily be altered to conform to the placing in the original transformer. For example, if, in the replacement, the green wire comes through the shield can for connection to a top cap on the converter tube, whereas, in the original, the grid wire was brought through the bottom to a 6SA7 converter, it takes only a few minutes to remove the coil from the shield can and reroute the wire.

When the replacement-transformer coil leads are brought to unmarked soldering terminals, the terminals can be identified as described in the next section.
How to Identify RF Transformer Coil Leads.—For the identification of RF transformer coil leads, see Fig. 14–10 and the following notes.

*Plate Lead.*—Look for the gimmick loop. Trace it to the coil terminal lug. This is the plate lead, which connects to the RF plate.

*B Plus Lead.*—Look for the leads on the primary coil. One goes to the plate lead. Trace the other lead to its terminal lug. This is the B plus lead.

*Grid Lead.*—Look for the secondary coil leads. Trace the top end of the secondary winding (near the gimmick loop) to its terminal lug. This is the grid lead, which connects to the tuning condenser stator and converter signal grid.

*Grid Return Lead.*—Check to see that the remaining terminal lug goes to the bottom end of the secondary winding. This is the grid return lead, which connects to the AVC circuit.

**Service Notes for an Antenna RF Transformer.**—An open secondary of an antenna RF transformer will be found by a signal check. The radio will operate at reduced gain and possible hum, when a test signal, either RF or IF, is applied to the converter signal grid, and at greatly reduced gain when the test signal is applied to the antenna terminal. An ohmmeter check then confirms the condition.

An open primary winding may or may not cause any appreciable difference in operation. The capacity of the gimmick loop may transfer sufficient energy from the antenna to the secondary winding, so that operation is apparently normal for local reception, and the trouble would not be found unless stage-gain measurements or routine ohmmeter checks are made. In receivers where the open pri-
mary winding causes a large difference in reception, even a rough signal check will show a loss in gain between the antenna and the converter signal grid.

All the service notes pertaining to the RF transformer can be applied to the antenna transformer, by making allowance for the fact that the primary connects to antenna and ground, instead of RF plate and B plus.

Fig. 14-11.—A typical antenna coil and a circuit showing antenna input to the converter tube

**Antenna Transformer Color Code.**—The R.M.A. color code for the antenna transformer follows:

- Blue lead ...................... antenna
- Red lead ........................ ground
- Green lead ...................... grid
- Black lead ...................... grid return

**How to Identify Antenna Transformer Leads.**—For the identification of antenna transformer leads, see Fig. 14-12 and the following notes.

**Antenna Lead.**—Look for the gimmick loop. Trace it to the coil terminal lug. This is the antenna lead, which connects to the antenna terminal of the receiver.

**Ground Lead.**—Look for the leads on the primary coil. One goes to the antenna terminal. Trace the other lead to its terminal lug. This is the ground lead.
Grid Lead.—Look for the secondary coil leads. Trace the top end of the secondary winding (near the gimmick loop) to its terminal lug. This is the grid lead, which connects to the tuning condenser stator and converter signal grid.

Grid Return Lead.—Check to see that the remaining terminal lug goes to the bottom end of the secondary winding. This is the grid return lead, which connects to the AVC circuit.

Replacement Notes for Antenna and RF Transformers.—When replacing an antenna or RF transformer, the serviceman should be careful of the placement of the leads. Improper lead dress may cause oscillation. The leads should be routed as they were in the original transformer of the receiver. If the wiring has been disturbed, the following general rules should be observed. The blue (plate or antenna) and the green (grid) leads are the “hot” wires. The transformer should be so mounted that the green lead or grid terminal points to its connection point on the tuning condenser stator or signal grid terminal of the converter tube. At the same time the blue lead (RF plate or antenna terminal) points to its connection point, the plate terminal of the RF tube socket or the antenna terminal. The leads are dressed close to the chassis and away from each other and all other wiring. The dress of the other two leads is not quite so important, but they should also be routed close to the chassis and directly to their connection points.

When an antenna transformer is being replaced in an AC/DC type of receiver, the transformer antenna terminal connects to the hank of wire that acts as the antenna or leadin of the receiver through a condenser. The purpose of this condenser is to insulate the receiver from accidental grounds through the antenna wire. The con-
CONVERTER: MIXER AND OSCILLATOR STAGES

denser is usually a paper tubular type that almost never gives any service difficulties. However, the moving of leads, coincidental with the replacement of the antenna transformer, may have caused one of the condenser terminal leads to break away from the tin foil of the plates, causing an intermittent or fading condition. It is a good idea, therefore, when replacing an antenna transformer in an AC/DC receiver to examine carefully the associated condenser terminal leads. If they appear to move under the wax, or if a gentle pull causes the receiver to fade, the condenser should be replaced. The capacity of the condenser is unimportant. Any capacity over 0.002 mfd will be satisfactory.

When the antenna or RF transformer is replaced, the circuit will have to be realigned as must be done when any component in any tuned circuit is changed. It is usual practice to realign the entire receiver.

When universal adjustable replacement antenna and RF transformers are employed, it is necessary to alter the standard alignment procedure somewhat, so that the replacement transformer may be adjusted to work properly in the circuit in which it is being placed. The adjustable feature of these coils is permeability tuning with a screw adjustment similar to that used in IF transformers, so that the inductance of the coil may be varied to suit the receiver. An adjustable replacement coil of this type is shown in Fig. 14–13.

The alignment procedure specified for the receiver being serviced, or the standard alignment procedure given on page 427, is followed down to the adjustment of the oscillator trimmer and padder condensers. At this point, the receiver dial is correctly calibrated. The hot lead of the signal generator is connected through a 0.00025-mfd condenser to the antenna terminal of the receiver, the signal generator and receiver dials are both turned to 600 kc, and the permeability adjustment screw of the replacement transformer is tuned for maximum response on the output meter. The receiver and signal-generator dials are then turned to 1,400 kc, and the RF or antenna trimmers on the gang condenser are aligned for maximum output in the usual way. The permeability adjustment-screw setting is then

![Fig. 14–13.—Universal adjustable replacement RF or antenna coil.](image)
checked at 600 kc and, if readjustment is required, the procedure at 1,400 kc is repeated.

Service Notes Pertinent to a Loop Antenna.—Loop antennas used with receivers are of many types, but they develop troubles that may be catalogued together. Loops are usually wound with heavy wire and, as a result, are rarely troubled with corrosion, which is the main cause of trouble in all other coils in the receiver. However, the posi-

![Diagram of a loop antenna and schematic diagram](image)

**Fig. 14-14.—** A loop antenna and the schematic diagram of a loop providing signal input to the converter tube.

tion of the loop in the back of the receiver makes it vulnerable to troubles of a mechanical nature. The leads connecting the loop to the receiver chassis become frayed and broken, various types of plug-in connectors lose contact, and sometimes the loop becomes partly unwound.

An open loop will be found on signal check. The radio will operate at reduced gain and possible hum when a test signal, either at modulated radio frequency or at modulated intermediate frequency, is applied to the converter signal grid. When the test signal is shifted
to the antenna lead, the radio may operate at greatly reduced gain or not at all. An ohmmeter check then confirms the condition.

It is rarely necessary to replace the loop. The broken lead or loose contact is found by inspection and repaired. A partly unwound loop is rewound, and the wire is held in place with coil dope.

If several leads have broken away, there is likely to be some confusion as to where they should be replaced. The manufacturer's service notes are helpful in this regard, since they often include a wiring diagram of the loop connections. When this information is not available, the serviceman should examine the loop antenna to determine whether the primary antenna winding (one or two turns) is on the outside or the inside of the loop winding. After that, the conventional connections for both types are shown in Fig. 14–15.

![Diagram of loop antenna connections](image)

Fig. 14–15.—Identifying loop antenna leads.

The outside and inside leads are always easily located. The two inner leads may not be so readily distinguished by visual inspection. A continuity check with the ohmmeter, however, will positively identify the inner leads. In the case of the AC/DC type of receiver, the serviceman should remember to check the insulating condenser, which should be in the antenna or ground lead.

**Troubles Common to the Tuning-condenser Gang Assembly.**—
Tuning condensers usually develop troubles of a mechanical nature which may be repaired by the serviceman. Replacement of a tuning gang with anything but the original part would be extremely difficult, since the replacement would have to match the condenser drive mechanism, and the dial and pointer. Also the plates would have to be so shaped that the dial calibrations would be reasonably accurate; in addition there are the usual considerations of size, capacity, etc. For this reason, maintenance notes on tuning-condenser gangs will be in considerable detail.

A very common trouble is slipping or failure of the condenser and dial drive mechanism. Since there are such a large number of differ-
ent types of drive assemblies in common use, the information under this heading will be generalized.

Sometimes the drive mechanism operates the dial pointer but the condenser rotor plates do not turn, resulting in no stations or one station all over the dial scale, depending on the position of the rotor plates. This is usually due to loose setscrews between the condenser drive and the rotor shaft. The cure is obvious—tightening the setscrew. Before doing so, however, the serviceman should refer to the receiver service notes to see if there are definite instructions about the positioning of the dial pointer. This information is usually given as part of the alignment instructions. If no reference can be found, the usual procedure is to rotate the gang tuning condenser until the plates are fully engaged, set the dial pointer to the last calibration mark on the low-frequency end of the dial scale, and tighten the setscrew in this position (see Fig. 14–16).

The trend in modern receivers is to use silk fish cord for the dial drive mechanism. Fortunately, receiver manufacturers are now issuing instructions for restringing the dial drive cords, as part of their service literature (see Fig. 15–2). Where this is not available, the serviceman must work out the mechanical details for himself. After some experience, a man with average mechanical ingenuity will have little difficulty with any of the multiplicity of dial drives in common use.

Servicing Condenser Contact Springs.—Another common trouble with tuning condenser gangs develops in the contact springs, often called “wipers.” Figure 14–17 shows the location of this item. The wiper makes contact between the rotor plates and the condenser shields that are grounded. Sometimes a ground wire is soldered to the contact spring, and sometimes no wire is connected. In either case, when dirt gets between the contact spring and the rotor, there will be resistance between the rotor plates and the ground. This may cause noisy reception, and even no reception over parts of the tun-
ing range. In TRF receivers, poor contact at this point is a cause of oscillation. The cure is to remove the wipers, clean them, readjust the spring tension, and return them to their positions. When the wipers are riveted in place, the spring can be pried back at the point of contact with a screw driver that has been dipped in carbon tetrachloride. The screw driver is then removed, and the drop of cleaning solution is worked back and forth by rotating the condenser gang quickly. When this procedure is repeated a couple of times for each wiper, the contact between the rotor plates and ground is reestablished.

At this time, it might be well to add a word about the general use of cleaning solutions, lubricants, and abrasives in radio service work.

Carbon tetrachloride makes a good general-purpose cleaning solution, since it dissolves grease, loosens dirt, dries quickly, is nonflammable, and is not harmful to radio parts. A light machine oil should be used for lubricating bearings, pulleys, shafts, etc. Tuning-condenser bearings should not be lubricated, since they are self-lubricating, and any oil at this point may work its way into the condenser contact springs and insulate the rotor from the ground. Where an abrasive is needed, sandpaper should be used. Steel wool and emery cloth should not be used on or near a receiver. Although steel wool will do a good cleaning job on a condenser contact spring, particles of it getting into the tuning gang or into the speaker will cause considerable trouble. The abrasive material in emery cloth is also a conductor and will cause similar troubles.

**Shunt Resistance and Shorts in Variable Gang Condensers.**—Condensers, especially when not covered by shielding, collect a considerable amount of dust and dirt. When a bakelite stator-plate
support or a trimmer condenser is dusty, the dust will act as a shunt resistor between the stator and the ground. The shunt resistance may cause very little effect on the operation of the antenna and RF stages, but it can seriously impair the operation of the oscillator. Dusting with a soft brush usually takes care of the trimmer condenser, and a wash with carbon tetrachloride cleans the stator insulator.

A short between the stator and the rotor plates of any condenser in the tuning gang will cause noisy reception and dead spots in the tuning range. The short may be due to a number of causes: one or more bent plates (usually in the rotor), shifted stator plate, dirt and dust between the plates, and, in the case of plated condenser plates, slivers of plating sometimes peel, causing shorts as the condenser is rotated. A detailed procedure for locating and removing these shorts is given as part of the general overhaul procedure that follows.

**General Reconditioning Procedure for Variable Gang Condenser.**

1. *Clean.* Blow out the dust by applying a gentle air pressure, as from a bicycle pump, to all parts of the variable gang condenser. Go over the trimmer condensers and stator supports with a soft brush. Wash the stator supports with carbon tetrachloride. Clean
the condenser contact spring as described on page 235. Clean and lubricate the dial drive mechanism.

2. **Tighten and align the stator plates.** Examine the insulators that hold the stator plates in position. Figure 14–18 shows a common method of supporting the stator plates. Most condensers have a similar arrangement. The machine screws that hold the assembly together may loosen, making for poor contact with the stator soldering lug and also allowing the stator plates to slip out of parallel alignment. Figure 14–19 represents a condenser where this has happened. To repair this condition, pry the stator plates back into parallel alignment with the rotor plates, making sure at the same time of equal spacing between the plates, and then tighten the screws. Even if the plates have not slipped out of position, the

![Diagram](image)

Fig. 14–19.—Stator plates out of parallel alignment because of loosened holding screws.

screws usually require retightening. In condensers where the spacing between plates is very small and parallel alignment and equal spacing cannot be judged by eye, spacing shims can be made by cutting stiff paper into strips. An ordinary business card is of about the right thickness. The shims are inserted between the plates on both sides of the rotor shaft, the screws are tightened, and the shims removed.

3. **Check the tension on the rotor.** The friction bearing on the rear of the rotor shaft should be tight enough to hold the rotor in any position, even if the radio is jarred, and should be loose enough so that the condenser rotor shaft can be turned easily by hand. If the tension is wrong, it should be adjusted. Most variable gang condensers have a tension adjustment screw similar to that shown in Fig. 14–20. The lock nut is loosened and the adjusting screw is turned. Tightening the screw tightens the tension. The screw should be turned about a quarter turn in the correct direction, while the rotor is held stationary. The lock nut is then tightened and the tension checked. If further adjustment is required, the procedure
is repeated. The front bearing of the rotor rarely requires any attention.

4. Locate and remove any shorts. The cleaning of the trimmer condensers and stator insulators, and the correct aligning of the stator plates, removed some of the possibilities for shorts and shunt resistance in the variable gang condenser. There are still dust between plates, bent rotor plates, and slivers of plating to be considered. To find these, remove the wiring from the condenser stator soldering lugs, and then apply high voltage between the stator connection and the chassis while turning the rotor. The high voltage will show an arc at any shorting position. The arc will probably burn up any dust or sliver of plating that caused the short (thereby automatically removing it) and will show the position of a bent plate. The high voltage is most easily obtained from the rectifier plate terminal. Use a test lead with an alligator clip on one end and an insulated test prod on the other. Clip the alligator to one of the plate leads of the full-wave rectifier (socket terminal 4 or 6 for a 5Y3-G rectifier) and keep the test prod where it can reach the condenser stator terminals. Switch the set on, touch the test prod to one of the stator lugs momentarily while watching for an arc either in the condenser or at the stator terminal. Turn the rotor plates in and out of mesh while the prod is connected. If a bent plate is discovered, turn the current off, straighten the plate, and then resume the procedure until all signs of shorts have disappeared. The procedure is then repeated for the other condensers in the tuning gang.

In this procedure, it must be emphasized that the serviceman is working with a live lead at 300 or more volts, which is quite dangerous. He should have the current on only when needed, the test lead should be well insulated, and he should exercise care and alertness in his movements. He should also remember that shorting the high-voltage winding may ruin the transformer. That is why the test prod is touched to the condenser stator momentarily for checking the location of a short. It should not be left on a shorted condenser for any length of time.

When an AC/DC receiver is serviced, the transformer high-voltage winding is not available right on the same chassis. In this
case, a separate transformer may be used, connecting one high-voltage lead to the chassis, and the other to the test lead. The same procedure is then followed.

When all shorts have been removed, the stator leads are then resoldered.

5. Check the dial drive. The dial drive mechanism is then checked. If it is the cord or belt type and shows signs of wear, replace it. If it is the type that uses a friction rim drive, it will usually respond to a thorough cleaning. Finally check the position of the pointer, as described on page 234.

Troubles Common to the Oscillator Coil.—As with all other coils in the receiver, the main difficulty encountered with oscillator coils is open windings. If either winding opens, the oscillator will not function and the receiver will not pick up any stations. Signal check will isolate the oscillator stage as the field of trouble, since when a modulated test signal is applied to the converter signal grid at the intermediate frequency, there will be normal response from the receiver, whereas when the signal generator test frequency is shifted to radio frequency, there will be no response. An open feedback winding will be indicated in a voltage check, when no voltage appears at the oscillator anode. Since an open R-20 or a shorted C-20
can also cause no voltage at the oscillator anode, an ohmmeter is used for the final check. The ohmmeter check will also show up an open grid winding on the oscillator coil.

If the oscillator coil proves defective, it is usually necessary to obtain an exact replacement of the original, since the oscillator circuit controls the calibration of the dial scale. When an exact replacement is used, it is necessary only to connect the wiring to the new coil without disturbing the lead dress and to realign. It is, of course, necessary to connect the leads correctly, since a reversal of the connections to either winding will reverse the phase of the feedback coil, and the circuit will not oscillate. A good way to make sure that the rewiring is correctly done is to follow the procedure suggested for replacing volume controls. The old coil is loosened with the wiring intact, the new coil is mounted, and the wiring is shifted one wire at a time to its corresponding soldering lug.

When an exact replacement oscillator coil is not obtainable, it is possible to use a universal adjustable replacement coil, where the inductance of the coil may be varied by means of a permeability adjustment screw. When this is done, it is necessary to follow the instruction sheet with reference to identifying the coil terminals, since oscillator coils are rarely color-coded. It is also difficult to determine the ends of the windings, since the windings are usually wax-impregnated and closely coupled.

The replacement coil is mounted in such a way that the oscillator grid and anode leads are short. The replacement coil is then wired and the receiver is realigned. However, it is necessary to alter the alignment procedure, so that the universal replacement oscillator coil may be adjusted to work properly in the receiver in which it is placed.

**Aligning a Universal Replacement Oscillator Coil.**—When the receiver is of the type that uses cut plates in the oscillator section of the variable gang condenser and there is no 600 paddler, the alignment procedure is as follows: First, the IF transformers are aligned in the usual way. Then the “hot” lead of the signal generator is connected through a 0.00025-mfd condenser to the antenna, and the generator is adjusted to give a modulated signal at 600 kc. The receiver dial is turned to 600 kc, and the permeability adjustment screw on the replacement oscillator coil is aligned to give maximum response. The signal generator and the receiver dials are shifted to 1,500 kc, and the high-frequency trimmer on the oscillator section of the gang condenser is adjusted for maximum response. The procedure is repeated at 600 and 1,500 kc for optimum results. The RF and antenna trimmers are then aligned in accordance with the standard alignment procedure.
When a universal adjustable replacement oscillator coil is placed in a receiver that uses a 600 padder, the alignment procedure is somewhat more involved.

Possibly, it would be best to review the function of each of the adjustments in the oscillator tuning circuit, in the hope that the procedure may become more understandable and usable. This is done in Fig. 14-22. Condenser C-6 is the main tuning condenser, which is

![Fig. 14-22.—Oscillator tuning-circuit adjustments when a universal adjustable replacement oscillator coil is used.](image)

the oscillator section of the gang. The condenser T is the high-frequency trimmer. The condenser labeled P is the series 600 padder. The adjustment screw on the universal replacement oscillator coil controls its inductance and is labeled L. It will be remembered that the high-frequency trimmer T controls the frequency of the oscillator tuning circuit at the high-frequency end of the dial, and the series padder controls the low-frequency setting of the oscillator tuning circuit. The actions of these controls are not entirely independent, since each will have some effect on the opposite end of the tuning range. This explains why alignment procedures always recommend repeating the setting of these adjustments until they are at their correct positions, as proved by no further need for readjustment.

When the inductance of the oscillator coil is also variable, as is the case when a universal replacement is used, its adjustment will control the frequency of the oscillator circuit all over the tuning range, since this depends on the inductance as well as the lumped capacity of the circuit. As a corollary, any adjustment of the inductance by means of its permeability screw L will necessitate readjustment of the series padder and shunt trimmer. With all three controls variable and dependent upon each other, proper alignment will be extremely difficult, unless a planned procedure is followed closely.

If the 600 padder has been undisturbed, one of these variables
will be eliminated, since the padders will be close to its correct setting. In this case, the 600 padders are neglected entirely, and the receiver realigned by the procedure just given for a circuit that uses cut plates in the oscillator section of the gang condenser, and no 600 padding adjustment.

If the serviceman is not sure of the setting of the 600 padders, two alignment procedures may be used. In the first, the settings of the three adjustments are first made roughly and, then by repeated readjustments, are brought to their final positions. This procedure, although simple, is not always operative, owing to varying circuit constants and limited trimmer ranges in many receivers. The second procedure is more difficult, but it is always successful. In it, the alignment of the receiver is carried out at several prefixed positions of the 600 padders, each one is checked, and finally the position of best tracking is chosen.

Alignment Procedure No. 1 for an Oscillator Circuit with Variable Trimmer, Padder, and Inductance.

1. Check IF alignment.
2. Connect the "hot" lead of the signal generator to the antenna terminal of the receiver through a 0.00025-mfd condenser. Adjust the signal generator for a modulated output on the broadcast band.
3. Set the trimmer and padder to center-capacity range. The average trimmer and padder condensers require three full turns of the adjustment screw from full to low capacity. For approximate center-capacity setting, tighten the screws fully, then loosen one complete turn.
4. Adjust L at 1,000 kc. Tune the signal generator and receiver to 1,000 kc, and adjust the permeability screw L on the oscillator coil for maximum output.¹
5. Adjust P at 600 kc. Tune the signal generator and receiver to 600 kc, and adjust the 600 padder P for maximum output.¹
6. Adjust T at 1,500 kc. Tune the signal generator and receiver to 1,500 kc, and adjust the high-frequency trimmer T for maximum output.¹

¹ If the signal cannot be tuned in, the adjustment range is not large enough, or the first rough setting for center capacity is too far from the correct setting. Try the second alignment procedure.
7. Repeat steps 4, 5, and 6 in sequence until each screw requires no further readjustment.

8. Align the RF and antenna trimmers in the usual way.

Alignment Procedure No. 2 for an Oscillator Circuit with Variable Trimmer, Padder, and Inductance.

1. Check IF alignment.

2. Connect the "hot" lead of the signal generator to the antenna terminal of the receiver through a 0.00025-mfd condenser. Adjust the signal generator for a modulated output on the broadcast band.

3. Set P for minimum capacity. Examine the 600 padder and the action of its adjustment screw. Set the adjustment screw in the position where the plates begin to move together. This is the low-capacity setting of the 600 padder.

4. Adjust L at 600 kc. Tune the receiver and signal generator to 600 kc, and adjust the permeability screw on the oscillator coil for maximum response. If the signal cannot be heard over the range of this adjustment, increase the capacity setting of the 600 padder by a quarter turn and try again. Repeat this until the signal-generator note can be heard.

If the receiver does not have an RF stage, and the signal-generator attenuator is well advanced, there is a possibility of tuning the oscillator stage to the second harmonic of the 600-kc signal. To make sure that this error does not spoil the alignment when the 600-kc note is first heard, tune the signal generator to 1,200 kc. If the signal is not heard at this point, L is correctly adjusted for 600 kc. If the signal is heard and with a stronger note, L has been adjusted for 1,200 kc. More inductance and probably more capacity are needed in the circuit.

5. Adjust T at 1,500 kc. Tune the receiver and signal generator to 1,500 kc, and adjust the high-frequency trimmer on the oscillator section of the gang condenser for maximum response. If the test signal cannot be heard, increase
the capacity of the padder $P$ by an eighth turn of its adjustment screw. Then readjust $L$ at 600 kc and try again to adjust $T$ at 1,500 kc. Repeat this until the signal-generator note can be heard. The receiver is now tracking at 600 and 1,500 kc.

6. Measure sensitivity at 1,000 kc. Tune the receiver to 1,000 kc. Rotate the signal generator through 1,000 kc, while watching the output meter for maximum deflection. At peak response adjust the attenuator for standard output. Note the attenuator setting. This gives the sensitivity of the receiver at 1,000 kc.

7. Adjust for maximum sensitivity at 1,000 kc. Tighten the padder another eighth turn. Adjust $L$ for maximum response at 600 kc. Adjust $T$ for maximum response at 1,500 kc. Measure sensitivity at 1,000 kc. Note the reading. The receiver should show an improvement over the reading taken in step 6.

Repeat with another eighth turn on $P$. Readjust $L$ at 600 kc, $T$ at 1,500 kc, and measure sensitivity at 1,000 kc. Continue until the sensitivity decreases. The previous adjustment of the 600 padder was the correct one. Loosen $P$ an eighth turn and complete the alignment.

Troubles Common to the Pentagrid Converter Tube.—The converter tube is a common cause of trouble in the stage. Tube checkers are not very reliable in indicating an inoperative tube, since the tube may show adequate emission but still not oscillate. If the signal check shows normal response when a test signal at the intermediate frequency is applied to the converter signal grid, but no response or weak response when the test signal is shifted to 600 kc, there is a sure indication that the oscillator is not functioning. The most probable reason is the tube. The best check is to substitute another similar tube that is known to be good.

Another trouble often experienced with pentagrid converters is modulation hum, caused by cathode-to-heater leakage. Again the best check is substituting a similar tube known to be good.

Sometimes a receiver is encountered where conditions for maintaining oscillations are critical, and the oscillator circuit will not operate over the entire tuning range. Substituting another penta-
grid converter tube usually clears this up. The original tube may not be defective and may operate perfectly in another receiver. This matter is treated in greater detail in the next section.

Critical Oscillator Conditions.—Superheterodyne receivers sometimes develop a peculiar trouble. Reception is normal on the high-frequency end of the tuning range, erratic at the middle frequencies, and dead on the low-frequency end. Such a condition could be caused by shorts in the gang tuning condenser; more often it is due to failure of the oscillator at the low-frequency end of the tuning range. Which of the two possibilities is responsible can be quickly determined by the following procedure: Start at the low-frequency end of the tuning range, and tune toward the high-frequency end, noting the frequency of the first station received. Let us assume that it is at 1,100 kc. Then starting at the high 1,600-kc end, tune toward the 540-kc end, noting the stations as they are passed. If the 1,100-kc station comes in, followed by stations at 1,000 and 900 kc, and no stations after that, the trouble is sure to be in the oscillator circuit. The stations at 1,000 and 900 kc cannot be tuned in unless the radio is being tuned from high to low frequencies.

It is normal for oscillator operation to be more efficient at high frequencies than at low. Then if we assume, for example, an oscillator tube with weak electron emission, it may oscillate at the high-frequency end of the tuning range, but not at the low. Also, when the circuit is in an oscillating condition, the oscillation may continue as the operating frequency is reduced beyond the point of a normally nonoscillating position. Such operation might be called "critical oscillating conditions."

A condition of critical oscillator operation may be caused by other factors than a weak tube. The tube, however, is the most easily checked, since we can substitute another that is known to be good. If the new tube does not entirely clear up the trouble but causes the oscillation to stop at a lower frequency than before, it may be advisable to try still another tube, with the hope of finding one that will continue to oscillate all over the tuning range.

At this point, it might be well to add that a condition of oscillation is easily determined by a check of the voltage between the oscillator grid and the chassis. When the circuit is oscillating, the oscillator grid voltage will be negative with respect to chassis. When oscillation stops, the oscillator grid will check zero or slightly positive.

When replacement of the tube fails to clear up the trouble, all components of the oscillator circuit should be carefully checked.
This includes cleaning the oscillator section of the gang tuning condenser, since a dusty shunt across the oscillator tank may be the cause of the condition.

If all components seem to be in good condition, refer to the receiver manufacturer’s service notes, to see if later changes incorporated in the receiver include any change in the oscillator circuit. Often the condition is widespread for a particular receiver, and later changes include remedial measures. The change may be a different value for the cathode resistor or for the oscillator grid resistor; or, the oscillator coil may have been changed, as indicated by a new part number. If any such alterations can be found, incorporating this same change in the receiver being serviced will clear up the difficulty.

Where the receiver service notes do not indicate any such changes, the serviceman should experiment with the ohmic value of the cathode self-bias resistor. When this is reduced, a stronger electron flow in the tube is assured, with consequent better chance for maintaining oscillations at the low-frequency end of the tuning range.

**Miscellaneous Oscillator Troubles.**—When the signal check indicates trouble in the oscillator section, any of the component parts might be at fault. The tube, oscillator coil, and tuning condensers, which are the most common offenders, have been covered in previous sections. The resistors and condensers in the cathode, oscillator grid, and anode circuits remain as possible sources of faulty operation.

Trouble in the cathode circuit would appear before the oscillator circuit is suspected, since it would interfere with the operation of the pentagrid converter as an amplifier and would therefore cause
trouble when the IF amplifier is checked from the converter signal grid. The usual trouble is an open bias resistor R-18. This would be found on voltage check, since the cathode voltage would be abnormally high, 50 volts or thereabouts, depending on the sensitivity of the voltmeter, instead of the normal value of approximately 3 volts. Self-bias by-pass condenser C-18 rarely gives any trouble.

In the oscillator grid circuit, resistor R-19 and condenser C-19 rarely give any trouble. Occasionally, a paper tubular condenser for C-19 may cause oscillator trouble owing to leakage. When replacing condenser C-19, use a mica condenser of the proper capacity.

In the oscillator anode circuit, resistor R-20 and condenser C-20 are in high-voltage circuits, where troubles and breakdown are more common. If condenser C-20 should short, the oscillator would not function owing to the absence of anode voltage. Signal check would show the inoperative oscillator, voltage check would show no voltage at the oscillator anode, and a resistance check would show a shorted C-20. Since no voltage at the oscillator anode might also be caused by an open R-20 or an open feedback winding, the resistance check would also disclose these defects. If the trouble is a short in condenser C-20, resistor R-20 should also be replaced, since it has been forced to feed heavier than normal current to the shorted condenser.

An open anode by-pass condenser C-20 would also cause the oscillator stage to be inoperative. Voltage check would show low voltage on the oscillator anode, and no or little voltage on the oscillator grid, the exact voltages depending on the stray capacity in the circuit. In addition, checking the oscillator anode voltage may cause the radio to play, since the capacity of the meter leads is added to the stray capacity in the circuit.
SUMMARY

Quick check for normal operation of the oscillator.
Tune the receiver to 600 kc. Connect the signal-generator output to the converter signal grid (mixer grid) through a 0.1-mfd condenser, and rotate the signal-generator dial through 600 kc. If the signal-generator modulation note is heard in the speaker at or near 600 kc, the oscillator is functioning.

Quick check for normal operation of the mixer.
Tune the receiver to 1,400 kc. Connect the signal-generator output to the RF grid (antenna if there is no RF stage) through a 0.00025-mfd condenser. Rotate the signal-generator dial through 1,400 kc. If the signal-generator modulation note is heard in the speaker, at or near 1,400 kc, the mixer stage of the converter is functioning.

Standard diagram.
This circuit is shown in the accompanying figure.

Normal resistance data for the converter.
Across L-4, primary of the signal input transformer T-2
Across L-5, secondary of the signal input transformer
Across L-6, grid coil of the oscillator transformer T-3
Across L-7, feedback coil of the oscillator transformer
Cathode to chassis
Signal grid (G-4) to chassis
Screen grid (G-3 and G-5) to chassis
Plate to B plus
Oscillator grid (G-1) to chassis
Oscillator anode (G-2) to B plus

* These readings are for the standard circuit and should be checked against service notes for any particular receiver.
In receivers where the signal input transformer T-2 is a loop antenna, the grid coil of the loop will measure 1 to 3 ohms. The antenna winding will measure less than 1 ohm.

Normal voltage data for the converter.
Readings taken from the indicated terminals to the chassis or common negative terminal of the receiver are given in the accompanying table.

<table>
<thead>
<tr>
<th>6A8 pin No.</th>
<th>AC receiver, volts</th>
<th>AC/DC receiver volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>3</td>
<td>250</td>
</tr>
<tr>
<td>Screen</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>Oscillator grid</td>
<td>5</td>
<td>−15</td>
</tr>
<tr>
<td>Oscillator anode</td>
<td>6</td>
<td>200</td>
</tr>
<tr>
<td>Cathode</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

Service Data Chart for an Inoperative Oscillator Stage
Assume an inoperative oscillator section in a dead receiver, as shown by normal response when an IF test signal is applied to the mixer grid, and no response when the test signal frequency is changed to RF. The following test procedure is recommended.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Reading</th>
<th>Trouble and subsequent check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make a voltage check</td>
<td>Oscillator grid reads zero or positive</td>
<td>Confirms the inoperative oscillator</td>
</tr>
<tr>
<td></td>
<td>Oscillator anode reads zero</td>
<td>Feedback coil is open. Oscillator anode dropping resistor R-20 is open. Oscillator anode by-pass condenser C-20 is short circuited. Confirm with a resistance check</td>
</tr>
<tr>
<td></td>
<td>Oscillator anode reads low</td>
<td>Oscillator anode by-pass condenser is open</td>
</tr>
<tr>
<td></td>
<td>Voltages normal except for oscillator grid</td>
<td>Nonoscillating converter tube. Substitute one that is known to be good. If the trouble still persists, it is in the oscillator grid circuit. Make ohmmeter check as shown below</td>
</tr>
</tbody>
</table>

Make a resistance check. Check for the following conditions:
Open oscillator coil grid winding L-6.
Shorted oscillator section of the gang tuning condensor C-6.
Leakage across the oscillator tuning condenser C-6 or the shunt trimmer C-6A.
Open paddler condenser C-7.
Open or leaking oscillator grid condenser C-19.
Open or wrong resistance value for oscillator grid leak R-19.
SERVICE DATA CHART FOR AN INOPERATIVE MIXER STAGE

Assume an inoperative mixer in a dead or weak receiver, as shown by normal response when an RF test signal is fed to the mixer grid, and no or weak response when the RF test signal is fed to the RF grid.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Reading</th>
<th>Trouble and subsequent check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply the test signal to the RF plate.</td>
<td>Normal response</td>
<td>Trouble is in the RF tube or its associated circuit. Substitute an RF tube known to be good. Make a voltage check and a resistance check of the RF stage to find the defective component.</td>
</tr>
<tr>
<td></td>
<td>No or weak response</td>
<td>Trouble is in the mixer grid circuit. Check the mixer input transformer T-2 for opens. Check the AVC decoupling filter R-29 and C-29 for opens.</td>
</tr>
</tbody>
</table>

SERVICE DATA CHART FOR THE CONVERTER

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Look for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hum</td>
<td>Open mixer grid coil L-5</td>
</tr>
<tr>
<td>Modulation hum</td>
<td>Defective converter tube. (Cathode-to-heater short or leakage)</td>
</tr>
<tr>
<td>No reception on LF end of the tuning range</td>
<td>Weak converter tube. Check oscillator circuit for critical oscillator conditions</td>
</tr>
<tr>
<td>Distortion</td>
<td>Short-circuited AVC condenser C-29</td>
</tr>
<tr>
<td>Weak reception</td>
<td>Open cathode by-pass C-18. Open plate by-pass C-22. Misalignment</td>
</tr>
<tr>
<td>Weak reception—high noise level</td>
<td>Open AVC condenser C-29</td>
</tr>
<tr>
<td>Squeals or birdies when tuning certain stations</td>
<td>Image frequency interference. See Chap. 16</td>
</tr>
<tr>
<td>Noisy, intermittent operation</td>
<td>Defective converter tube. Corrosion in input transformer T-2 and oscillator transformer T-3. Check gang tuning condenser for shorts and poor wiper contacts. Check wiring for loose connections and rosin joints</td>
</tr>
<tr>
<td>One station all over the tuning range</td>
<td>Condenser gang not turning. IF amplifier tuned to the wrong frequency</td>
</tr>
<tr>
<td>Receiver will not track on alignment</td>
<td>Tuning-condenser stator plates incorrectly spaced</td>
</tr>
</tbody>
</table>
CHAPTER 15

FURTHER NOTES ON THE CONVERTER—VARIATIONS

There are probably more variations in the converter than in any other stage in the receiver. Some receivers use separate mixer and oscillator tubes. Others use different converter tubes. In addition, there are a large number of oscillator circuits other than the anode feedback type, shown in the standard circuit for the 6A8 pentagrid converter tube. And finally, the mixing of the received signal and the locally generated signal can be accomplished in other ways than the electronic mixing described for the 6A8 tube. However, in all cases, the functions of the components remain the same, the signal check remains the same, and the service notes, applying to the main component parts of the stage, can be equally well applied to identical or similar components, regardless of the type of mixer and oscillator stage employed.

The variations chosen for this section will be those commonly found, or those requiring a special service procedure. They will include the popular 6SA7 or 12SA7 converter tubes, multiband receivers, push-button tuning, and permeability tuning.

Receivers Using the 6SA7 or 12SA7 Pentagrid Converter.—Many receivers employ a 6SA7 instead of a 6A8 for the converter tube. The signal input circuit and the IF output circuit are the same for either tube. There are some important differences in the oscillator circuit. The oscillator circuit employed is the Hartley type, using a tapped coil with the feedback winding in the cathode circuit. The oscillator anode and the screen are combined in the second and fourth grids.

From the serviceman’s point of view, the following differences should be kept in mind. The signal input grid is pin No. 8 rather than the top cap. Signal-generator test signals, therefore, are most conveniently applied to the stator terminal of the tuning condenser C-5. Since the oscillator anode and screen are combined, one voltage measurement suffices for both and is usually called “screen” voltage. In AC/DC receivers, the screen voltage of the 6A8 averages 50 volts, whereas the 6SA7 or 12SA7 averages 90 volts. The oscillator grid-leak R-19 is approximately 20,000 ohms in circuits using a 6SA7, whereas grid-leak values approximating 50,000 ohms are found in
circuits designed around the 6A8 tube. Adjustments of the 600 paddler condenser C-7 must be performed with a special aligning screwdriver made of insulating material, since both sets of plates are at high RF potential and, as a result, any adjustment will be affected by hand capacity.

Fig. 15-1.—Schematic diagram of a 6SA7-type pentagrid converter.

Normal Voltage Data for a 6SA7 Converter.—Readings are taken from the indicated terminal to the chassis or common negative terminal. Data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Test terminal</th>
<th>6SA7 or 12SA7 pin No.</th>
<th>AC receivers, volts</th>
<th>AC/DC receivers, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>3</td>
<td>250</td>
<td>90</td>
</tr>
<tr>
<td>Screen</td>
<td>4</td>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td>Oscillator grid</td>
<td>5</td>
<td>-15</td>
<td>-10</td>
</tr>
<tr>
<td>Cathode</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The signal check and the approximate stage-gain measurements are the same as those given for the standard circuit.

Figure 15-2 shows the service data wiring diagram of the RCA 45 X 18 receiver which uses a 12SA7 pentagrid converter. Note the following points in the converter stage. The tube is labeled 1ST DET. OSC. Condenser C-21, between the oscillator coil and the
Fig. 15-2.—The RCA 45 X 18 receiver diagram.
tuning condenser, is a fixed condenser, which means that there is no 600 paddler, and the oscillator section of the gang-tuning condenser has cut plates. The oscillator grid condenser is replaced by a capacity winding on the oscillator coil, connected to terminal 4 of the oscillator coil. The oscillator grid voltage is minus 11 volts at 1,500 kc and minus 9 volts at 600 kc, indicating greater oscillator output at the high-frequency end of the tuning range. The signal input transformer is a loop so that the receiver may be operated without

Fig. 15-3.—Simplified switching circuits for a multiband receiver.

an antenna for local reception. For reception of weak signals, an antenna may be connected as indicated to the primary winding of the loop. Condenser C-15, connected between the primary loop winding and the chassis, insulates the receiver against accidental short circuits in the power line, if the antenna should become grounded.

Note also the following points of general interest in this diagram. The arrangement of the tube elements may make the diagram more difficult to read, but it facilitates the finding of tube pins for voltage checking. The voltages are marked for easy reference right at the socket terminal. Gain data are included above the diagram and, although the figures given are for the RCA Rider Chanalyst, they may be interpolated for any system of measuring gain.

Multiband Receivers.—In multiband receivers, the inductances in the tunable circuits are switched, so that the receiver may operate over more than one band of frequencies. A simplified circuit indicating how this may be accomplished is shown in Fig. 15-3.

The gang tuning condensers C-5 and C-6 are permanently con-
nected across the signal grid and oscillator grid circuits. Switch S-2 is the wave-band switch. In the broadcast (BC) position shown, coil L-5 with its trimmer C-5A is connected in the signal grid circuit. In the oscillator grid circuit, for broadcast, the B section of the switch throws coil L-6 with its low-frequency padder C-7 and its high-frequency trimmer C-6A across the main oscillator tuning condenser C-6.

When the switch is thrown to the short-wave (SW) position, coil L-105 with its associated trimmer C-105A is connected in the signal grid circuit, while coil L-106 with its associated low-frequency padder C-107A and high-frequency trimmer C-106A is connected across the oscillator tuning condenser C-6. An arrangement such as the above makes it possible to align each wave-band position individually.

By using more positions on the wave-band switch, each one throwing in a different set of coils with their associated trimmers, it is possible to have a multiband or all-wave receiver. The common bands used for radio receivers are as given in the accompanying table.

<table>
<thead>
<tr>
<th>Band</th>
<th>Approximate frequency range</th>
<th>Type of program</th>
</tr>
</thead>
<tbody>
<tr>
<td>X or LF</td>
<td>150—400 kc</td>
<td>Maritime and aircraft</td>
</tr>
<tr>
<td>A or BC</td>
<td>540—1,600 kc</td>
<td>Standard broadcast</td>
</tr>
<tr>
<td>B or police</td>
<td>1.5—4.6 mc 2—6.2 mc</td>
<td>Police, amateur</td>
</tr>
<tr>
<td>C or SW</td>
<td>5.8—18 mc</td>
<td>U.S. and foreign short wave</td>
</tr>
</tbody>
</table>

The B or police band has either of the two frequency ranges shown, depending on whether it is desired to include state police at 1,600 to 1,800 kc or the United States and foreign broadcast stations at 6 to 6.2 megacycles. When the latter range is chosen, the broadcast band is usually extended to 1,750 kc to include the state police broadcasts.

Multiband receivers usually include two or three of the frequency ranges listed above. All-wave receivers include all bands, and sometimes add a fifth which extends the high-frequency range to approximately 40 megacycles.

The circuit of Fig. 15-3 is simplified in that it makes no provision for shorting the unused coils (a usual procedure), and does not show the primary of the coil in the signal grid circuit or the feedback winding of the oscillator coils, either or both of which may also require switching.

Practical multiband receivers use a variety of switching and coil arrangements. In addition to changing coils, the switch may in-
clude extra sections which accommodate auxiliary functions. For example, pilot lights may be switched on and off so that the proper frequency range on the dial scale is illuminated. Another common practice is to increase sensitivity and to alter the tone response, when the receiver is switched to short-wave reception.

Figure 15-4 is a three-band superheterodyne receiver. C-1 and C-2 are the gang tuning condenser. The antenna coil assembly includes the antenna transformer T-1, the broadcast loading coil L-2, and the three trimmer condensers, C-3, C-4, and C-5. The proper coil, with its associated trimmer, is switched to the tuning condenser C-1 and the signal grid of the 6SA7-GT converter by the A section of the band switch. The oscillator coil assembly includes the oscillator coils, all labeled T-2, with their associated high-frequency trimmers, C-6, C-7, and C-8. Note the low-frequency padder C-21 for the broadcast coil, the fixed condenser for the police coil, and no condenser for the short-wave coil. The B section of the wave-band switch connects the proper coil with its trimmer and padder to the main oscillator tuning condenser C-2 and the oscillator grid circuit. The C section of the band switch connects the proper feedback coil to the cathode circuit of the 6SA7-GT converter tube. Note the shorting arm on all three sections of the wave-band switch.

Figure 15-5 is a two-band superheterodyne receiver. The range switch has four decks or wafers, labeled A-1 to A-4. The switch has three positions: broadcast band (antenna), broadcast band (loop), and short-wave band. In the position shown, broadcast band (antenna), range switch sections A-1 and A-2 connect the antenna to the center tap of antenna coil L-3; antenna tuning condenser C-4 is connected across L-3 with its trimmer C-1; and the tuning circuit, composed of L-3 and C-4, is connected in the grid circuit of the RF amplifier tube, which is a 6SK7 type. Oscillator tuning condenser C-5 is connected through switch sections A-3 and A-4 to broadcast oscillator coil L-6 and the oscillator grid circuit of the 6SA7 tube. The cathode of the 6SA7 tube connects through the tap on short-wave oscillator coil L-7 to the tap on broadcast oscillator coil L-6. Terminals 6 and 7 on switch deck A-3 throw a short across condenser C-28A in the grid circuit of the lower 6V6-GT tube through the wires labeled Y-Y. This is a tone-compensation circuit which will be open on short-wave reception.

When the range switch is moved one position to broadcast (loop), switch section A-2 opens the antenna circuit, and A-4 shorts out the minimum-bias resistor in the cathode circuit of the RF 6SK7 tube. The other connections remain the same as in the broadcast (antenna) section.
Fig. 15-4.—Schematic diagram of the Emerson DX-356 three-band receiver.
When the range switch is moved to the short-wave position, the following changes take place: The antenna is connected to the center tap of short-wave antenna coil L-4 through terminals 9 and 10 on range-switch section A-2. Terminals 1 and 2 on the same section connect short-wave antenna coil L-4 to the 6SK7 grid circuit. Terminals 7, 6, and 5 on the A-1 section of the range switch short the lower halves of the loop and broadcast antenna coil. Terminals 2 and 3 on the same section connect antenna tuning condenser C-4 through C-6 to the grid circuit of the 6SK7 tube. Condenser C-6 is for band-spread purposes. In the oscillator section, terminals 8, 9, and 10 of section A-4 keep the RF tube in the sensitive position by shorting out the cathode resistor, and by grounding the bottom lead of the short-wave oscillator coil L-7 as well as the bottom half of the broadcast oscillator coil L-6. Oscillator tuning condenser C-5 is connected through band-spread condenser C-11 to the top lead of short-wave oscillator coil L-7 and the oscillator grid circuit of the 6SA7 tube. Switch terminals 6 and 7 of section A-3 connect the condenser in the grid circuit of the 6V6-GT tube for tone compensation.

Servicing Multiband Receivers.—Although multiband receivers look more complicated than a single-band unit and may take a little longer to service, they are no more difficult. As a matter of fact, the range switch opens a possibility of faster diagnosis in some ways. When a receiver is dead on the broadcast band but operates normally on other bands, the defective condition is more quickly narrowed down to defective coils in the RF or oscillator portions of the receiver.

Servicing procedures for the multiband receiver are the same as for any other, until the RF portion of the receiver is reached. At this point the serviceman need only make sure that the range switch is in the broadcast position in order to continue in the usual way.

There are, of course, some service problems connected with multiband receivers that will not be present in single-band radios. These include the short-wave coils, the range switch, and alignment.

Short-wave coils are usually wound as a single-layer inductance using heavy wire. This type of winding rarely gives any service trouble. The serviceman, however, should be able to check the windings with an ohmmeter. This may not be so easy as it sounds, since it is sometimes difficult to determine which lead is which on a multiunit coil assembly. Also, the serviceman may not be sure as to whether the winding is being shorted by the range switch.

A better method would be to work with the schematic diagram and check the coils and switch at the same time. For example, in
checking the receiver of Fig. 15–4, the feedback winding of the oscillator coils could be checked as follows: Connect one ohmmeter terminal to chassis, the other to the cathode of the 6SA7 tube, and rotate the range switch. The ohmmeter would read the resistance of each winding, which would be approximately 2 ohms for the broadcast position, \( \frac{1}{2} \) ohm for the police band, and "short" for the short-wave band. The other coils could be checked in a similar manner. To check the oscillator grid coils, one ohmmeter terminal would connect to the junction of condensers C-29 and C-12, while the other ohmmeter prod would be moved with the band switch. It would connect to the 600 paddler when checking the broadcast band, C-20 when checking police, and ground when checking the short-wave range. Because of the diversity of range switches, no standardized procedure can be arranged for checking coils and switches. However, the examples given will help to clarify the method of procedure.

When an open coil is found, the serviceman should first make sure that the defect is not due to a broken lead wire. If the coil must be replaced, it is necessary to obtain an exact duplicate from the manufacturer of the receiver. Even if it is necessary to replace an entire coil assembly for one open winding, this must be done since the chances of finding a usable section are very slim.

The lead dress between the range switch and the short-wave coils is very important. In high-frequency circuits, stray capacity of the wiring represents a considerable portion of the total capacity of the circuit. Very often, the wiring in these circuits makes use of heavy bus bar, so that the positioning will be maintained. Any replacement of switch or coils should be accomplished with a minimum of bending or rearranging of the wiring, so as to avoid undesirable coupling or changes in the stray capacity.

Range switches become covered with a layer of dust and dirt, resulting in poor contact and sometimes leakage between terminals. Dusting with a soft brush and then cleaning with carbon tetra-chloride comprise the usual service procedure. A good way to clean the contacts is to wet them and the contact arms with carbon tetra-chloride and then rotate the switch rapidly.

If a switch contact or wafer becomes broken, it is necessary to replace the entire switch. Again, an exact duplicate must be obtained from the manufacturer. Service notes on the replacing of switches were given in connection with radio-phonograph switches (see page 176).

**Aligning Multiband Receivers.**—In realigning a multiband receiver, the manufacturer's instructions should be followed to the
last detail. This advice is given whenever the word "alignment" is mentioned. However, in the case of multiband receivers, it is of more than usual importance for two reasons. One is that the alignment on one wave band may affect the alignment on the other ranges, and the proper alignment sequence should be followed. The other is the fact that some receivers are so designed that the oscillator frequency should be 455 kc lower than the signal frequency on the short-wave band, while the conventional 455 kc higher signal on the other bands is maintained. Often both frequencies are within the scope of the trimmer adjustment, and it is important to use the peak at the lower or higher capacity setting, as instructed, in order to maintain proper tracking. If alignment instructions are not obtainable, the following suggestions may be of value.

**IF Alignment.**—First turn the range switch to the broadcast position, short the oscillator section of the gang tuning condenser, and align the IF trimmers in accordance with the general alignment instructions given in Chap. 22. Then remove the short from the oscillator section of the tuning condenser and check the position of the dial pointer, by turning the gang tuning condenser to full capacity (full mesh). The dial pointer should be in line with the last calibration mark on the low-frequency end of the dial scale.

As for the sequence of range alignment, when trimmer settings of one band affect another, it is suggested that the broadcast band be aligned last, because the cumulative effect will be most noticeable on the lowest frequency band. In addition, the owner of a receiver is usually most concerned about the operation of the broadcast band. For these reasons, when more exact instructions are not available, it is advisable to align the broadcast band last.

**Short-wave Alignment.**—Connect the signal generator through a dummy antenna of 400 ohms to the antenna and ground of the receiver. Turn the range switch to the highest frequency band on the receiver, and set the dial at a convenient mark near the high-frequency end of the scale. Adjust the signal generator to a modulated output at the same frequency as shown on the receiver dial. Adjust the short-wave oscillator coil trimmer for maximum response. If only one peak is obtained, the oscillator is adjusted to the proper frequency. If two peaks are obtained, choose the peak at minimum capacity. This sets the oscillator to a higher frequency than the signal.

If the receiver has an RF stage, the interstage coil trimmer is next to be aligned. If there is no RF stage, the antenna-coil trimmer follows the oscillator adjustment. In either case, the trimmer is adjusted for maximum response. If two peaks are obtained, the
one that maintains the oscillator at the higher frequency is the peak that is nearer the maximum capacity setting of the trimmer. If the peak is unobtainable or if the receiver does not track at the low-frequency end of the dial, the alignment should be tried with the oscillator set for a lower frequency than the signal. This is done by choosing the maximum capacity peak for the oscillator trimmer and the minimum capacity peak for the antenna trimmer.

If the receiver has more than one short-wave band, the next lower frequency range should be aligned. The same procedure is followed as for the highest frequency band except that the oscillator circuit should be adjusted for a higher frequency than the signal. However, it is doubtful if two peaks are obtainable on any but the highest frequency band. This band may or may not include a low-frequency padder.

Broadcast Alignment.—Set the range switch at the broadcast position and adjust the tuning condenser until the dial reads 600 kc. Connect the signal generator to the antenna and ground, using a 0.00025-mfd condenser as the dummy antenna. Adjust the signal generator for a modulated signal at 600 kc. Adjust the 600 padder for maximum response. Then set the receiver dial to 1,500 kc and adjust first the oscillator-coil high-frequency trimmer, then the RF coil trimmer (if present), and finally the antenna-coil trimmer for maximum response. Return both dial and signal generator to 600 kc and readjust the 600 padder, if necessary. Then return to 1,500 kc and check alignment. If readjustment is necessary, repeat the alignment at 600 kc and check at 1,500 kc until further readjustment is unnecessary.

 Receivers with Push-button Tuning.—Receivers that employ push buttons for tuning favorite stations use either mechanical or switching arrangements. In the mechanical method, the tuning-condenser gang is turned to predetermined positions by means of an electric motor, or by the actual push on the button. In the switching method, the tuning condensers or the entire tuning circuits are switched out, and trimmers or tuning circuits preset to the favorite station are switched in.

There are a large number of types of each of these arrangements. A typical example of each type will be described, together with applicable service notes.

Switched Push-button Tuning Circuits.—Figure 15–6 shows the schematic diagram of the Zenith Model 7S633R receiver. Push-button tuning is inaugurated by turning the range switch to the automatic tuning position. This disconnects the gang tuning condenser, all three sections of which are labeled C-1, throws a row of
Fig. 15-6.—Schematic diagram of the Zenith model 7S633R push-button receiver.
preset trimmers across the antenna tuning circuit, eliminates the
converter signal-grid tuning circuit by converting it into an untuned
resistance-coupled circuit, and throws any one of a row of permea-
bility-tuned coils in the oscillator grid circuit.

The predetermined station is then tuned in by depressing the
proper push button. The buttons are sprung so that they are nor-
mally in the off position. Then as any button is depressed, a catch
holds this button in place while automatically releasing any button
previously depressed. Each button controls a double-pole switch,
one pole of which connects one of the permeability-tuned coils in the
oscillator grid circuit, while the other pole connects the proper asso-
ciated trimmer in the RF grid circuit.

The trimmers and coils in the automatic tuner have a limited
range (approximately 400 kc), so that each button cannot tune
many desired stations in the broadcast band. However, the values
of coils and condensers are staggered, so that any station can be
tuned in on some one button. The tuning range of each button is
usually marked near the adjustment screws.

Figure 15–7 shows a simplified drawing of the tuning circuit of the
Zenith receiver of Fig. 15–6, when the range switch is in the auto-
matic position. One push button is depressed, showing one preset
trimmer connected across the RF tuning circuit and one preadjusted
permeability coil in the oscillator tuning circuit. The coupling be-
between the RF and converter tubes is of the resistance-capacity type. This coupling also remains the same for the short-wave position of the range switch. The circuit is tuned only in the manually operated broadcast position of the range switch.

The system just described is typical for push-button tuners of the switching type. These systems differ mainly in the number of preset stations available. In some cases, switching from manual to automatic tuning is taken care of by an extra similar push button, rather than a position on the range switch. Often the radio-phonograph switch is also an extra similar push button. In addition, some types provide two sets of trimmer condensers, instead of one set of trimmers and one set of permeability-tuned coils. In these types, the regular broadcast oscillator coil is used, the oscillator tuning condenser is switched out of the circuit, and one of the preset trimmer condensers is substituted for it.

Servicing Push-button Tuners of the Switching Type.—Push-button systems of the switched tuning-circuit type give very little service difficulty. Occasionally, the switches do not make good contact. When this happens, the following cleaning procedure is effective: Dust the entire switch assembly with a soft brush. Depress the first switch, and apply carbon tetrachloride to its contacts and also the arm and contacts of the next switch. Then depress the two switches alternately: first the second, then the first. Repeat the procedure for the first and second switches, this time depressing the second button before applying the carbon tetrachloride to it. Repeat on the next pair, making sure that each switch has been washed in both the open and the closed position.

Another service problem is resetting the adjustment screws, which may change their position with time. When doing this, the receiver should be allowed a warm-up period of about 15 min, to allow all components to reach normal operating temperature. The oscillator control is adjusted first, followed by the antenna adjustment. If the adjusting screws are not marked, the serviceman can identify them by checking the wiring diagram or by the operation of the adjustments. The oscillator adjustment is critical—a fraction of a turn will bring the station in or out. The antenna adjustment is broad in comparison. If the receiver is equipped with a magic eye, it should be used to indicate exact resonance. An output meter cannot be used for this purpose, since the reading will vary with the modulation of the program. A vacuum-tube voltmeter, if available, connected to the AVC bus, can also be used as the resonance indicator. If neither the magic eye nor a vacuum-tube voltmeter is available, the adjustments are set for best volume and tone by ear. A good
check for correct settings is to tune to the same station with the switch set for manual operation, and then switch from manual to push button and note any difference. Operation should be the same, except in the case of a receiver like that of Fig. 15-6, where the manual switch throws in an extra tuning circuit.

When push buttons are set up or when the adjustment screws are far from their correct alignment positions, it would be timesaving to use the signal generator for finding the desired stations.

Figure 15-8 shows the method of connecting the signal generator to the receiver. Adjust the signal generator for a modulated output at the frequency of the first desired station. Depress the first push button, and adjust the associated oscillator control until the signal-

![Signal Generator and Receiver Diagram](image)

Fig. 15-8.—Using a signal generator as an aid in quickly presetting push buttons.

generator note is heard. It will be accompanied by a squeal, caused by the beating action between the generator signal and the signal from the desired station. Disconnect the signal-generator “hot” lead. If the squeal does not stop because of leakage, detune the signal generator. Then readjust the oscillator control for maximum response from the station. Finally, adjust the antenna trimmer. Repeat the procedure for the other buttons.

**Mechanically Operated Push-button Tuners.**—Figure 15-9 shows two views of a typical mechanically operated push-button tuning system. This type is known as a “rocker-bar” mechanism and is probably the most popular of all push-button tuners. Each button depresses a preset pawl, which turns the rocker bar as far as the pawl setting will allow. A gear connected to the rocker bar rotates the gang tuning condenser. The tuning knob and dial pointer rotate with the condenser gang. The return spring maintains the push button in its normal out position and, at the same time, keeps the pawl away from the rocker bar.
When a button is set up, the locking screw is loosened. A screw driver is kept pressed against the loosened locking screw, thereby depressing the push bar and pushing the pawl against the rocker bar. The desired station for each button is tuned in manually, thereby pushing the pawl to its proper setting. The locking screw is then tightened, fixing the pawl firmly between the shoe and push rod. Subsequently, when the button is depressed, the pawl pushes the rocker bar to its set position, thereby bringing in the desired station.

From the servicing point of view, loosened adjustments are about the only difficulty experienced with mechanical buttons of this type. A complete adjustment procedure follows.

**Adjustment of Push Buttons for Mechanical Automatic Tuners.**

--- Rotate the range switch to the broadcast position. Select the stations desired for automatic tuning. Choose one of these stations.
and any button to be adjusted for it. Follow the procedure outlined below:

1. Grasp the button firmly and remove it from its shaft by pulling straight out (see Fig. 15–10A).

2. Insert a screw driver into the slot of the locking screw. Press in and loosen the screw 1 to 1½ turns (see Fig. 15–10B).

3. With the screw driver seated in the screw slot, press the screw in as far as possible. Hold it in firmly with one hand, and tune in the desired station with the other hand by pressing in and rotating the selector knob (see Fig. 15–10C).

4. Release the selector knob and tighten the screw firmly.

5. Check the adjustment by tuning well past the station, using the selector knob and then pushing in the button shaft. The station should come back in again clearly and with maximum volume. After the adjustment is tested, check to see that the locking screw is tightened firmly. Replace the button on its shaft.

6. Adjust the remainder of the buttons in the same manner as outlined above.

Figure 15–10D shows a common method of inserting station tabs.

**Mechanically Operated Push-button Tuners of the Motor-driven Type.**—Motor-driven push-button tuners are too varied in their operation, adjustment, and service problems for any generalized treatment in a book of this nature. The serviceman is referred to the manufacturer's service notes when he experiences difficulty with any of these devices. For teaching purposes, as an example, the diagram and station-setting instructions of the Stromberg-Carlson No. 440 receiver are included in the text.

**Instructions for Setting Up Push Buttons.**—Before reading the instruc-
tions for setting up push buttons, note carefully the following important items.

*Important.*—(1) The stations selected should be the local favorite ones that give good reception at all times. (2) Set up stations in the daytime to avoid unnecessary interference. (3) Allow the set to run for about 20 min before setting up stations. (4) Always use the tuning indicator unit when setting up stations in order to determine when a station is exactly in tune.

![Diagram](image-url)

**Fig. 15-12.**—Brush and commutator assembly of the receiver of Fig. 15-11.

1. Put the call letters of the selected stations in place above the push buttons. The stations should be arranged according to frequency, with the highest frequency at the right and the lowest frequency at the left, just as on the dial.

2. Set the *treble* control in normal position.

3. Turn the setup switch (located on the base just back of the brush and commutator assembly) to the setup position. (The slot in the screw should point toward SETUP.)

4. Push the button of the highest frequency station to be set up (button No. 3) and then tune in that station manually. Be sure that the station is exactly in tune by tuning carefully and watching the cathode-ray indicator.

5. Slide the brush to which the blue wire is connected until it is over the slot in the commutator. Then adjust it very carefully until the pilot light goes out. This indicates exact adjustment.
6. Repeat operations 4 and 5 for each station. Work from right to left or from the higher to the lower frequencies in accordance with the accompanying table.

<table>
<thead>
<tr>
<th>Push button No.</th>
<th>Purpose</th>
<th>Color of wire on brush</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manual</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Remote</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Highest frequency station</td>
<td>Blue</td>
</tr>
<tr>
<td>4</td>
<td>Next lower frequency station</td>
<td>Orange</td>
</tr>
<tr>
<td>5</td>
<td>Next lower frequency station</td>
<td>Green</td>
</tr>
<tr>
<td>6</td>
<td>Next lower frequency station</td>
<td>Brown</td>
</tr>
<tr>
<td>7</td>
<td>Next lower frequency station</td>
<td>Slate</td>
</tr>
<tr>
<td>8</td>
<td>Next lower frequency station</td>
<td>Red</td>
</tr>
<tr>
<td>9</td>
<td>Next lower frequency station</td>
<td>Black</td>
</tr>
<tr>
<td>10</td>
<td>Lowest frequency station</td>
<td>Blue-white</td>
</tr>
<tr>
<td>11</td>
<td>Phonograph</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Off</td>
<td></td>
</tr>
</tbody>
</table>

7. Turn the setup switch back to the operate position.

8. Check the operation of all the push buttons to be sure that each has been accurately set up. If it is necessary to readjust any of the buttons, follow the procedure given above.

**Permeability Tuning Systems.**—In the conventional receiver, tuning is accomplished by changing the capacity of a variable condenser connected across a coil, thereby changing the resonant frequency of the combination. The same effect can be brought about by allowing the condenser capacity to remain fixed and changing the inductance of the coil. This is the basis of permeability tuning systems, where the inductance of the coil is changed by varying the position of an iron-core plug in the coil.

Coils with adjustable cores are used as IF transformers, and for the fixed-tuned antenna and oscillator coils of the circuit-switching type of push-button tuners. In these cases, the inductances of the coils are adjusted during the alignment procedure or when setting up the push buttons, and remain undisturbed thereafter. In some receivers, instead of using a variable condenser, the antenna and oscillator core plugs are ganged, and their adjustment is brought out to the front control panel as a continuously variable adjustment of the tuning range of the receiver. Such a tuning system is known as a "permeability" tuner. Figure 15–13 shows a tuner of this type, where the positions of the core plugs are varied by means of a drive cord.
The coils, drive pulley, and idler pulley are fastened to a subassembly. The coil mounts are so arranged that either coil may be shifted slightly to the right or left for tracking purposes. Ordinary dial-drive cord is used to vary the position of the core plugs. Note that when the drive shaft is rotated in the direction shown, both core plugs are pulled into their respective coils.

![Diagram of drive-cord type of permeability tuner.]

Fig. 15-13.—Drive-cord type of permeability tuner.

From the servicing point of view, any trouble in the permeability tuner would be found in the same way that a similar trouble would be found in a conventional tuner, since the circuits are alike. The alignment procedure is somewhat different, and the manufacturer’s service notes should be followed closely in this regard. Another difference lies in the fact that restringing the drive cord calls for realignment, since the restringing process will slightly alter the relative positions of the tuning slugs.

If specific restringing and alignment notes are not available from
the receiver manufacturer, the following generalized procedure should be of help. The skeleton schematic diagram of Fig. 15–14 is included as an aid in locating and identifying the trimmers.

Restrunging and Alignment Procedure for Drive-cord Permeability Tuners.

1. Restrung the tuning slugs, using the frayed or torn pieces of the old drive cord as a guide, so that the relative positions of the tuning slugs are as close as possible to their original settings.
2. Set the antenna coil in the center of its positioning range, so that it may be shifted either to the right or left.
3. Rotate the drive so that the antenna core plug is completely out of the winding.
4. Set the oscillator coil so that its core plug is in the same relative position as the antenna coil and its core plug. Set the dial pointer to the highest frequency division on the dial scale.
5. Rotate the drive to make sure that the dial pointer and tuning slugs move together and cover the entire tuning range.
6. Check the alignment of the IF amplifier, and if necessary, align in the usual manner.
7. Connect the signal generator to the receiver antenna, using a 0.00025-mfd dummy antenna. Rotate the drive to the high-frequency end of the dial scale, and adjust the signal generator for a modulated output at the same frequency. Adjust the oscillator trimmer C-2 to a maximum response. Then adjust the antenna trimmer C-1 to a maximum response.
8. Rotate the drive to 1,400 kc, and adjust the signal generator frequency control to a peak. This should occur at 1,400 kc. If it is too far off, the starting position of the oscillator core plug was incorrectly adjusted. This should be corrected and steps 7 and 8 repeated.
9. When the peak at 1,400 kc in step 8 has been obtained, the antenna coil is shifted to the right or left for a maximum tracking peak.
10. Return the dial and signal generator to the highest frequency reading on the dial scale, and check the adjustment of the antenna trimmer C-1. If no appreciable change is needed, the antenna coil is in track. If a considerable change has been made, repeat steps 9 and 10.

Screw-drive Permeability Tuners.—Another type of permeability tuner uses a screw for driving the ganged tuning slugs. Figure 15–15 shows a tuner of this type. The proportions have been altered to permit viewing the operation of the unit.
The coils $L_1$, $L_2$, and $L_3$ are mounted on the back plate of the carriage. The bakelite strip is threaded to take screws attached to the core plugs. Adjusting these screws permits adjustment of the relative positions of the individual core plugs with respect to their coils. Rotating the drive shaft causes the bakelite strip to move in and out, carrying the core plugs with it, and thereby changing the inductance of the coils. The drive shaft is the tuning control for the radio. The gear ratio is usually chosen to allow several turns of the drive shaft for complete coverage of the tuning range, thereby giving vernier tuning. A similar ratio on a drive pulley (not shown in the diagram) operates a conventional dial pointer from the same tuning shaft.

A tuner of this type, employing three coils, may be used for a receiver with an RF stage. It may also be used in a receiver with a converter stage only, the antenna coil being used in a preselector circuit. Figure 15–16 shows a receiver of the latter type.

Coils $L_1$, $L_2$, and $L_3$, with their core plugs ganged in the permeability tuning unit, are identified as the antenna, mixer, and oscillator coils, respectively. Actually, coil $L_3$ is not the oscillator coil with a function similar to the one in the standard receiver. The actual oscillator coil that furnishes the feedback voltage for operation of the oscillator circuit is coil $L_4$, which is outside the permeability tuning unit. This coil, $L_4$, is referred to as the master oscillator coil. Coil $L_3$, in the tuner, is shunted across a portion of the master oscillator coil and acts to tune it. Trimmer condenser $C_3$. 

![Diagram of a permeability tuner of the screw-drive type.](image-url)
is the high-frequency aligner for the oscillator circuit. The 600-kc aligner is the permeability adjustment screw on the master oscillator coil L-4.

The antenna plate is a sheet of metal, insulated from the chassis, and acting as a self-contained antenna for the receiver. It is usually mounted behind the chassis so that it also acts as the back of the cabinet. The lead for a standard antenna is capacitively coupled, as shown, by a few turns of the antenna lead around the antenna plate lead. The antenna signal is impressed across the antenna coil L-1 and condenser C-4. The condenser acts as the common coupling to feed the mixer coil L-2 in the converter signal grid circuit. Trimmer condensers C-1 and C-2 are the alignment controls for the antenna and mixer circuits.

Antenna plates are commonly used in receivers employing permeability tuners. However, there are some receivers that employ a loop antenna. Figure 15–17 shows a two-gang permeability tuner of the screw-drive type fed by a loop antenna.

From the servicing point of view, the screw-drive type of permeability tuner likewise offers no new problems, except from the standpoint of alignment. A generalized alignment procedure follows.

**Alignment Procedure for Screw-drive Permeability Tuners.**

1. Align the IF amplifier in the usual way.
2. Check the dial pointer setting and positioning of the core plugs by the following steps.
   a. Rotate the tuning shaft to the low-frequency stop.
   b. Rotate the core plugs by means of the screws in the bakelite rack until they are fully engaged in their respective coils.
   c. Set the dial pointer at the lowest frequency calibration mark on the dial scale.

![Diagram](image)

Fig. 15–17.—Two-coil permeability tuner fed by a loop antenna.

3. Connect the signal-generator output lead to the antenna connection through a 0.00025-mfd dummy antenna. Do not connect to the antenna plate.

4. Set the signal generator to feed a modulated signal at 600 kc, rotate the tuning shaft to read 600 kc on the receiver dial, and align the master oscillator-coil permeability adjustment for maximum output.

5. Tune the receiver to a quiet point near the high-frequency end of the tuning range, adjust the signal generator to feed the same frequency as that shown on the receiver dial scale, and align the oscillator high-frequency trimmer for maximum output. This trimmer is labeled $C-3$ in Figs. 15–15, 15–16, and 15–17.

6. Check the 600-kc adjustment by repeating step 4. If considerable readjustment is necessary, realign the high-frequency adjustment by repeating step 5 and then recheck at 600 kc.
7. Tune the signal generator and receiver to a peak near 1,400 kc, and align first the mixer and then the antenna trimmers for maximum output.

QUESTIONS

1. Outline a procedure for determining the cause of a defective oscillator circuit in a dead receiver.

2. Outline a procedure for determining the cause of a defective mixer circuit in a dead receiver.

3. A receiver operates on the high-frequency end of the broadcast band but not on the low-frequency end. List the probable causes and state how you would check for each.

4. The receiver of Fig. 15–2 does not operate. Signal check shows normal response when checking with an IF signal at the 12SA7 mixer grid, and no response when checking with an RF test signal from the same point. Voltage check shows no reading at the oscillator grid and normal readings for the 12SA7 plate and screen. Resistance check on the oscillator coil shows a reading of 6.5 ohms. Where is the trouble likely to be? How would you check for it? How would you remedy the condition?

5. The receiver of Fig. 15–4 operates normally on both short-wave ranges but not on the broadcast band. Outline a procedure to locate the cause of the trouble.

6. The receiver of Fig. 15–5 gives no reception. Signal check shows normal operation when a test signal, either RF or IF, is applied to the 6SA7 signal grid, and no reception when an RF test signal is applied to the RF grid. Voltage check on the RF tube shows a reading of zero at the plate terminal. What are the probable causes of the trouble? How would you check each?

7. The receiver of Fig. 15–6 operates normally on the manual and short-wave positions of the range switch, but gives no reception on any push button. What is the most likely cause of the trouble? How would you check for it? How would you remedy the condition?

8. What is the function of L-4 in Fig. 15–17? What is the function of L-3 in the same drawing?

9. What are the important points to remember when replacing an oscillator coil?

10. A receiver has a tunable hum. The line filter is checked and found to be O.K. What else is likely to cause this condition? How would you check for it?

11. A superheterodyne receiver squeals all over the tuning range. How would you check the converter stage for this complaint?

12. The receiver of Fig. 15–2 does not operate. When a test signal, either RF or IF, is applied to the converter signal grid, the response is heard weakly and with a rough note. What is likely to be wrong? How would you check for it?

13. The receiver of Fig. 18–19 operates, but reception is a little weak and the noise level is high. Stage-gain measurements show a normal response when an
RF test signal is applied to the converter signal grid, and a loss in gain when the test signal is applied to the antenna lead. What is likely to be the cause of the trouble? How would you check for confirmation?

14. The receiver of Fig. 15-4 is inoperative. Signal check shows a normal response when a 455-ke test signal is applied to the 6SK7-GT grid. There is no response when the 455-ke test signal is shifted to the 6SA7-GT grid. A resistance check of the converter tube shows the following abnormal readings:

Plate to chassis ......................... 40 ohms  
Plate to B plus .......................... open

What is wrong?
CHAPTER 16
RF AMPLIFIER STAGE

Many receivers incorporate a stage of RF amplification ahead of the converter. It is called the "RF" stage, or sometimes the "antenna" stage. It requires no quick check for operation. Since it is last in a line of stage checks, if all others check perfect for a defective receiver, the RF stage must be defective by a process of elimination.

Of course, the entire receiver may be normal and the trouble may lie in the antenna system, which is the first link in the signal chain. This possibility, however, should not occur on a test bench setup. Only at the customer's home will such trouble arise, and the alert serviceman will recognize the condition. Checking the antenna is usually a routine part of the home service call. Service notes relating to antennas will be included later in this text.

Function of the RF Stage.—The RF stage receives energy from the antenna, tunes the desired signal (station), amplifies the signal, and passes it on to the converter. Because of these functions—tuning and amplification—it increases the selectivity and sensitivity of the receiver. The RF stage provides other advantages. One is the reduction of the noise level when a stronger signal is fed to the converter. Another is the improvement of the AVC action, since another controlled tube is added in the RF and IF chain. A third is the elimination of image-frequency interference—peculiar to superheterodyne receivers.

Image-frequency Interference.—Examine the operation of a superheterodyne receiver. The antenna picks up station signals broadly at all frequencies. Where a receiver has no RF stage, the antenna energy is fed through a tuned circuit to the signal grid of the converter tube. For example, suppose the tuning circuit is set to receive a desired signal at 1,000 kc. The local oscillator of the receiver will then have an output at 1,455 kc if the IF amplifier of the receiver is fix-tuned to 455 kc. The station and oscillator signals are mixed in the converter tube and the output from the latter is many frequencies. The IF amplifier, usually sharply tuned by four resonant circuits, accepts only the signal that is the difference in frequency between the station and the oscillator signal—in this case 455 kc, the intermediate frequency. This IF signal is then amplified and sent on to the detector and AF amplifier.

279
Any signal at 455 kc in the converter plate circuit will be accepted by the IF amplifier and passed on. We have just seen how one 455-kc signal is developed at the input of the IF amplifier. Is it possible for a second one to be present at the same time?

Reexamine the converter signal grid. It is tuned to 1,000 kc by means of one tuned circuit that is somewhat broad. As a result, the grid may receive signals of widely different frequencies picked up by the antenna. Normally, these signals mix with the local oscillator signal (1,455 kc) and produce difference frequencies which are rejected by the sharply tuned IF amplifier. However, there might be one station signal at 1,910 kc on the converter grid which, after mixing with the local oscillator signal of 1,455 kc, will produce a difference frequency at 455 kc. This 455-kc signal will be accepted by the IF amplifier and result in two stations at the speaker output—1,000 and 1,910 kc.

Similarly, if the receiver is tuned to a station at 600 kc, the oscillator will be tuned to 600 + 455, or 1,055 kc, and an intermediate frequency of 455 kc will be produced at the IF amplifier grid. And a station signal at 1,510 kc at the converter signal grid will mix with the oscillator signal and again produce a difference, or IF frequency of 455 kc which will appear as an interfering station. Thus, any desired station is likely to experience interference from another station that happens to have a frequency which is higher than that of the desired station by twice the intermediate frequency (as much above the oscillator frequency as the desired station is below the oscillator frequency). This defect of superheterodyne receivers is known as “image-frequency interference.”

Since the two stations are rarely exactly twice the intermediate frequency apart, they will beat with the oscillator signal to produce intermediate frequencies very close to 455 kc and to each other. These two intermediate frequencies will be accepted by the IF amplifier, where they will beat with each other to form a difference frequency which will be AF and result in a high-pitched squeal. Thus, image-frequency interference appears in the receiver in a form called “birdies” or “whistles,” which mar reception on certain stations.

Early superheterodyne receivers employed an intermediate frequency of 175 kc. Here, image-frequency interference would occur from stations 350 kc from the desired ones (twice the intermediate frequency, or 2 × 175 kc). If there were only one tuned circuit before the converter, that tuned circuit would not be sufficiently sharply tuned to eliminate image frequencies 350 kc from the desired signal and interference would be troublesome. Modern prac-
RF AMPLIFIER STAGE

tice employs an intermediate frequency of 455 kc, thereby placing
the image frequency much farther away, 910 kc from the desired
station. As a rule, with such a wide spread between desired and
image frequency, even one RF tuning circuit is adequate to keep a
station 910 kc away from affecting the converter signal grid.

A preselector circuit is an added tuning circuit between the an-
tenna and the converter signal grid, the purpose of which is to
sharpen the tuning to reduce image-frequency response. Figure 16–1
shows a typical preselector circuit together with its over-all selec-
tivity curve.

![Diagram of Preselector Circuit](image)

Fig. 16–1.—A preselector circuit and its effect on selectivity before the converter signal grid

Preselector circuits are rarely used in modern receivers, since they
reduce the sensitivity, and the same reduction in image-frequency
response is possible by increasing the intermediate frequency.

A tuned RF stage, ahead of the converter, combines the added
selectivity of the preselector in reducing image-frequency response
and, because of the amplification of the tube, adds to the sensitivity
of the receiver.

Standard Circuit.—The standard circuit is shown in Fig. 16–2.

Functions and Values of Component Parts.—The antenna trans-
former T-1 couples the energy picked up by the antenna to the grid
of the RF tube. The secondary winding L-2 is tuned by C-2, the
antenna section of the gang tuning condenser. As explained before
in connection with the components of the converter stage tuning
system, the values of parts in any tuning system are important parts
of the design of the receiver and cannot be changed without alter-
ing the calibration and tracking.

When the receiver is of the loop-operated type, antenna trans-
former T-1 is replaced by the loop antenna. In this case, the main
portion of the loop winding acts as the antenna for the receiver and is tuned by condenser C-2. Should it be desired to connect an external antenna for greater sensitivity, the loop is equipped with a primary winding of one or two turns which is connected to the antenna and ground.

**IF Wave Traps.**—Any superheterodyne receiver is especially sensitive to its intermediate frequency. With an intermediate frequency adjusted to 455 kc, if a signal at or near this frequency gets to the converter grid, it will be present in the converter plate and be accepted by the IF amplifier and cause interference with the desired station. In areas near the seacoast, many powerful shore-to-ship stations operate at frequencies close to 455 kc. These cause interference that blankets the low-frequency half of the broadcast band and, in severe cases, covers the entire tuning range.

A wave trap located in the antenna circuit of the receiver will minimize this effect. In the standard circuit of Fig. 16-2 a series-resonant wave trap, composed of L-3 and C-3, is shunted across the primary of the antenna coil. The trap circuit is tuned to the intermediate frequency of the receiver, and offers a low-impedance path to ground for signals of that frequency present in the antenna.

In most cases the trap is tunable by means of trimmer condenser C-3, as shown in the standard circuit. In some cases, the wave trap is fixed-tuned to the intermediate frequency of the receiver, and the condenser corresponding to C-3 is a fixed mica condenser. Some-
times, the trap is tunable by means of an adjustable permeability plug in the coil in conjunction with a fixed mica condenser.

In loop receivers, the trap is usually placed in the converter signal grid circuit, where it serves a similar purpose by providing a low-impedance path to ground for signals at the intermediate frequency, which may be present in the converter signal grid circuit. Coil L-12 and condenser C-28 make up this type of wave trap in the receiver of Fig. 16–10.

In some receivers, especially where the primary of the antenna transformer is of the low-impedance type, the wave trap is a parallel resonant circuit connected in series with the antenna transformer primary, as shown in Fig. 16–3. The wave trap is tuned to the intermediate frequency of the receiver. This trap offers a high-impedance path to signals at the intermediate frequency appearing across the antenna circuit, and tends to dampen them.

**Decoupling Filters in the RF Stage.**—When a receiver incorporates an RF stage, there is more likelihood of undesirable coupling. As a result, there must be more decoupling filters not only in the RF stage, but also throughout the receiver. The RF cathode may be tied to the converter cathode or IF cathode, but rarely to both. In some receivers the RF cathode resistor R-1 is variable. This provides a variable minimum-bias resistor for the RF tube, and acts as a sensitivity control for the entire receiver. Such a sensitivity control is usually 25,000 ohms.

The screen supply voltage may also be common with that of the converter or IF tube, but again rarely to both. The most common screen supply consists of a suitably by-passed voltage-dropping
resistor in series with B plus for the IF tube and a voltage-divider arrangement for the RF tube. The converter screen is then usually tied to the RF screen. The standard circuit connects the RF screen to the voltage divider through the decoupling resistor R-14. Condenser C-14 by-passes the screen to ground, and its usual value is 0.1 mfd/400 volts.

![RF Amplifier Circuit Diagram](image)

**Fig. 16-4.—Decoupling filters in the RF stage.**

The plate supply also usually includes decoupling filters for one or more of the RF, IF, and converter plate circuits. The decoupling resistor R-4 for the RF plate is usually 600 to 1,000 ohms. The plate by-pass condenser C-4 is usually 0.05 to 0.1 mfd/600 volts.

**Tubes Commonly Used in the RF Stage.**—The 6K7 supercontrol pentode is the most commonly used RF amplifier tube. When the 6K7-G or 6K7-GT tube is used in this stage, it is usually covered by a closely fitting shield. The single-ended 6SK7 supercontrol pentode is also often used. The characteristics of this tube are similar to those of the 6K7, the main difference being in the location of the grid terminal as pin No. 4 instead of the top cap. Multiband receivers generally use the 6SG7, which is also a triple-grid supercontrol pentode with a higher gain and leads brought out in such a way as to provide for wiring with minimum coupling effects. Receivers with locking-base tubes use the 7A7 or the 7G7/1232. The 7A7 is similar to the 6SK7 and the 7G7/1232 is similar to the 6SG7. Older receivers use the 6D6 and 78 tubes, which are similar except for lower gain.

AC/DC receivers use any of the above tubes in circuits designed for 0.3-amp heaters. When the circuit is designed for 0.15-amp heaters, the RF tubes used are the 12K7, the 12SK7, the 14A7, and the 6SS7.
NORMAL TEST DATA FOR THE RF STAGE

Normal Signal Check for the RF Stage.—The signal generator is connected to the antenna and ground through a 0.00025-mfd condenser, and adjusted for a modulated output at 1,500 kc, with the attenuator set for a very low output. The receiver is adjusted for maximum gain; that is, volume control full on, tone control at maximum high AF response, and fidelity control in the selective position. The receiver dial is set for a quiet point between 1,400 and 1,500 kc. If an output meter is connected to the receiver, it should be on a high-voltage range. The signal generator dial is then rotated through 1,400 to 1,500 kc.

When the receiver is operating normally, the signal generator modulation note will be heard in the speaker very strongly as the signal-generator dial passes the point at which the receiver is tuned. The RF stage is then known to be functioning. Usually, the output in the speaker will be greater than the standard output of 50 mw, even with both attenuation controls set at zero. In addition, with the receiver gain controls set at maximum, random noise pulses, picked up by the receiver, cause considerable output meter deflections, so that stage-gain measurements for the RF stage cannot be made to get the usual standard output.

However, if the signal check does not show some gain over a signal measurement from the RF grid, it may be assumed that there is trouble between the antenna and the RF grid.

Normal Voltage Data for the RF Stage.—Readings are taken from the indicated terminal to the chassis or common negative. Normal voltage data for the RF stage are given in the accompanying table.

<table>
<thead>
<tr>
<th>Tube terminal</th>
<th>6K7 or 12K7 pin No.</th>
<th>AC receiver, volts</th>
<th>AC/DC receiver, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>3</td>
<td>250</td>
<td>90</td>
</tr>
<tr>
<td>Screen</td>
<td>4</td>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td>Cathode</td>
<td>8</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Normal Resistance Data for the RF Stage.—Normal resistance data are given in the following table:

Antenna to ground, or across L-1 (primary) ........................................... 30–50 ohms
Across L-2, secondary of the antenna transformer T-1 ............................... 5 ohms
Cathode to chassis ................................................................. 300 ohms
Plate to B plus ................................................................. 40 ohms plus the resistance of a decoupling filter, if used
Control grid to chassis .............................................................. 1,600,000 ohms
Screen grid to chassis ............................................................... 30,000 ohms
Screen grid to B plus ................................................................. 30,600 ohms
The screen grid readings are for the standard receiver and will vary, depending on the screen grid circuit of the receiver being tested.

In receivers where the antenna transformer is replaced by a loop antenna, antenna to ground will measure less than 1 ohm and the grid coil of the loop will measure 1 to 3 ohms.

**COMMON TROUBLES IN THE RF STAGE**

Most of the parts used in the RF stage are similar to those used in other stages in the receiver. In this section, the common troubles and how they are found will be covered, but the reader will be referred to other parts of the text to avoid repetition of replacement notes.

**Troubles Common to the Antenna Transformer.**—Either winding of the antenna transformer $T-1$ is likely to open. An open secondary would cause weak, noisy reception, possibly accompanied by hum. The trouble would be localized on a signal check since there would be no gain between the RF grid and the antenna. An ohmmeter check would then confirm the difficulty.

An open primary winding might not be so easily found, owing to the fact that the capacitive gimmick winding may transfer sufficient energy to the secondary for fair operation of the receiver. The nature of the open in the winding will affect the type of trouble experienced with the radio. Usually it will be noisy, and a noisy receiver always calls for a routine check of coils that will locate the trouble.
Replacement notes on antenna transformers will be found in Chap. 14.

Troubles Common to the Antenna Tuning Condenser.—The antenna tuning condenser develops troubles in common with any section of the gang tuning condenser. The plates may touch and cause a short and no operation or very noisy operation over parts of the tuning range. Also the plates and the associated trimmer condenser collect dust and cause noisy operation and a partial short. Sometimes the wipers make poor contact, again causing noisy operation or weak reception over parts of the tuning range.

A shorted tuning condenser or trimmer would be found on signal check. When the converter stage from the RF grid is checked, the defective condenser would short the signal-generator output and cause no signal. An ohmmeter check would then disclose the short. Since this might be in the trimmer or the plates of the tuning condenser, the serviceman must determine which unit is defective. An easy way of doing this is to rotate the tuning condenser to the full open position and check again. If the short remains, it is probably due to cracked mica in the trimmer condenser.

When the tuning condenser is causing noisy reception over part of the range, a thorough overhaul of the tuning-condenser gang will be necessary. A procedure for doing this is given in Chap. 14.

Troubles Common to the RF-stage Decoupling Filters.—The resistors in decoupling filters usually give no service troubles unless the associated condenser shorts. If C-14 or C-4 should short, there would be an overload of current through R-14 or R-4 which might damage them. When this happens, the resistors are usually replaced. Condenser C-30 in the AVC circuit rarely shorts and, if it should, there is insufficient voltage in this circuit to harm resistor R-30.

If condenser C-4 shorts, the stage becomes inoperative owing to lack of plate voltage. The condition would be found much earlier in the test procedure, however, since the short would reduce the total B voltage and affect the operation of stages previously tested. Similarly, a short in condenser C-14 would affect the operation of any later stage whose screen supply came from the same source. The shorted condensers would be found by voltage and resistance checking.

If condenser C-30 shorts, the AVC voltage applied to the stage would be shorted out. This would cause the stage to be operating at maximum volume with consequent overloading of itself or succeeding stages. The overload would cause poor tone on all but weak
signals, a symptom of defective AVC operation, which would focus attention on this circuit.

If any of these condensers open, the trouble would be found by checking for the symptom that ensues. If plate condenser C-4 opens, the gain of the stage would be reduced with possible oscillation also resulting. Signal check and stage-gain measurements would show normal response from the converter grid and insufficient gain from the RF grid. This could be caused by a weak RF tube, improper operating potentials, a defective interstage RF trans-

![Diagram of RF Amplifier](image)

**Fig. 16-6.—Decoupling filters in the RF stage.**

former, or an open plate by-pass condenser C-4, all of which would have to be investigated. The condition would be found when a test condenser, bridged across C-4, restores normal operation.

If the screen by-pass condenser C-14 opens, the receiver will oscillate. The oscillation will be tunable; that is, as the receiver is tuned, each station will come in with a squeal. This should not be confused with image-frequency interference. The latter causes a whistle on only one or two stations. Standard servicing procedure for oscillation includes bridging all by-pass condensers with a test condenser. This will disclose the open screen condenser.

If AVC by-pass condenser C-30 opens, the tuning circuit in the RF stage becomes ineffective. This causes a weakening of the received signal, which in turn causes the AVC to step up the gain of the controlled tubes. The net result is that strong locals come in like weak stations, that is, with a high noise level, and weak ones do not come in at all. The trouble would be found on signal check, since opera-
tion would be normal from the RF gr'd and show no gain or a loss when checking from the antenna. An open antenna coil primary may give the same results. The trouble would be confirmed when a test condenser bridged across C-30 restores normal operation. A second check that may be used for confirmation is that the trimmer condenser across the antenna section of the gang tuning condenser is ineffective.

Troubles Common to the Wave-trap Circuit.—The wave-trap circuit composed of L-3 and C-3 rarely causes service difficulties. Figure 16-7 shows the two common connections for the wave trap.

In either circuit, even if the wave-trap coil L-3 should open, the receiver would continue to operate normally. There may, of course, be a tendency for the receiver to have "code" interference, a heterodyne effect, but this would occur only if the receiver is located near a station transmitting at or near the intermediate frequency.

If the complaint is code interference all over the tuning range, the wave-trap circuit would naturally be suspected and checked. Then, when the trap is found to be defective, it is repaired or replaced. Using an exact replacement is desirable, but not essential. Any wave trap that is tunable to the intermediate frequency of the receiver will do.

Correct alignment procedure for the wave trap is first to have the receiver in perfect alignment, then to tune the receiver to 1,000 kc, feed a strong modulated signal at 455 kc (or the intermediate frequency of the receiver) into the antenna, and adjust the trap trimmer condenser or permeability-tuned coil for minimum response. In some cases, the interference is more completely eliminated if
the trap is adjusted for minimum response at the frequency of the interfering signal.

Reduction of Image-frequency Interference.—Interference caused by the normal response of superheterodyne receivers to stations operating at the image frequency causes service difficulties in relatively few instances. Receivers that incorporate a tuned RF stage are not troubled. Loop-operated receivers are likewise little affected, since the tunable loop antenna is less responsive to a station 910 kc off resonance than are the ordinary antenna and antenna coil which respond to a very large band of frequencies. The usual offenders, as regards image-frequency interference, are the types of receivers that employ an antenna and no RF stage, or an RF stage followed by an untuned converter stage. Also, the trouble is a local one, since another requirement is the presence of a strong image-frequency signal at the high-frequency end of the broadcast band (twice the intermediate frequency above the frequency of the desired station).

Image-frequency interference can be recognized as a whistle, or "birdie," which mars reception on one station at the low-frequency end of the broadcast band while reception is normal for all other stations. In the metropolitan New York area the stations affected are either WMCA—570 kc, or WNBC—660 kc. In the case of station WMCA, the interference will be prevalent in the vicinity of station WHOM operating at 1,480 kc \( (570 + 910 = 1,480) \). Station WNBC may be troubled with image-frequency whistles caused by the presence of a signal from WQXR operating at 1,560 kc \( (660 + 910 = 1,570) \). In addition, reception at many points in the tuning range may on occasion experience image-frequency interference, if the receiver should be in the vicinity of police or amateur stations operating on frequencies ranging from 1,700 to 2,400 kc.

When the service job is to reduce image-frequency interference, various methods can be employed by the serviceman. A simple yet sometimes effective method is to reduce the signal input to the receiver. Modern superheterodyne receivers are usually more sensitive than needed for normal requirements of local reception, and may perform satisfactorily with very little antenna pickup. When this is the case, a reduced antenna may receive so much less signal from the interfering station that the whistle disappears. It is always worth while, therefore, to try the effect of a short indoor antenna on the interference. If it is effective, the serviceman should then check carefully to see that reception from all desired stations is satisfactory with regard to both signal strength and freedom from noise.

Another expedient is the installation of a wave trap tuned to the
frequency of the interfering station. This frequency may be determined by adding twice the receiver intermediate frequency to the frequency of the station experiencing the interference. The wave trap chosen should have a range which includes the frequency of the interfering station. If such a wave trap is not obtainable, it may be made by adding a series mica condenser of approximately 0.0001-mfd capacity to a standard IF wave trap. The circuit is shown in Fig. 16-8. Several capacities from 0.00005 to 0.0002 mfd should be tried for the series condenser, in order to extend the range of the wave trap so that it covers the frequency of the interfering station.

Still another method of reducing image-frequency interference is to change the intermediate frequency of the receiver. The operation of a receiver is not greatly altered in respect to sensitivity, selectivity, tracking, etc., if the intermediate frequency is shifted about 10 kc, provided the receiver is completely realigned. The change, however, may reduce image-frequency interference. For example, assume a receiver with an IF amplifier tuned to 455 kc and experiencing an image whistle when tuned to a station at 570 kc. The whistle is caused by a station operating at 1,480 kc (1,480 − 910 = 570). Suppose now that the IF amplifier is retuned to 465 kc, and the entire receiver is realigned to operate at this intermediate frequency. The station at 1,480 kc will still be present and will cause image-frequency interference when a station at 550 kc is tuned in (1,480 − 930 = 550). But there is no local station at 550 kc and the image-frequency interference that marred reception from the station at 570 kc will be greatly reduced or entirely eliminated.

Variations in the RF Stage.—Multiband receivers will, of course, cause changes in the RF stage. These will be in the tuning circuit, switching arrangements, etc. The servicing of these components has been dealt with in connection with multiband circuits in the converter stage, and it is felt that the serviceman will be able to apply the same techniques to similar situations in the RF stage.

However, a few points should be mentioned. One is that the RF stage is used only on the broadcast band in some receivers. Another is that some provision must be made for a loop antenna to operate.
on more than one band. The Motorola 103K1 receiver of Fig. 16–9 illustrates both of these points.

The antenna winding of the loop feeds the arm of the range switch section marked "58–1." This arm is open in the broadcast position, and the grid winding of the loop feeds the control grid circuit of the RF tube. In the police and short-wave positions of the range switch, the antenna winding of the loop feeds the appropriate antenna coil through this same switch arm. The secondary of either antenna coil feeds the signal grid circuit of the converter tube through the arm of range switch section 58–2, thereby dispensing with the RF tube in these positions. In the broadcast position of switch 58–2, the converter signal grid is fed by the interstage RF transformer which is marked BC-RF COIL in the diagram.

Note also that the push-button arrangement for this receiver makes use of a motor-driven tuning condenser gang. A switching push-button system would require the removal of one of the three tuned circuits or three rows of trimmer adjustments.

**RF Stage Followed by an Untuned Converter.**—Many receivers employ an RF stage that is resistance-coupled to the converter signal grid. This arrangement gives the receiver some of the advantages of an RF stage while using only two tuned circuits: the RF grid and the oscillator. The Stromberg-Carlson No. 1000 receiver shown in Fig. 16–10 uses this type of circuit.

The coupling between the RF and the converter tubes consists of RF plate load R-14, coupling condenser C-5, and converter signal grid load R-13. The circuit composed of L-12 and C-28 in the converter signal grid is a wave trap tuned to the intermediate frequency of the receiver. Similar circuits in other receivers use different values for the components in the resistance-coupling circuit. The plate load varies from 5,000 to 10,000 ohms. The coupling condenser varies from 0.0001 to 0.0005 mfd. The grid-load resistor is often smaller than the one shown in the diagram, 25,000 to 100,000 ohms being more usual. Another circuit difference is that some receivers bring the grid-load resistor to ground or common negative rather than to the AVC bus, as shown in Fig. 16–10.

From a servicing point of view, receivers of this type are checked in the same manner as the standard receiver. There would be only two differences noted. In a voltage check, the RF plate voltage would measure lower than usual, owing to the voltage drop across the plate load resistor. And also, in stage-gain measurements, when checking from the RF grid, there would be a lower gain found than for the tuned coupling. A tuned coupling produces an average gain of 20 between the RF and converter grids. Checking between the
Fig. 16-9.—Schematic diagram of the Motorola 108K1 receiver.
same two points will show an average gain of approximately 7 for an untuned coupling.

The components of the resistance coupling circuit rarely give any service difficulties. The coupling condenser is usually a mica type which is comparatively trouble-free. An open plate-load resistor would be readily found on signal and voltage checks. The grid-load resistor is also trouble-free.
RF AMPLIFIER STAGE

Fig. 16-10 — Schematic diagram of the Stromberg-Carlson No. 1000 receiver.
SUMMARY

Quick check for normal operation of the RF stage.

If all previous stages checked showed a normal response, the trouble must be in the RF stage.

Standard RF stage diagram.

The accompanying figure shows the standard RF stage.

Normal voltage data for the RF stage.

Readings are taken from the indicated terminal to the chassis or common negative. Normal voltage data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Tube terminal</th>
<th>(6\text{K7 and }12\text{K7} ) pin No.</th>
<th>AC receivers, volts</th>
<th>AC/DC receivers, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>3</td>
<td>250</td>
<td>90</td>
</tr>
<tr>
<td>Screen</td>
<td>4</td>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td>Cathode</td>
<td>8</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Normal resistance data for the RF stage.

<table>
<thead>
<tr>
<th>Across L-1</th>
<th>30–50 ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across secondary of the antenna transformer</td>
<td>5 ohms</td>
</tr>
<tr>
<td>Cathode to chassis</td>
<td>300 ohms</td>
</tr>
<tr>
<td>Across primary of interstage RF transformer</td>
<td>30–50 ohms</td>
</tr>
<tr>
<td>Control grid to chassis</td>
<td>1,600,000 ohms</td>
</tr>
<tr>
<td>Screen grid to chassis</td>
<td>30,000 ohms</td>
</tr>
<tr>
<td>Screen grid to ( B ) plus</td>
<td>30,000 ohms</td>
</tr>
<tr>
<td>Symptom</td>
<td>Abnormal reading</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>No signal from the speaker</td>
<td>Plate voltage = 0. Other</td>
</tr>
<tr>
<td></td>
<td>voltages normal</td>
</tr>
<tr>
<td></td>
<td>Plate voltage = 0. Other</td>
</tr>
<tr>
<td></td>
<td>voltages low</td>
</tr>
<tr>
<td></td>
<td>Cathode voltage high. Other</td>
</tr>
<tr>
<td></td>
<td>voltages normal</td>
</tr>
<tr>
<td></td>
<td>Screen voltage = 0. Other</td>
</tr>
<tr>
<td></td>
<td>voltages normal</td>
</tr>
<tr>
<td></td>
<td>Cathode voltage = 0. Other</td>
</tr>
<tr>
<td></td>
<td>voltages normal</td>
</tr>
<tr>
<td></td>
<td>All voltages normal</td>
</tr>
<tr>
<td>Weak signal</td>
<td>All voltages normal</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Oscillation</td>
<td>All voltages normal</td>
</tr>
<tr>
<td>Noisy operation</td>
<td>All voltages normal</td>
</tr>
<tr>
<td>Code interference</td>
<td>All voltages normal</td>
</tr>
<tr>
<td>Poor tone quality</td>
<td>All voltages normal</td>
</tr>
<tr>
<td>Whistles on one or two</td>
<td>All voltages normal</td>
</tr>
</tbody>
</table>
QUESTIONS

1. Outline a procedure for checking the source of trouble in a receiver that has a defective RF stage.

2. A weak AC superheterodyne receiver gives a normal response when the proper test signal is applied to the RF grid and a weaker response when the same test signal is applied to the antenna. What are the likely sources of the trouble, and how would you check for each?

3. A dead AC superheterodyne receiver gives a normal response when the proper RF test signal is applied to the converter signal grid and no response when the same test signal is shifted to the RF grid. Use the standard circuit of Fig. 1–1 and list the possible causes of the trouble. How would you check for each?

4. The receiver of Fig. 16–10 gives poor reception in the customer's home although it operates normally on the service bench. A long outdoor antenna was suggested and installed. The reception was greatly improved but the receiver is now troubled with code interference all over the tuning range. What is likely to be wrong and how should it be checked?

5. A superheterodyne receiver gets a station operating at 570 kc all over the dial. What is likely to be wrong? How can you check for this condition?

6. The receiver of Fig. 18–19 operates normally on all local stations except one at 660 kc. On this station, there is a persistent whistle that cannot be tuned out. What is the most likely cause of the difficulty? Outline a procedure to be followed in an attempt to minimize the condition.

7. The receiver of Fig. 16–9 is inoperative. Signal check shows that the trouble is in the RF stage. A voltage check of the RF stage gives the following results:

<table>
<thead>
<tr>
<th>Component</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>250 volts</td>
</tr>
<tr>
<td>Screen</td>
<td>100 volts</td>
</tr>
<tr>
<td>Cathode</td>
<td>50 volts</td>
</tr>
</tbody>
</table>

   What is likely to be wrong? How would you confirm your assumption?

8. Assume the receiver of question 7 gave the following voltage readings:

<table>
<thead>
<tr>
<th>Component</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>250 volts</td>
</tr>
<tr>
<td>Screen</td>
<td>100 volts</td>
</tr>
<tr>
<td>Cathode</td>
<td>0 volt</td>
</tr>
</tbody>
</table>

   What is likely to be wrong in this case? How would you confirm your assumption?

9. The receiver of Fig. 16–9 has poor tone quality on local stations. Removing the RF tube and connecting the antenna to the plate terminal of the RF tube clears up the tone. What in the RF stage can cause this trouble? How would the ser-viceman confirm the cause?

10. A receiver with an RF stage like the standard circuit of Fig. 1–1 picks up local stations but the reception is below normal in strength and is coupled with considerable noise. A signal check shows normal response when the proper test signal is applied to the RF grid, and a loss when the same test signal is applied to the antenna. Name the parts that may cause this condition. How would each one be tested?