CHAPTER 9

LOUDSPEAKERS

Quick Check.—To determine whether a loudspeaker is functioning, momentarily unseat the second AF tube. A loud click should be heard. Where the output stage is of the push-pull type, removing either tube will produce the same result.

Function of the Loudspeaker.—The loudspeaker is a device that takes electrical energy or power at audio frequencies from the second AF output stage and converts it into sound energy. Its fidelity of reproduction depends on its ability to convert into sound all the component frequencies at the second AF output.

Types of Loudspeakers.—Many varieties of loudspeaker have paraded across the stage throughout the period of radio evolution. All of them, however, can be grouped into three main types: the magnetic loudspeaker, the crystal loudspeaker, and the dynamic loudspeaker. Much could be said about each of these, but the trend in recent years has been toward the dynamic type. Therefore, the balance of the description will concern itself with that type.

Theory of Operation of the Dynamic Loudspeaker.—The theory of operation of a dynamic speaker is quite simple. In these speakers, the AF signal from the second AF stage is impressed across a small, free-floating coil of wire (called the "voice" coil), which is suspended in a strong stationary magnetic field. The AF current causes a varying magnetic field around this coil. This varying field reacts with the stationary field and causes motion of the voice coil. The latter is cemented to a paper cone which vibrates with the voice coil and produces the audible sound waves.

Two main varieties of dynamic loudspeakers have been developed. The difference between the two lies in the manner in which the stationary magnetic field is produced. The two types are the electromagnetic dynamic speakers and the permanent-magnet (P-M) dynamic speakers.

In the electromagnetic type of dynamic speaker, a powerful stationary magnetic field is created by passing a direct current through a field coil, wound on an iron core which is part of an electromagnet. The pole pieces of the electromagnet are brought very close together.
The voice coil, suspended freely by means of its paper cone, rides between the field poles. AF currents are fed to the voice coil from the output transformer coupled to the second AF stage. (The output transformer may be mounted on the speaker unit itself.) The result is a vibratory motion of the voice coil and its attached cone. The outer edge of the paper cone is attached by means of soft leather or plastic, or even directly to its basket, so that the voice coil may float freely. A typical electromagnetic dynamic speaker is shown in Fig. 9–1. A flexible membrane, called a “spider,” is usually attached to the voice-coil form and guides its motion within the space between the center pole piece and the pot. A dust cap, usually made of felt, is cemented at the front end of the voice-coil form to prevent dust or other grit from getting in between the voice-coil form and the adjacent poles.

The other type of dynamic speaker is the P-M dynamic speaker. This type is exactly like the electromagnetic dynamic speaker except that the field is created by a permanent magnet, made of such material as alnico, rather than by an electromagnet. In all other respects, the construction and operation of the two speakers are identical.
Fig. 9-2.—Energizing the field coil; field coil used as filter choke.

Fig. 9-3.—Energizing the field coil; field coil across the rectifier.

Fig. 9-4.—Energizing the field coil; field coil used as a voltage divider.
Energizing the Electromagnetic Dynamic-speaker Field.—The field of the electromagnetic dynamic speaker must be energized by means of a direct current. This DC supply is usually obtained from the power supply itself.

In most cases, the speaker field serves as a filter choke and therefore passes through it direct current with a small ripple component. Such a circuit is shown in Fig. 9-2.

In other circuits, the field coil receives its DC supply by being placed across the rectifier output. Such a circuit is shown in Fig. 9-3.

In other circuits, the field coil receives its DC supply by acting as a voltage divider across the filter circuit in the power supply. This circuit is shown in Fig. 9-4.

![Diagram of Electrodynamic Speaker with Hum-bucking Coil](image)

**Fig. 9-5.**—Electrodynamic speaker with a hum-bucking coil.

The Hum-bucking Coil.—The electrodynamic speaker is very likely to have a high hum component. This condition occurs because the DC supply for the field is not pure direct current but has a ripple component that affects the voice coil. Several devices have been employed to reduce this hum in the speaker so that it is not objectionable. The most widely used device is the hum-bucking coil, which consists of a few turns of wire, wound on the center core and fixed stationary to the field coil. This hum-bucking coil, however, is connected in series with the voice coil. The two coils are connected in such manner that any voltage induced in them will be in opposite phase and cancel out. Thus, the hum component from
the field coil will be canceled out in the voice coil. Figure 9–5 shows an electrodynamic speaker with a hum-bucking coil.

Another device used to reduce hum from the field is the shading ring. Here, a thick copper ring, fixed between the field and the voice coil, acts as a single-turn coil in which eddy currents are produced and tends to shield the voice coil from the ripple component in the field coil.

The hum-bucking coil is used in speakers in which the field coil is the filter choke. Speakers in which the field is connected across the rectifier output use a hum-bucking coil or a shading ring. Speakers in which the field coil acts as a voltage divider do not require any hum-bucking device, since they are being fed direct current from which the hum ripple has been removed.

CHECKS FOR LOUDSPEAKER OPERATION

When the quick check indicates trouble in the speaker or if the servicing complaint is rattles or poor tone quality, the speaker should be carefully tested. The following section describes the quick check in detail and discusses other tests that may be applied to the loudspeaker.

Quick Check for Speaker Operation.—In the quick check, the second AF tube is unseated. When this is done, a click should be heard in the speaker. Unseating of the tube causes the B plus voltage to the plate pin of the tube to rise to maximum, with a consequent surge through the primary of the output transformer. This surge, induced in the secondary of the transformer, momentarily energizes the voice coil and produces the click.

This quick check does not tell us how well the speaker is functioning, merely that the voice coil is not open.

To determine if the field coil of an electromagnetic dynamic speaker is open, a blunt piece of iron, like a socket wrench, should be held near the center pole piece. A perfect field coil will cause the tool to be attracted strongly. An open field coil will give either no attraction or a slight attraction due to residual magnetism. Unfortunately, the dust cover may in some cases make this test somewhat unreliable. Of course, this latter test is not necessary for a P-M dynamic speaker.

Signal-substitution Check for Speaker Operation.—In the signal-substitution test, an audio signal is fed into the speaker, and its response observed. The test may be made with a signal generator whose level of audio output is sufficiently high to drive the speaker directly.
The "hot" lead from the signal generator is connected, in such case, to the primary of the output transformer, and output from the generator is turned on full. The receiver is turned on to energize the speaker field, if the speaker is of the electrodynamic type. The receiver should be tuned to an off-station position, and its volume control set to minimum position to remove any station signal from interfering with the test. When the signal generator is turned on, the audio note should be heard clearly and loudly, if the speaker is operative. If no note is heard, the voice coil is probably open. If the note is weak, the field coil is open or not receiving sufficient current.

If the signal generator is of the type delivering a variable-frequency output, other checks may be made. After the test just described indicates that the speaker is operative, its frequency response may be checked by swinging the signal generator output from low audio frequency through high audio frequency. In addition, this last check will indicate rattles from the speaker or a vibrating component in the receiver. Sympathetic vibrations of objects in the receiver, at any one audio frequency, will also be found.

The tests just described may be made with a beat-frequency oscillator (BFO), if that instrument is available on the service bench. It furnishes high-level, variable-frequency audio output. The output from the BFO is a pure audio wave form, with good frequency and output stability.

In using the BFO to check speakers, the speaker and the BFO are hooked up as shown in Fig. 9–6. Its proper impedance output is connected across the voice coil. It is not necessary to disconnect the

![Diagram](image-url)
voice coil from the secondary of the output transformer. If the
speaker is of the P-M dynamic type, the test may now be made.
If it is of the electrodynamic type, the receiver must be turned on to
ergize the speaker field. Then tune the receiver to an off-station
position and reduce its volume control to minimum position. Adjust
the BFO at a low output level for a 400-cycle note, which should be
heard in the speaker. As with the signal generator, no note indicates
open voice coil; a weak note indicates that the field coil is open or not
receiving sufficient current.

If a normal response is heard, the BFO frequency control is ro-
tated from low to high frequency. The sound will indicate the
frequency response of the speaker. In addition, rattles and symp-
thetic vibrations will be found.

Substitution of a Test Speaker.—When the serviceman is not sure
that the speaker is the cause of weak operation or distorted output,
substitution of a test speaker will resolve this doubt. If the dis-
tortion also appears in the test speaker, the cause is in the receiver,
etc. A description of a bench test speaker is given in Chap. 24 on
the Service Bench.

Resistance Check for the Loudspeaker.—In the final analysis,
the speaker is checked with an ohmmeter. To test that the voice coil
is neither open nor shorted, disconnect it from the secondary of the
output transformer and measure its ohmic resistance with the ohm-
meter. It should have the resistance indicated by the receiver
manufacturer on his schematic. If this information is not indicated,
voice-coil resistance measurements are found to vary from 2 to 15
ohms, the higher values being found in larger speakers.

The resistance of the field coil may be measured without discon-
necting. There will be considerable variation from receiver to re-
ceiver, and it is best that its value be determined by actual reference
to the schematic diagram. However, average values will be given
where schematics are not available.

Where a field coil acts as a filter choke in the power supply, as
shown in Fig. 9—2, its value may be found on the average to be as follows:

For AC receivers ........................................ 800—2,000 ohms
For AC/DC receivers .................................. 450 ohms

Where a field coil is connected across the rectifier output, as shown in
Fig. 9—3, its value may be found on the average to be as follows:

For AC receivers ........................................ 6,000—10,000 ohms
For AC/DC receivers .................................. 3,000 ohms
Where the field coil is part of the voltage-divider system, as shown in Fig. 9-4, no average value can be given, and the serviceman should refer to the schematic diagram and service notes for the receiver being checked.

TROUDBLES COMMON TO THE LOUDSPEAKER

From the servicing point of view, the loudspeaker may be responsible for many receiver defects. The receiver may be dead because the voice coil is defective, or because the field coil, acting as a filter choke in the power supply, is open. The receiver may produce a weak output because the speaker field, used across the rectifier output, is open. Strange rattles may develop because of loose parts, torn cone, off-center voice coil, dirt between the voice-coil form and the field poles, or sympathetic vibrations of parts within the receiver. Each defect will be described from the point of view of its source.

Troubles Common to the Voice Coil.—Many receivers are brought in for servicing because of troubles attributed to the voice coil and its associated paper cone. Such conditions may be an open voice coil, an off-center voice coil, dirt and grit between the voice coil and the field pole pieces, loose voice-coil wires, broken cement between the voice coil and the paper cone or spider, and a broken lead from the voice coil to the voice-coil connection strip.

If a receiver is brought in as dead and unseating of the second AF tube does not produce a click, the voice coil may be presumed to be open. The signal-substitution and resistance check for continuity may then be used to confirm the condition. If an open is found, the leads to the voice coil should be inspected to see if one has not broken loose. The lead may be resoldered. If the open is in the voice coil, it is not advisable to try to rewind it. Rather, it and its associated paper cone must be replaced with an exact duplicate.

Replacement of a voice coil and cone involves several steps, executed with extreme care. First, an exact duplicate is necessary. If such is not obtainable, a new speaker unit must be obtained. Second, the voice coil must be properly centered around the center pole piece.

Centering of the voice coil is dependent upon the variety of speaker used. Usually, the outer edge of the paper cone is fastened to the outer housing or basket of the speaker by means of a ring and several bolts and nuts or cement. The voice coil itself is kept centered and freely floating by means of a membrane, called a "spider," which is cemented to the voice coil. The spider permits movement of the voice coil parallel with the length of the center pole piece but restrains it from making sidewise movements.
Several types of spiders are used. One, shown in Fig. 9-7, is attached to the paper cone near the voice coil. A bolt through the center attaches it to the center pole piece. When a replacement is made, the new voice coil and cone should be placed over the center pole piece. By means of cone-centering shims, which are flat steel or fiber strips made for the purpose, the voice coil should be centered around the center pole piece. The shims are inserted through the spaces in the spider between the center pole piece and the voice-coil form, as shown in Fig. 9-8. Use three or four shims evenly spaced, depending on the spider structure. Then tighten the centering screw. This retains the voice coil in a centered position. Then fasten the outer rim of the cone, by means of cement or nuts and
bolts, to the basket of the speaker. Finally, remove the shims. A check is then made to see that the voice coil floats freely. Move it gently in and out manually, and watch for rubbing against its surroundings. The dust cap of the speaker, if one is used, should be cemented over the end of the voice-coil form.

As a final step in replacing the voice coil of an electrodynamic speaker, the hum-bucking coil, if present, must be reconnected to the new voice coil and be in such phase that it reduces hum. If, after connection, hum is excessively loud, reverse the connections of the hum-bucking coil to the voice coil.

Another type of spider consists of a membrane, attached to the voice-coil form at its center and connected to the housing either by cement or by machine screws. This type is shown in Fig. 9-9. Here again, in replacement, the voice-coil form is centered around the center pole piece by means of shims. The spider is cemented or bolted to its support to keep the voice coil in position, and the outer rim of the cone fastened to its basket. Then the centering shims are removed. Move the voice coil gently in and out, and observe that it

Fig. 9-9.—Inside spider connected to speaker basket.
floats freely. Finally, cement the dust cap over the voice coil and reconnect the hum-bucking coil, if present.

Another condition that may develop from the voice coil is rattle. If the spider in some way becomes loose, it will permit the voice coil to go off center and rub against adjacent parts. The result is rattle and loss of power in the speaker, as well as distortion. The condition may be checked by moving the voice coil in and out manually, and observing if rubbing occurs; or a substitute test speaker will show improvement in power, tone, and elimination of rattle. Where such is the condition, repair is fairly simple. The voice coil is recentered in the manner just described, and the spider screws are retightened.

Sometimes, the same condition of a rubbing voice coil may be caused by grit and dirt collecting between the voice-coil form and the center pole piece or pot. Here, the cone and voice coil are removed, the dirt is cleaned out with a pipe cleaner, and the coil and cone unit are replaced and recentered.

A rubbing voice coil may result from a voice coil whose shape has become warped. This condition may be presumed when repeated recentering of the voice coil does not remedy the condition. It is not advisable to try to reshape the coil. Replacement of the voice coil and cone is suggested.

Sometimes, the cement binding the voice coil itself breaks, and the turns come loose. This condition, too, will cause mysterious buzzes. The voice coil and cone should be removed, and new coil cement carefully applied. Then replace and recenter, as described.

Again, rattles may occur if the voice coil loosens its cement connection to the cone or spider. Recementing is the cure. Then replace and recenter as before.

Infrequently, the pot and center pole piece may loosen or warp, giving the effect of an off-center voice coil. This condition will become obvious when repeated centering of the voice coil does not remedy the condition. The voice coil is removed under the impression that it may be warped, but inspection shows that it is round but the field gap is not uniform. In some cases, the field gap is adjustable, and a procedure for resetting the top pole piece is given in the section describing the replacement of field coils. When the gap cannot be adjusted, the entire speaker must be replaced.

Troubles Common to Electrodynamic Speaker Field Coils.—The speaker field of an electrodynamic loudspeaker may be the source of many receiver defects. The manner in which it will make itself manifest depends on the way in which it receives its excitation. Where a defective field coil is indicated, replacement depends upon
the construction of the speaker and the availability of a similar coil. If replacement is not possible, the entire speaker must be replaced.

Where the speaker field coil is used as a filter choke, the defect will be located in a power supply check. It will be noticed from Fig. 9–2 that an open coil will cut off the $B$ plus supply, so that all stages will be inoperative. The receiver will be brought in dead. A check of the power supply will show no $B$ voltage. Disconnect the power plug and discharge the filter condensers. An ohmmeter check for continuity will confirm the open field. The open may be due to a

![Diagram of a speaker field coil and a screwdriver checking magnetic pull.](image)

Fig. 9–10.—Checking the magnetic pull of a speaker with a socket wrench.

break in the field leads or in the connection between the field wire itself and the lead. These should be inspected and, if found at fault, repaired.

The effects of a defective speaker field coil across the rectifier output, as shown in Fig. 9–3, will be different from that given above. The receiver will be brought in for weak operation if the coil is open. This is because the set is operating with no field, but only the residual magnetism in the pole piece. The $B$ voltage will not be disturbed. The quick check for speakers will show a weak click, focusing attention on the field. Confirmation will be obtained by trying the receiver with the test speaker or by checking the magnetic pull of the speaker field, as shown in Fig. 9–10. A blunt piece of iron like a socket wrench is brought near the center pole piece. Make this check with care, lest the tool tear the paper cone or dust cover.
When the field excitation circuit includes a separate rectifier and filter, as is the case in the circuit of Fig. 9–3, the lack of field strength may be due to defects in the rectifier or filter, while the field coil itself is perfect. These associated components should be checked.

Final confirmation of the field condition may be made with an ohmmeter. The serviceman is again cautioned to discharge any associated filter condensers before making ohmmeter checks on a speaker field.

![Diagram of an electrodynamic speaker with a replaceable field coil.](image)

**Fig. 9–11.**—A typical electrodynamic speaker with a replaceable field coil.

Where the speaker field is used as a voltage divider, as in Fig. 9–4, defects would show up differently. If the field coil opened, the defect would be found in a routine check of plate voltages. The set would be dead. There would be no B plus voltage on the RF and IF tubes. High B plus would, however, be present in the other stages. The socket-wrench test would show no field strength. Substitution of a test bench speaker for both field and voice circuits would restore normal operation. The ohmmeter check for continuity would finally confirm the defect.

Another field-coil defect, common to all three excitation circuits, is that of shorts between the field winding and the center pole piece or the outside pot. If the speaker is mounted on the chassis, the
short will cause partial or complete loss of $B$ voltage and possible
damage to the power supply. This condition will be found in a check
of the power supply. The power-supply check would seem to indi-
cate a shorted filter condenser. The actual defect would be found
when removal of the suspected filter condenser does not remove the
short from the circuit. If the speaker is not on the chassis, the
speaker case will become "hot" with high voltage, but the receiver
operation may not be affected.

**Replacing a Speaker Field Coil.**—The construction of the speaker
pot does not always lend itself to the replacement of the field coil.
Nor are field coils obtainable for all speakers. When the field coil
cannot be replaced, the entire speaker must be replaced.

A typical electrodynamic speaker, which has a replaceable field
coil, is shown in Fig. 9–11. Here, the entire pot can be taken apart.

The procedure for removing the field coil is outlined in the fol-
lowing steps:

1. Remove the voice coil and cone in the manner described under
Troubles Common to the Voice Coil.
2. Remove the nuts from the bolts that hold the basket and the
top pole piece to the pot.
3. Remove the field coil (and hum-bucking coil, if used) by sliding
it forward over the center pole piece. This may involve first un-
soldering the field-coil terminals from a terminal strip.
4. Slip a replacement field coil over the center pole piece and,
where necessary, solder its leads to the terminal strip. The replace-
ment coil should be as nearly like the original as is possible. Replace
the hum-bucking coil (if used).
5. Replace the basket and the top pole piece. Replace the bolts
$B$, and loosely engage them with their nuts.
6. The next step centers the center pole piece, so that the field
space in which the voice coil floats is uniform. Place three or four
pieces of drill rod of the proper size to fit exactly in the field space,
as shown in Fig. 9–12.
7. The nuts for bolts $B$ are then tightened. It is wise not to
tighten any one nut completely while the others are loose. The
recommended procedure is to tighten one nut loosely, then the next,
and the next, etc. Continue around several times until each nut is
securely tightened. A socket wrench is used in this step. The
serviceman is cautioned to use care, so as not to strip the nuts or
bolts.
8. Remove the drill rods.
9. Replace and recenter the voice coil and cone, as described in
the section on Troubles Common to the Voice Coil.
Since the above operation may have reversed the phase of the hum-bucking coil, should a hum now develop, the serviceman should try reversing the voice coil or hum-bucking coil connections, as well as checking the power-supply filter circuit.

Where a pot and center pole piece may loosen or warp, giving the effect of an off-center voice coil, the procedure listed above must be followed, except for replacing the field coil.

![Diagram of a loudspeaker](image)

**Fig. 9-12.** — Centering the center pole piece with drill rod.

**R.M.A. Color Code for Loudspeakers.** — The various terminal wires of a loudspeaker may often be identified for servicing by means of the R.M.A. color code, tabulated below.

**Voice coil:**
1. Green ............................................ finish
2. Black ........................................... start

**Field coil (if any)**
1. Black and red ..................................... start
2. Yellow and red .................................... finish
3. Slate and red .................................... tap (if any)

**Troubles Common to the Paper Cone.** — The troubles common to the paper cone are those usually associated with the voice coil. The cement binding the cone to the voice-coil form may dry and crack,
with resulting rattles from the speaker. This condition may be remedied by using a standard voice-coil cement for reconnection. This latter procedure should be done with care.

On occasion, the paper cone may tear or crack and produce rattles. As a rule, it is not advisable to try to patch it, because the cement usually contracts when it dries and distorts the cone shape. A distorted cone produces distortions from the speaker. The entire cone and voice coil should be replaced. Where such a replacement is not available, the patch job should be done with a standard speaker-cone cement.

In many receivers, there is a felt or cardboard ring that is fastened around the rim of the basket. Its purpose is to prevent acoustic continuity between the speaker and the baffle to which it is attached. After replacing a voice coil and cone or a speaker field coil, the ring should be either bolted or cemented back into position.

**Troubles Common to Speaker Assembly and Mounting.**—After continuous operation, various parts within the receiver may have a tendency to become loose. Various screws in the speaker or associated with its mounting may also loosen, because of continuous operation. Where such is the case, rattles and buzzes may mar the speaker reproduction. The serviceman may verify this condition by connecting in a substitute test speaker from his test bench and observing if improvement results. If the rattles and buzzes disappear, a careful hunt must be made for any loose part prone to vibrate. This is done by holding various parts with the fingers while the receiver is operating, and observing if the vibrations are damped. No part should be beyond suspicion. Even the cabinet must be inspected for loose or cracked parts.

**Replacing a Complete Loudspeaker.**—Many speaker defects require the complete replacement of the entire loudspeaker assembly. Where such is the requirement, an exact replacement is most desirable. This may not always be possible, and a speaker that resembles the original as closely as possible must be used.

Several factors must be kept in mind by the serviceman. Is there sufficient space within the cabinet? Can the new speaker be mounted with sufficient ease? Is the resistance of the field coil, if an electrodynamic speaker is used, similar to that of the original? Is the current-carrying capability of the field coil of the replacement speaker sufficient for the receiver? Is the impedance of the new voice coil the same as that of the old speaker? And finally, is the power-handling capability (wattage) of the voice coil of the new speaker sufficient for the receiver?
Replacement speakers are usually listed according to the following factors:
1. Diameter of the basket in inches.
2. Voice-coil impedance in ohms.

Although the current-carrying capability of the field coil is not listed, it is an important factor that must not be overlooked. In this consideration, the size of the pot is an indication of the current-carrying capability of the field coil. The pot of the replacement speaker should be no smaller in size than that of the old speaker.

If the wattage output of the receiver is not indicated in the manufacturer's schematic, the proper wattage for the voice coil may be determined in another manner. The tube or tubes used in the second AF or output stage are determined by inspection. Then reference to a tube manual will give the undistorted power output for that tube. This wattage may be considered as the voice-coil wattage.

Often in making a speaker replacement, the old output transformer, mounted on the old speaker, may be removed and used with the new replacement speaker. The transformer primary will thus match the second AF stage. Care must then be taken that the transformer secondary impedance matches that of the voice coil of the new replacement speaker.

If the chosen replacement speaker has a voice-coil impedance differing considerably from the original, this will necessitate changing the output transformer for proper impedance match. Replacement notes on output transformers are found in Chap. 10.

Replacing an Electrodynamic with a P-M Speaker.—Sometimes an electrodynamic speaker has to be replaced, and a similar speaker is unobtainable. In such a case, a P-M dynamic speaker of proper voice coil, wattage, and size may be used with some provision to replace the field coil in the circuit of the receiver.

When the field excitation is obtained by connecting the field across the rectifier output, no provision for its replacement need be made. When the field coil is acting as the filter choke for the receiver, it should be replaced by a choke coil of equivalent inductance and current-carrying capability. The choke will probably have a lower ohmic resistance than the field. This will increase the available $B$-plus voltage. This increase in voltage will be small and will not alter the operation of the receiver to any great extent.

When the speaker field acts as part of the voltage divider, it must be replaced by an equivalent circuit, composed of a choke that is an equivalent inductance, and a series resistor to give the unit an equal
resistance. The latter consideration is necessary to maintain proper operating potentials for the tubes in the receiver. The choke must have proper current-carrying capabilities. The series resistor plus the ohmic resistance of the choke should equal the resistance of the original field coil. The current in the field can be determined by Ohm's law, and the wattage of the resistor can be determined by substituting in the wattage formula \( W = \frac{E^2}{R} \). Figure 9–13 shows a replacement of this type.

![Circuit Diagram](image)

Replaced by

![Circuit Diagram](image)

**Fig. 9–13.**—Replacing an electromagnetic with a P-M dynamic speaker—field-circuit adjustments.

**Dual Speaker Systems.**—Some receivers are built with two speakers within the same cabinet. Where a condition develops in such a receiver that one of these speakers must be replaced or requires a voice coil and cone replacement, the procedure is similar to that described for single-speaker replacements.

However, a new consideration develops. If one voice coil moves in while the other moves out, interference effects develop and reduce the volume of total output. This condition is undesirable and may be remedied by reversing the voice-coil or field-coil leads to one of the speakers. The voice coils will then move in and out together, and the speakers are said to be in phase.
To determine if the speakers are properly phased after replacement, turn on the receiver and tune to a nonstation position. Place your hands on the cones of the two speakers. Then apply the voltage of a dry cell across the output transformer secondary. The movement of the cones will be felt and seen, and proper phase may be found.

Adding a Speaker to a Receiver.—In some cases, a customer may desire a second speaker connected to his receiver and installed in another room. Since the speakers are remote from each other, phasing is not important.

![Diagram of speaker setup](image)

Fig. 9–14.—Adding an auxiliary P-M dynamic speaker to a receiver.

A simple procedure in this requirement is to obtain a P-M dynamic speaker and connect its voice coil in parallel with the voice coil of the receiver speaker. Of course, this will cause mismatch with the output transformer secondary, but the effect will not be too poor. Besides, the larger the impedance of the voice coil of the P-M dynamic speaker, the less will be the total mismatch, although less power will be fed to the auxiliary speaker. This may be of advantage, since it is generally desirable to operate the auxiliary speaker at a reduced volume. The combination is shown in Fig. 9–14.

In the setup described above, both speakers will operate simultaneously. If it is desired to shut off the receiver speaker while the auxiliary speaker functions, it is necessary to use a single-pole double-throw switch to cut out the first voice coil. In addition, a resistor, of comparable impedance to that of the voice coil just cut out, should be connected across the secondary of the output transformer. A second switch is connected at the auxiliary speaker to cut it out when not in use. This setup is shown in Fig. 9–15.
It is now possible to control the volume of the receiver and auxiliary speakers only by means of the receiver volume control. If it is desired to vary the volume of the auxiliary speaker at the speaker itself, a standard $L$ pad control may be inserted across the voice coil of the auxiliary speaker. The ohmic rating of the pad should match the impedance of the auxiliary voice coil. The complete setup is now shown in Fig. 9-16. No switch is required at the second auxiliary speaker, since the $L$ pad can replace its function. The minimum position of the $L$ pad will cut out the auxiliary speaker.

**Adding Headphones to a Receiver.**—A customer may request that headphones be installed on his receiver, so that he may turn off the loudspeaker and still listen to the radio late at night. The simplest procedure is to connect the phones across the voice coil. The high impedance of the phones will cause great mismatch and keep power fed to the phones low, giving low volume. A switch may be installed to cut out the speaker voice coil and to cut in an equivalent
impedance resistor. A second switch may be used to cut out the phones. The setup is shown in Fig. 9–17.

![Circuit for connecting earphones to a receiver.](image)

The same effect may be achieved by the installation of a circuit-switching phone jack, as shown in Fig. 9–18. Pushing the phone plug only part way in will allow simultaneous operation of the phones and speaker. Pushing the phone plug all the way in will cut out the speaker voice coil and allow operation of the phones alone.

![Circuit for adding phones to a receiver—using jack and plug.](image)
### QUESTIONS

1. A receiver is brought in as dead. No plate voltage appears to be present. If you suspect that the speaker is defective, what part would you suspect? How would you test for it?

2. A new voice coil and cone are installed in a receiver. When the set is turned on, it hums excessively. What is probably wrong? What remedial measures would you take?

3. A receiver requires a new speaker. An exact replacement is not obtainable. What considerations must be made in replacing a new speaker?

4. A rattling, rasping speaker is reported by a customer. Examination shows an off-center voice coil. What remedial measures would you make?

5. A receiver has a dual speaker system. One speaker requires replacement of a voice coil and cone. List the steps in order by which you would make this replacement.

6. A customer has a receiver in his living room. He wants to add an auxiliary speaker to operate in the cellar. He wants to be able to operate either or both speakers and also to control the volume of the cellar speaker in the cellar. Design a circuit for these requirements.

7. A customer wants to use headphones with his receiver at night, so that he can cut off the loudspeaker. Design a circuit for him.

8. A receiver with a power supply like the one of Fig. 9–3 gives very weak reception. A signal check produces a very weak click in the speaker. What factors can cause this condition? How would you check for each?
CHAPTER 10

SECOND OR POWER AUDIO-AMPLIFIER STAGE

The second AF amplifier stage is also called the "power-amplifier" stage or "output" stage.

Quick Check.—If a plugged-in soldering-iron tip or finger is placed on the control grid of the second AF amplifier tube and causes a low growl to be heard in the speaker, the second AF stage is probably functioning properly, and the trouble shooter moves on to the first AF stage.

Standard Circuit.—Figure 10–1 represents our standard second AF stage.

![Circuit Diagram](image)

**Fig. 10–1.**—Standard circuit for a typical second AF stage.

**Function of Second AF Stage.**—The control-grid circuit is the signal input of the stage; the plate circuit is the signal output. The signal fed into the stage is an AF voltage, the magnitude of which would be about sufficient to operate headphones. It is the function of the second AF stage to amplify this signal to an amount sufficient to operate a loudspeaker. To get an idea of the magnitude of the signal voltages handled by the second AF stage, a 6V6-G tube (most commonly used) gives an output of 4.25 watts with an input grid signal voltage of 12.5 volts peak. A smaller signal-input voltage would give a smaller output power; 12.5 volts is the maximum the tube will handle without undesirable distortion. The input signal is fed from the preceding first AF stage. The plate or output circuit of the stage feeds the amplified signal to the speaker.
Regardless of whether the receiver is AC, AC/DC, or battery-operated, the function and operation of the second AF stage is the same. Indeed, this is true for all stages but the power-supply stage.

FUNCTIONS AND VALUES OF COMPONENT PARTS

Grid-load Resistor R-12.—Resistor R-12 is the grid-load resistor, and the input signal is impressed across it. Its value usually is 500,000 ohms. When a different ohmage is used, a lower value would result in lower gain and better frequency response, while a higher value would give slightly higher gain at a sacrifice of tone quality.

Self-bias.—Since grid-bias voltage affects tone quality and amplification and is a valuable indication of trouble to the serviceman, the theory underlying self-bias circuits should be thoroughly understood.

Let us first remember that, in order to maintain a grid-bias voltage, the grid must be made negative with respect to its cathode. Assume no signal input voltage, and examine the amplifier circuit redrawn as in Fig. 10-2, with components unnecessary to the self-bias circuit eliminated. Observe that resistor R-13 and the tube V-5 are in series across the B power supply. Tracing the screen circuit, current flows from B minus through R-13, through the tube to the screen and B plus. Tracing the plate circuit, current flows from B minus through R-13, through the tube to the plate, and finally through L-12, the output-transformer primary, to B plus. It is seen that both screen and plate currents flow through R-13 and, as a result, a voltage drop is developed across it. Note also that the cathode is made positive with respect to B minus by this voltage drop. Then, when the grid is returned to B minus through R-12, the grid is negative with respect to the cathode. A negative grid will not attract electrons and, as a result, there is no current in the grid circuit through R-12 and no voltage drop across it. The full voltage developed across R-13, therefore, is applied to the grid as the bias voltage.

This system of obtaining grid-bias voltage is known as “self-bias,” since the tube’s own screen and plate currents cause the voltage drop, which is used for biasing the grid. The self-bias circuit can be used
with a triode type of tube also, in which case the voltage drop is caused by the plate current alone.

The ohmic value of $R\text{-13}$ will depend on the tube used and its operating potentials. Several common values follow:

<table>
<thead>
<tr>
<th>Tube</th>
<th>Ohm Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6V6-G</td>
<td>800 ohms</td>
</tr>
<tr>
<td>25L6-G</td>
<td>150 ohms</td>
</tr>
<tr>
<td>6K6-G</td>
<td>410 ohms</td>
</tr>
<tr>
<td>6L6-G</td>
<td>410 ohms</td>
</tr>
<tr>
<td>6L6-G</td>
<td>170 ohms</td>
</tr>
<tr>
<td>25A6</td>
<td>600 ohms</td>
</tr>
</tbody>
</table>

**Self-bias By-pass Condenser C-13.**—The input circuit of the tube is between grid and cathode. This involves grid-load resistor $R\text{-12}$ and self-bias resistor $R\text{-13}$. The input-signal voltage divides itself between them, most of the signal being across the larger grid-load resistor $R\text{-12}$. The output circuit of the tube is between plate and cathode. This includes the output transformer primary $L\text{-12}$, the $B$ power supply, and self-bias resistor $R\text{-13}$. The output signal divides itself among these three, most of it being across $L\text{-12}$, which has the highest impedance to the output signal. Resistor $R\text{-13}$ is common to both the input and the output circuits, and some of the input signal and some of the output signal will mix in $R\text{-13}$. This is coupling. Since a tube’s output signal is 180 deg out of phase with its input signal, cancellation takes place where the two signals are coupled, as across $R\text{-13}$. This effect of coupling, where cancellation takes place, is known as “degeneration” and results in a decrease in the gain of the tube.

The degenerative action can be minimized by bridging $R\text{-13}$ with a condenser. The current through $R\text{-13}$ has components made up of the DC screen and plate currents of the tube, the AC input signal, and the AC output signal. When $R\text{-13}$ is bridged by a condenser, the impedance of the parallel combination to the signal current is reduced, while its opposition to direct current remains the ohmic value of $R\text{-13}$. The voltages across the parallel combination therefore are reduced as regards signal voltage, while the DC bias voltage remains the same. The reduced input- and output-signal voltages across the parallel combination decrease the degenerative effect.

The action of the parallel condenser has been called “by-pass,” since, from one point of view, the signal current is taken out of resistor $R\text{-13}$ and passed around it through the condenser. The by-pass action depends on the impedance of the condenser to the signal frequencies. To be effective, it should be lower than the ohmic value of the resistor being by-passed.

Since the signal in the second AF stage is at audio frequency, a
high-capacity condenser will be necessary for adequate by-pass action. Condenser C-13 is usually a low-voltage electrolytic type. Capacities from 5 to 25 mfd will be found in various receivers. The higher capacities will provide better by-pass action, with a consequent improvement of the response, especially at the low audio frequencies.

Self-bias circuits similar to R-13 and C-13 are used to obtain bias voltages for the RF and IF tubes. The action in these tubes is similar, except that the cathode by-pass condensers need be only 0.1 mfd for adequate signal by-pass, owing to the higher signal frequencies at radio frequency and intermediate frequency.

Output Condenser C-12.—Condenser C-12 across the signal-output circuit by-passes high audio frequencies to ground. The pentode and beam-power tubes introduce a considerable amount of harmonics, which will be most noticeable in the high AF range. Placing C-12 across the signal output circuit by-passes some of the signal away from the output transformer. This effect will be greatest at the high audio frequencies, since the impedance of a condenser decreases as the frequency increases. Therefore, the harmonic content will be reduced by the action of this condenser.

An average value for condenser C-12 is 0.005 mfd. In individual receivers, this value may vary from 0.001 to 0.02 mfd. Receivers using the higher capacity values have been designed to favor the bass register, since the higher capacity by-passes more of the high frequencies out of the output transformer and speaker, making the response deeper by comparison.

Output Transformer T-6.—Transformer T-6, called the “output” transformer, is often mounted on the speaker. Its function is to couple the output circuit of the tube to the speaker. The average beam-power tube requires a load of 5,000 ohms, and the average speaker voice coil has an impedance of 8 ohms at audio frequencies. The coupling transformer is designed, therefore, to have a primary impedance of 5,000 ohms and a secondary of 8 ohms. Obviously, if the output transformer should become defective, the original manufacturer’s part should be obtained for best results. However, where this is not possible, a universal-type transformer may be used satisfactorily. The replacement notes on output transformers explain this procedure more fully.

Vacuum Tube V-5.—Vacuum tube V-5 is called the “power” tube, sometimes the “output” tube, as well as the second audio tube. The tube most commonly found in this stage is the 6V6-G beam-power amplifier. Smaller receivers, where the B supply voltage and the power output are lower, use the 6K6-G power-amplifier
pentode. Receivers equipped with locking-base type tubes use the 7C5-LT.

Older receivers use power-amplifier pentodes, like the 6F6-G, 42, or 47. Receivers of the AC/DC type use the 25L6 or 50L6 beam power amplifiers. Older AC/DC receivers use a type 43 or 38 tube.

All these tubes are characterized by high power sensitivity; that is, a low signal-input voltage causes a high power output. For example, in the case of a 6V6-G, an input signal of 12.5 volts gives an output power of 4.25 watts. By way of comparison, the very much older 45 power-amplifier triode requires an input signal of 50 volts to give an output power of 1.6 watts.

NORMAL TEST DATA FOR THE SECOND AF STAGE

Check for Normal Stage Operation.—The signal check for the second AF stage is shown in Fig. 10–3. The signal generator is adjusted to give an AF signal, and the attenuator is set for maximum output. The signal generator ground lead is connected to the receiver chassis, and the “hot” lead is connected through a 0.1-mfd/600-volt condenser to the plate terminal of the second AF tube (pin No. 3 for a 6V6-G tube). The purpose of the condenser is to prevent the DC voltage, present at the plate of the second AF tube, from affecting the signal generator circuits. Normally, the full AF output of the signal generator is just sufficient to cause an audible note in the speaker. The hot lead of the signal generator is then shifted to the grid terminal (pin No. 5 for a 6V6-G tube) of the second AF tube. The signal-generator note should be heard in the speaker at a much greater volume. The gain in volume is an indication of the gain of the tube.

Experienced servicemen rarely go to the trouble to use this meth-
od. A much faster check, given as the quick check at the beginning of this chapter, is to touch the grid terminal with a finger or the tip of a plugged-in soldering iron. In either case, a low growl will be heard from the speaker, indicating that the stage is functioning.

**Normal Second AF Voltage Data.**—Voltages are measured from chassis or common negative to tube terminal indicated. In some AC/DC receivers, where the circuit insulates $B$ minus from the chassis, the negative terminal of the voltmeter is connected to the common negative. This is most easily found at the line switch. See Chap. 18 on AC/DC Power Supply.

<table>
<thead>
<tr>
<th>Tube terminal</th>
<th>25L6 and 6V6-G 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>235</td>
<td>85</td>
</tr>
<tr>
<td>Screen</td>
<td>4</td>
<td>250</td>
<td>90</td>
</tr>
<tr>
<td>Grid</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cathode</td>
<td>8</td>
<td>12.5</td>
<td>6</td>
</tr>
</tbody>
</table>

Voltages may vary somewhat from those given in the accompanying table. A significant point for the observant serviceman to note, however, is that the screen voltage is slightly higher than the plate voltage. This is due to the plate current of the tube, which causes a voltage drop across the output transformer primary. Variations in this voltage relationship are indicative of trouble. For example, if the plate and screen voltages are exactly the same, there is no voltage drop across the output transformer primary. This fact indicates no plate current, a condition resulting from either an open self-bias resistor, or no emission in the tube.

A positive voltage reading at the grid is indicative of breakdown of the coupling condenser $C-32$ in the preceding stage. Service notes on this fault will be found in the chapter describing the first AF stage.

**Normal Second AF Stage Resistance Data.**—These data are given in the following table:

- Chassis to cathode: 300 ohms
- Chassis to control grid: 500,000 ohms
- Plate to $B$ plus: 200–600 ohms

The 300 ohms of resistance from chassis to cathode is the ohmic value of self-bias resistor $R-13$. When a tube other than the 6V6-G tube is used, a different value will be found. Refer to the diagram of the receiver being tested, or to the table on page 102. The plate
to $B$ plus reading measures the resistance of $L-12$, the primary of the output transformer.

**COMMON TROUBLES IN THE SECOND AF STAGE**

Troubles Common to the Grid-load Resistor.—Resistor $R-12$ rarely causes trouble. Occasionally it may open, thereby opening the grid circuit and causing lack of grid-bias voltage. This will result in bad distortion. At other times, signal voltage at the grid may build up and discharge periodically through dirt at the socket terminals, acting as a resistance parallel to $R-12$ and allowing a surge of current with each discharge. These surges may be heard in the speaker as a put-put known as “motorboating.” If the surges come more rapidly, they will take the form of a low-pitched growl. The latter is sometimes mistaken for hum, which is also a low-pitched growl. Standard procedure in trouble shooting for hum is first to check the filter condenser in the power supply and then to look for an open grid-load resistor in this or any other stage.

Open $R-12$ would be found in a voltage check of the stage, since an open grid causes a much heavier plate current. This condition makes for a greater than normal voltage drop across $L-12$ and, as a result, the plate voltage is lower. Since the screen voltage remains near its normal value, there will be a greater than normal difference between plate and screen voltages. Since conditions other than an open grid-load resistor will cause heavy plate current, confirmation must be obtained. This can be done with an ohmmeter.

In replacing resistor $R-12$, nothing in particular need be stressed. An exact duplicate of the original is desirable although not necessary. An ohmic value differing by as much as 20 per cent either way will cause no noticeable difference, and the wattage rating is
unimportant. However, the soldering must be carefully done, and the socket must be cleaned of dirt and excess rosin.

Troubles Common to the Cathode By-pass Condenser.—The cathode by-pass condenser C-13 often causes trouble. Like all electrolytic condensers, it is likely to dry out and lose capacity. As C-13 loses capacity, approaching an open condenser, the stage would give low gain and poor low-frequency response. This condition would be found in checking for low gain or for poor tone by bridging the condenser with one of 5 mfd or greater that is known to be good.

Less frequently, C-13 shorts or leaks badly, acting as a partial or complete short across R-13. This will result in poor tone quality due to lowered bias and would be found by a voltage check. Since plate current increases at lowered bias, a greater than normal voltage drop across the output transformer primary would be produced. This results in a lowered plate voltage and a large difference between screen and plate voltages. A shorted C-13 may have been caused by an open cathode resistor R-13. Check this condition before replacing.

In replacing condenser C-13, the serviceman watches for proper polarity, the positive side being connected to the cathode. The defective condenser should be removed. A capacity larger than the original may be used since, if anything, this will improve the low-frequency response. However, a condenser of capacity lower than the original will adversely affect the low-frequency response. Low-voltage electrolytic condensers are usually rated at 25 or 50 volts. Either will do for C-13, since the voltage across the condenser is approximately 12.5 volts for AC receivers and 6 volts for AC/DC receivers. This is the voltage developed across R-13 for self-bias.

It is important to emphasize again that a shorted C-13 may have been caused by an open bias resistor R-13. Therefore, when replacing a shorted C-13, the bias resistor should be checked immediately after the shorted condenser has been removed.

Troubles Common to the Self-bias Resistor.—Self-bias resistor R-13 is a likely source of trouble. It carries considerable current and is subject to heating. Sometimes it changes in ohmic value, and sometimes it opens. A change in ohmic value affects the bias voltage and, therefore, the tone quality. When R-13 is open, the cathode circuit is completed by the leakage resistance of parallel condenser...
C-13. Since this leakage resistance is comparatively high, the voltage drop across it will be high, making for abnormally high bias voltage. The condition would be found in a voltage check. The screen and plate voltages would be nearly equal, since at the high bias voltage, plate current would be low, the voltage drop across the output transformer primary would be low, and plate voltage would be high. The open would result in a high cathode bias voltage which might damage parallel condenser C-13.

Any change in ohmic value of R-13 is found in a voltage check of the stage. If it becomes low in ohmage, cathode voltage will be low, resulting in high plate current and a large voltage drop across the output transformer, increasing the voltage difference between screen and plate.

When replacing R-13, it would be wise to use at least a 1-watt resistor, regardless of the size of the original. Manufacturers often cut corners on this item by using the less expensive %2-watt size.

Troubles Common to the AF By-pass Condenser.—Condenser C-12, the high AF by-pass, often comes up as the cause of a dead radio. Its position in the receiver is not only at a high DC potential but also where the AC signal potential (audio variation) is at its highest. This high voltage causes frequent breakdown of insulation, resulting in a shorted condenser, which shorts out the audio signal from the primary of T-6 and also the power supply at this point. This condition is quickly found in a voltage check. Plate voltage equals zero, and screen or B plus voltage is low, since the power-supply voltage drops with the heavy load.

Condenser C-12 may also open. However, a radio will rarely come in for this defect alone, since an open C-12 will merely increase the high-frequency response, and the customer may overlook this. In some radios, an open C-12 may cause a high-frequency oscillation. If this is the case, bridging C-12 with a similar condenser or with a higher capacity condenser is the standard check procedure.

When condenser C-12 is replaced, a good quality of condenser should be used. Regardless of the original value, the voltage rating of the replacement condenser should be at least 600 volts. The outside foil lead or ground lead should be connected to the chassis. Condenser C-12 sometimes is connected from plate to B plus. In that case, the outside foil lead is connected to B plus. The replacement condenser should have the same capacity as the original. If the capacity of the replacement condenser is changed for any reason, it should be borne in mind that a higher capacity will cut more highs out of the signal delivered to the speaker, while a lower capacity will increase the high-frequency response.
Troubles Common to the Output Transformer.—Output transformer T-6 is also a common source of trouble. In addition to carrying the audio signal, the primary winding also carries the normal DC plate current of the tube. An open primary often results. When the plate circuit opens, the positive screen attracts the total cathode emission. It was not intended to carry so heavy a current, and the screen mesh becomes red-hot. This can be seen in the case of a glass pentode and is one of the things the experienced serviceman looks for when making a visual inspection of the receiver. In the case of a metal tube, the condition cannot be seen and will be found by voltage analysis, since the open plate circuit will cause zero plate voltage.

As explained before, the output transformer should be replaced with an exact duplicate where obtainable. When this is not possible, a universal output transformer may be substituted. These usually come with an instruction sheet, but servicemen sometimes find it confusing and connect the transformers improperly. This results in poor tone quality. A bit of theory might help to clear up this matter.

The output transformer, as an impedance matching device, works on the principle of reflected load, a term the average serviceman shies away from. Let us first try to explain it.

Assume a power transformer that is being used to light lamps.
For simple arithmetical figures, let us also assume a 100-volt line, rather than the usual 110 or 120 volts, and lamps requiring 10 volts at 1 amp each. For further simplification, assume 100 per cent efficiency in the transformer; that is, watts input equals watts output. The transformer has a 10 to 1 step-down ratio to furnish the 10 volts needed for the lamps. Each lamp has a resistance of 10 ohms \((R = E/I = 10/1 = 10 \text{ ohms})\).

When one lamp is connected, as in Fig. 10-7, 1 amp flows through the lamp. Wattage dissipated is 10 watts \((W = E \times I = 10 \times 1 = 10 \text{ watts})\). To satisfy watts input equals watts output, the primary current will be 0.1 amp \((I = W/E = 10/100 = 0.1 \text{ amp})\). To the 100-volt line, the transformer primary looks like a 1,000-ohm impedance or resistance load, since it will drive only 0.1 amp into it \((Z = E/I = 100/0.1 = 1,000 \text{ ohms})\). Now let us light two lamps from the same transformer, as in Fig. 10-8. Two 10-ohm lamps in parallel have a combined resistance of 5 ohms and will draw 2 amp \((I = E/R = 10/5 = 2 \text{ amp})\) from the secondary, which remains at 10 volts. The actual impedance therefore is 5 ohms. Watts consumed is 20 watts, \((W = E \times I = 10 \times 2 = 20 \text{ watts})\). Once again to make watts input equal watts output, the primary current must now increase to 0.2 amp \((I = W/E = 20/100 = 0.2 \text{ amp})\). The 100-volt line now looks at the transformer primary as though it were a 500-ohm impedance, since it must furnish 0.2 amp to it \((Z = E/I = 100/0.2 = 500 \text{ ohms})\). This is called "reflected load." Under the above conditions, a 10-ohm actual load reflects back to the primary a 1,000-ohm load, while a 5-ohm actual load gives a 500-ohm reflected load in the primary. Note also the ratio of reflected to actual load, 100 to 1, which is the square of the turns ratio 10 to 1; that is, a transformer with a 10 to 1 turns ratio would make the reflected load in the primary 100 times \((10^2)\) as great as the actual load in the secondary.

Now let us apply this bit of transformer theory to the output transformer. Assume a 10-ohm voice coil connected to the same...
10 to 1 transformer that was used before to light lamps. The connections are shown in Fig. 10–9. The primary would look like 1,000 ohms to any line feeding it. Obviously, this transformer would not do to couple the 10-ohm voice coil to a 6V6-G tube, which requires a 5,000-ohm load resistance for optimum results. A turns ratio of 20
to 1 would make a much better match, since the reflected load in the primary of a 10-ohm voice coil in the secondary would be \((20)^2\), or 400 times as great (4,000 ohms). A turns ratio of 22.4 to 1 would be exactly right.

A universal output transformer is one supplying many possible combinations of turns ratio, so that almost any voice coil may be matched to almost any tube or combination of tubes. A typical universal output transformer is shown in Fig. 10–10. The primary is center-tapped for use in push-pull circuits. In second AF stages using a single tube, the center tap should be taped up and disregarded. Then, either end of the primary winding is connected to the plate, and the other to B plus. The secondary usually has six taps,

numbered 1 to 6, and a great number of turns ratio combinations is possible.

In using a universal output transformer as a replacement, the first requisite is to use the proper size. They are rated by wattage. Physical size of the transformer is a rough indication of the wattage. Make sure that the replacement is as large as the original. Confirma-
tion may be obtained by comparing the wattage size used with the tube-manual rating for the output tube or tubes in the receiver. The tube manual will also give the recommended load impedance.

The next step is to determine the voice-coil impedance. To do this, determine its resistance on the low-ohm scale of your ohmmeter. Then multiply the reading by 1.25. (This rule of thumb is close enough for general service work.) Then check with the instruction sheet, which comes with the universal output transformer for the proper taps to use. Figure 10–11 is a sample instruction sheet. As an example of how the sheet is to be used, let us find the proper taps for the standard receiver. The voice coil is measured on the low-range ohmmeter and found to be 5 ohms. Multiplying by 1.25, its approximate impedance is found to be about 6 ohms. The single 6V6-G output tube requires a load impedance of about 4,000 ohms. The output transformer must therefore match about 4,000 ohms to 6 ohms. Look for the single 6V6-G, which is found in the column headed by 4,000 as the primary load impedance. Run down this column into the voice-coil impedances looking for 6 ohms. Then, read across horizontally to find secondary taps 1 and 5, which are to be used.

There is sometimes an inverse feedback lead connected from the secondary of the output transformer back to a previous point in the audio amplifier circuit. In this case, when the output transformer is replaced, the voltage fed back may be in the wrong phase and cause an audio oscillation or squeal, which will be present with or without any signal being fed into the amplifier. When this happens, reversal of either the primary or the secondary leads will clear up the difficulty. More will be said regarding this matter in the section on circuit variations dealing with inverse feedback.

Troubles Common to the Second AF Tube.—The tube itself may
### Simplified Chart Showing Proper Use of Secondary Taps

<table>
<thead>
<tr>
<th>Primary load impedance</th>
<th>18,000</th>
<th>14,000</th>
<th>10,000</th>
<th>8,000</th>
<th>7,000</th>
<th>4,000</th>
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<tbody>
<tr>
<td>Single</td>
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<td></td>
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**Secondary Tap**

<table>
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<tr>
<th>Tap</th>
<th>Voice-coil impedance</th>
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<td>24.2</td>
<td>21.2</td>
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**Fig. 10-11.—Universal output transformer—instruction sheet.**
be the cause of poor operation of the stage. Low emission will cause low gain and poor power-handling capacity. A tube checker usually shows this condition, or it will show up on voltage analysis. Low emission results in low plate current, consequently low self-bias voltage, and a too small difference between plate and screen voltages. The tube also might be noisy (possible loose elements) or cause hum (cathode-to-filament leakage). The best check for these conditions is to substitute a similar type of tube, known to be good.

A fairly common trouble, particularly in the case of 43, 25L6, and 25A6 tubes, is known as “grid emission.” The complaint here is that the radio starts playing normally, but after 5 min or so begins to distort badly. A voltmeter connected from chassis to grid will begin to show positive at the grid as the distortion begins.

CIRCUIT VARIATIONS OF THE SECOND AF STAGE

Tone Control in the Second AF Stage.—There are many tone-control circuits, the most common of which is shown in Fig. 10–12. Condenser C-112 and variable resistor R-112 are in parallel with condenser C-12. Like condenser C-12, condenser C-112 by-passes high audio frequencies out of the speaker circuit. Condenser C-112 has a comparatively high capacity, 0.05 mfd being usual. By itself, it would remove most of the high audio frequencies from the signal and make the low notes seem more prevalent by comparison. Variable resistor R-112, which by its setting allows more or less of the by-passing of high frequencies through C-112 to take place, constitutes a tone control. The usual value of R-112 is 50,000 ohms.

All tests for the standard second AF stage are equally applicable to this variation, and all notes applying to condenser C-12 may also be used for tone condenser C-112. If this condenser should short, however, the path for the high B plus voltage to ground would be through the tone-control variable resistor R-112. This would give a variable shunt path depending on the tone-control setting. At the maximum bass position, there would be a very low resistance from plate to ground through the shorted condenser, the B voltage would be low, and the receiver would not operate. At the minimum bass position there would simply be a 50,000-ohm shunt path for the B supply, and the receiver would operate. The erratic action of the tone control would, of course, focus the serviceman’s attention to this circuit, and the defect would be found by ohmmeter check. When a shorted tone condenser is replaced, the heavy current through R-112 may have damaged the tone control. It would therefore be wise to replace the tone control also. Replacement notes on volume controls given in Chap. 11 may be applied to the tone control.
A modern trend in the use of tone controls is to replace the variable resistor \( R-112 \) with a switch, thereby making a 2-point tone control. An example of this is shown in Fig. 10–13. Note the tone condenser \( C-23 \) and its associated switch in the plate circuit of the 50L6 tube. When the switch is open, there is no shunting action, and this is the treble position. In the bass position, where the switch is closed, \( C-23 \), which is 0.04 mfd, shunts some of the high audio frequencies out of the speaker.

![Fig. 10–12.—Tone Control in the second AF stage.](image)

Figure 10–14 shows a similar 2-point tone control. In this case, the shunting action of \( C-21 \) and its associated switch is in the input circuit of the second AF tube.

**Inverse Feedback in the Second AF Stage.**—Inverse feedback is a form of desirable degeneration often used in the audio amplifiers of radio receivers. There are many types of inverse feedback circuits in common use. In all of them, part of the output signal is fed back in an out-of-phase relationship (hence the name “degeneration”) to some point in the input signal circuit, to provide improved over-all audio fidelity by canceling out harmonic distortions. Inverse feedback is always accompanied by a loss in gain, but the amplifier is designed for higher than normal gain to compensate for this loss.

In Fig. 10–13, the cathode by-pass condenser has been omitted to provide degeneration through self-bias resistor \( R-3 \), which is common to both the input and output circuits of the 50L6 tube. Since the input and output circuits of a tube are 180 deg out of phase, degeneration is automatic. Condenser \( C-18 \), the high-frequency by-pass condenser, is returned directly to cathode rather than to ground, so that the degenerative effect is greater at the higher frequencies (especially the high harmonic frequencies), thereby making for more uniform response for the stage. In Fig. 10–14 the inverse feedback
Fig. 10-13—Schematic diagram of Emerson Model GB receiver.
Fig. 10-14.—Schematic circuit of the Stromberg-Carlson No. 400 receiver.
circuit is shown by the heavy lines. The feedback voltage is taken from the plate of the 6V6-G output tube and fed through resistor R-14 back to the plate of the first AF section of the 6SQ7 tube.

As a general rule, inverse feedback circuits do not cause many complications to the serviceman. All tests and service notes pertaining to the standard amplifier circuit may be applied. Resistor R-14 in the feedback circuit, represented in Fig. 10–14, will rarely cause any service difficulty.

Fig. 10–15.—Inverse feedback circuit where the feedback is taken from the secondary of the output transformer.

A servicing problem pertaining to inverse feedback circuits occurs when the feedback voltage is taken from the output transformer secondary, as shown in Fig. 10–15. In this case, the feedback voltage is reintroduced into the cathode circuit of the first AF tube, which has no by-pass condenser. Another variation of this same circuit introduces the feedback voltage into a tap in the grid load of the first AF tube. In either case, if the output transformer leads should become reversed, as may easily happen when the output transformer is replaced, the feedback voltage will be in phase with the signal voltage rather than out of phase. This will produce regeneration rather than degeneration, and the audio amplifier becomes an audio oscillator. The oscillation appears in the speaker, usually as a high-pitched squeal, and will, of course, be unaffected by tuning the receiver. The serviceman must be aware of this possibility when replacing the output transformer, since the usual service procedure for oscillation will not disclose it. Reversing the primary or secondary leads, whichever is simpler, will clear up the difficulty.

**Fixed Bias in the Second AF Stage.**—The fixed-bias circuit is found in radios where the negative leads of the filter condenser are not at chassis potential, as shown in Fig. 10–16. In this circuit the cathode is grounded, and negative grid bias is obtained by connecting
the grid return to a point in the power-supply stage more negative than ground, and therefore more negative than cathode. Various circuits for the power supply stage are given in Chap. 8. Resistor R-113 and condenser C-113 form a filter circuit for the bias voltage. Representative values are 0.5 megohm (500,000 ohms) for R-113 and 0.1 mfd for C-113. This filter circuit may be omitted.

Normal test voltage data for this type of circuit will be different from the standard circuit and are given below.

![Fixed bias circuit in the second AF stage.](image)

**Normal Voltage Data for Fixed-bias Second AF Stage.**—Voltages are measured from chassis to tube terminal indicated. In some AC/DC receivers, where the circuit insulates B minus from the chassis, the negative terminal of the voltmeter is connected to the common negative. This is most easily found at the line switch. See Chap. 18 on AC/DC Power Supply.

<table>
<thead>
<tr>
<th></th>
<th>AC receivers, volts</th>
<th>AC/DC receivers, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate voltage</td>
<td>235</td>
<td>90</td>
</tr>
<tr>
<td>Screen voltage</td>
<td>250</td>
<td>95</td>
</tr>
<tr>
<td>Grid voltage</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Cathode voltage</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The measured negative grid voltages will depend on the ohms-per-volt rating of the test voltmeter, owing to the high resistance in the circuit involved. High-resistance meters will show more voltage than low-resistance meters. All meters, however, will show some negative indication. The actual bias voltage can be measured more accurately from C minus to chassis in the power supply, a low-resistance circuit.
All parts have the same functions, values, and likely troubles as in the standard circuit. Of the parts peculiar to this circuit, there is little likelihood of trouble from $R-113$ in the $C$-minus bias filter. The associated condenser $C-113$ is a paper tubular condenser. Since it is in a high-resistance circuit, any leakage will cause decreased bias voltage, resulting in various degrees of distortion and power handling capacity. The condition would be found in a voltage check, since the decreased bias would cause high plate current, a large voltage drop across the primary of the output transformer, and a greater than normal difference between plate and screen voltages.

The schematic diagram of the Motorola Model 61T23 receiver, shown in Fig. 10–17, is an example of the fixed-bias type of second AF stage. The bias circuit has been indicated by the heavy lines. Note the following conditions: The common terminal of the filter condenser block is connected to the center tap of the high-voltage winding. The cathode of the 6K6-GT second AF tube is connected to the chassis. The grid-load resistor, part number (38), is connected to the negative end of the bias voltage divider, parts numbers (46) and (47). The bias voltage is filtered by the 20-mfd/25-volt condenser section of the electrolytic condenser block (16). And the bias voltage for the second AF tube is indicated in the voltage chart as being measured from $B$ minus to ground. Note also the 3-point tone switch (50) in the input circuit of the second AF stage.
SECOND OR POWER AUDIO-AMPLIFIER STAGE 121

Fig. 10-17—Schematic diagram of the Motorola Model 61T23 receiver.
SUMMARY

Test for normal operation of the second AF stage.

The tip of a plugged-in soldering iron applied to the grid of the tube causes a growl to be heard in the speaker.

Diagram of a typical second AF stage.

The accompanying figure shows the typical second AF stage.

Normal voltage data.

Voltage is measured from the chassis or common negative lead. Voltage data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Tube terminal</th>
<th>25L6 and 6V6-G 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>235</td>
<td>85</td>
</tr>
<tr>
<td>Screen</td>
<td>4</td>
<td>250</td>
<td>90</td>
</tr>
<tr>
<td>Grid</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cathode</td>
<td>8</td>
<td>12.5</td>
<td>6</td>
</tr>
</tbody>
</table>

Normal second AF stage resistance data.

Chassis to cathode .......................................................... 300 ohms
Chassis to control grid ...................................................... 500,000 ohms
Plate to B plus ............................................................. 200–600 ohms

The 800 ohms of resistance from chassis to cathode is the ohmic value of self-bias resistor $R_{13}$. When a tube other than the 6V6-G is used, a different value will be found. Refer to the diagram of the receiver being tested, or to the table on page 102.

The plate to $B$ plus reading measures the resistance of $L_{12}$, the primary of the output transformer.
### SERVICE DATA CHART FOR THE SECOND AF STAGE

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Abnormal reading</th>
<th>Look for</th>
</tr>
</thead>
<tbody>
<tr>
<td>No signal from the speaker</td>
<td>Plate voltage = 0. Screen voltage = 0</td>
<td>Trouble in the power supply. See Chap. 8</td>
</tr>
<tr>
<td></td>
<td>Plate voltage = 0. Screen voltage low</td>
<td>Short-circuited high AF bypass condenser C-12</td>
</tr>
<tr>
<td></td>
<td>Plate voltage = 0. Screen voltage normal or high. (Screen of a glass second AF tube glows)</td>
<td>Open primary winding of output transformer T-6</td>
</tr>
<tr>
<td></td>
<td>Plate voltage normal or high. Screen voltage same as plate</td>
<td>Weak second AF tube. Open self-bias resistor R-13</td>
</tr>
<tr>
<td>Poor tone quality</td>
<td>Plate voltage low. Screen voltage normal (large difference between plate and screen voltages)</td>
<td>Defective second AF tube. Short-circuited cathode bypass condenser C-13. Open grid-load resistor R-12. Shorted or leaky coupling condenser C-32 (see Chap. 11)</td>
</tr>
<tr>
<td></td>
<td>Voltages normal</td>
<td>Open cathode by-pass condenser C-13. Mismatched replacement output transformer</td>
</tr>
<tr>
<td>Motorboating</td>
<td></td>
<td>Open output filter condenser C-16. Open grid-load resistor R-12</td>
</tr>
<tr>
<td>Squeal or oscillulation</td>
<td>Voltages normal</td>
<td>Open output filter condenser C-16. Open high AF bypass condenser C-12. Degenerative feedback connection from replacement output transformer incorrectly phased</td>
</tr>
</tbody>
</table>

### QUESTIONS

1. A receiver is brought in for repairs, the complaint being "no reception." Visual inspection shows a red-hot screen grid in the type 6F6-G power tube. What is likely to be wrong? Indicate the tests that should be made to confirm your assumption.
2. In a dead receiver, the power supply is found to be operating normally. A voltage check of the second AF stage shows the following:

Plate .................................................. 300 volts
Screen ............................................... 300 volts

What are the likely causes of the trouble? Indicate the tests that should be made to confirm the actual cause of the trouble.

3. An AC receiver, using a 6V6-G tube in the second AF stage, gives a high-pitched squeal regardless of the setting of the volume control or tuning dial. What are the possible causes of the trouble? How would you check for each?

4. The receiver of Fig. 10–17 has an open output transformer. If an original replacement is not obtainable, use the universal output transformer chart of Fig. 10–11 for reference and choose (1) the type of transformer that should be used, and (2) the secondary taps that should be used.

5. The receiver of Fig. 10–14 has low volume and sounds tinny. A voltage check shows normal voltage readings. Substitution of the bench test speaker causes no improvement. What should the next check be?

6. The receiver of Fig. 10–14 motorboats. Bridging the output filter condenser C-26 with a 20-mfd/450-volt condenser causes no improvement. What should the next check be?

7. The receiver of Fig. 10–13 begins to distort after it has been playing for 15 min. What would you suspect is wrong? How would you confirm your suspicion?

8. A distorting receiver gives the following voltage check for the 6V6-G tube in the second AF stage:

Plate .................................................. 200 volts
Screen ............................................... 250 volts
Grid .................................................. 0 volts
Cathode ............................................. 2 volts

What is likely to be the cause of the distortion? How would you confirm your assumption?

9. The receiver of Fig. 10–13 is brought in as dead and gives the following voltage readings for the second AF stage:

Plate .................................................. 95 volts
Screen ............................................... 95 volts
Cathode ............................................. 30 volts

What is likely to be the cause of the trouble? How would you confirm your assumption?

10. What precautions should be observed in replacing a shorted high-AF by-pass condenser?
CHAPTER 11

FIRST AUDIO-AMPLIFIER STAGE

Quick Check.—If a wet finger or a plugged-in soldering iron is applied to the input of the first AF stage and a very strong growl comes out of the speaker, the stage is probably functioning properly, and the serviceman moves on to the next stage.

Function of First AF Stage.—The control grid circuit is the stage input and is coupled to the detector output circuit. The plate circuit is the stage output, which is in turn coupled to the grid or input circuit of the second AF stage. The detector has an output of roughly 1 volt of AF signal. The second AF stage, if it contains a 6V6-G beam-power amplifier, requires an input signal of 12.5 volts to drive the speaker to full volume. It is therefore the function of the first AF stage to build up the detector output signal voltage (1 volt) to the level necessary to drive the second AF stage (12.5 volts).

Theory of Operation, Functions, and Values of Component Parts. From the function of the stage, to amplify 1 volt of signal to 12.5 volts, it would seem that a voltage amplification of 12.5 for the stage would be sufficient. However, the detector output may be less than 1 volt, in which case there would be insufficient volume. The first AF stage, therefore, is usually designed for high voltage gain, 50 or higher, so that low input signals can be amplified to the required level to operate the second AF stage. Then, should the input be excessive, the detector signal level feeding the first AF stage is reduced through a potentiometer, which is the manually operated volume control of the receiver.

The first AF stage is called a “voltage” amplifier, while the second AF stage is called a “power” amplifier. The reason for these descriptions lies in their functions. The second AF stage drives the speaker and must furnish power to vibrate the speaker cone and the surrounding air. Electric power is measured in watts, which incorporates both voltage and amperage. The second AF tube, the output transformer, and the speaker are all rated in watts. The second AF stage, therefore, is a power amplifier developing enough power to drive the speaker. The first AF stage, on the other hand, furnishes the grid excitation for the second AF tube. The grid of the second AF tube is always kept at a negative potential by the bias voltage.
supply, and the signal voltage does not normally exceed the bias voltage. As a result, the grid circuit does not draw current from the previous stage, and the signal grid excitation therefore requires voltage but not current. For this reason, the first AF stage, which furnishes the grid excitation for the second AF stage, is called a “voltage amplifier.” If the signal voltage at the second AF grid should exceed the bias voltage and grid current result, the first AF stage would also be furnishing power. Likewise, if the first AF stage were used to drive a pair of headphones, it would be operating as a power amplifier.

The tube used as the first audio amplifier is usually a high-mu triode. Most often, it is the triode section of a dual-purpose diode and high-mu triode, like the 6SQ7, which will be used in our standard circuit. The diode section is used as the detector and will be described in Chap. 12.

![Fig. 11-1.—Typical first audio-frequency amplifier stage.](image)

**Standard Circuit.**—Potentiometer $R-27$ is the manual volume control for the receiver. Its usual value is 500,000 ohms. The detector signal output is connected across $R-27$, and the position of the potentiometer arm determines how much of the detector signal output voltage is fed to the audio amplifier. For example, if the arm is near the grounded end, little of the detector output voltage developed across $R-27$ gets amplified, and this is the low-volume position. If the arm is nearer the ungrounded end, more of the available signal voltage gets amplified, and this is the high-volume position.

Condenser $C-31$ is the coupling condenser. It feeds the audio signal voltage from the volume control to the grid or input circuit of the tube and is usually 0.005 mfd. It may vary in different receivers from 0.001 to 0.02 mfd.

Resistor $R-31$ is the grid load. It returns the grid directly to the cathode in a circuit known as “contact bias.” As will be explained,
the grid-load resistor in a contact bias circuit usually is high: 2 to 15 megohms. The average size for the standard circuit is 10 megohms.

Operation of Contact Bias.—When the schematic diagram is studied, it would seem at first glance that there is no grid-bias voltage on the triode section of $V-4$, since the grid goes to ground through $R-31$ and the cathode is also at ground potential. To understand how a bias voltage is developed between grid and cathode, first assume a condition of no signal input. In the tube, the cathode is emitting electrons which are attracted by the positive plate, as shown in Fig. 11–2. Some of these electrons impinge on the grid located between cathode and plate, as shown in Fig. 11–3. These

![Fig. 11–2. Electrons being attracted from the cathode to the positive plate.](image)

![Fig. 11–3. Electrons impinging on the grid of a tube in developing contact bias.](image)

will flow through the grid load $R-31$ back to cathode. Since $R-31$ usually has a high resistance, it will not require very much grid current flow to develop a voltage across it. By applying Ohm's law, $E = I \times R$, a current of only 0.1 microampere (0.0000001 amp) will develop 1 volt across 10 megohms, the usual size of $R-31$. Note the arrow showing direction of electron flow through $R-31$ in Fig. 11–3. Since electrons flow from negative to positive, the grid end of $R-31$ is negative, with respect to the ground or cathode end, by this voltage drop. Therefore, a small negative bias is established on the grid. This negative bias remains constant for a particular circuit because, as fast as electrons leak off the grid across $R-31$, new electrons impinge on it, and therefore a condition of equilibrium is set up whereby a slight negative bias is maintained on the grid. Condenser $C-31$ prevents electrons from leaking across $R-27$ to ground.

In amplifiers used in radio receivers, grids are maintained at all times at a negative potential. When the signal voltage is placed on
the grid, it drives the grid more negative or less negative with each alternation. If the signal voltage should be larger than the steady negative grid-bias voltage, the grid will be driven positive on the positive half of the signal cycle, resulting in serious distortion. For this reason, the signal voltage must always be lower than the grid-bias potential. In the case of contact bias, the grid-bias potential is low, and as a result the signal handling capacity is low. Contact bias, therefore, is used only in the first audio stage where the input signal is at a low level of potential.

**Tubes Used in the First AF Stage.**—Vacuum tube V-4 is the voltage amplifier tube. The one most often used in the first AF stage is the high-mu triode section of the type 6Q7 or 6SQ7 tube. Receivers equipped with locking-base tubes use the similar 7C6 loctal type. When lower gain for the stage is desired or the stage is to be followed by transformer coupling, the type 6R7 tube is employed. Where a separate diode is used for the detector stage, the tube employed for the first AF stage is a 6F5 or 6SF5; these have the same characteristics as the triode section of the 6SQ7. Even in the latter case, the 6SQ7 is often used with the diode plates grounded. Older receivers used the 75 type of tube in a similar circuit arrangement.

 Receivers of the AC/DC type use the 6Q7 and 6SQ7 in circuits employing 0.3-amp filament tubes, and the 12Q7 or 12SQ7 types in 0.15-amp filament tubes.

**Coupling Circuit to the Second AF Stage.**—Resistor R-32 is the plate load of the first AF tube. The value most often found is 0.25 megohm (250,000 ohms). It may go as high as 0.5 megohm and as low as 0.1 megohm. Higher values would give somewhat greater gain; lower values would result in reduced gain. When the first AF tube is a low-mu triode like the 6SR7, resistor R-32 is lower in value, 50,000 to 100,000 ohms being usual. In all cases, wattage dissipation is relatively unimportant. The resistors generally in use are the $\frac{1}{2}$-watt size.

Condenser C-32 is the audio coupling condenser. This condenser, plate-load resistor R-32, and grid-load resistor R-12 of the following stage make up a resistance coupling circuit between the two stages, as shown in Fig. 11-4. Its function is twofold: It conducts the AF signal from the plate circuit of the first AF tube to the grid of the second AF tube; at the same time, it keeps the positive plate potential of the first AF tube from affecting the grid of the second AF tube.

The capacity of coupling condenser C-32 varies considerably with different receivers. Capacities ranging from 0.01 to 0.1 mfd are
common. The standard receiver uses 0.05 mfd. The larger capacities give better bass frequency response. Some receivers purposely use a small-capacity condenser at C-32 and are generally designed to give a poor response to low audio frequencies so as to minimize the hum frequency (120 cycles for a full-wave and 60 cycles for a half-wave rectifier).

![Diagram of first AF and second AF stages](image)

**Fig. 11-4.**—Resistance coupling between the first AF and the second AF stages.

The insulation of condenser C-32 must be good, since any leakage would put a positive bias on the second AF grid from the first AF plate. Paper tubular condensers are usually used with a voltage rating of 400 or 600 volts DC.

**NORMAL TEST DATA FOR THE FIRST AF STAGE**

**Signal Check.**—In the signal-substitution method of service procedure, only the final audio stage is measured as a single unit. Thereafter, as each stage is added, the test is over-all. In the case of the first AF stage, the test signal is applied to the first AF stage input circuit while the output indication is taken from the speaker.

Most signal generators provide a pair of terminals, where a 400-cycle current is available for the testing of AF circuits. When this test signal is applied to the input of an AF amplifier, a 400-cycle note is heard in the speaker.

When the audio output from a signal generator is not readily available, a good substitute is found on every service bench. The tip of the soldering iron is a length of copper rod, partly enclosed in a heating coil, which is energized by 60-cycle current. The heating coil induces a small voltage in the tip, which is usable as a source of signal input voltage for AF amplifiers. The test frequency is low,
60 cycles, which accounts for the note heard in the speaker being described as a growl. Also, the human body seems to pick up some 60-cycle voltage, and many practical servicemen use a moist finger as their signal source. This last procedure is not recommended for beginners, who might accidentally touch a plate lead at 300 volts instead of a grid lead at zero volts.

Quick Check for the First AF Stage.—If a wet finger or a plugged-in soldering iron tip is applied to the ungrounded (called the “hot”) end of the volume control with the control in the full ON position, a very strong growl should be heard in the speaker. If it is not heard or if it is not considerably stronger than the growl heard when the second AF stage was checked, the trouble is in the first AF stage.

The quick signal check can also be used for further narrowing down the location of the trouble. Assume normal response from the second AF grid (a low growl) and no response from the ungrounded (hot) end of the volume control, as in Fig. 11-5.

![Fig. 11-5.—Trouble shooting an inoperative first AF stage by a signal check.](image)

Then, if the test signal is applied to the plate of the first AF tube, normal response (a low growl in the speaker) indicates that coupling condenser C-32 is functioning and the trouble is before the first AF plate. No response at this point indicates an open coupling condenser, or a first AF plate-to-ground short.

If there is normal response from the first AF plate, the test signal is shifted to the first AF grid. Normal response (a strong growl) from this point indicates trouble in the volume control or coupling condenser C-31. No response means that the trouble is between the first AF grid and the plate. The likely causes are

1. An Inoperative First AF Tube.—Confirm by substituting a good tube.
2. A Grounded Grid Lead.—Confirm with an ohmmeter. (The ground is probably caused by defective shielding.)
3. An Open Plate-load Resistor R-32.—Confirm by voltage and resistance checks.

Use of Output Meter.—The ear, judging differences in sound intensity, can make only a rough estimate. Except at very low sound levels, the judgment of the ear is not very reliable. A more quantitative check for all receiver testing is to measure the actual signal power that is put into the speaker.

Radiomen usually work to a definite level of output from any receiver and then make comparisons of input signal necessary to attain that output. This reference level is called "standard output" and is defined as 50 mw (0.05 watt) of signal power into the speaker. Note that the 50 mw is well below the output capabilities of any radio receiver and, therefore, the test signal level at any point in the receiver, necessary to attain standard output, will not overload any tube.

The output power may be determined by measuring the signal voltage across the speaker voice coil with an AC voltmeter. For example, if we have a 5-ohm voice coil, 0.5 volt will correspond to standard output.

\[
W = \frac{E^2}{R} = \frac{0.5 \times 0.5}{5} = \frac{0.25}{5} = 0.05 \text{ watt}
\]

The only trouble with this is that \(\frac{1}{2}\) volt is not easily read on the low AC range of the usual multimeter.

A more easily read output indication is obtainable at the primary of the output transformer where, owing to the turns ratio of the transformer, standard output will correspond to approximately 16 volts. The primary of the output transformer, however, is in a circuit where direct current, the plate current of the second AF tube, is flowing, the signal itself being a pulsation of this current. To keep the direct current of the plate circuit from affecting the AC meter, a condenser must be inserted in series, so that the meter will read only the AC signal component. This is shown in Fig. 11–6, which indicates the connections for an output meter. A convenient size for this series condenser is 0.1 mfd/600 volts. Some multimeters have the output condenser built in, in which case there will be test jacks on the instrument labeled OUTPUT METER, and the 0.1-mfd condenser need not be connected externally. The meter should be used on a suitable AC range where 16 volts will give a good indication. (About half scale is best.) It might be advisable for the serviceman to work to a reading of 15 or 20 volts as his reference level, to take advantage of a convenient marker on the meter scale. Then as far as his test bench is concerned, 15 or 20 volts, as the case may be, is
standard output, and he will work at this level except where service notes issued by the manufacturer of the receiver concerned specify differently. The voltage chosen to represent standard output will not vary too much from 50 mw and is sufficiently accurate for any service work.

![Diagram of AC voltmeter connection](image)

**Fig. 11-6.**—Connection of an AC voltmeter as an output meter.

The serviceman would do well to provide himself with some special test leads for convenience in checking the output voltage. If the multimeter has a built-in output condenser, a pair of test leads terminating in alligator clips will be all that is needed. If the output condenser is not built in, one test lead is provided with a series 0.1-mfd/600-volt condenser, as shown in Fig. 11-7.

![Test leads for output meter](image)

**Fig. 11-7.**—Test leads for the output meter.
Stage-gain Measurements.—Now, having established standard output, let us make some gain checks on a receiver known to be perfect to determine how this information may be used in later servicing. Figure 11–8 shows the audio amplifier of the standard receiver. The output meter and the AF output of the signal generator are connected to make gain checks. The condenser in the hot lead of the signal generator (which may be connected internally) serves to keep DC plate potentials out of the signal generator circuit when the hot lead is connected to a plate terminal in the radio. The receiver volume control is set for maximum output (full on) and the tone control, if any, is set for the minimum bass position.

The gain per stage is approximately 50 for the first AF stage and 10 for the second AF stage, as is indicated in Fig. 11–8. Now let us assume our test bench works to a reference level of 20 volts as standard output indication. Then when the hot lead of the signal generator is connected to point 1, the second AF grid, a 2-volt signal will be needed to give standard output from this point, since 2 volts input times 10, the amplification of the stage, equals 20 volts output. It is not necessary to measure the input signal voltage. Accurate stage-gain measurements would call for expensive test equipment and, although this would be of advantage in design engineering, service work to find a poorly operating stage does not require any-
thing more than comparative data. For an idea of 2 volts input, simply note the position of the attenuator on the AF signal generator to obtain standard output on this perfect receiver.

When the test signal is connected to point 2, the first AF plate, the signal-generator attenuator will have to be advanced slightly to maintain 20 volts on the output meter, to compensate for the loss caused by coupling condenser C-32.

When the test signal is connected to point 3, which is the grid of the first AF tube, only 0.04 volt will be needed to give standard output, since

\[
\text{Input volts} \times \text{gain of first AF stage} \times \text{gain of second AF stage} = \text{output volts}
\]

\[
0.04 \times 50 \times 10 = 20
\]

The signal-generator attenuator position is again noted for the 0.04-volt position.

Moving the test signal to point 1, the hot end of the volume control, will again require a slight increase in signal input voltage to compensate for the loss caused by coupling condenser C-31.

Having established comparative reference points on his signal generator and output meter, by trying the above procedure on a number of perfect receivers, the serviceman is in a position to determine the normal gain to be expected from any audio stage of a receiver brought in for servicing.

**Normal First AF Voltage Data.**—Voltages are measured from chassis or common negative to tube terminal indicated. In some AC/DC receivers where the circuit insulates B minus from the chassis, the negative terminal of the voltmeter is connected to the common negative. This is most easily found at the line switch. Normal data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Tube terminal</th>
<th>12SQ7 and 6SQ7 pin No.</th>
<th>AC receivers, volts</th>
<th>AC/DC receivers, volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>6</td>
<td>100–170</td>
<td>40–60</td>
</tr>
<tr>
<td>Grid</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cathode</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Voltages vary with different receivers and also with the ohms-per-volt rating of the multimeter. Since the plate-load resistor $R$-32 has an average value of 250,000 ohms, the plate circuit is a high-resistance circuit, and the plate voltage as read by a meter will depend on the extent to which the meter loads the circuit. In general, a
1,000-ohms-per-volt meter will read considerably less in this circuit than a 20,000-ohms-per-volt or vacuum-tube voltmeter.

**Normal First AF Resistance Data.**—These data are given in the following table:

- Chassis to cathode (pin 3)..........................0 ohms
- Chassis to grid (pin 2)..................................10 megohms
- B plus to plate (pin 6).................................250,000 ohms

**COMMON TROUBLES IN THE FIRST AF STAGE**

**Troubles Common to the Volume Control.**—Volume controls sometimes open. Since a signal check may give normal response even with an open volume control, this difficulty may not be found until the detector stage is checked, the volume control being also an important component of the detector stage.

More often, volume controls are noisy in operation, usually because of dirt between the sliding arm and its contact ring. Al-
though a temporary repair is often possible by a cleaning, such pro-
dcedure is questionable, since a noisy control is also a possible cause of
intermittent operation or fading. Debit the control to normal wear
and tear of a moving part and replace it with a new one.

In replacing the volume control for electric and mechanical de-
fects, it is best to obtain an exact replacement. When this is not
possible, a replacement control as similar to the original as possible
must be selected. When choosing the replacement control, the
serviceman must keep several factors in mind:

1. *Space Requirement.*—The replacement must not be physically
larger than the original unless there is room for it.

2. *Length of Shaft.*—The shaft of the replacement control may be
longer but not shorter than the original. The excess can be cut off.
If the original has an unusually long shaft, an extension shaft
(see Fig. 11–10) may be used.

3. *Flat Side of Shaft.*—The
volume-control knob should be
examined. If it fastens with a
setscrew, any shape of shaft may be used. If it is a spring push-
on type of knob, the knob must fit the shaft snugly with spring
tension. Too small a shaft will not do, since the knob will be loose.
A round shaft or one with a small flat section will do, since it can
be filed to shape.

4. *Resistance and Taper.*—The total resistance and taper of the
replacement control should be the same as the original. The wrong
taper will cause the control to bunch all its action in a small segment
of the control rotation, while the rest of the turn has very little effect.
The serviceman need not concern himself too much about the taper,
however, since the replacement-control manufacturers have gone
into the matter thoroughly and specify the proper taper to use in
accordance with the circuit arrangement of the control.

5. *Switch.*—Volume (or tone) controls are usually combined with
the line on-off switch in one unit. When this is the case, if the
volume control is defective, the switch is replaced at the same time.
Similarly, if the switch is defective, the volume control is replaced
at the same time.

**How to Replace a Volume Control.**

1. Choose a proper replacement control as described above.

2. Do not remove the wiring from the old control. Loosen the
mounting nut, slip the shaft through the hole, and let the old control
dangle from its leads.
3. If necessary to cut the shaft of the replacement control, proceed as follows:
   a. Measure it against the original as shown in Fig. 11–11 and mark the proper length.
   
   ![Diagram showing measurement of replacement volume control](image1)

   Fig. 11–11.—Measuring the replacement volume control for length.

   b. Clamp excess portion in vise with mark showing and cut to the mark with a hack saw, as shown in Fig. 11–12.
   c. Remove saw burr with a file.

   ![Diagram showing cutting of volume control shaft](image2)

   Fig. 11–12.—Cutting the volume-control shaft to size.
4. If shaft is to be filed for a push-on type of knob, proceed as follows:
   a. Measure against the original, as shown in Fig. 11–13, and indicate with a mark the amount of shaft to be removed.

   ![Fig. 11–13.—Marking the volume-control shaft for a push-on knob.](image)

   b. Clamp in vise with mark showing. Cut vertically at A with a hack saw, as shown in Fig. 11–14. Stop cutting before reaching the horizontal line. File the material away, almost down to the line with the file held horizontally.

   ![Fig. 11–14.—Cutting the volume-control shaft for a push-on knob.](image)

   c. Try the push-on knob. If too tight, one or two file strokes will bring the shaft down to the line where the knob spring should fit just right.

5. Slip the replacement control through the chassis hole, using a lock washer or locating pin, as shown in Fig. 11–15. If there is no
hole for the locating pin, bend it down if it is metal or snap it off if it is bakelite. If this is not done, the locating pin will force the control at an angle when the nut is tightened up, either damaging it or giving the control erratic action. Tighten the mounting nut with an open-end wrench. An open-end wrench marked \( \frac{1}{2} \) in. on one end and \( \frac{3}{16} \) in. on the other will handle most volume-control mounting nuts.

6. Remove the wires from the old control, one at a time. Each wire is to be soldered to the corresponding terminal lug on the replacement control.

If the wiring has been disturbed before the new control is in place, it will be necessary to trace the leads before soldering them into place. First the switch leads are traced, one to the line cord and the other to the power-transformer primary. Next the wire to the first AF control grid through condenser \( C-31 \) is found and soldered to the center terminal of the potentiometer. The last two leads go to ground and the detector circuit, and the serviceman must be careful not to reverse them or the control will work backward. The easiest way to be sure is to turn the control to the full on position and imagine the position of the arm inside the control. At the full on position the arm is stopped at the detector circuit end of the control, and the detector lead is soldered to the lug that stopped the arm. The final soldering lug connects to the chassis. These connections are illustrated in Fig. 11–16.
To check the volume-control action, tune the receiver to a strong local station. Turn the volume control to the position just before the switch shuts off power. The sound from the speaker should be just a whisper or completely off. As the volume control is rotated in a clockwise direction, the volume should gradually increase. At the halfway point, the volume should be just about right to fill the average home living room. As the rotation is continued, the volume should increase. Beyond the three-quarter point there will probably be distortion, rattling of the speaker, and microphonics.

To check the volume control for noisy action, the RF section of the receiver is made inoperative by removing the IF tube and rotating the volume control while listening for noise. In the case of an AC/DC receiver, where a tube cannot be removed without stopping all operation, the RF section of the receiver may be made inoperative by grounding the IF grid or the oscillator condenser stator. Grounding the oscillator condenser stator is a standard servicing procedure. A description of how the oscillator section of the gang tuning condenser may be easily recognized is given on page 159.

Troubles Common to the Input Coupling Condenser.—Coupling condenser C-31 rarely causes any service difficulties. It may open, in which case the condition would be found by a signal check: normal response from the grid of the first AF tube and no response from the arm of the volume control.

When replacing the condenser, be sure to use one with the same capacity as the original. Place the condenser in the same position as the original and dress the leads in the same manner. The positioning of the condenser and leads is stressed because any hum picked up at this point is amplified by the entire audio amplifier that fol-
lows. Also follow the original for the placement of the outside foil lead, although this procedure may be unimportant, since either end of the condenser is equally "hot."

Fig. 11-17.—The input coupling condenser and its position in the input circuit of the first AF stage.

Control-grid Wiring—Any of the wiring from the detector output to the first AF grid is likely to pick up hum and, as a result, should be either carefully routed or shielded. Where shielding is not used, the wiring is usually kept close to the chassis and away from filament leads that carry 60-cycle current. Often, when a top grid contact tube like the 75 or 6Q7-G is used, the wire goes up to the grid, inside the tube shield. In replacing tubes, people sometimes leave the grid lead off, replace the shield, and bring the grid wire up outside of the shield. Besides increasing the possibility of hum, the shield also may cut through the insulation of the grid wire grounding the signal. When a shielded wire is used, an end of the shielding may work its way through the wire insulation and likewise ground the signal.

In either case, the trouble would be found by means of a signal check: normal response from the first AF plate and no response from the first AF grid. An ohmmeter check from grid to ground will confirm the trouble.

In repairing the radio where the tube shield has cut through the insulation, it would be safest to replace the entire lead, since any repair job so close to the chassis is likely to work away and ground the grid wire again.
When a radio with a defective shielded lead is repaired, replacement of the entire lead is also necessary.

**How to Prepare Shielded Wire for Use.**

1. Cut off the proper length. Include allowance for connections.
2. Push back the shielding to loosen the weave, as shown in Fig. 11–18A.

![Diagram of Insulation, Shield, Tinned Lead, Insulation, Shield](image)

3. Bend a loop in the lead, as shown in Fig. 11–18B.
4. Work the weave back and forth with a pointed instrument at the top of the loop, until the hole made is large enough to pull the wire through. See Fig. 11–18C.
5. Slide the scriber under the wire and pull the end through the hole, as shown in Fig. 11–18D.
6. Pull out the empty piece of sleeving, as shown in Fig. 11–18E.
7. Repeat steps 1 to 6 at the other end of the shielded wire.
8. Strip and tin the ends of the lead ready for connecting, as shown in Fig. 11–18F.
When a shielded cable is replaced, use the prepared ends of the sleeving for the connection to the chassis. Do not attempt to solder the shielding in the middle of the lead to the chassis. The heat of the iron will probably ruin the insulation inside the shield.

Troubles Common to the Grid-load Resistor.—Grid-load resistor $R-31$ may open, resulting in motorboating as was described for $R-12$.

![Diagram of the first AF grid-load resistor and its position in the circuit.](image)

Fig. 11-19.—The first AF grid-load resistor and its position in the circuit.

the grid-load resistor of the second AF stage on page 106. This would be found by the standard check for motorboating, which is to check the filter condensers in the power supply and then to look for an open grid circuit.

When replacing $R-31$, be sure to use the same ohmic value as is called for in the receiver diagram. A wrong value here would change the contact bias (see page 127) and result in poor tone.

Troubles Common to the First AF Amplifier Tube.—The first AF amplifier tube $V-4$ is the most likely source of trouble in the stage. Hum, no reception, weak reception, noisy reception, and intermittent reception might all be due to the tube. The best check is to substitute a similar tube known to be good. When the signal check shows normal response from the first AF plate and weak or no response from the first AF grid, the tube is a likely suspect.

Troubles Common to the Plate-load Resistor.—Plate-load resistor $R-32$ sometimes opens. The signal check would show normal response from the first AF plate and no response from the first AF grid. A voltage check would then show no voltage at the first AF plate.

Troubles Common to the Output Coupling Condenser.—Coupling condenser $C-32$ is subject to many ills that impair performance of
the receiver. It opens, shorts, becomes leaky, and opens intermittently.

An open condenser would result in a dead receiver and is found by a signal check. There would be a normal response from the second AF grid and no response from the first AF plate. Such a response could also be caused by a plate-to-ground short or an open plate-load resistor. These last two possibilities would be eliminated by a normal plate-voltage reading. The open condenser would then be confirmed by substituting a test condenser.

If C-32 is shorted or has low leakage resistance, the tone quality would be badly affected. Positive voltage from the first AF plate would leak over the defective coupling condenser to the second AF grid, disturbing the bias voltage on the second AF tube, with distortion as a result. The condition would be found in a voltage check of the second AF stage. Insufficient or positive bias on the second AF tube grid would cause heavier than normal plate current and result in an abnormally large potential across the output transformer primary and an unusually large potential difference between plate and screen voltages. This check is more reliable than a positive indication on the second AF grid, which may be small and therefore missed in the case of high leakage resistance. In the latter case, even though a small positive voltage leaks across the coupling condenser, it will still decrease the applied bias voltage, with consequent increased plate current and reduced signal handling capabilities. Since a leakage resistance of several megohms would be hard to measure on the average ohmmeter but would still cause distortion, a good confirmation check would be the following: Open the coupling condenser from its grid connection, and check for voltage to ground, as shown in Fig. 11-21. With a good condenser, the voltmeter needle will swing up as the condenser charges and return to the zero position, when the condenser is fully charged. Leakage resistance in the condenser will cause the voltmeter needle to remain
at some position higher than zero. Owing to the high activating voltage at the first AF plate, a leakage resistance of several megohms will cause a readable deflection on even a 1,000-ohms-per-volt voltmeter.

If the coupling condenser is intermittently open, fading will result; the receiver will not operate when it is open and will resume operation when it is closed. This condition is due to a poor contact between one of the condenser leads and the tin foil of the condenser plates. Usually the condition can be confirmed by yanking gently on the condenser leads, thereby starting and stopping reception. Parenthetically, it may be added that, when a receiver is serviced for fading, all coupling condensers should be replaced as a matter of course.

When coupling condenser C-32 is replaced, a good-quality condenser should be used. The condenser should have a rating of 600 volts. Although a 400-volt condenser is sufficient for the voltages normally found in this circuit, the thicker dielectric of the 600-volt size makes for less likelihood of leakage. The capacity used should be the one called for in the receiver diagram. If a different capacity is used, the serviceman should remember that a higher capacity will give a better low-frequency audio response.

CIRCUIT VARIATIONS IN THE FIRST AF STAGE

**Bass Compensation Circuit.**—It is characteristic of the human ear to be less sensitive to low audio frequencies than to high ones at reduced volume levels. To compensate for this deficiency, the circuit of Fig. 11-22 is found in many receivers.

Potentiometer R-27 is a tapped volume control with the tap located in the low-volume area. When the arm is in the high-volume position near the ungrounded end of the volume control, C-127 has little effect. As the volume is reduced and the arm approaches the
tap, C-127 by-passes some of the high AF signal from the amplifier, thereby making the low audio frequencies seem stronger. The effect is greatest at the tap which will be at the low-volume position for the particular receiver. Resistor R-127, which may be omitted from some circuits, is to keep the by-passing effect from being too pro-

![Diagram of Circuit](image)

Fig. 11-22.—Bass compensation in the first AF stage.

ounced at the tap and to broaden the region around the tap where the bass compensation circuit is effective.

Some receivers carry out the tone compensation at two points on the volume control, as shown in Fig. 11-23. The volume control is

![Diagram of Circuit](image)

Fig. 11-23.—Bass compensation at two points in the volume range.

tapped at two points. Again, at the high-volume position the high-frequency by-pass circuits have little effect. As the volume is reduced, a slight amount of bass compensation is attained through C-127 and R-127. As the volume is reduced further, more bass compensation is attained through condenser C-131. All checks and operations are the same as for the standard circuit.
Condensers C-127, C-131, and resistor R-127 rarely if ever give any service difficulty. Volume control R-27, however, is subject to all the ills of volume controls. In replacing R-27, the serviceman must find an exact replacement for proper operation of the bass compensation circuit.

Figure 11-24 illustrates some of the points taken up in this chapter on the first AF stage. Note the tone-compensation circuit connected to the volume control R-6. At high-volume levels the filter is ineffective. When the potentiometer arm is in a low-volume position near the tap, condenser C-31 and resistor R-12 by-pass high audio frequencies to ground. Since the attenuation of very high audio frequencies will be excessive, the circuit composed of R-11 and C-30 restores some of these frequencies to the arm of the volume control. The net result is an increase in low AF response at low-volume levels without entirely removing the high audio frequencies.

Note also the use of a separate detector tube, the 6J5-GT, with the plate tied to the cathode as one diode element while the grid functions as the other. The rest of the first AF circuit follows the standard circuit closely except for the use of condenser C-22 across the plate circuit of the tube. This limits the high-frequency response. Note that C-22 is a 600-volt condenser and will therefore give little service difficulty. If condenser C-22 were shorted, the trouble would be narrowed down to the first AF stage by signal check, since there would be normal response from the second AF grid and no response from the first AF grid. A voltage check would show no plate voltage at the first AF plate. Since this condition could also be caused by an open plate-load resistor R-8, an ohmmeter check would finally confirm R-8 open or C-22 shorted.
Values of Resistors and Condensers in the I-F Stage

R-6 500,000 Ohms C-20 .002 MFD.
R-7 10 Megohms C-22 .0002 MFD/600 V.
R-8 250,000 Ohms C-23 .02 MFD/400 V.
R-9 500,000 Ohms C-30 .00005 MFD.
R-10 10,000 Ohms C-31 .0005 MFD/400 V.

Fig. 11-24—Emerson Model EQ-308 receiver. The first AF circuit is shown in heavy lines.
SUMMARY

Quick check for normal operation of the first AF stage.

A wet finger or a plugged-in soldering-iron tip applied to the ungrounded end of the volume control causes a very strong growl to be heard in the speaker.

Standard first AF diagram.

The accompanying figure shows the standard first AF diagram.

Normal first AF voltage data.

Voltage is measured from chassis or the common negative in an AC/DC receiver. Data given in the accompanying table.

<table>
<thead>
<tr>
<th>Tube terminal</th>
<th>12SQ7 and 6SQ7 pin No.</th>
<th>AC receivers, volts</th>
<th>AC/DC receivers, volts</th>
</tr>
</thead>
<tbody>
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<td>Plate</td>
<td>6</td>
<td>100–170</td>
<td>40–60</td>
</tr>
<tr>
<td>Grid</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cathode</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Normal first AF resistance data.

Chassis or common negative to cathode...........................................0 ohm
Chassis or common negative to grid............................................10 megohms
Plate to B plus.................................................................250,000 ohms
**Service Data Chart for an Inoperative First AF Stage**

Assume an inoperative first AF stage as shown by normal response when an AF test signal is applied to the second AF grid, and no response when the test signal is applied to the un-grounded end of the volume control. The following service procedure is recommended.

<table>
<thead>
<tr>
<th>Step</th>
<th>Signal check</th>
<th>Response</th>
<th>Trouble</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apply AF test signal to first AF plate</td>
<td>None or weak</td>
<td>Look for open coupling condenser C-32 or first AF plate short-circuiting to chassis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal</td>
<td>Proceed to step 2</td>
</tr>
<tr>
<td>2</td>
<td>Apply AF test signal to first AF grid</td>
<td>None or weak</td>
<td>Look for plate voltage on first AF plate (open R-32). Substitute a good first AF tube. Look for a shorted grid lead (shielding)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal</td>
<td>Proceed to step 3</td>
</tr>
<tr>
<td>3</td>
<td>Apply AF test signal to volume control arm</td>
<td>None or weak</td>
<td>Look for open coupling condenser C-31. Look for grounded volume-control arm (shielding)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal</td>
<td>Open volume control. Grounded “hot” end of volume control</td>
</tr>
</tbody>
</table>

**Service Data Chart for Other Symptoms**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Abnormal reading</th>
<th>Look for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor tone quality</td>
<td>First AF plate voltage low</td>
<td>Short-circuited or leaking coupling condenser C-32</td>
</tr>
<tr>
<td></td>
<td>Voltages normal</td>
<td>Short-circuited or leaking coupling condenser C-31. Incorrect value of grid load R-31</td>
</tr>
<tr>
<td>Motorboating</td>
<td></td>
<td>Open grid load R-31</td>
</tr>
<tr>
<td>Hum</td>
<td>Voltages normal</td>
<td>Defective first AF tube. Incorrectly dressed grid leads. Positioning of coupling condenser</td>
</tr>
<tr>
<td>Intermittent reception (fading)</td>
<td></td>
<td>Coupling condensers C-31 and C-32 may open intermittently. Defective first AF tube. Defective volume control</td>
</tr>
</tbody>
</table>
QUESTIONS

1. A receiver is being serviced for weak reception. A signal check shows no gain for the first AF stage. Outline a test procedure for determining the cause of the trouble.

2. The receiver of Fig. 11–24 has poor tone quality. A voltage check shows 50 volts on the first AF plate. What is likely to be wrong and how would you confirm your assumption?

3. The receiver of Fig. 11–24 has a noisy volume control. After the volume control is replaced with an exact replacement, the volume remains at one level regardless of the position of the control arm. What is wrong? How would you check to prove it?

4. A receiver very much like the standard superheterodyne motorboats. How would you check to find the cause in the power supply? In the second AF stage? In the first AF stage?

5. An AC receiver hums excessively. When the first AF tube is removed from its socket, the hum level drops to normal. How would you check the various possibilities for hum in the first AF stage?

6. What are the possible causes of intermittent reception in the first AF stage? How would you check for each?

7. A receiver gives normal response when an AF test signal is applied to the first AF grid and a very weak response when the test signal is shifted to the hot end of the volume control. What are the possible causes of the defect and how would you check for each?

8. A receiver gives normal response when an AF test signal is applied to the second AF grid and no response when the test signal is shifted to the first AF grid. What are the possible causes of the trouble and how would you check for each?

9. What is a good test for high leakage resistance in a coupling condenser between a first AF plate and a second AF grid?

10. The receiver of Fig. 10–14 has been completely overhauled and reconditioned. As part of the servicing procedure the first AF grid-load resistor $R_{11}$ had been found to be open and replaced. However, it had been replaced with a 1-megohm resistor in error. The customer later complains that his radio does not sound so clear as before. Could the incorrect first AF grid-load resistor be the cause of this condition? Explain your answer.
CHAPTER 12

DETECTOR STAGE—AVC

Quick Check for Operation of the Detector Stage.—A modulated signal at the intermediate frequency of the receiver being checked is applied to the IF control grid. If the signal-generator modulation note is heard in the speaker, the detector stage is probably functioning properly, and the serviceman moves forward to the next stage.

Since the AVC (automatic volume control) action is dependent on the operation of the RF converter and IF stages, there is no quick check for AVC operation at this point.

Function of the Detector and AVC Stage.—In modern receivers, detection and automatic volume control are accomplished in one circuit and, although they are two separate functions, must be treated together.

The input signal, normally fed to the detector stage, is an alternating voltage at the intermediate frequency of the receiver and modulated by the audio component of the original signal picked up by the antenna. The signal that appears across the output of the detector stage is the audio component only. One function of the detector and AVC stage, therefore, is to demodulate the signal; that is, to remove the audio component and pass it on to the audio amplifier.

The detector stage or tube is sometimes called the “demodulator,” the reason for which is obvious from its function. It is also sometimes called the “second detector” to distinguish it from the mixer tube, an old name for which was “first detector.”

AVC action can be described as follows: A strong local station delivers a strong signal to a receiver. A station at some distance away will deliver a much weaker signal to it. Yet it is desirable for each of these stations to produce approximately the same volume from the speaker. This effect could be performed manually by means of a volume control, but it is far superior if this effect is performed automatically. That is the function of the AVC system.

The upper limit of sensitivity of a receiver is set by the design characteristics of the receiver itself. However, the AVC circuit reduces the sensitivity of the receiver more or less below the upper limit—more for a strong signal and less for a weaker signal. This effect is produced by the use of supercontrol (variable-mu) tubes in
the RF and IF stages of the receiver. The gain of these tubes changes with different control grid-bias voltages: at greater negative bias, the gain is lower; at lower negative grid bias, the gain is greater. In an AVC circuit, the station signal itself develops negative bias voltage for the control grids of the supercontrol tubes. A strong signal develops a large negative bias voltage which reduces the gain of the controlled tubes. A weak signal develops a smaller negative bias voltage which does not reduce the gain of the controlled tubes so much. As a result, a fairly constant volume is obtained from the speaker, regardless of the original strength of the received signal within the limits of the sensitivity of the receiver.

![Diagram of a half-wave rectifier circuit with input and output waveforms.](image)

**Fig. 12-1.—Half-wave B power supply.**

**Theory of Operation.**—The detector and AVC stage in modern receivers performs its functions in a circuit arrangement very similar to that of a power supply; that is, it also employs a diode rectifier and filter circuit. Since power-supply circuits are generally understood, a parallel will be drawn to explain the operation of the detector and AVC stage.

Consider the half-wave rectifier circuit shown in Fig. 12-1, common in AC/DC receivers. The input is 110 volts AC. Only when the positive phase of the input voltage is impressed on the plate will current flow through the tube. The circuit is completed through load resistor DL. Condensers $C_x$ and $C_y$ and choke $L$ make up the smoothing filter. The wave forms of Fig. 12-1 show the complete action of the circuit. Note the polarity of the voltage across load
resistor $DL$ and the hum ripple that is present. If it is desired to eliminate the hum ripple, a second section $L-C$ filter would be added, as in Fig. 12–2.

![Diagram of a filter circuit](image)

Fig. 12–2.—Eliminating hum ripple by means of a second section filter.

In the detector stage, to draw a parallel, the input voltage is across the tuned secondary of the IF transformer $T-5$, as shown in Fig. 12–3. The graph below $T-5$ represents the input voltage at the intermediate frequency and modulated by its audio component. Similar to the action in the power supply, the rectifier chops off the negative half of the input voltage, as represented in the graph under the rectifier tube V-4A. Now let us examine the filter circuit. A filtering resistor $R-26$ has been substituted for the choke. It serves a similar function. In the power supply, the filter condensers are usually 20 mfd each. In the detector filter circuit, $C-26$ and $C-27$ are usually 0.0001 mfd apiece. This filter circuit will not give unvarying direct current as its output but will make an effective filter at the intermediate frequency (455 kc). The output at this point will be the audio component of the signal which is impressed across the resistor $DL$, since the audio signal cannot be by-passed across the low-capacity condensers $C-26$ and $C-27$. Resistor $DL$ is called the “diode load” and is usually the manual volume control of the receiver. With the audio signal across the volume control, the position of its arm determines the strength of the signal fed to the audio amplifier.
The audio signal, owing to its strong pulsations, is not suitable for use as an automatic bias voltage, since any bias voltage should be pure direct current. Therefore a second section filter, $R-28$ and $C-28$, is added after the audio circuit to smooth it to direct current, as shown in Fig. 12–4. The capacity of $C-28$ is 0.05 mfd to make it effective at audio frequency.

Now note again the polarity of the voltage across the diode load. If the diode cathode is grounded, the voltage at $R-28$ will be negative with respect to ground, and therefore suitable for use as bias voltage. The amount of voltage available at $R-28$ will depend on the voltage of the signal impressed across the secondary of the IF transformer $T-5$, since it is the rectified and filtered output of the signal voltage. For strong signals, the signal voltage across $T-5$ is high, the AVC bias voltage is high, and the amplification of the controlled RF and IF tubes is reduced. For weak signals, the signal voltage across $T-5$ is low, the AVC bias voltage is low, and the amplification of the controlled tubes is greater.

Figure 12–5 shows the detector and AVC system, including the control-grid circuits of the controlled tubes, and the coupling to the first AF stage. The wire that feeds the AVC voltage to the controlled tubes is known as the "AVC bus."
Resistor R-30 and its associated condenser C-30 in the RF grid return lead isolate the RF stage from the other stages. This is called a "decoupling" filter, which will be described in a later section.

![Circuit Diagram]

Fig. 12-4.—Developing audio signal and AVC voltage from the modulated intermediate-frequency signal.

Resistor R-29 and condenser C-29 serve a similar function for the converter stage.

![Circuit Diagram]

Fig. 12-5.—Typical detector and AVC circuit.

Functions and Values of Component Parts.—Potentiometer R-27 is the manually operated volume control for the receiver. In the detector stage, it acts as the diode load resistor, and the audio com-
ponent of the signal voltage is developed across it. A portion of this voltage is taken off at the volume-control arm and is amplified as was described in Chap. 11. The ohmic value of $R-27$ is usually $500,000$ ohms, although higher values are sometimes found in circuits where, at the increased load resistance, a higher value of audio output voltage is possible.

Condensers $C-26$ and $C-27$ and resistor $R-26$ make up the IF filter circuit. In this circuit, the IF pulsations are removed, leaving the audio envelope. Resistor $R-26$ is usually $50,000$ ohms, and condensers $C-26$ and $C-27$ are usually $0.0001$ mfd for an intermediate frequency of 450 to 480 kc. Sometimes these capacities are a little higher, not so much for more efficient filtering as for attenuation of high audio frequencies with resultant improvement of the apparent low AF response.

Resistor $R-28$ and condenser $C-28$ form the additional filter for the AVC voltage. In this circuit, audio pulsations are removed. Since the controlled grid circuits do not require current, $R-28$ can have a high value of resistance for efficient filtering of the AF pulsations, and $C-28$ by-passes the remainder to ground. In receivers containing an RF stage, $R-28$ is usually $1$ megohm. In receivers that do not employ an RF stage, $R-28$ is usually higher, 2 megohms being the average size. $C-28$ is almost always $0.05$ mfd.

The diode employed in the detector and AVC stage is the duo-diode section of the 6SQ7 tube, with the diode plates connected together, and the triode section functioning as the first AF amplifier tube. Some receivers use a 6Q7 duo-diode high-mu triode which is very similar to the 6SQ7, the difference being in the location of the audio grid pin. Receivers that use the loctal type of tubes employ the 7C6. When a separate tube is used for the detector, it is the 6H6 twin diode.

Occasionally, the detector diode is combined with the IF amplifier in one tube, as is the case with the 6B8 duplex-diode pentode. In these receivers, the following AF tube is usually a twin triode like the 6SC7 which combines the first AF and inverter functions in one tube.

Older varieties of the circuit combined the detector, AVC, and first AF functions in the 75 tube. Older circuits, using a separate tube, use the 37 triode with cathode and plate tied together to form one diode electrode while the grid functions as the other. An early issue of the 6B8 is the 6B7 duplex-diode pentode, where the detector, AVC, and IF amplifier functions are combined in one tube.

In AC/DC receivers employing 0.3-amp heaters, the 6Q7 and 6SQ7 are widely used. Where the 0.15-amp heater tubes are used, the 12Q7, 12SQ7, and 14B6 duplex-diode, high-mu triodes are found.
IF transformer T-5 couples the IF stage output signal to the detector stage. Usually both primary and secondary are tuned to the intermediate frequency by trimmer condensers C-10 and C-11. The latter are usually part of the transformer assembly. Sometimes condensers C-10 and C-11 are fixed, and tuning is accomplished by varying the position of powdered-iron core plugs inserted in the coils of the transformer. The latter method is known as "permeability tuning."

**Fig. 12-6.—Signal check and stage-gain measurement connections for the detector and AVC stage.**

**NORMAL TEST DATA FOR THE DETECTOR AND AVC STAGE**

**Signal Check.**—The input of the detector stage is the IF transformer T-5. However, when the stage is checked, the signal generator is connected to the grid of the IF tube, as shown in Fig. 12-6. There are several reasons for this connection:

1. The IF tube is generally a 6K7 with the control-grid connection at the top of the tube and therefore readily available for connection to the signal generator.

2. Since the detector input is the last step in the RF chain, the signal voltage at this point is high, higher than the RF output of most signal generators, and the amplification of the IF tube may be needed to make the signal more easily heard in the speaker.

3. If the added capacity of the signal-generator leads were connected to the IF plate, the normal input of the detector stage, it would seriously detune the primary circuit of T-5, making the response broad and possibly at an off-frequency setting.
The 0.1-mfd condenser in the hot lead of the signal generator acts to isolate the signal generator from DC receiver potentials in case the signal input is connected to a plate lead. It is also the standard dummy antenna capacity (coupling device) between the signal generator and the receiver for IF measurements. The output indication is the signal-generator modulation note in the speaker. This can be measured by connecting the output meter (35- to 60-volt AC range of the multimeter with a 0.1-mfd/600-volt condenser in series) from the second AF plate to ground, as was discussed on page 132.

When the signal check is made, it is also wise to check the intermediate frequency of the receiver, which is always listed in the manufacturer’s service notes. In modern receivers it is usually 455 kc. For several years, the intermediate frequency chosen by the receiver manufacturers has varied between 450 and 480 kc. In very old receivers intermediate frequencies of 260, 175, and 130 kc have been used. In checking the alignment and operation of the stage, the previous stages of the receiver should be made inoperative. This is done by shorting the oscillator section of the tuning condenser. To determine which of the sections of the gang tuning condenser is the oscillator, the serviceman should trace the circuit; or it is sometimes possible to locate the oscillator section by faster methods. In some receivers, the oscillator rotor plates are smaller than the other rotor plates in the gang condenser. Another method that can be used when the receiver is operating on a station is to touch only the stator plates of the various sections. When the RF and converter sections are touched, there will be little difference observed. When the oscillator section is touched, the added capacity of the body will cause the station to disappear. A short piece of flexible wire with a clip at each end will serve as the short. One end is clipped to either stator terminal lug; the other is clipped to the condenser frame.

To check alignment, the signal-generator dial is rotated through the intermediate frequency, while the output meter reading is observed. The presence of two peaks, broad tuning, too low an output, or the peak at a considerable difference from the specified frequency—all indicate misalignment.

Stage-gain Measurements for the Detector Stage.—When making sensitivity and stage-gain measurements, since it is unlikely that the test oscillator has a calibrated output, the serviceman should run checks on several receivers in perfect condition, as was done for the audio amplifier (see Chap. 11), until he has a basis of comparative data for normal gain to be expected from the stage.
The signal generator, receiver, and output meter are hooked up, as shown in Fig. 12-6. The receiver is adjusted for maximum output as follows: The volume control is set at maximum; the tone control is set at the minimum bass position; the fidelity control (if present) is set for maximum selectivity. The RF portion of the receiver is made inoperative by shorting the oscillator section of the gang variable condenser.

The signal generator is adjusted to give a modulated signal at the intermediate frequency of the receiver. The signal-generator dial is rotated back and forth through the intermediate frequency while the output meter is being watched, and is carefully adjusted for peak deflection. If the output meter deflection goes off scale, the signal input is reduced by adjusting the signal-generator attenuator. After the peak deflection has been obtained, the signal-generator attenuator is further 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 signal input at the IF grid necessary to give standard output is 3,500 microvolts. The attenuator setting just obtained, therefore, corresponds to 3,500 microvolts. After several perfect receivers have been checked by the above procedure, a reference point corresponding to 3,500 microvolts has been duly established. It would be more important for the serviceman to remember this average attenuator setting for his signal generator rather than the corresponding 3,500 microvolts. For example, if his average attenuator setting turns out to be $50 \times 100$, or 5,000, he knows that a
setting of approximately 5,000 on the attenuator of his signal generator should produce standard output when connected to the IF grid of any receiver. Any substantial variation from his average or normal attenuator setting indicates trouble in the stage.

**Normal Voltage Data for the Detector Stage.**—The voltages normally present in the detector and AVC stage are the signal voltage and the developed AVC voltage. Normal-voltage data are usually given as an aid in determining the cause of defective operation. Since measurements of these voltages would require expensive equipment and are therefore not easily obtained, normal voltages will not be given, and defects for this stage will be localized by means of resistance measurements.

**Standard Circuit for the Detector and AVC Stage.**—This is best illustrated by Fig. 12–7.

**Normal Resistance Data.**—These data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Description</th>
<th>Iron core</th>
<th>Air core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary (L-10) of output IF transformer (T-5)</td>
<td>5–15 ohms</td>
<td>30–50 ohms</td>
</tr>
<tr>
<td>Secondary (L-11) of output IF transformer (T-5)</td>
<td>5–15 ohms</td>
<td>30–50 ohms</td>
</tr>
<tr>
<td>Chassis to diode plates (pin Nos. 4 and 5)</td>
<td></td>
<td>550,000 ohms</td>
</tr>
<tr>
<td>Across entire volume control</td>
<td></td>
<td>500,000 ohms</td>
</tr>
<tr>
<td>Chassis to AVC bus</td>
<td></td>
<td>1,500,000 ohms</td>
</tr>
</tbody>
</table>

**COMMON TROUBLES IN THE DETECTOR AND AVC STAGE**

**Troubles Common to the Output IF Transformer Assembly.**—The trimmer condensers C-10 and C-11 are parts of the transformer assembly and will be considered with it. From a service standpoint, the trimmer condensers do not often cause difficulty, except in relation to alignment. At worst, they collect dust or a trimmer screw is lost because of careless alignment. The cures for these conditions are obvious. In permeability-tuned transformers, the alignment screws and fixed mica condensers cause even less trouble.

For ease in recognition, the symbol of a permeability-tuned transformer and the illustration of a typical unit are given in Fig. 12–9.

In operation, IF transformers open and cause noisy reception. Should either winding of the transformer open, the receiver would become inoperative. A signal check would locate the stage; a resistance check would show the open winding. Noisy reception, when
it is caused by the transformer, is due to corrosion of the fine wire in the windings. A resistance check discloses this condition also, since the resistance of a corroded winding is several hundred ohms instead of the 5 to 50 ohms that the winding should read.

Fig. 12-8.—Typical output IF transformer assembly and its position in the detector stage. Enlarged view of trimmers is shown at lower right.

There is a rather wide divergence in the design of individual IF transformers, and the serviceman should make every effort to secure an original replacement. Where this is impossible, coil manufactur-
ers offer a rather large variety of universal replacement IF transformers. These are listed by the following factors:

1. Size of the shield can.
2. Type of core (air or iron).
3. Type of aligning adjustment (trimmer or permeability tuning).
4. IF range of the transformer (scope of trimmer).
5. Type of transformer (input, interstage, output). These are the factors that the serviceman should have in mind when replacing an IF transformer.

Sometimes the IF filter circuit composed of R-26, C-26, and C-27, or part of it, is mounted with the transformer and trimmer assembly inside the shield can. When this is the case and an exact replacement is unobtainable, provision should be made to include the filter circuit in the replacement-transformer shield can.

Replacement IF output transformers are usually color-coded in accordance with the R.M.A. specifications as follows:

- Blue ............ Plate lead
- Red ............ B plus lead
- Green ............ Diode plate lead
- Black ............ Diode return

Before removing an IF output transformer for replacement, the serviceman should study the wire dress of the leads, since oscillation can result from incorrectly dressed wiring. If the leads have already been disturbed, the following general notes should be observed. The leads are usually well separated as they come out of the shield can. In the case of a square shield can, the leads come out of the four corners. Before the replacement transformer is mounted, it should be so turned that the blue plate lead points toward the IF tube socket and the green diode plate lead points toward the detector-tube socket. These are the “hot” leads. They should not cross, and they should be dressed close to the chassis and routed directly to their connection terminals.

When the transformer has been replaced, the trimmers should be aligned in accordance with the receiver manufacturer’s service notes or the general alignment instructions given in Chap. 22.
Troubles Common to the IF Filter Circuit.—The voltages and currents encountered in this circuit are so small that there is no danger of burned-out resistors and condensers. In addition, condensers C-26 and C-27 are the molded bakelite type with mica as the dielectric. This type of condenser does not give any trouble from leakage resistance.

Troubles Common to the Volume Control.—The volume control sometimes opens. When this occurs, the receiver becomes inoperative. A signal check will show that the audio amplifier is working but the detector stage is not. A resistance check of the components in the detector stage will confirm the open control.

![IF filter circuit diagram](image)

**Fig. 12-10.—The IF filter circuit.**

The volume control is also part of the audio amplifier. Replacement notes on the volume control are found on page 136.

Troubles Common to the Detector Tube.—The tube is the most likely source of trouble in the stage. A defective tube may cause hum, no signal, weak signal, or distortion. When checking for these symptoms, substitute a similar tube known to be good. In the case of a multunit tube like the 6SQ7, which combines both the detector and the first AF functions, there is a possibility that the AF portion operates normally but that the detector does not. The serviceman should not assume that the tube is good because it shows normal operation as an audio amplifier.

Troubles Common to the AVC Filter and Decouplers.—Figure 12-11 illustrates the AVC circuit and shows it connected to the RF, converter, and IF stages. Resistor R-28 and condenser C-28 make up the AVC filter described previously.

Strictly speaking, the purpose of the AVC circuit is to develop a biasing voltage, and it would seem best to test it by means of a voltage test. However, such a measurement would require a vacuum-tube voltmeter, since the instrument would be across a low-voltage high-impedance circuit. It would also require an accurately calibrated attenuator on the signal generator, and too often it is not
accurate. Therefore, analysis of troubles in the AVC circuit will be made from the symptoms encountered.

Resistor $R-28$, being one of high resistance, may have a tendency to open. If it does so, the receiver will become inoperative and may develop hum because the grid returns to ground of the associated tubes will be open. Replace the resistor with one of similar value.

The AVC filter condenser $C-28$ may open or become leaky. If it opens, the signal will become weak and oscillation may result. This condition would be found in a signal check of the IF stage. The gain of this stage would be abnormally low. Also, the IF tuning would be very broad and possibly off true frequency, with adjustments of trimmer condenser $C-9$ ineffective.

If condenser $C-28$ becomes leaky, the AVC voltage would drop to an extent dependent on the resistance of the leak. This would result in insufficient bias to handle a strong signal. As a result, the receiver would overload and distort on strong local stations. Reducing the setting of the manual volume control would have little effect on this distortion. Whether the condenser is open or leaky, confirmation of the condition would be obtained by substituting a similar condenser that is known to be good. If the trouble disappears, the condenser was defective. In replacing $C-28$, the serviceman should be careful to use the same capacity value as the original condenser. Even though the voltage across it is quite low, it is advisable to use a condenser of high voltage rating so that the leakage resistance will be quite large.

Associated with the AVC circuit are the decouplers, $C-29$ and $R-29$ for the converter and $C-30$ and $R-30$ for the RF stage. As a rule, the resistors cause little trouble and are therefore of little conse-
quence to the serviceman. However, condensers C-29 and C-30 can cause trouble. If either one opens, reception would be very weak. This condition would be confirmed with a signal check when their respective trimmer condensers would not produce a peak. Condenser C-30 is a particularly odd one. When it opens, the tuning circuit in the RF stage becomes inoperative, with a resulting drop in signal output. At the same time the loss of signal in the RF stage causes the AVC voltage to drop, resulting in high sensitivity so that the noise level goes up. The receiver sounds exceptionally lively even though strong local stations come in as weak ones do when the receiver is normal.

Condensers C-29 and C-30 may become leaky. When this is the condition, the developed AVC voltage will be low and the receiver will overload and distort. If the external antenna (when used) is disconnected and the sound of the receiver improves, the serviceman should hunt for leaky condensers.

VARIATIONS IN DETECTOR AND AVC STAGE

Use of Electron-ray Tuning Indicator.—Unless the superheterodyne receiver is tuned exactly to a station, serious distortion due to side-band cutting may result. Many receivers use some form of tuning indicator as an aid in tuning correctly, so as to avoid this distortion. The tuning indicator in most general use in modern receivers is an electron-ray (often called a "magic eye") tube like the 6U5/6G5. This is a cathode-ray tube which shows a wide deflection when a low voltage is applied to its grid. The deflection narrows as the applied grid voltage is increased. The magic-eye grid is connected to the AVC bus as shown in Fig. 12–12. At no signal, the AVC voltage is zero and the deflection is wide; as a signal is tuned in, the AVC voltage increases and the deflection narrows. When the signal is tuned accurately, the AVC voltage is at a maximum and the deflection is at its narrowest. To tune any station accurately, simply tune the receiver for the narrowest deflection of the magic-eye tube.

Since this tube must be located on the front panel of the receiver, its socket is not on the chassis. The tube is usually supported in position by a clamp, with a cable of connecting leads running down to the chassis.

Resistor R-128 is a 1-megohm/¼-watt resistor. In an AC/DC receiver, it is a ½-megohm/¼-watt resistor. In either case, it is usually located inside of the tube socket.

From a service point of view, the magic-eye tube adds few complications. All checks and tests are the same as for the standard receiver. If the tube does not glow, a new tube is needed; if the
tube glows but the deflection does not change as stations are tuned in, and if the receiver operation is normal in all other respects, R-128 is probably open. To change R-128, the tube socket must be opened.

A receiver equipped with an electron-ray tube has a virtual vacuum-tube voltmeter already connected to the output of the RF and IF stages. It can be used as an indication of the AVC voltage and as an output meter for alignment purposes.

Fig. 12-12.—Electron-ray tube connected to the AVC bus as a tuning indicator.

Delayed AVC.—The standard circuit of the detector and AVC stage furnishes a type of control known as “simple AVC.” Some receivers use a modified circuit known as “delayed AVC,” shown in Fig. 12-13.

The diode plates are separated, and one is used for the detector function while the other develops the AVC voltage. In simple AVC circuits, all signals—even weak ones—will develop AVC bias voltage. As a result, all signals will reduce the gain of the RF and IF stages. Since weak signals require all available gain, the reduction of gain for weak signals is undesirable. In delayed AVC (DAVC), a negative delay voltage of about 2 to 3 volts is fed through resistor R-128 to the AVC diode plate of the tube. This fixed voltage is obtained from a tap at the proper point on the C voltage divider R-115/R-116 (see Fig. 8–21).

Part of the signal energy from the secondary of the IF transformer is coupled through condenser C-110 to the AVC plate. This plate
is maintained at a small negative voltage, referred to above, which prevents it from rectifying and developing the AVC voltage until the peak voltage coupled to it through C-110 overbalances the negative voltage of this diode. When the signal is weak, enough voltage is not developed on the AVC diode plate to overcome the existing negative potential. No AVC voltage is developed, and the gain of the RF

![Diagram of the delayed AVC circuit](image)

**Fig. 12–13.**—Delayed AVC circuit.

and IF stages remains the same as if AVC were not being used. But when strong signals are received, enough voltage will be coupled to the AVC diode to overcome the small negative plate potential and produce an AVC voltage drop across resistor R-128.

From the serviceman's point of view, operation of the DAVC stage and testing of components is the same as for the simple AVC circuit of the standard receiver.

Figure 12–14 is the schematic diagram of a receiver with a DAVC circuit. Note the following conditions. The delay voltage is developed across resistor (52) in the C voltage divider in the power supply and is applied through resistors (36) and (34) to the AVC diode plate of the 7C6 detector tube. Resistor (35) and condenser (20) form the filter circuit and carry the AVC voltage to the first
Fig. 12-14—Philco Model 42-330 receiver. The DAVC circuit is shown in heavy lines.
IF and mixer stages. The second IF stage is fed a lower AVC voltage from the center tap of resistors (34) and (36). Condenser (19) filters this circuit. The 455-ke filter (part numbers 32B, 32C, and 32D) in the conventional detector circuit is enclosed in the IF transformer assembly (32).

Radio-phonograph Operation.—Many receivers are equipped with a phonograph in a radio-phonograph combination. Or the receiver may come equipped with a phonograph switch and input jack so that the phonograph turntable and pickup unit may be added when desired. The phonograph will utilize only an audio amplifier and therefore will use only the audio stages and speaker of the receiver. At such time, it would be undesirable to have the RF portion of the receiver in an operating condition. Therefore, a switch is used to block the radio signals from entering the audio stages. Likewise, when radio signals are being received, it is desirable that the phonograph pickup be disconnected from the audio stages. The setup is shown in the block diagram of Fig. 12-15, together with a simplified switching arrangement. The switch is shown in the Radio (R) position used for the reception of radio signals.

The switching is usually arranged in the coupling between the detector and AF stages before the volume control so that the latter is operative for either the radio or the phonograph. A typical radio-phonograph switch hookup is shown in Fig. 12-16.

The switch is shown in the Radio (R) position which is normal operation for the receiver. When the switch is changed to the Phonograph (P) position, the pickup feeds the audio amplifier through the volume control. Since some radio signals may leak through the switch and spoil the phonograph reception, provision is made to kill the radio when the switch is in the phonograph position. This is accomplished by opening the cathode, screen, or plate circuits.

![Block diagram of radio-phonograph operation.](image-url)
of one or more of the tubes in the RF section of the receiver. The lower half of the double-pole switch in Fig. 12–16 opens the plate circuit of the IF tube when the switch is adjusted for phonograph operation.

The radio-phonograph switch is sometimes combined with other functions, making the switching arrangement somewhat complicated. As radiomen must service, replace, and sometimes design switching circuits, an example of a rather elaborate switching arrangement is chosen for detailed study.

The radio-phonograph combination of Fig. 12–17 combines the on-off switch, the phonograph-motor switch, and the tone control with the radio-phonograph switch. The switch used is of the 5-point, 2-gang wafer type. The front-panel view of the switch is shown below the wafers in the schematic diagram. The operation of the switch can be analyzed by a study of the diagram and the following table.

Switch positions as marked on the front panel:

1. OFF
2. RADIO MINIMUM HIGH (bass)
3. RADIO MAXIMUM HIGH (treble)
4. PHONOGRAPH MINIMUM HIGH
5. PHONOGRAPH MAXIMUM HIGH
Rear wafer terminal connections:
Terminal 10 is connected to the line cord.
Terminal 9 is connected to the common negative.
Terminal 7 is connected to the phonograph motor.
Terminal 2 is connected through the tone-control condenser C-9 to the first AF plate.

Front wafer terminal connections:
Terminal 12 is connected to the volume control (input of the audio amplifier).
Terminal 1 is connected to the audio output of the detector diode.
Terminal 11 is connected to the phonograph input jack.
Terminal 5 is connected to B plus.
Terminal 6 is connected to the plate and screen circuits of the IF and converter tubes.

The switch is shown in the off position. When it is turned to the next position, the rotating arms move one position in the direction of the arrows on the diagram.

Position 2. Radio Minimum High (bass).
Rear wafer:
Terminal 10 contacts 9.
Terminal 2 contacts 9.
Power is fed into the radio.
Tone condenser C-9 is shunted across the output of the first AF tube.

Front wafer:
Terminal 12 contacts 1.
Terminal 5 contacts 6.
Receiver RF section is connected to the audio amplifier.
B plus is connected to the IF and converter tubes.

Position 3. Radio Maximum High (treble).
Rear wafer:
Terminal 10 still contacts 9.
Terminal 2 is open.
Power connected to radio.
Tone condenser C-9 is open.

Front wafer:
Terminal 1 still contacts 12.
Terminal 5 still contacts 6.
Radio remains connected to audio amplifier.
B plus remains connected to converter and IF tubes.

Rear wafer:
Terminal 10 still contacts 9.
Terminal 10 also contacts 7.
Terminal 2 contacts 9.
Power connected to radio.
Power connected to phonograph motor.
Tone condenser C-9 is shunted across the first AF output.

Front wafer:
Terminal 1 is open
Terminal 12 contacts 11.
Receiver RF section is disconnected from the audio amplifier.
The audio amplifier is connected to the phonograph input jack.
Terminal 5 is open.
B plus is disconnected from the IF and converter tubes.
Position 5. Phonograph maximum high.

Rear wafer:
Terminals 10, 9, and 7 in contact.
Terminal 2 is open.

Power is connected to the radio and phonograph motor.
Tone condenser C-9 is open.

Front wafer:
Terminal 12 still contacts 11.
Terminal 5 is still open.

The audio amplifier remains connected to the phonograph input jack.
B plus remains disconnected from the IF and converter tubes.

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**Fig. 12-18.**—Stroboscope disk used in regulating speed of phonograph motors.

**Troubles Common to Radio-phonograph Combinations.**—Radio-phonograph considerations present two main problems to the serviceman: the servicing of radio-phonograph combinations, and the rewiring of existing straight radios so that they may be used to play...
records through the radio loudspeaker. In the servicing category are troubles with the motor, the pickup, the wiring, and the switches.

The servicing of phonograph motors and record changers is a field in itself and lies outside the scope of this book. The radio serviceman, however, should be able to check a motor for proper operation and to make a proper installation of a replacement unit, as well as minor repairs.

**Phonograph-motor Maintenance Notes.—**When a phonograph motor fails to operate, the line switch and wiring should be checked before condemning the motor. If the turntable speed is incorrect, the tone quality of the recording will suffer. The speed can be checked by means of a stroboscope disk, such as the one shown in Fig. 12–18. The turntable is operated under a single fluorescent or neon lamp. One of the circles of dots will appear to stand still. Reference to the number above the stationary circle of dots will give the number of revolutions per minute (rpm) of the turntable. Most recordings are designed to operate at a turntable speed of 78.26 rpm. The stroboscope disk of Fig. 12–18 has a solid line under the row of dots which corresponds to 78.26 rpm for easy identification. If the turntable has a speed adjustment, it may be properly set with the aid of the disk.

If the proper circle of dots remains stationary for the most part but shows a periodic jump for some of the dots, erratic action of the motor or drive mechanism is indicated. A worn spot on a rubber-rim friction-drive wheel could cause such an effect.

When the phonograph motor is supplied with oil cups, they should be filled with light machine oil. In lubricating a motor, the serviceman should be careful that oil is not smeared on the motor spindle or the rubber-tired drive wheel of a rim-drive motor (see Fig. 12–19). These should be washed with carbon tetrachloride to remove any oil or grease. The same applies to the inner rim of the turntable.

The phonograph motor and turntable should float freely on rubber or springs. In some cases the motor mounting is floating; in others, it is solid and the entire motor board is floated. Figure 12–20 shows the mounting details for a typical phonograph motor.

In case the spring or rubber suspension is inadequate, rumble might ensue. This is particularly important in combinations where the phonograph motor and speaker are housed in the same cabinet.
The rumble is caused by a sort of mechanical feedback between the speaker and the pickup. Speaker vibrations cause the turntable and the pickup to vibrate. The vibration is in turn amplified and builds up the rumble.

![Diagram of phonograph-motor board assembly](image)

**Fig. 12-20.**—Phonograph-motor board assembly, showing rubber suspension mounting for the motor and spring mounting for the motor board.

**Troubles Common to Radio-phonograph Switches.**—Radio-phonograph switches are subject to erratic action due to dirt between the contacts. This is almost always the case when it is necessary to flip the switch two or three times before positive contact takes place.

![Typical wafer-type switch](image)

**Fig. 12-21.**—Typical wafer-type switch used for radio-phonograph switching.

A cleaning with carbon tetrachloride usually takes care of this difficulty. The usual procedure is to wet the switch arms and contacts with the carbon tetrachloride and then rotate the switch quickly. The procedure may be repeated if necessary.

Sometimes a switch contact or the entire assembly becomes broken with use. When this happens, the switch must be replaced. Owing to the large variety in radio-phonograph switches, it is essen-
tial that one similar to the original switch be obtained. In replacing the switch, considerable care must be exercised to make sure that the wiring is correct and that the heat of the soldering iron does not draw the temper from the spring contacts. For correct wiring on an identical switch, it would be best to remove the old switch with its wiring intact, install the new one, and then change the wires, one at a time.

In soldering the switch terminals, it would be best to solder "uphill" where possible, so that the solder or resin does not roll down to the switch contact. Production speed soldering will not draw the temper from the spring contacts. In this method of soldering, the resin-core solder is applied to the joint first, as shown in Fig. 12-22. Then the iron tip is pressed to both the joint and the solder. This makes a fast, clean joint that will not heat the contact unduly.

When an original replacement switch is unobtainable, the serviceman must exercise his ingenuity to perform the operations of the original radio-phonograph switch with whatever standard switch is available and will fit the space requirement. For an extreme example, assume a defective radio-phonograph switch in the receiver of Fig. 12-17 and that an original replacement is unobtainable. A two-deck, four-arm, five-position switch could be substituted in accordance with the diagram of Fig. 12-23.
The front wafer takes care of the radio-phonograph switching. The top half of the rear wafer takes care of the tone-control circuit. The bottom half of the rear wafer is the on-off switch for the radio. Switching the phonograph motor on and off cannot be done with the same switch. An auxiliary switch mounted on the motor board of the phonograph takes care of this function.

![Diagram of radio-phonograph switching circuit](image)

**Fig. 12-23.—Alternate radio-phonograph switching circuit for the receiver of Fig. 12-17.**

**Troubles Common to the Pickup Unit.—**Most pickups in common use are of the crystal type. These develop troubles of no output, weak output, and distorted output. A good indication as to whether the pickup is at fault is to check the operation of the radio. If the tone quality and volume of the radio half of the combination are normal, the trouble lies in the phonograph unit, since the audio amplifier and speaker operate on both.

No output from the pickup might also be caused by a defect in the radio-phonograph switch or phonograph wiring. The switch operation may be checked by reference to the schematic diagram, visual inspection, and an ohmmeter. The wiring usually consists of shielded flexible leads, which may break, or the shielding may short through the insulation to the wire. In either case a visual inspection and an ohmmeter will check the wiring. The wiring is particularly
vulnerable to defects near the point where it goes through the swivel of the pickup arm. A procedure for replacing shielded wiring is given in Fig. 11–18.

The best check to determine whether the pickup is operating properly is to substitute another crystal unit known to be in good condition. The test pickup should be temporarily connected to the handiest soldering lugs on the pickup line, and its operation should be tried on a record.

When a pickup unit is replaced, a replacement crystal cartridge is often obtainable. This should be the same as the original in weight,

![Typical phonograph pickup unit.](image)

mounting details, and output. Where a new cartridge cannot be obtained, the entire pickup unit must be replaced. Again it is preferable to replace with one similar to the original unit. In cases where a different pickup unit must be used, an important detail in making the replacement is to place the arm so that the needle will describe approximately the same arc across the record as was done by the original. For example, when replacing the pickup of Fig. 12–25, a replacement with a longer arm will describe a different needle arc than the original, if the replacement is mounted in the same hole. Moving the replacement pickup farther back will allow the needle to describe more nearly the same arc across the record. Readjusting the rest to accommodate the new pickup is also a matter of importance, since carelessness in this item may result in the new crystal being jarred and ruined.

Rewiring Radios for Phonograph Operation.—The serviceman is often called upon to rewire an existing radio so that it may be used to reproduce recordings. When this is done, it would be wise to refer to the appropriate diagram manuals to see if the manufacturer also made a radio-phonograph combination similar to the radio being
rewired. If such a diagram can be found, there will be several distinct advantages. In the first place, a diagram known to be satisfactory is available. Then also, the exact switches and outlets are often procurable as replacement parts. Finally, since the chassis are often stamped alike for both models, there may be unused chassis holes or knockouts to accommodate the parts that must be added. Such a procedure may mean drilling a hole in the front panel of the cabinet to accommodate the radio-phonograph switch, but this is best in any case. The switch should be readily accessible, and a workmanlike job on the front panel with a knob to match the others is far more desirable to the owner of the radio than the make-shift arrangement of a switch screwed to the back of the cabinet or dangling from wires.

The radio-phonograph service notes may even include a picture diagram, which would solve the problem of correct lead dress. Where this is not the case, the serviceman should remember that the pickup wiring is in the input circuit of the audio amplifier and that any coupling with other wiring may cause hum and oscillation. The wiring should be shielded and dressed close to the chassis and away from all other wiring.

In cases where a diagram of a radio-phonograph combination similar to the radio being rewired cannot be found, the serviceman must make up his own. This is not very difficult for modern superheterodyne receivers, since audio amplifiers usually follow a similar pattern of two stages of AF amplification with varying amounts of undistorted power output. The serviceman simply follows general principles; that is, he incorporates a switch that connects either the detector output or the pickup output to the input circuit of the audio amplifier. At the same time, the phonograph position of the switch breaks the plate, screen, or cathode circuit of the converter.
or IF tubes, so that the radio is completely inoperative when recordings are being reproduced. If possible, the switch will be mounted on the front panel of the radio, and the general instructions regarding lead dress and working with shielded wire will be followed.

As a concrete example, if the receiver of Fig. 12–14 were to be rewired for phonograph operation, the serviceman might make up a circuit similar to Fig. 12–26. The phonograph motor is operated from a switch on the motor board, as shown in Fig. 12–25.

![Diagram](image)

**Fig. 12–26.**—Adding a radio-phonograph switching circuit to the receiver of Fig. 12–14.

Since this is a fixed-bias circuit, opening the plate circuits of the RF tubes will cause the total B current to drop, changing the voltage across resistors (52) and (53) in the fixed-bias circuit. This may seriously affect the tone quality in the phonograph position. The resistor marked 10,000 OHMS/10 WATTS has been added to replace the load of the tubes in the RF portion of the receiver. The serviceman should try several values for this resistor, using the one that shows no change in the bias voltage across resistors (52) and (53) in either position of the phonograph switch.

The above precaution need not be taken in the case of a circuit using self-bias circuits, unless it is felt that the decreased B loading on phonograph operation will reduce the magnetizing current through the speaker field.

Sometimes the rewiring job includes mounting the phonograph unit in an existing cabinet. In this case, the serviceman makes up a motor board similar to the typical mounting shown in Fig. 12–25. In laying out the motor board, he should remember to center the turn-
table spindle so that 12-in. records can be accommodated without chopping holes in the cabinet. The pickup often includes mounting instructions relating to the proper arc that the needle should describe on the record. If no instructions are included, the arc shown in Fig. 12-25, where the needle extends just beyond the turntable spindle, is about average for most installations. The motor or motorboard suspension is important for the reduction of rumble. Lining the phonograph compartment with felt may also help in this regard.
SUMMARY

Quick check for normal operation of the detector and AVC stage.

The signal generator is adjusted for a modulated output at the receiver intermediate frequency and its output is applied to the grid of the IF tube. When the stage is functioning properly, the modulation note will be heard in the speaker.

Diagram of standard detector and AVC stage.

A diagram of standard detector and AVC stages is given in the accompanying figure.

Resistance data.

These data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Component</th>
<th>Iron core</th>
<th>Air core</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary of output IF transformer</td>
<td>30–50 ohms</td>
<td>5–15 ohms</td>
<td></td>
</tr>
<tr>
<td>Secondary of output IF transformer</td>
<td>5–15 ohms</td>
<td></td>
<td>30–50 ohms</td>
</tr>
<tr>
<td>Chassis to diode plates</td>
<td>550,000 ohms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Across entire volume control</td>
<td>500,000 ohms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chassis to AVC bus</td>
<td>1,500,000 ohms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Service Data Chart

Assume an inoperative detector stage, as shown by normal response when an AF test signal is applied to the ungrounded end of the volume control, and no response when a modulated test signal at the intermediate frequency is applied to the IF grid.

<table>
<thead>
<tr>
<th>Step</th>
<th>Check</th>
<th>Response</th>
<th>Trouble</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Advance the signal-generator attenuator and rotate the dial through the intermediate frequency</td>
<td>The modulation note is heard at an off-frequency setting</td>
<td>The IF transformer is out of alignment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The modulation note is not heard</td>
<td>Proceed to step 2</td>
</tr>
<tr>
<td>2</td>
<td>Apply the IF test signal to the IF plate. Rotate the signal-generator dial and advance the attenuator to full output</td>
<td>The modulation note is heard in the speaker</td>
<td>The trouble is in the IF tube or its supply voltages. See Chap. 18 on the IF stage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The modulation note is not heard</td>
<td>Defective tube. Substitute a detector tube known to be good. The trouble may be an open IF transformer winding, a shorted trimmer condenser, etc. Make a resistance check of all components in the stage</td>
</tr>
</tbody>
</table>

### Service Data Chart for Other Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Abnormal reading</th>
<th>Look for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hum</td>
<td></td>
<td>Defective detector tube. Substitute a good one. Poorly dressed leads in the diode plate and plate return circuits. Open wiring or shielding in the phonograph section</td>
</tr>
<tr>
<td>Weak reception and oscillation</td>
<td>If equipped with an electron-ray tuning-indicator tube, the eye will not close fully</td>
<td>Incorrect alignment. Open AVC by-pass condensers C-28, C-29, and C-30</td>
</tr>
<tr>
<td>Distortion on strong signals</td>
<td></td>
<td>Leaky AVC by-pass condensers C-28, C-29, and C-30</td>
</tr>
</tbody>
</table>
QUESTIONS

1. A dead AC receiver gives a normal response when checking the AF stages but gives no response when a test signal at the proper intermediate frequency is applied to the IF grid. Outline a service procedure to be followed in finding the cause of the trouble.

2. List the likely sources of trouble that will cause a receiver to give no response when an IF test signal is applied to the IF plate and normal response when an AF test signal is applied to the "hot" end of the volume control.

3. A radio-phonograph combination has a distorted output when it is tuned to local stations. The tone quality is normal when it plays phonograph recordings. Would you check the audio stages for the trouble? Why? What is likely to be wrong? How would you prove it?

4. When a receiver with weak reception is checked, it is noted that the trimmer across the input IF secondary has no effect on the output. What circumstances can cause this condition? How would you check for each?

5. Which components in the detector stage may cause hum? How would you check each?

6. The receiver of Fig. 12–7 has a defective phonograph-radio switch. An exact replacement is not obtainable. The customer indicates a desire to have the phonograph motor operated from the phonograph-radio switch and, since he always uses his radio in the position of maximum high, he is not interested in the tone control. Redraw the diagram of Fig. 12–23 to meet these conditions.

7. It is desired to rewire the receiver of Fig. 10–13 for phonograph operation. Design a circuit for the necessary rewiring. Include provision for the radio-phonograph switch to make the radio inoperative in the phonograph position.

8. After the rewiring of the receiver of question 7, it is found that the tone on phonograph operation is poor. Radio operation is normal, and the pickup is not at fault since the test pickup gives the same results. When the receiver is checked with the bench (P-M) test speaker, operation is normal for both the radio and phonograph. This indicates insufficient magnetizing current through the field coil of the radio loudspeaker. What circuit rearrangement would you advise to overcome this condition?

9. What precautions in regard to lead dress should be taken when replacing an output IF transformer? What conditions might result from improper lead dress?

10. A receiver equipped with an electron-ray tuning-indicator tube operates normally, but the magic-eye tube deflection does not change as stations are tuned in. What is likely to be wrong and how can it be checked?

11. A radio-phonograph combination has poor tone on phonograph and normal tone on radio operation. What factors can cause this condition? How can you check for each?

12. A radio is brought in with a complaint that reception is weak. The serviceman also notices that the noise level is high. What is likely to be wrong? How can this condition be checked?