

# How to Make Extra Money **FIXING RADIOS**

NATIONAL RADIO INSTITUTE, WASHINGTON, D. C.

**No. 25** How To Fix a Receiver  
That Distorts  
**RADIO SERVICING METHODS**



# NRI TRAINING PAYS...

Dear Mr. Smith:

When I enrolled with your school I did not understand anything in radio, and I was afraid I could not take such a Course because my education did not amount to much. I can read and write English, but not very well. But I have found your Course so well written in simple language that I believe anyone can understand it. You can be sure that I am very proud of my NRI diploma and I can say that I will never make a better investment in all my life.

J.O.B., Canada



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## How To Fix A Receiver That Distorts

**D**ISTORTION is one complaint to which you can apply effect-to-cause reasoning very successfully almost every time. There are only a few defects that can cause distortion, and most of these can be identified rather easily by the effect they have on the sound output of the receiver. Thus, when you turn on the set to confirm the complaint, the harsh, muffled, raspy, or otherwise unnatural sound that you hear will tell you more than the simple fact that the receiver is distorting. Very often, the kind of sound produced will also tell you exactly what defect to look for in the set.

Of course, before you can use effect-to-cause reasoning, you must learn to recognize the special kind of distortion each particular defect produces. The NRI Practical Training Plan will teach you to do so. Perform every step of the Plan given in the last section of this Booklet. Create each type of distortion in your experimental receiver, listen to each carefully, and learn to tell the various kinds apart. It will not be long before you can listen to a distorting receiver and tell almost at once what is probably the matter with it.

Before we take up the defects that cause distortion, let's first review the general facts about this complaint. Of the three main kinds of distortion, amplitude distortion is the only one you will meet much in servicing sound receivers. Phase distortion is troublesome only in television. Frequency distortion occurs fairly often in sound receivers, but, for reasons we will now mention, it is seldom a service complaint.

**Frequency Distortion.** Frequency distortion occurs whenever an amplifier does not amplify all frequencies in its pass-band equally. A radio containing such an amplifier will not reproduce sounds as they were originally made, but will instead accentuate the low, middle, or high frequencies.

Very often the customer does not consider frequency distortion to be a defect when it takes the form of excessive bass response. Many a person prefers such a response, and either buys a set that has it or turns the tone control to achieve the same effect.

People are more likely to object to excessive response in the higher frequencies. However, the defects (open output filter condenser or open plate-cathode by-pass condenser in the power output stage) that are likely to cause this also produce hum or oscillation, so you will be called for these complaints rather than for frequency distortion.

You are not likely to get many calls to correct frequency distortion except from those who appreciate and want high-fidelity response. One reason is that frequency distortion is ordinarily caused by gradual changes in part values. It may take months for the distortion to develop very far, and the day-to-day change is usually so slight that the receiver owner often does not notice it.

**Amplitude Distortion.** Amplitude distortion occurs when there is a change in the harmonic content of the signal. Usually it occurs because a tube or a transformer is caused to operate over a non-linear portion of its characteristic, or because of trouble with the loudspeaker.

Since amplitude distortion is very unpleasant to the ear, it is not apt to be allowed to go uncorrected. Furthermore, there is little chance that the receiver owner will not notice the distortion, for it is likely to occur suddenly.

Now let's learn what specific defects can cause amplitude distortion.

## COMMON CAUSES OF DISTORTION

In the following list, we have not set down the causes of distortion in the order in which they are most likely to occur. Instead, for convenience in study, all the possi-

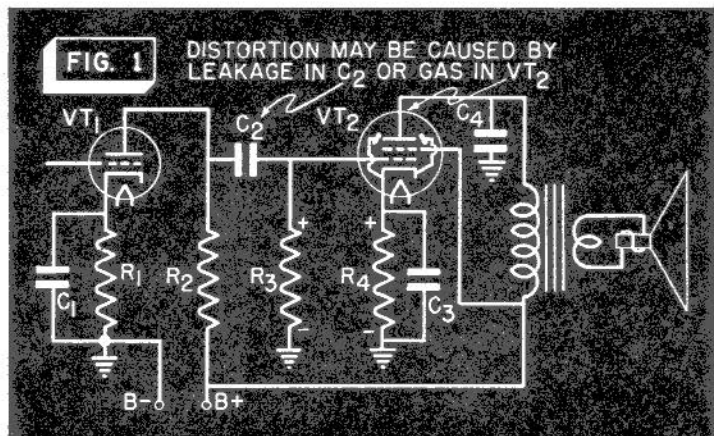
ble defects that can occur in each class of part have been combined in one section. For example, all loudspeaker troubles are in a single grouping, even though some of these troubles occur much more frequently than others.

In each instance, we have shown why the particular defect described causes distortion, and how the offending part may be found. For the moment we will assume that you either know the kind of part that is causing trouble or have localized the defective stage. Later in this Booklet you will learn how the part or stage is localized.

**Leaky Coupling Condensers.** One of the most common causes for distortion is a leaky coupling condenser, such as  $C_2$  in Fig. 1. When this condenser becomes leaky, it acts like a resistor; the B supply voltage then divides between  $R_2$ ,  $C_2$ , and  $R_3$ . The polarity of the resulting voltage across  $R_3$  is shown in the diagram. As you can see, the  $R_3$  voltage subtracts from the normal bias voltage developed across  $R_4$ , decreasing the negative voltage on the control grid of  $VT_2$ , and in some cases actually making the control grid positive with respect to the cathode. As a result, the grid of  $VT_2$  draws current and may cut off the peaks of the signal, thus causing distortion.

The same result will also be produced if tube  $VT_2$  is gassy. Let's see why, then take up the tests that show whether the condenser or the tube is at fault.

**Gassy Tubes.** If tube  $VT_2$  in Fig. 1 becomes gassy,



current will flow in the control grid circuit. Electrons will flow through  $R_3$  to the control grid where they will join with positively charged gas ions. The current flow through  $R_3$  results in a drop across this resistor, having the same polarity as the voltage that would be caused by a leaky coupling condenser.

► When a gassy tube or a leaky coupling condenser is suspected as a cause of distortion, connect a high-resistance d.c. voltmeter across  $R_3$ , with the positive voltmeter probe going to the control grid end of the resistor. *Normally, no d.c. voltage is present across the resistor.* If the meter shows the presence of a voltage, you have definite proof that the tube is gassy or the condenser is leaky. The problem now is to find whether the tube or the condenser is to blame.

Leave the voltmeter probes connected across  $R_3$ . If the receiver is a.c.-operated and has a power transformer, pull  $VT_2$  out of its socket. If the voltage across  $R_3$  disappears, the tube is gassy, and a new one must be installed. If the voltage is still present with  $VT_2$  removed,  $C_2$  is leaky, and a new condenser must be installed.

In battery and a.c.-d.c. receivers, where tubes must not be removed while the power is on, another procedure must be followed. In this case, do *not* remove  $VT_2$  from its socket. Instead, with the power turned off, unsolder one lead of  $C_2$ , then turn on the receiver again. (The voltmeter should still be connected across  $R_3$ .) If a reading is obtained with  $C_2$  disconnected, the tube is gassy; but if no reading is obtained,  $C_2$  is leaky.

Once in a great while you will find  $C_2$  leaky and  $VT_2$  gassy at the same time. In this case the voltage will drop when  $C_2$  is disconnected or the tube is pulled out, but it won't disappear altogether. Both the tube and the condenser must be replaced.

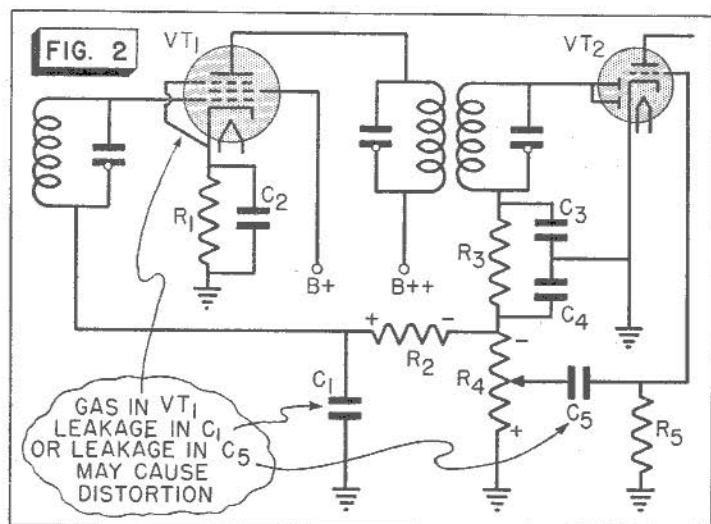
**Overloading.** Two kinds of "overloading" may be noticed. One occurs only on one or two powerful local stations; this is a true case of overloading, in that the powerful signal forces a tube to operate beyond the straight portion of its characteristic. Another kind is the result of improper operating voltages and will occur on any fairly powerful signal.

Overloading on one local signal is not likely to occur suddenly unless the strength of some nearby broadcast station is increased, or unless the receiver owner has just moved into the neighborhood and is unaware of the high signal level of some nearby station. Since this overload condition appears on just one station, it is a clue telling you what to do. You can reduce the pickup from the local station by shortening the antenna or by using a wave trap in the antenna circuit. Tune the wave trap to the frequency of the powerful local station. This will reduce the amount of signal from this one station.

► Several difficulties in the receiver may cause overloading on more than one signal. For example, someone may have installed sharp cut-off tubes in place of the variable-mu tubes that are always used in a.v.c.-controlled stages. This is particularly likely when the receiver owner has removed the tubes to have them tested. Be on the lookout for such incorrect substitutions as a 24 for a 35, a 6J7 for a 6K7, or 6SJ7 for a 6SK7, a 12J7 for a 12K7, etc.

A leaky or shorted a.v.c. filter condenser ( $C_1$  in Fig. 2) will remove the a.v.c. voltage and may permit overloading to occur in one of the r.f. or i.f. stages.

Furthermore, if any of the a.v.c.-controlled tubes such as  $VT_1$  in Fig. 2 becomes gassy, the voltage drop caused





by the gas current drawn through resistor  $R_2$  will oppose the a.v.c. voltage (which has the polarity marked across  $R_4$ ) and will therefore reduce the amount of a.v.c. voltage applied to the a.v.c.-controlled tubes in the set. This reduction in voltage may cause overloading and distortion.

When distortion caused by overloading occurs in a receiver using a.v.c., and you have localized it to the r.f. stages, remember to:

1. Check the types of tubes used in the a.v.c.-controlled stages.
2. Check for gas in the a.v.c.-controlled tubes.
3. Check for leakage or shorts in the a.v.c. filter condensers.

► In connection with Fig. 2, you may sometimes find receivers using this circuit that distort if the volume control is advanced to a higher volume position. This may be caused by audio overloading, but it may also be caused by leakage in coupling condenser  $C_5$ . This latter defect allows the a.v.c. voltage developed across  $R_4$  to be applied to the control grid of  $VT_2$ , thereby increasing the negative bias on this tube and causing it to operate on the lower bend of its  $E_G$ - $I_P$  curve. When the volume control is adjusted to give louder reception, more of the a.v.c. voltage is applied to  $VT_2$ , and the distortion becomes worse. Reducing the volume control setting will allow the reception to clear up somewhat. If you have reason to suspect this condition, be sure to check across  $R_5$  for voltage (the negative terminal of the voltmeter goes to the grid end of this resistor in this case), or else temporarily substitute another condenser for  $C_5$ .

**Bias Troubles.** If an improper bias is applied to a tube because of some circuit defect, the tube may then operate over a curved portion of its characteristic and so create distortion. The condition we just described (a leaky condenser  $C_5$  in Fig. 2) is one example of this. There are also a number of other things that can upset the grid bias.

For example, in Fig. 1, resistor  $R_4$  (the bias resistor for  $VT_2$ ) may open. The leakage resistance of condenser  $C_3$  will then complete the plate circuit, but this leakage



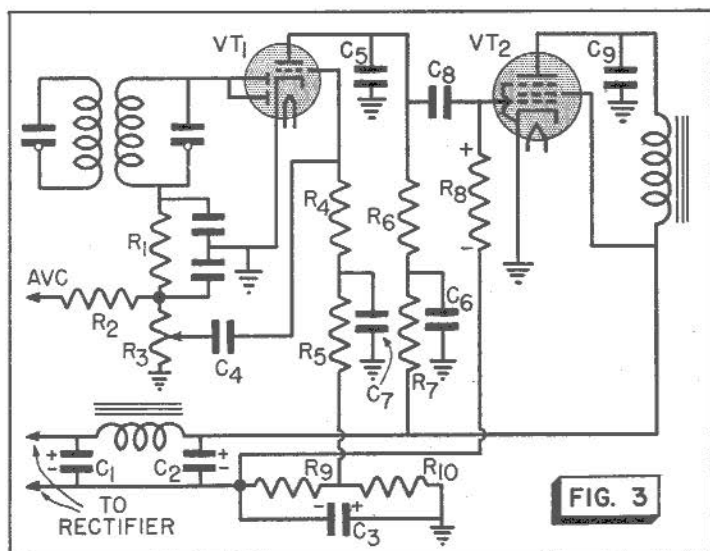


FIG. 3

resistance is far higher than the resistance of  $R_4$ , which is normally a few hundred ohms. Therefore, there will be a rather large voltage drop across the leakage resistance of  $C_3$ . Of course, this means that a high bias will be applied to the grid of  $VT_2$ , so distortion will occur. (If  $C_3$  has a very high leakage resistance, the set will be entirely dead.)

At the other extreme, condenser  $C_3$  may short-circuit, thus removing all bias. Furthermore, cathode-to-heater leakage may at rare times also remove the bias and cause distortion rather than hum. (As you know, there will be hum only if there is leakage to an ungrounded side of the filament. If there is leakage to the grounded side, only the bias will be upset.) A quick check with a voltmeter will show that the bias is too low in either case, so you can quickly localize the trouble.

► Circuits that use a fixed bias that is obtained from a power supply, as in Fig. 3, all have a common weakness. The plate currents of all the tubes flow through resistors  $R_{10}$  and  $R_9$ .  $VT_1$  is biased by the drop across resistor  $R_{10}$ , and the voltage across both  $R_9$  and  $R_{10}$  acts as the grid bias for  $VT_2$ . This circuit works very well as long as the current flow through these resistors is unchanged. However, any change may produce distortion.

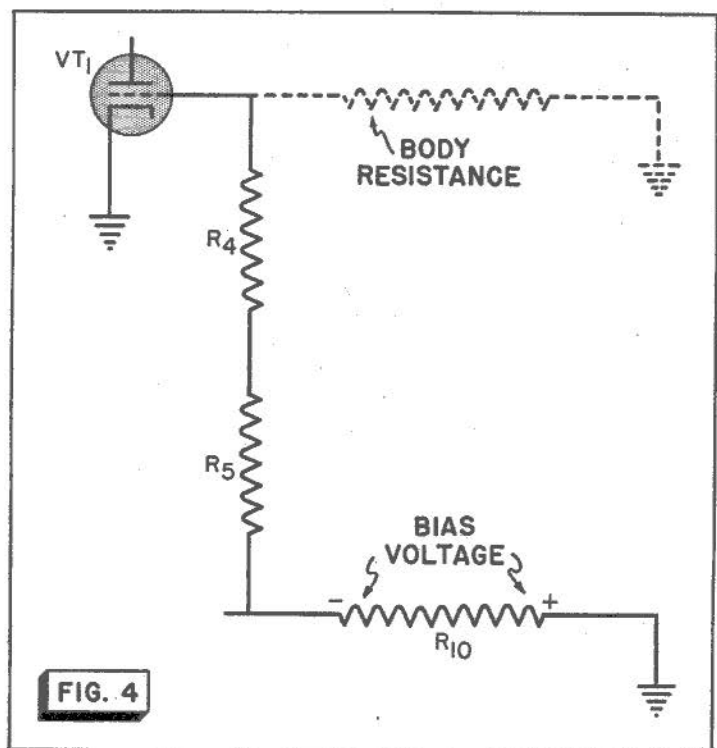
For example, suppose that a slight leakage develops in coupling condenser  $C_8$ , or tube  $VT_2$  becomes slightly gassy. Either defect will cause the voltage across  $R_8$  to assume the polarity shown and thus cause the current of  $VT_2$  to increase. The operation of  $VT_2$  will not be much affected, because its bias (the voltage across  $R_9$  and  $R_{10}$ ) will also increase. (Of course, a large amount of leakage in  $C_8$ , or a severe gas condition in  $VT_2$ , cannot be compensated this way, and distortion will occur in  $VT_2$ .) However, the increased drop across  $R_{10}$  means that the bias on  $VT_1$  will be increased, since  $R_{10}$  serves as the bias source for  $VT_1$ . This increase in bias may be enough to overbias  $VT_1$  and so cause distortion. (The first audio tube in most radio receivers requires very little bias: a volt or two increase in the bias can easily cause  $VT_1$  to operate over the curved portion of its characteristic.)

If the triode grid of  $VT_1$  comes to a top cap, you can quickly check for an increased bias by touching both the top cap and the chassis with one hand. This will serve to reduce the bias on the tube (we will explain why in a moment). If the distortion is reduced or cleared up, you can be rather sure that it is being caused by excess bias on  $VT_1$ .

If the tube has no top cap, you can make a similar test by holding a 100,000-ohm resistor between the grid and the cathode.

► To see why touching your hand to the top cap of  $VT_1$  and to the chassis reduces the bias on the tube, examine the circuit shown in Fig. 4. This shows the essential bias supply circuit of  $VT_1$  in Fig. 3, which consists of the supply resistor  $R_{10}$  and the series resistors  $R_4$  and  $R_5$ . Ordinarily, when no d.c. current flows in this grid circuit, resistors  $R_4$  and  $R_5$  have no effect on the grid bias voltage; all the bias voltage developed across  $R_{10}$  is applied to the grid of  $VT_1$ .

However, touching your hand to the chassis and to the tube top cap effectively connects a resistance (the resistance of your hand) between the grid and the chassis. This resistance is shown by dotted lines in Fig. 4. Notice that now there is a complete d.c. path from  $R_{10}$  through  $R_5$ ,  $R_4$ , and the resistance of your hand to the



**FIG. 4**

chassis. The voltage across  $R_{10}$ , which we can consider to be a voltage source for this circuit, will produce a d.c. current flow through this path. The result will be that the voltage across  $R_{10}$  will divide between  $R_5$ ,  $R_4$ , and your hand; and only the part across your hand will be applied to the grid of  $VT_1$  as a bias.

An inexperienced serviceman, finding that the bias in such a circuit is upset, often attempts to correct the condition by short-circuiting resistor  $R_{10}$ . This will often clear up the distortion for a while, but it should not be considered a real repair; the original trouble in  $C_8$  or in  $VT_2$  still exists and will only become worse with time. If you find that the bias resistor is short-circuited, or that excessive bias exists, be sure to locate the actual trouble and clear it up.

► Once in a great while an open grid circuit will cause distortion rather than weak reception or severe hum. For example, if the grid resistor in a resistance-coupled

amplifier opens, the grid will then be floating free. It will trap some electrons from the electron stream, thus building up a negative charge on itself. Usually this charge will build up to such a value that the plate current will be sharply reduced, or even cut off altogether. Once in a while, however, the charge may build up only enough to cause excessive bias and distortion.

The distortion produced will sound somewhat like that caused by a leaky coupling condenser, so you will probably try to measure voltage across the grid resistor. If so, you will find that the distortion clears up as soon as you connect the voltmeter but reappears when you remove it. (This occurs because when the voltmeter is connected across the defective resistor, its resistance completes the grid circuit.) When you find this action occurring, and there is no voltage across the grid resistor, you can be fairly certain the grid resistor is open. Check it by trying another resistor in its place.

**Low Plate Voltage.** In a self-biased stage, a reduction in the plate voltage is accompanied by reduction in the bias, so distortion will not occur unless the signal levels handled by that stage are so large they exceed the new bias value. If the signal does exceed the bias, the stage will overload and distortion will occur. This is not apt to occur in r.f. or i.f. stages, but does happen in audio stages—in fact, low plate voltage is very often the reason why a self-biased audio stage overloads.

► If the stage uses a fixed bias, such as  $VT_1$  in Fig. 5, distortion occurs if the plate voltage drops even slightly. For example, let's suppose condenser  $C_6$  becomes leaky. This effectively connects a resistance (the leakage resistance of  $C_6$ ) between the  $R_6$ - $R_7$  junction and the chassis. This leakage resistance acts as a voltage divider with  $R_7$ , so the plate voltage of  $VT_1$  is lowered. The bias on  $VT_1$ , however, remains normal, because the bias is determined by the voltage drop across  $R_{10}$ , which in turn is determined mostly by the plate current of  $VT_2$ . This normal bias voltage is too high for the lowered plate voltage, so distortion occurs.

As you just learned, touching the top cap and chassis with your fingers, or connecting a resistor between the

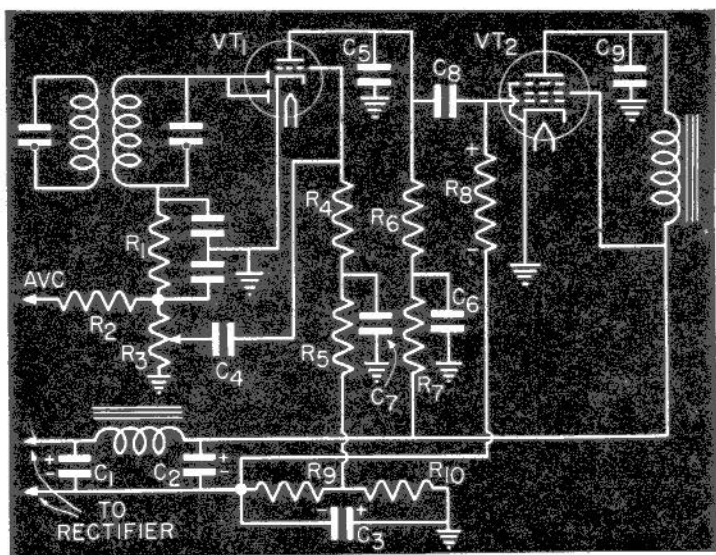


FIG. 5. This circuit is the same as that in Fig. 3. It is repeated here for your convenience in reference.

grid and the cathode, will show you whether the distortion is caused by excessive bias. However, it won't show you whether the plate voltage is normal and the bias excessively high, or the bias normal and the plate voltage low. The first condition (normal plate voltage, high bias) can be caused by leakage in  $C_8$  or gas in  $VT_2$ ; the second condition (normal bias, low plate voltage) can be caused by leakage in  $C_6$  or  $C_5$ . To find out which condition you have, see if you can find a d.c. voltage across  $R_8$ . If no voltage exists across it,  $C_8$  and  $VT_2$  are probably all right, and you should check  $C_5$  and  $C_6$  for leakage.

There are several simple ways of checking for leakage in these condensers. If the set is an a.c.-operated receiver with a power transformer, pull  $VT_1$  from its socket and then measure for voltages across resistors  $R_7$  and  $R_6$ . There should be no voltage drop across either resistor when the tube is out of its socket. If there is a drop across  $R_7$  and none across  $R_6$ , condenser  $C_6$  is leaky. If a voltage drop exists across both resistors, then  $C_5$  is leaky.

In receivers where  $VT_1$  cannot be pulled from the

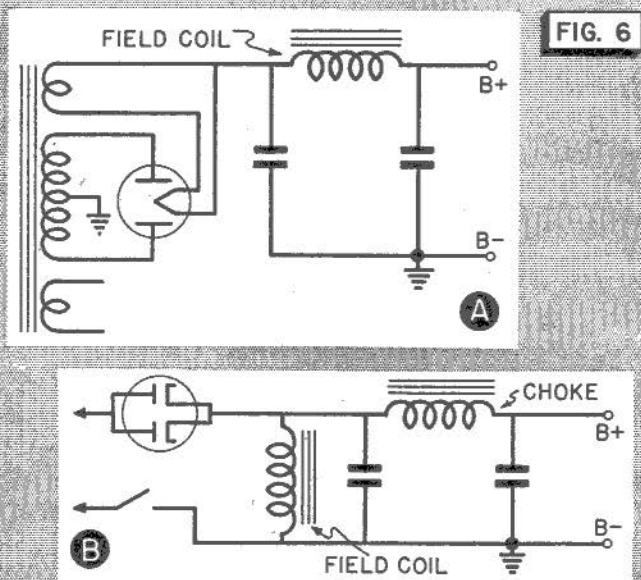
socket, it may be fairly simple to unsolder its cathode or plate lead and make the same check across the resistors. If this is difficult, disconnect the condensers and check them with an ohmmeter.

## LOUDSPEAKER TROUBLES

The repair of loudspeakers has been covered in an earlier RSM Booklet. Here, we shall briefly describe the troubles that may result in distortion. In each case, you should refer to the other Booklet for details on making the repair once the trouble has been localized.

**Open Field Coils.** Two possible connections between the power supply and the field coil of an electrodynamic speaker are shown in Fig. 6. If the field coil shown in Fig. 6A opens up, the B supply circuit will be broken, making the receiver dead. However, in the shunt connection shown in Fig. 6B, an open field coil will not interrupt the supply voltage. Instead, it will cause severe distortion and weak reception.

To test the speaker field, hold a screwdriver or another iron or steel tool near the pole piece with the re-



ceiver turned on. You will notice a strong pull if the field coil is properly energized. Lack of a pull or a very weak pull shows that the proper current is not flowing through the field coil. Turn off the receiver, unsolder one of the field coil leads, and check the coil for continuity with an ohmmeter.

► The permanent magnets of p.m. speakers and magnetic speakers may weaken, reducing the field strength and causing distortion. This trouble usually develops gradually, however, so the distortion may go unnoticed for some time.

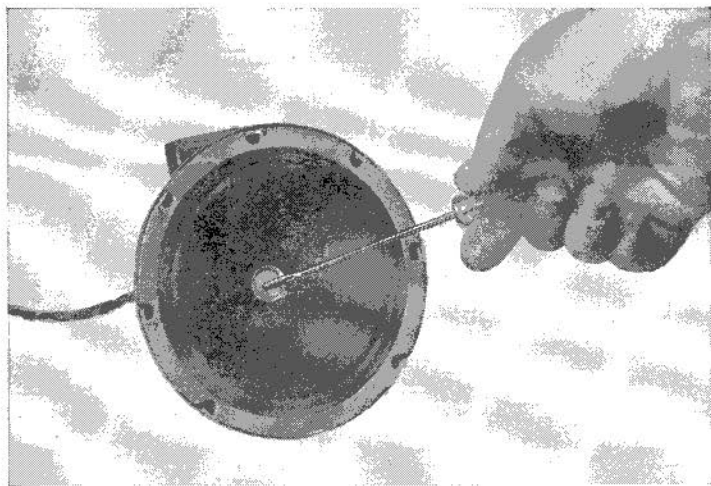
You can get a good idea of the effectiveness of the magnet of a p.m. speaker by holding a screwdriver near the pole piece. The pull should be strong whether the receiver is turned on or off. If a dust button is glued over the apex of the cone so that you cannot bring a screwdriver blade near enough to the pole piece, you may be able to judge the pull from a rear edge of the magnet. If not, either try another speaker or else carefully cut a slit in the button with a razor blade. (A piece of Scotch Tape will close the opening in the dust button.)

The easiest way to test a magnetic speaker is to substitute another for it. If you do not have a speaker like the original one, make the test with a 5-inch p.m. speaker that is equipped with a universal output transformer. Match this speaker to the plate impedance of the output tube by using the proper taps on the transformer. If the reception is about the same when you use the p.m. speaker, the magnetic speaker is probably all right. If using the p.m. speaker (or another magnetic speaker) removes the distortion, the original speaker is undoubtedly defective.

**Cone and Voice Coil Troubles.** An improperly centered voice coil will cause considerable distortion of an unforgettable kind. The distortion is unusual in that it is most noticeable on low-frequency sounds. For example, a male voice will be reproduced with considerable distortion while a female voice may be reproduced naturally and clearly.

Recenter the voice coil if possible—by adjusting the spider if there is any provision for doing so, or, if not, by bending the speaker frame. You can tell when the





**Here's how to use a screwdriver to check the field strength of either a p.m. dynamic or an electrodynamic speaker.**

cone is properly centered by moving it with your fingers. If the trouble cannot be corrected by bending the frame or by adjusting the spider, install a new cone and voice coil or replace the entire speaker.

Metal filings in the magnetic air gap will produce the same effect as an off-center voice coil, since the voice coil will rub against them as it travels back and forth. Loose turns on the voice coil will produce much the same effect.

A tear or rip in the cone will cause a buzzing or rattling sound, as will an unglued cone. If you can see no tear, pull on the edge of the cone with your fingernails. If the cone comes away from the speaker frame or rim, work speaker cement between the cone and the frame or around the rim.

► It is always possible to check for speaker defects by using a test speaker. To do so, simply disconnect the original speaker *voice coil* and connect the voice coil of a 5-inch p.m. speaker in its place. The tone quality will undoubtedly be different from that of the original, but judge by the clarity of response or rather by the absence of distortion in the response. If the reproduction from the test speaker is clear, the original is defective and should be repaired or replaced.

## HOW TO LOCALIZE DISTORTION

As we mentioned earlier, the particular sounds produced by certain receiver defects are easily recognizable once you have heard them and learned their characteristics. Therefore, with experience, distortion becomes relatively easy to localize, because you can go at once to the two or three things that might cause that particular kind of distortion.

In practically all cases of distortion, the source will be in the audio amplifier or loudspeaker. If the set is a phono-radio combination, you can always prove that the trouble is in this section of the receiver by trying the phonograph. Distortion indicates that the audio-loudspeaker portion of the radio is defective.

If you haven't the experience to recognize the cause of the distortion, it will be necessary to localize the defect. Stage blocking cannot be used, since the distortion will occur only when the signal is passing through the defective stage. Therefore, it is necessary either to introduce a signal or to listen to the signal at various points in its progress through the defective section.

The signal generator is not very helpful in localizing distortion, for it is hard to tell when its tone is distorted. Some form of signal tracing is almost the only satisfactory means of localizing distortion. A signal tracer of the type having a loudspeaker output, so that the sound is audible, is necessary—a signal tracer that has only a signal strength indicator cannot be used.

The receiver loudspeaker may interfere with your ability to hear the output of the signal tracer. If so, disconnect the voice coil of the loudspeaker. Whenever this is done, be sure to supply the proper load for the output tube so that the output stage will not be upset. You can do this by connecting a 5-ohm or 10-ohm, 10-watt, wire-wound resistor across the secondary of the output transformer in place of the voice coil.

To use a signal tracer, tune in the signal and be sure the output of the receiver is distorted. Then replace the speaker voice coil by a resistor, if necessary. Finally, use your signal tracer to follow the signal through the audio end of the receiver until you encounter the point where the distortion occurs.

In those rare instances in which distortion arises in the r.f. stages, use your signal tracer to follow the signal from the input of the receiver to the point where the distortion occurs.

For tracing in the audio end of the set, many servicemen make a simple, homemade listening device like that shown in Fig. 7. In this device, the blocking condenser prevents short-circuiting the B supply when the device is used in the plate circuit, and the volume control is used to adjust the sound in the headphones to a comfortable level.

With this headphone device, the proper procedure is to start at the output of the second detector and move through the audio amplifier towards the speaker, a circuit at a time. Tune in a signal, then listen at the output of the second detector, at the grid of the first audio tube, at the plate of the first audio tube, at the grid of the power tube, and at the plate of the power tube, in order. Whenever the sound in the phones becomes distorted, you have just passed over the section in which the distortion arises.

A word of caution is necessary here. Returning to Fig. 1—leakage in coupling condenser  $C_2$  or a gassy tube  $VT_2$  does not cause distortion in the *grid* circuit of  $VT_2$ —the signal across  $R_3$  will not sound distorted. This upset in the bias produces distortion in the *plate* circuit of this tube. Therefore, if you find the signal distorted in the plate circuit, either something is wrong in the plate circuit, or the tube is improperly biased because of a defect in its grid circuit.

► Eventually, you may own a professional signal tracer. When that time comes, you will be able to listen to the signal in the same manner as with the headphone device. The professional type does not upset any circuits and allows you to listen to a loudspeaker. Furthermore, it makes it possible to move back through the r.f. stages and to locate the overloaded stage, if the distortion originates ahead of the a.f. amplifier.

► Of course, once you have localized the defective stage or circuit, you can then follow the test procedure given earlier in this Booklet to locate the upset voltage or to find the defective part.

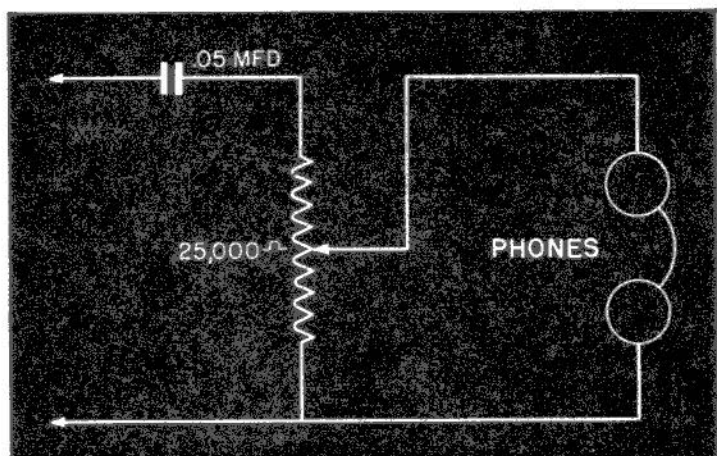


FIG. 7. You can make this useful audio signal tracer very easily. The values shown are not critical: You can use any condenser with a d.c. working voltage of 600 volts and a capacity between .01 and .5 microfarads, and any wire-wound variable resistor with a resistance between 10,000 and 50,000 ohms. Use high-impedance headphones.

### NRI PRACTICAL TRAINING PLAN

At the earliest opportunity, carry out the following demonstrations and notice carefully the kind of distortion produced. Undoubtedly most of these can be carried out on the receiver you have for training purposes. If any of these tests are not suitable for your receiver because of its circuit design, plan to demonstrate them when a suitable receiver comes in to your shop for repair.

**Leaky Coupling Condenser.** In your receiver, locate the coupling condenser that is between the plate of an a.f. tube and the control grid of the power output tube. This corresponds to  $C_2$  in Fig. 1. To give the effect of leakage in the condenser, connect a 50,000-ohm,  $\frac{1}{2}$  to 1-watt resistor across it. Now turn the receiver on, and tune in a station. The program should sound highly distorted. Lowering the value of the resistor shunted across  $C_2$  will increase the distortion. Do not use too low a value— $VT_2$  may be damaged by the excess plate current. (To protect the tube, keep the radio on for only short periods of time.)

Now connect a d.c. voltmeter across  $R_3$ , the positive meter probe going to the grid of  $VT_2$ , and the negative

probe to the chassis. The meter will read upscale, showing that d.c. is flowing through  $R_3$ . Leaving the meter in place, unsolder one lead of  $C_2$  and one lead of the shunting resistor. Note that the voltage across  $R_3$  now disappears. If the voltage had remained with  $C_2$  out of the circuit, tube  $VT_2$  would have been gassy. Now remove the shunt resistor from the circuit, and reconnect  $C_2$ .

**Volume Control Coupling Condenser Leaky.** Locate the condenser that is the equivalent of  $C_5$  in Fig. 2. Simulate leakage in this condenser by shunting it with a resistor—one having a value of about 25,000 ohms should be satisfactory. Now tune in a program from a strong local station. Advance the volume control, and note the distortion. Particularly note that the distortion increases as the volume control is turned towards maximum. This is caused by the fact that more and more of the d.c. voltage across  $R_4$  is being applied to the control grid of  $VT_2$ . In some cases, this voltage may be high enough to block the tube and may make the receiver dead. A high resistance d.c. voltmeter across  $R_5$  will show the presence of this voltage, although observation of the effect of the volume control setting on the distortion is enough to show the possibility that  $C_5$  is leaky. Remove the shunting resistor across  $C_5$ .

**Open Bias Resistor.** It is not safe to open a bias resistor and leave the cathode by-pass condenser connected, because the higher-than-normal voltage may ruin the condenser. Therefore, it is necessary to simulate the condition of an open resistor that is replaced by the leakage resistance of a condenser. To do this, remove from the cathode circuit of an audio tube the bias resistor *and its by-pass condenser*. Then insert a resistor of about 10 times the resistance of the original bias resistor in place of it.

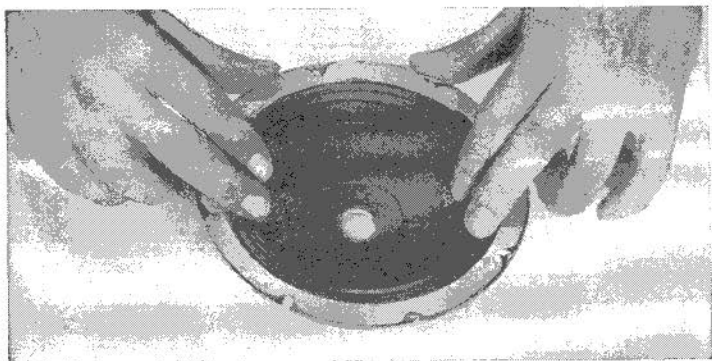
Tune in a program, and note how distorted the reproduction sounds. Measure the voltage across the test resistor, and notice how much higher it is than normal. Remove the test resistor, and replace it with the original bias resistor and the by-pass condenser. Be sure the electrolytic by-pass condenser is installed with the proper polarity.

**Shorted Bias By-Pass Condenser.** Make this test with caution; it is possible to damage the power tube. In your receiver, locate the condenser corresponding to  $C_3$  in Fig. 1. Short this condenser with a piece of wire by connecting the cathode of  $VT_2$  to the chassis. Tune in a program and note the distortion. A voltmeter connected across  $R_4$  will show no bias voltage, because of the short. Cautiously feel  $VT_2$  with your hand, and notice how hot the excess plate current has made it. Turn off the set and remove the short across  $C_3$ .

**Effect of Open Field Coil.** Probably your receiver will use the loudspeaker field coil as a choke. If so, opening the field coil will make the receiver dead. Wait until you service a receiver with the field connected as in Fig. 6B before opening the field. When you have such a set, disconnect one of the field leads. Listen to a program to learn how the distortion sounds. Test for the field strength with a screwdriver, and compare it with that obtained when the field is reconnected.

**Effect of Off-Center Voice Coil.** If there are no provisions for recentering the voice coil of your receiver's loudspeaker, put off this demonstration until you obtain a suitable loudspeaker. To put the voice coil off-center, loosen the adjustment screws and gently push on one side of the cone. Tighten up the adjustments. Now place the fingertips of both hands on opposite sides of the cone rim and gently push in. You will hear a rasping sound as the voice coil grates against the pole pieces. You will also be able to feel this grating through your fingertips. (The same effect would be caused by dirt or metallic particles in the voice coil aperture.) Now tune in various programs. Notice that some sound all right and some sound distorted. Try to get one on which a man and a woman are talking. The man's voice will be distorted while the woman's will be much clearer, possibly undistorted. Now recenter the voice coil in the manner described in an earlier Booklet.

**Effect of Unglued Cone.** This can best be demonstrated by getting a receiver in which the glue holding the cone rim to the speaker frame has dried out. Such a cone can easily be pulled loose with your fingernails;



**Push on a speaker cone with your hands placed like this to hear the grating noise produced by an off-center voice coil.**

you can then tune in different programs and observe how the sound is distorted. Such a cone should, of course, be reglued with speaker cement after the demonstration. If you don't run across such a speaker, hold your fingernail against the cone, barely making contact. The resulting noise made when the moving cone rattles against your fingernail is much like the sound produced by an unglued cone.