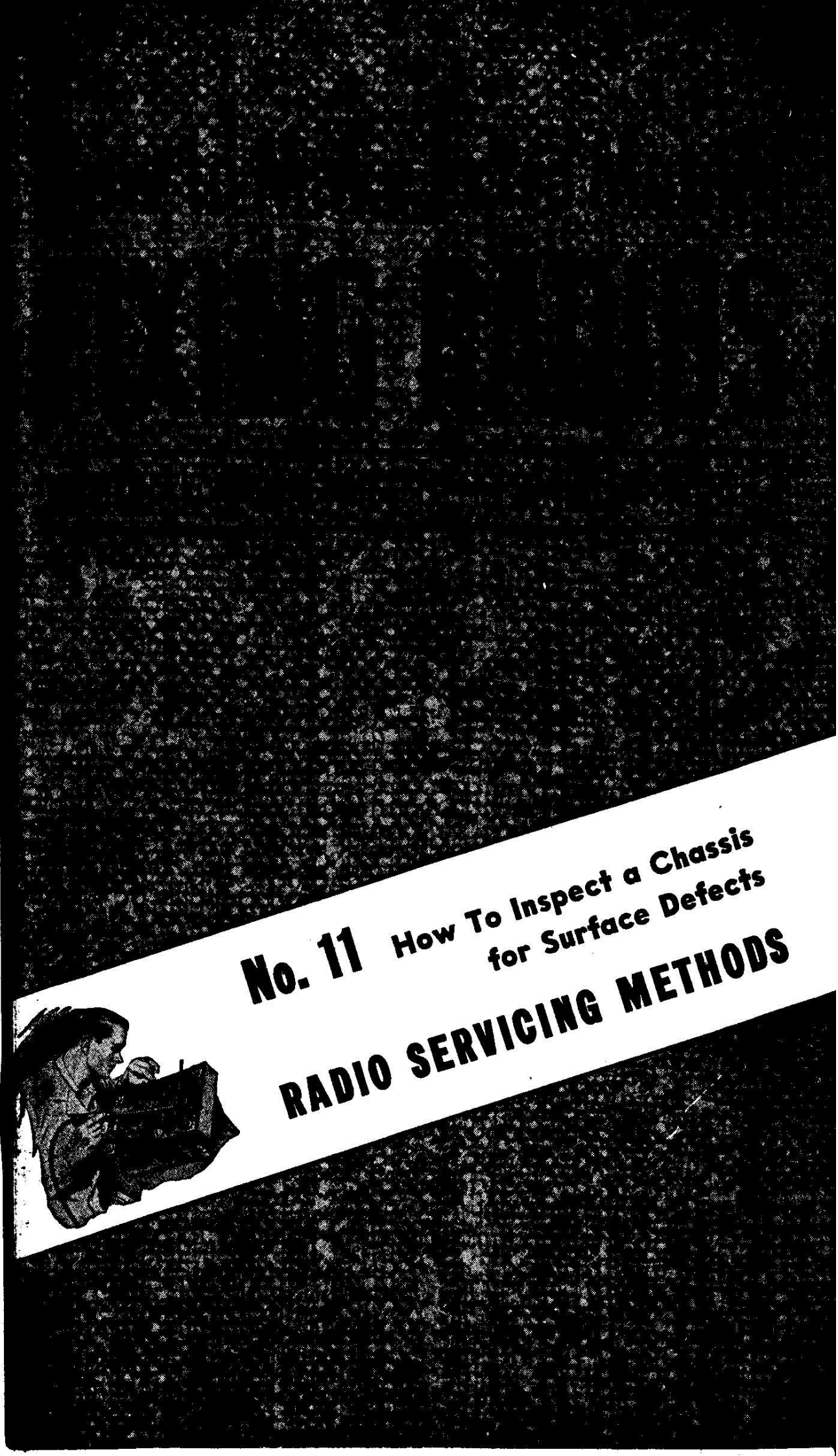
No. 11 How To Inspect a Chassis for Surface Defects
RADIO SERVICING METHODS

NRI TRAINING *Pays...*

Dear Mr. Smith:

It sure was a turning point in my life when I saw your advertisement and decided to take your Course. At the time I didn't see how I could possibly ever make the grade and pay for the Course, but now my repair work has earned me many times the cost of the Course. At present I am doing spare time radio repair work and getting all that I can handle. I am planning on having a shop of my own soon.

L.R.F., Penna.

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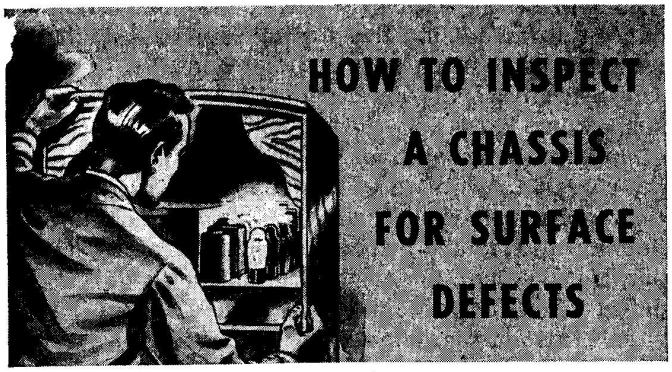


SO far, you have learned how radio parts are tested. Even the professional serviceman has to have this information, because a test of the suspected part is an important step of his service procedure. However, if your knowledge stopped here, you would be in the "radio mechanic" class—unable to locate a defect except by checking part after part until you found the defective one. Furthermore, you would have to test each part for every possible defect.

Naturally, this is far too time-consuming to be a practical way of servicing radio receivers. Even if a person starts this way, he soon begins to notice that certain troubles repeat themselves, and that radio receivers always act or sound in the same way when these troubles or defects appear. Thus, even the radio mechanic soon slides into the methods of the semi-professional, in that he notices some of the more obvious troubles and, when faced with a particular complaint, first checks the parts most frequently causing the complaint.

The first step in becoming a semi-professional is to learn what part *defect* can cause the complaint. For example, suppose you had two sets to repair—one dead and the other distorting. A defective coupling condenser could produce either condition. However, the condenser would have to be leaky to produce distortion, and it would have to be open to make the receiver dead. Therefore, you would test the coupling condensers in the dead set for opens, but you would check those

in the distorting receiver for leakage. Obviously, it is quicker to make just these tests than to test all the parts for all possible defects.

The professional serviceman, like the semi-professional, first checks on the more probable causes of a complaint. Included in his checking is an inspection of the chassis to see if there are any surface indications that will reveal what the trouble is. Often this preliminary testing and inspection will disclose the defect, but, if it does not, the professional proceeds to find the defect through a process of localization.

It is this ability to find even the most obscure defect through a process of localization that sets the professional above the semi-professional. Later RSM Booklets and your lessons will teach you professional localizing methods. In this Booklet, you are going to learn one of the basic servicing steps that precedes localization—finding defects through an inspection of the chassis.

RADIO COMPLAINTS

First, however, you should learn something about the more usual complaints, so that you will have a better idea of what you are looking for.

Radio complaints fall into two broad classifications: either the receiver *does not play at all, or it plays improperly.* In the first case, we say that the receiver is dead. It is not so easy to describe the second condition, for there are many ways in which a receiver can operate improperly. Here are several examples:

► Loud popping sounds, or sounds like rushing water, grinding gears, or pieces of sandpaper being rubbed together are heard along with the program. We say that the receiver is *noisy.* The exact kind of noise is a valuable clue to the trouble, because, as we will show later, each kind of noise is produced by a particular defect.

► A steady humming sound of constant intensity is heard. We say that the receiver *hums.* Depending on the defect causing it, hum may range in intensity from a barely audible sound to one so loud that it drowns out the program.

► Sharp shrill whistles, squeals, or howling sounds are

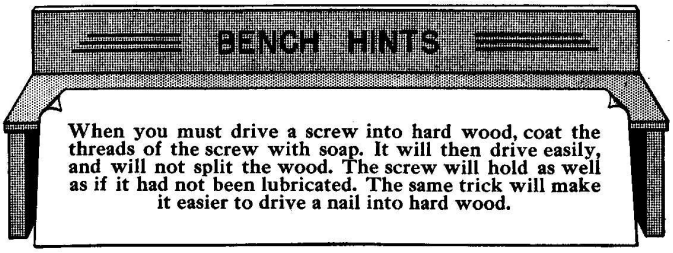
heard. We say that the receiver *oscillates.* Oscillations may occur either continuously, or only when a station is tuned in.

► The receiver seems to play properly, but the sounds coming from it are unnatural. We say that the set *distorts.* In extreme forms of distortion, the sounds may be muffled, harsh, raspy, or even unintelligible. Milder forms are not easy to recognize, except that they are extremely tiring. That is, the human ear "fills in" and tries to correct some of the distortion that occurs. It gets tired doing this. The usual result is that the customer turns the radio off after listening to it for a short time.

► The receiver plays only weakly even with the volume control turned on fully. We call this complaint *weak reception.* Sometimes both local and distant stations can be heard weakly; at other times only the most powerful local stations can be heard.

► The receiver operates normally for a time, then exhibits one of the preceding defects for a while, then returns to normal operation only to repeat this cycle of conditions over and over again. We call this condition an *intermittent defect.* The intermittent condition may occur at either regular or irregular intervals.

► The exact differences between the various ways in which a receiver operates improperly will become clearer to you as you progress. Once you have heard a case of hum, you will find it easy to recognize other similar cases. However, you must remember that your customer has never had this experience. If the set hums, he may say that it roars, howls, or buzzes. You cannot, therefore, depend on what the customer tells you about the performance of the set, but must instead



The customer will seldom describe a defect in technical terms. Always be sure you confirm the complaint yourself.

listen to it yourself to make sure what is wrong. This is known as "confirming the complaint." Be sure to listen to the customer's explanations carefully, however, because often he will give you valuable clues about defects.

Once you have confirmed the complaint, you will at once (when you are experienced) think of several things for which you should look. Some of these things will produce visible symptoms, so you should use your eyes, even before you make any tests. Look over the top of a chassis while you let it warm up to see if any mechanical or visible defects are present. Then, if it is necessary to remove the receiver from the cabinet for testing, run your eyes over the under-chassis side of the set. Finally, use your nose and ears to locate defects that are invisible in themselves but have noticeable effects—such as the odor of burned insulation from a defective transformer, or noise heard from the loudspeaker when the tuning dial is turned.

Now, let's see what common defects you can expect to find by an inspection of the chassis. We will take them up in groups so that you will be able to check them quickly when servicing receivers. Naturally, we are not going to cover all the possible defects that may exist —only the ones you can readily observe. We will sometimes suggest, however, certain tests that lead on to the defective part.

SURFACE DEFECTS ON TOP OF THE CHASSIS

First, let's consider those surface indications that you can perceive without removing the chassis from the cabinet.

We will presume that you have questioned the customer and have determined whether the set is dead, or is noisy, or hums, or just how it acts. (Be sure to ask the customer how the receiver acts, not "what is the matter with it?" You are there to find out what is the matter with it—the customer does not know.)

To confirm the customer's complaint, turn the receiver on (if it is not already on). Take a few moments to examine the controls on the front of the receiver. There are thousands of different kinds of radios, and you are certain to encounter many types that you have never seen before. You must learn the purpose of the various controls on each radio. The on-off switch is usually combined with a volume or tone control, but not always. Turn the controls to see which ones actuate switches if there are no markings on the radio panel to guide you. Don't be surprised to find several switches, because wave-band switches, radio-phonograph switches, etc. are commonly operated by a front-panel control. Usually, if the receiver owner is watching you, he will volunteer information as to the purpose of certain of the controls, or he will automatically reach for the on-off switch.

Now let's see what we may observe in each of the conditions mentioned earlier.

Dead Receiver. When you turn the set on, watch the dial face to see if the pilot lamps light. If they *do light,* then you know that power is being supplied from the wall outlet, that the power cord is good, and that at least the power transformer is good (in an a.c. receiver using a power transformer). In all probability, also, filament voltage is supplied to some or all the tubes in both a.c. receivers and a.c.-d.c. receivers, so you do not need to check any of these items at this time. (Of

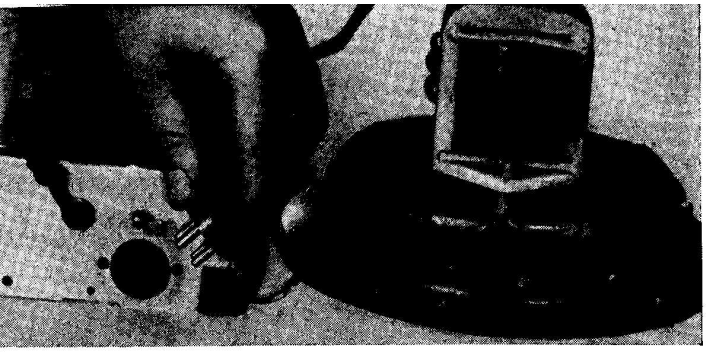


FIG. 1. If no sound comes from the speaker, make sure it is plugged into the set.

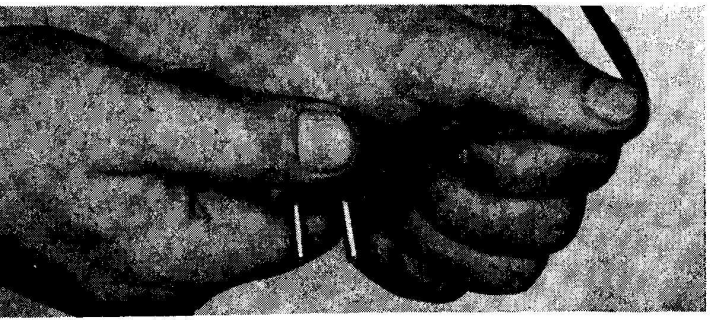
course, remember that many battery receivers do not have pilot lights.)

If a pilot light is used and *it fails to light,* then it may be burned out or there may be trouble in the power supply. Turn the receiver around and see what can be seen from the rear. Are any of the tubes lighted? As we mentioned in an earlier RSM Booklet, you should be able to see the light in some glass tubes and others should become warm. If the tubes are lighted, the pilot lamp is probably burned out.

► Also, listen carefully to the loudspeaker. If the power supply is defective, there will probably be *no sound whatever* from the loudspeaker. If the power supply is all right, there will probably be a *slight amount of hum* from the loudspeaker—enough to be heard in a quiet room. Sometimes, too, in the latter case, you can hear a certain amount of noise if you rotate the volume control. (If the volume control is defective there will be much more noise.)

If there is *no sound whatever* from the speaker, check

FIG. 2. If you suspect the cord is broken, pull it like this; the cord is probably broken if it stretches.



on the speaker plug. As shown in Fig. *1,* many speakers plug into the receiver, and someone may have pulled out the plug. (In some sets this plug may be on the speaker instead of the receiver.) If this has occurred, the speaker will not be connected to the radio, and one of the filter condensers may have been damaged (because the voltage across it rises to a high value when the speaker field is disconnected). *Never operate a receiver with a speaker plug removed.*

► *If no sounds come from the speaker, and none of the tubes appear to be lighted,* probably the trouble is in the power transformer (if one is used), the power cord, the on-off switch, or the wall outlet, or possibly there is no power at the wall outlet. If the set has no power transformer, or uses at least two tubes with a filament voltage rating of 25 volts or more, its tube filaments are connected in series. In this case, none of the tubes will light if any one of them has a broken filament. However, don't check the tubes until you have made the surface inspections that follow; they will take you only a minute or so.

Be sure the receiver is plugged into a wall power-outlet. If the plug is in the outlet, then make sure power is coming from the outlet by plugging in a lamp to see if it will light. Be sure good contact is made at the wall outlet—wiggle the power plug to see if the receiver will come on.

The power cord will frequently be broken right at the plug because the receiver owner has unplugged the set by pulling the cord rather than the plug. You can check for a break here as shown in Fig. *2.* If the cord stretches when you pull on it in this manner, the wire is probably broken.

Examine the general condition of the power cord, too. When the insulation frays, as shown in Fig. *3,* the wire may be dangerously exposed, so make a mental note to replace the cord in such cases even if it is not open or shorted.

► Let's suppose that the tubes light up, and a slight hum is heard from the speaker, but the set is otherwise dead. In this case, concentrate on the controls for a

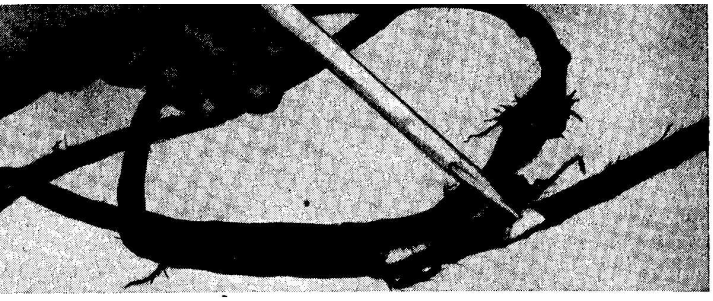
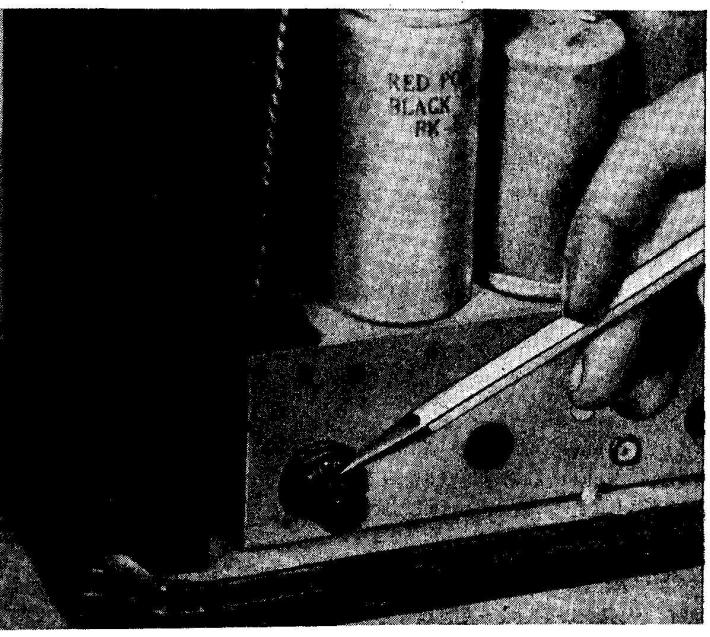


FIG. 3. A cord as badly frayed as this should be replaced, even if it is causing no trouble at the moment.

moment. Turn the controls to be sure that they all work properly. For example, if turning the tuning control does not cause the dial pointer to move, the dial cord may be broken. Should this break occur while the set is not tuned to a station, the owner may believe the receiver to be dead, because he cannot tune in any signals. A dial repair job will, in this case, restore reception.

Check carefully on the wave-band switch and its setting. Sometimes it may have been left accidentally in a short-wave position, so of course broadcast-band stations can't be received. Some sets have these controls on the front, but others have them at the rear

FIG. 4. In this set, the wave-band switch is at the rear of the chassis. Be sure it is at the right setting.



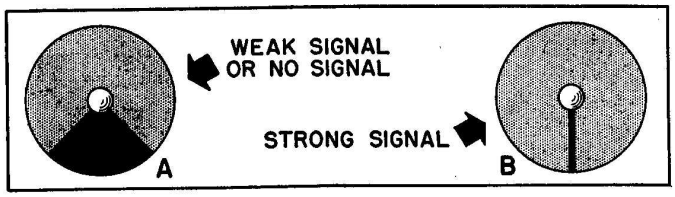


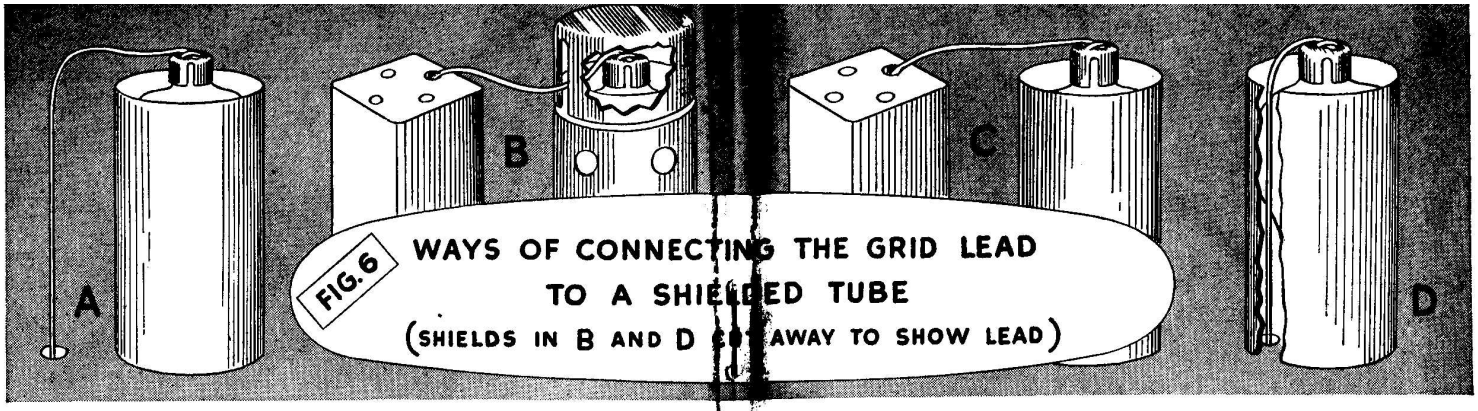
FIG. 5. These sketches show how the shadow of a "magic eye" tuning indicator changes as the signal varies.

(Fig. *4*). When in doubt as to the setting of such controls, throw them to another position and then tune over the range to see if the receiver comes to life. Incidentally, sometimes a receiver may be dead only on the broadcast band but will work on the short-wave bands. As you will learn elsewhere, this indicates trouble in the r.f. (or preselector) section of the receiver.

Check the phono-radio switch also; it may be set in the phonograph position.

► Many receivers have a tuning indicator, usually a tuning "eye" that lights with a green glow and has a "shadow" that narrows as stations are tuned in. Fig. *5A* shows the "no-signal" and *5B* shows the "strong-signal" indications. If the tuning eye lights with its normal green color but the shadow does not vary as you tune the receiver, there is trouble between the input of the receiver and the second detector (where the indicator is connected). However, if the tuning eye works but no sound comes from the loudspeaker, the trouble is in the audio end of the receiver. On the other hand, if the tuning eye has a reddish color instead of a green glow, and there is no shadow, it is probable that there is no plate voltage applied to this tube, which also means that the supply voltage probably will not be present at some of the other tube sockets.

► While examining the tubes for glow, you may find that the rectifier tube has a bright blue or pinkish glow that seems to fill the tube. If so, turn off the set at once. If the rectifier is not a mercury-vapor tube, such as the type 82 or the 0Z4, either it is gassy, or a filter condenser has broken down and is drawing excessive current through the tube. Since the set in our example is dead, you can be sure that a filter condenser



is bad; if the tube were gassy, the receiver would probably play, but a loud hum or roar would accompany the program.

If the trouble is apparently a short-circuited filter condenser, then naturally you must check for this condition and replace the defective part before turning the set on again, or before installing a new rectifier tube.

► Customers frequently take the tubes out of the set to have them tested at some local radio shop, and then find that the set is dead when they are reinstalled. Often this trouble is caused by the customer's getting the wrong tube in some socket. Always check this possibility. If you don't happen to know where the tubes should go in the receiver, see if there is a tube layout chart attached to the radio. (On a.c.-d.c. receivers the chart is often fastened to the bottom of the cabinet.) Sometimes the sockets are marked with the tube numbers. However, watch out in inexpensive midget receivers, particularly "nameless" kinds, for the manufacturer may have purchased "salvage" sockets with meaningless labels.

FIG. 7. Don't exert too much force on a tube top cap—it can be broken off like this rather easily.

Sometimes you will find tubes so misplaced that you can judge this fact from the top cap leads. Fig. *6* shows the normal ways of running top cap leads to tubes. If any lead has been stretched to an unusual degree, or is doubled up because a tube of different shape or size has been installed in the radio, suspect that tube of being in the wrong socket unless it is a replacement for the original. Sometimes a glass tube is used to replace a metal tube and vice versa, and because of the differences in heights of the tubes, this will double up the grid lead in one case and stretch it out in the other.

Be sure the grid clips are all on the top caps of the tubes. The set owner may have improperly connected the top cap if its lead is one of the kind that should come up inside the tube shield (Fig. *6D*). Often this lead is brought outside; then, when the shield is forced down, it cuts through the wire insulation and short-circuits the grid lead.

► If you find it necessary to take out a tube, remember that sometimes the top-cap clip is very tight. If you try to force it off, the top cap may be broken from the tube, as shown in Fig. *7*. Fig. *8* shows how you can avoid this difficulty. With one kind of top-cap clip, you can press down on the top cap of the tube with a screwdriver while you force off the clip. With another kind, the screwdriver can be forced under the clip edge.

► It also pays to examine the antenna and the ground connections. Although usually a receiver will play weakly with the antenna disconnected, there are receivers that will not play at all, particularly in districts far re-

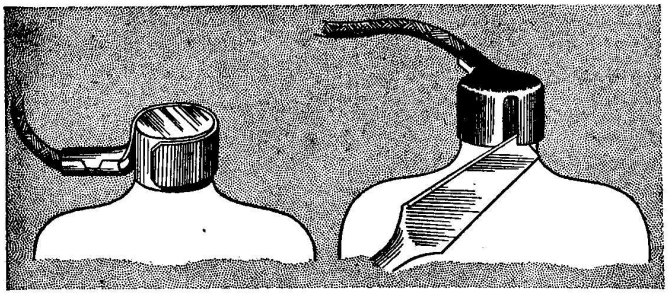


FIG. 8. Two common types of top cap clips. To remove the kind at left, press down on the cap with a screwdriver while you pull up the clip; remove the other kind as shown.

moved from broadcast stations.

Summary. If the receiver is dead, a surface inspection may disclose the reason at once—the speaker unplugged, the set not plugged in, no power at the wall outlet, the power cord broken, the set on the wrong wave band, tubes misplaced, a top cap lead not in place, etc. If the surface inspection does not disclose the defect, it may show at least which *section* of the receiver is defective. If the tubes do not glow or become warm, and the pilot lamp does not light, the trouble is probably in the power supply (unless the set has a series-filament arrangement); and if the tuning indicator works properly, the trouble is in the audio portion of the set. Therefore, even though you do not find the trouble exactly, your time spent in glancing over the receiver is well worth while. Although our description of the inspection has been fairly long, the actual time you will spend in examining the receiver will be a matter of a few seconds.

► Now, let's see what indications of other troubles may be found without removing the chassis.

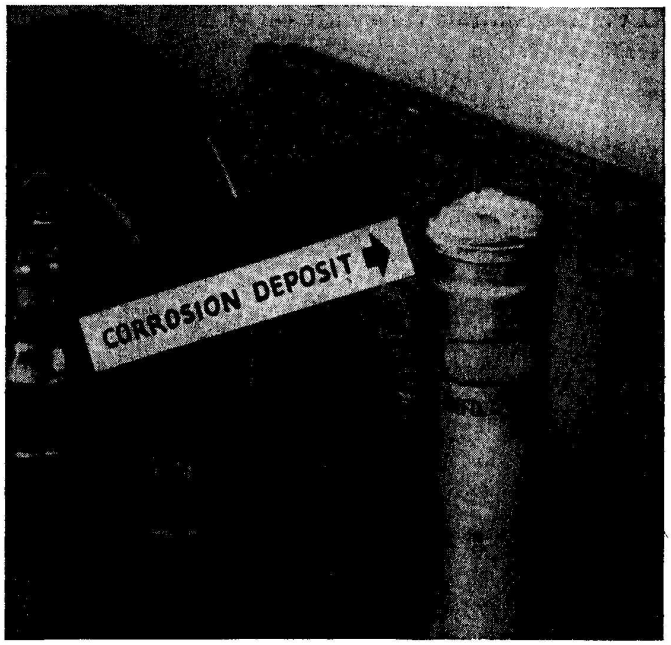
Hum. When the receiver plays but has a considerable amount of hum, there is usually either a defect in the power supply or a cathode-to-heater leakage in one of the tubes. Occasionally hum is caused by the set owner's having tucked part of the power cord into the cabinet near the chassis.

Turn the set around and look for electrolytic filter

condensers, which are frequently on top of the chassis. These electrolytic condensers may have a crust of chemical about the top (see Fig. *9.*) This crust indicates that a certain amount of the electrolyte has escaped through the gas vents on the condenser; this may mean that the condenser has lost so much capacity that it no longer operates satisfactorily. Even though this crust is present, the condenser is not necessarily defective if there is no hum. However, when there is both hum and the crust, it is quite likely that the filter condenser needs replacement. (You will learn soon about filter condensers in your Lessons in Radio Fundamentals.)

Sometimes a leaky filter condenser can be detected because it becomes rather warm when it passes excess current. However, don't grab an electrolytic condenser to feel it without first turning the set off and waiting a few seconds. Some electrolytic condensers are insulated from the chassis, and in such cases there will be a voltage between the condenser case and the chassis. Should you happen to touch both, you would get a shock. You

FIG. 9. Be on the lookout for a white corrosion deposit like this on the tops of electrolytic condensers.



must have some experience before you can judge whether a condenser is unusually warm, because it is always heated to some extent by nearby tubes.

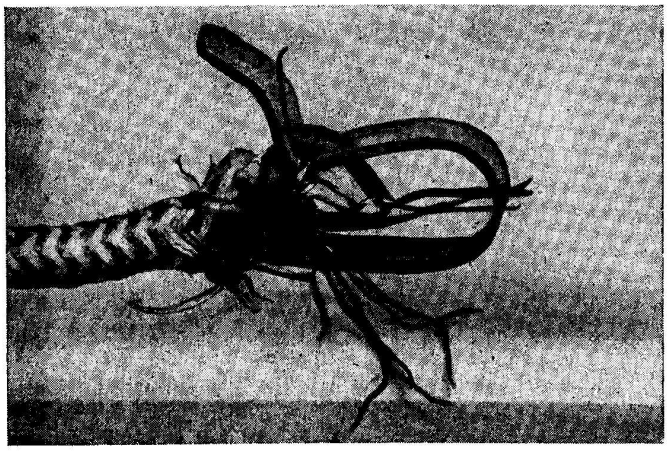
► There is no indication of when a tube has cathode-to-heater leakage insofar as its appearance is concerned. This can be discovered only by making a tube test. Therefore, if the filter condenser does not show signs of being defective (or it is not visible), the next step usually is to test the tubes. Once the tubes are found to be good, then you can be fairly sure that the condensers are defective.

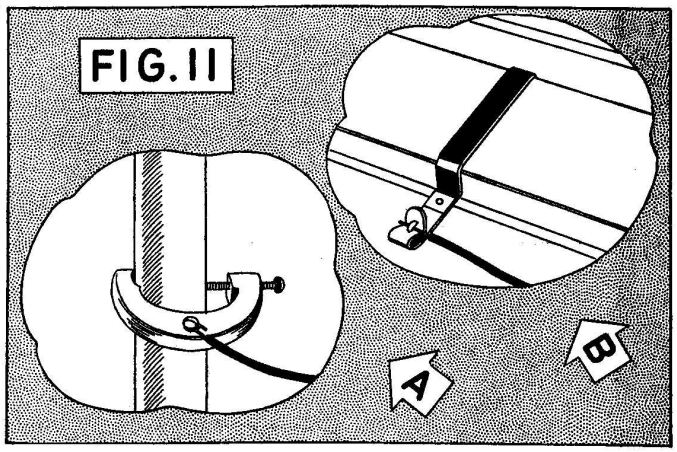
► However, if a part of the power cord has been tucked into the cabinet, pull it out and see if this causes the hum to disappear. Even if it does not, do not replace the cord in the cabinet; instead, tie a sheepshank in it, or loop up the excess and tape the loop together behind the cabinet—away from the chassis.

Noise. There are a number of indications to watch for when the receiver is noisy. First, rotate the various controls. If you find that the receiver is very noisy when the tuning knob is touched or rotated, but the noise quiets down when the knob is not being moved, there is a possibility of dirt between the tuning condenser plates.

Volume controls frequently cause noise. If the control is defective, you will find that rotating it causes a great increase in the noise, but that the noise quiets

FIG. 10. Watch out for loose strands of wire rubbing on the chassis, particularly on connections to clips like this.





down when you release the knob. Frequently, also, wiggling the knob or pulling it slightly will make the noise appear and disappear.

► If all the controls work normally, turn the receiver around and examine the chassis carefully. Often the antenna and the ground are connected to the receiver by Fahnestock clips. Stranded wire is often used for the lead-in; this wire may be frayed, with loose ends touching the chassis as shown in Fig. *10*. This will cause noise. To remedy this condition, twist the ends of the wires together carefully and insert them properly in the clip.

Trace the antenna and ground leads to their sources. The ground lead frequently gives trouble because many people connect the ground lead to steam pipes or to radiator valves. Any heating system is likely to cause trouble because the pipes do not make the best of electrical connections to each other. To seal the joints, plumbers installing the pipes use a paint that acts as a partial insulator. Furthermore, the ground wire may be just wrapped around the pipe. In all such cases, it is best to install a proper ground. A cold-water pipe, if available, makes a far better ground than does the heating system. Of course, if a cold-water pipe is not available, try the heating system, but use a ground clamp (Fig. *11A*) to make the proper connections to the pipe.

Similarly, trace the antenna lead-in, paying particular attention to the manner in which it gets into the house. In many instances, there will be a lead-in strip of a patented type to bring the antenna lead under a window (Fig. *11B*). These lead-in connectors use fastening clips that may lose their tension. Furthermore, the strip itself may break under the window. Be sure to examine these points carefully.

Shake the antenna and the ground leads one at a time to see if you can make the noise become worse. If so, there is undoubtedly a poor connection along the wire that is being moved.

► At the same time, examine the receiver for other possible loose connections. Sometimes the clips will not fit tightly on the tube top-caps. Try wiggling the grid leads to see if this makes the noise worse. If so, take off the clip and bend it to make a better connection.

Weak Reception. If the set plays weakly, or is dead altogether, check the antenna system. Make sure that the receiver is connected to the antenna and that the latter is adequate for the set. (In the near future, you will receive an RSM Booklet on antennas.)

If the set is an a.c.-d.c. type, you may find that the antenna coil is burned, as shown in Fig. *12*. This damage may occur because lightning strikes the antenna system, or because the antenna itself is accidentally grounded, and a short circuit occurs in a condenser that is in the antenna lead of these receivers. (Since one side of the power line connects directly to the chassis in these sets, any ground of the antenna system may cause an excess current to pass through the antenna coil if the blocking condenser short-circuits.) We mention the a.c.-d.c. receiver particularly, in this case, because the coils in most other receivers are within shield cans or are underneath the set chassis and cannot be seen.

Oscillation. A whistling or squealing noise may be heard because a tube does not have a shield. Examine the set carefully. You may find that there is a clip or shield base about the socket of one of the tubes. Any tube having such a base around its socket should also

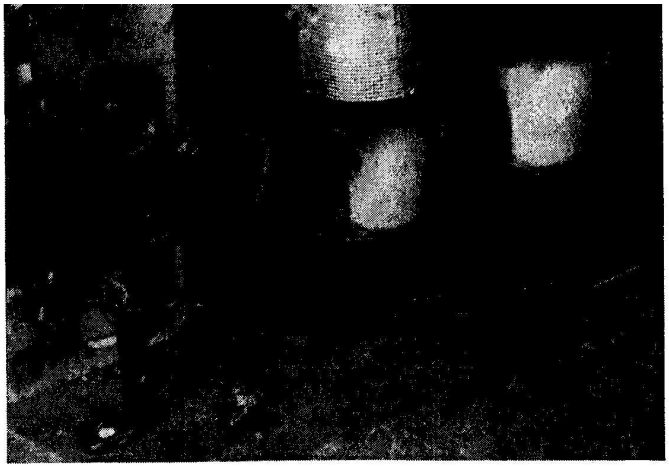


FIG. 12. The antenna coil of an a.c.-d.c. set is not usually shielded, so you can easily see whether or not it is burned.

have a shield; if no shield is present, install one. Also, you may find that someone has substituted (in an r.f. or an i.f. stage) a glass tube for a metal one bearing the same type number. This is perfectly all right as long as oscillations do not develop, but the metal tube is shielded and a glass tube is not. In these cases, it is best to reinstall a metal tube; otherwise, you must install a shield for the glass tube.

Distortion. There are practically no surface defects in the case of distortion, except those observable on the loudspeaker. We have reserved a discussion of this condition for last because, to examine the loudspeaker, it may be necessary to remove the set from the cabinet.

Among many of the possible troubles in the loudspeaker, some are: cone out of position, a torn cone, a cone loose about its edge, the voice coil off-center, etc.

In another RSM Booklet you have been shown how to repair most of these defects. You can find when the cone is loose at the edge by pushing around the cone itself to see if you can separate the cone edge from the frame. A torn cone is instantly visible and may be repaired in some instances with Scotch tape.

Sometimes you will find that the set owner or some other serviceman has made a temporary repair on the cone. He may have discovered that the cone is warped and may have stuffed paper behind the cone to wedge it into shape. This works, after a fashion, for a

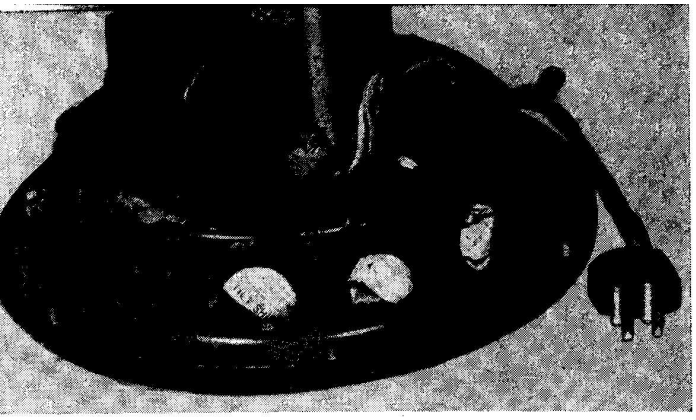


FIG. 13. Packing paper in this manner behind a warped cone is only a temporary repair.

few days, but soon is worse than before, because the paper packs down and then interferes even more with the cone motion. An example of paper packing is shown in Fig. *13*.

Other Clues. When transformers are overheated, the enamel insulation burns and produces a characteristic odor that is easy to recognize. (Incidentally, the odor of a burned power transformer is quite different from that of an audio transformer.) Sometimes you can see that sealing compound or wax has been melted from the container of an iron-core device, as in Fig. *14*. Here, the output transformer has leaked wax. This indicates, in all probability, that the output tube has been drawing excess current, or that there is a short circuit

FIG. 14. Wax melting out of a transformer in this manner shows that the transformer has been overheated.

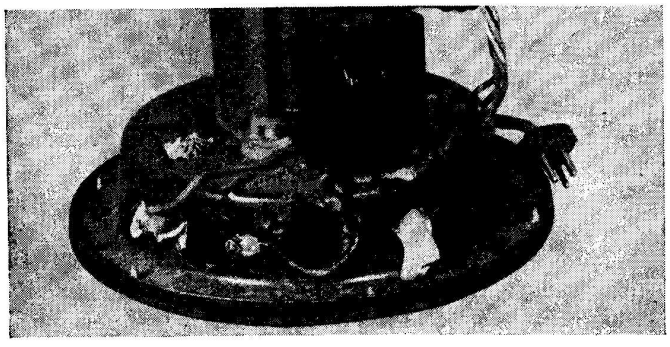


FIG. 15. A condenser that is swollen and discolored like this one is usually defective.

from the plate circuit of this tube to the chassis. (As you will learn later, there is a by-pass condenser connected here that may be short-circuited.) If you see smoke coming from any radio part, consider that part to be at least overloaded and possibly defective.

UNDER-CHASSIS DEFECTS

When it is impossible to see anything from the top of the chassis, it must be removed from the cabinet. You can then look over the bottom of the chassis, where there are often valuable clues.

► For example, in the case of hum, an under-the-chassis electrolytic condenser may be swollen and discolored like the one shown in Fig. *15*. If so, it is probably de-

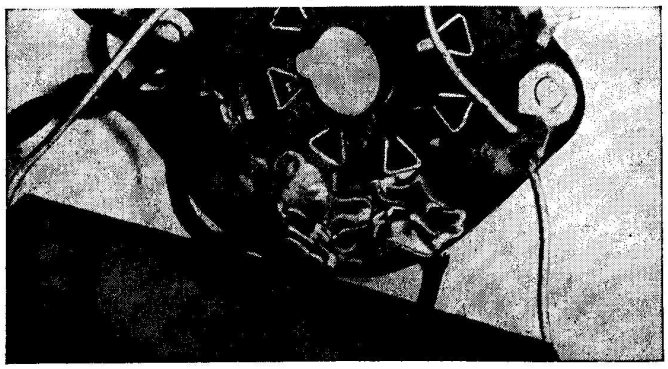
FIG. 16. Leakage may develop through the case to the strap in a condenser mounted this way.

fective; you should check it for excessive leakage and for loss of capacity.

Hum may also be caused by a filter condenser of the type shown in Fig. *16*, particularly if there is leakage through its case to the metal strap that is used to mount it. First, check such a condenser for lost capacity and for excessive leakage. Then, if it appears O.K., there may be leakage to the strap. If the strap is not riveted to the chassis, the easiest way to make a check for this is to disconnect the strap from the chassis and allow the condenser to hang in the air. If the hum disappears, then case leakage is present. (If the strap is riveted, disconnect the condenser leads from the circuit and use an ohmmeter to check between the leads and the strap.) Sometimes it is possible to slip the strap along the condenser to a spot where leakage does not occur, but in most cases it is best to replace the condenser.

► Watch for poor soldering in a receiver that has been repaired previously. Some servicemen are careless in soldering—for example, they leave large lumps of solder on terminals. These may not cause trouble at once, but sooner or later such a lump may break loose and lodge between the two terminals. Fig. *17* shows how excess solder can cause a short between two tube socket terminals; the exact complaint this produces will depend on which prongs the lump touches.

FIG. 17. Using too much solder may produce shorts between terminals, particularly at tube sockets.



► If the set is noisy, turn off the lights and watch the bottom of the receiver carefully. Often you can see a tiny spark where a piece of insulation has charred or where two wires are touching.

LOOKING AHEAD

From the foregoing, you can see that it pays to use your eyes and ears in servicing radio receivers. Questioning the customer carefully, confirming the complaint, and making a careful inspection for possible surface defects will either lead you to the trouble or at least narrow down the number of possible suspects.

Of course, many of these surface indications mean something only when you know just how various radio parts are supposed to work in a radio receiver. Therefore, it will be necessary for you to study carefully the operation of radio stages. Once you know just how a stage is supposed to operate, it will be easier to see what is wrong when trouble occurs. For this reason, your next few Lessons in Radio Fundamentals are extremely important. Be sure to study them carefully so that you will be prepared to go into the advanced servicing techniques of the expert. Shortly, you will be getting RSM Booklets that deal specifically with various radio troubles. You will learn all the common causes for each complaint and will learn the processes followed by the expert in quickly localizing each of these troubles.