HOW TO FIX A
DEAD RECEIVER

ONE of the most common servicing jobs is fixing a
dead receiver—one that does not play at all. To a
radio mechanic, such a job is baffling. Almost anything
can prevent a receiver from playing, and he may have
to spend hours testing parts before he finds the defect.
The professional serviceman, however, considers a dead
set the easiest to repair, because his test procedures
quickly and definitely locate the defective section and
stage. Then a few simple tests are all he needs to locate
the defective part.

As you know, a professional serviceman uses two
powerful tools: 1, effect-to-cause reasoning; and 2, the
six-step localization plan. As you learn to service like
the professional, you will find that you can use effect-
to-cause reasoning at any time—before making any
tests, along with tests, or after having completed cer-
tain tests. Reasoning is important as a means of short-
cutting steps in the already short series in the localiza-
tion plan. However, if there are no clues leading to rea-
soning, you can follow the localization steps in order,
with the assurance that you will be led to the defect in a
quick, logical manner, no matter what it is.

You will seldom find it necessary to use the complete
isolation procedures we will present here and in succeed-
ing Booklets. Very often you will be able to skip steps,
especially as you become more experienced and learn
how to use effect-to-cause reasoning. However, we want
you to learn all there is to know about isolation proce-
dures now, for not until you know all about them will
you be able to choose the procedures that will be best in any particular servicing job.

Now let's learn how to isolate the defective section, stage, circuit, and part in a dead set.

THE FIRST TWO STEPS

You have already learned how to confirm the complaint and check for surface defects, but we'll review these first two steps of the general servicing procedure briefly. To confirm the complaint, simply turn on the receiver, and tune it to see if any stations are picked up; if not, the set is dead. Then look the chassis over for surface defects. Since the set is dead, look particularly for tubes that do not light, broken antenna and ground connections, an unplugged speaker, and flaring up of the rectifier tube. Be sure that tube top caps are in place and are not shorting to shields. Look for grid leads on the outside of tube shields when they should be on the inside. Check the position of the wave band switch (and phono switch if used). Notice whether the tuning pointer moves along the dial as you tune the receiver. A careful examination of the set may lead you directly to the cause of the trouble. If not, proceed to the next step.

EFFECT-TO-CAUSE REASONING

Without making any localization tests, it is frequently possible to locate the defective section (or at least to reduce the number of possibilities) while the chassis is in the cabinet. For example, you can learn a great deal by listening to the speaker and reasoning from what you hear.

First, there may be no hum or noise of any sort from the loudspeaker when the receiver is turned on. Any such absolute silence indicates that the trouble is in the power supply, in the speaker, or in the plate circuit of the output tube. (Even if the output tube is the only one working, there will be at least a slight hum from the loudspeaker.)

Of course, if you can hear a slight hum, the output stage and the speaker are working, and the power supply of the output stage is O.K., so you can proceed to other tests.

Wiggle the volume control knob rapidly back and forth. This produces a certain amount of noise. Since the volume control is generally located at the input of the audio amplifier, the audio amplifier must be working if you hear any noise. (However, the amplifier is not necessarily defective if no noise is heard.)

If the receiver is alive from the first detector to the speaker, you will usually hear a hissing or frying noise along with the hum when the volume control is turned up high. This hiss is the normal converter noise produced in the first detector tube. Its presence indicates that everything past the first detector is working, so the defect must be in the input of the receiver or in the oscillator stage. Absence of hiss does not show where the defect is.

LOCATING THE DEFECTIVE SECTION

What the Tuning Eye Shows. Locating the defective section is usually easy if the set has a "tuning eye." To see why, let's review the action of this device.

The tuning eye is a vacuum tube with a fluorescent screen in one end. (The screen end protrudes through the front of the receiver panel and gives a visual indication of the accuracy of the tuning.) Any part of this fluorescent substance that is struck by electrons glows a bright green color; parts not struck remain dark—almost black. How much of the screen is hit by electrons depends on the d.c. voltage applied to the control grid of the tube. This control voltage is the filtered a.c. voltage obtained from the second detector circuit, and its value depends on the strength of the signal at this point.

With no signal at the second detector, the eye appears as in Fig. 1A. A large section of the screen is dark. The dark area decreases when a signal reaches the second
detector, becoming smaller as the strength of the signal becomes greater. When a strong local station is tuned accurately, the eye "closes" to the thin line shown in Fig. 1B. Weak and distant stations close the eye only slightly.

Thus, the eye "samples" the signal at the output of the second detector stage. It also samples the output of the power supply, since the tube depends on the power supply for its plate and filament voltages.

Now, let's see what the eye, plus effect-to-cause reasoning, can tell us about a dead set.

**Case No. 1. Eye Does Not Turn Green.** If the eye does not have its characteristic green color, but a faint reddish glow from its heated cathode is observed, you know that d.c. plate voltage is not being applied to the eye. Hence, the power supply is probably defective. (If the eye glows bright pink instead of faint red, and a dim shadow is seen, the tube may be gassy. It will have to be replaced before it can be depended on as an indicator.)

**Case No. 2. Eye Closes Normally.** If the eye closes as it should when you tune the receiver to a station, but no sounds are heard, the trouble is in the audio section of the set. The fact that the eye works means that the power supply is all right, and that normal signals are reaching the second detector—only the audio section is left as a possible source of trouble.

**Case No. 3. Eye Does Not Close.** If the eye becomes green, but does not close up as you tune past stations (and no sounds are heard), the defect is in the r.f.-i.f. section; r.f. signals are not reaching the second detector.

**Other Indicators.** A meter-type tuning indicator does not show quite as much. If it works properly (the meter hand swings as stations are tuned), then the defect must be in the audio amplifier. However, if it fails to work, you must make other tests to determine whether the trouble is in the r.f.-i.f. section or in the power supply.

If the set is a phono-radio combination, try the phonograph. The phonograph connects to the input of the audio amplifier, so, if it works, the audio and power supply sections are good, and the trouble must be in the r.f.-i.f. section. However, if it fails to work, then other tests are needed to show whether the audio section or the power supply section is at fault. (Be sure that the phono-radio switch is properly set to the phono position, and that the volume control is turned to the maximum volume position when you try the phonograph.)

From the foregoing, you can see that reasoning, coupled with a few clues and tests, may tell you the section of the receiver in which the trouble lies, and perhaps even the stage in that section. If these steps fail, then you must go on to other methods of localization. Since these methods will all localize the defective stage as well as the section, these two steps are frequently combined.

**LOCATING THE DEFECTIVE STAGE**

The best method of stage localization to use for a dead set depends on the equipment available, and on the kind of radio. For example, a signal tracer can be used on any radio, so signal tracing is a universal method of locating the defective stage. If the set is a.c. operated, then one form of circuit disturbance can be used; another form must be used on a.c.-d.c. receivers. On some sets, one method may be better or faster than another, but the opposite may be true on other receivers. To show all the methods, let's first suppose that you are servicing a broadcast-band a.c.-operated superheterodyne of the type shown in Fig. 2. (You will study the superheterodyne in detail in your Course, so, if the
operating descriptions seem vague now, remember you will learn more about them.)

Circuit Disturbance Procedures. A circuit disturbance test, as you know, is made by disturbing the circuit in some manner (say by pulling out a tube or by touching or pulling off a grid cap). This creates the electrical equivalent of a noise in the set. If the receiver is all right between the speaker and the point where the disturbance is created, the disturbance will travel through the set and create a click or buzz in the speaker.
(The methods of creating a circuit disturbance were covered in an earlier RSM Booklet.)

To prepare the set for your tests, proceed as follows: 1, be sure the set is turned ON; 2, turn the volume control to maximum volume; 3, set the wave band switch (if any) to the broadcast position; 4, set the phonoradio switch (if any) to the radio position. The set is now ready for tests.
▷ Always begin your tests at the first audio tube; this serves at once to localize the defective section. In the set shown in Fig. 2, the triode section of the 6Q7 is the first audio tube. If a click or buzz is heard when you disturb it, then the audio and power supply sections are O.K.—the trouble is in the r.f.-i.f. section. In this case, disturb the i.f. tube. A click means everything is normal in the i.f. and second detector stages.

If no click is heard when the i.f. stage is disturbed, you won’t know whether it is the i.f. stage or the second-detector stage that is at fault. You should make a tube test, and then proceed to circuit localization tests; these will be explained later.

CIRCUIT DISTURBANCE TABLE
1. TOUCH TOP CAP OF FIRST AUDIO TUBE.
2. BREAK AND MAKE THE GRID CONNECTION BY PULLING OFF AND REPLACING THE GRID CLIP.
3. PULL OUT AND REPLACE THE TUBE.
Method 2 is the easiest to use when the tube has a top cap, and can be used on a.c. battery, or a.c.-d.c. sets.
Method 3 is necessary for single-ended tubes, but can be used ONLY on auto sets or on a.c. sets operating from a power transformer.

Of course, if the i.f. stage disturbance is heard, the 6A8 first-detector and oscillator is left as the logical suspect. If disturbing this tube produces a sound from the loudspeaker, then either the oscillator has stopped working, or there is trouble in the input circuit. No sound indicates a tube defect, a plate or screen grid trouble, or a defect in the i.f. transformer.
▷ Going back to the test on the 6Q7 tube—naturally, if there is no click, you will have to localize the trouble in the audio and power sections. You can pull out the 6K6 power output tube (it has no top cap) and listen for a click. (However, don’t pull out the power output tube if you can avoid it. This tube draws considerable current. When it is pulled out, the d.c. drop in the power supply is reduced; this may let the supply voltage rise enough to damage a filter or a by-pass condenser.)

No click when the 6K6 tube is pulled out indicates:
1, a power supply defect; 2, a defect in the speaker; 3, a defective output transformer; or 4, a defective 6K6 tube. On the other hand, a strong click from this tube but none from the 6Q7 tube shows that the trouble is in the 6Q7 triode stage or in its coupling to the 6K6 grid circuit. (An open coupling condenser is a logical suspect if the 6Q7 tube is good.)

Circuit Disturbance with a Voltmeter. Unfortunately, the foregoing simple tests cannot be used on an a.c.-d.c. set like the one in Fig. 3. (Since you will refer to it
several times in this Booklet, Fig. 8 has been placed on pages 10 and 11 for convenience.) The tubes in this set have no grid caps and cannot be pulled out (since their filaments are in series), so some other method of disturbing the circuit must be used.

One handy way of doing this is to measure voltages in the set with a voltmeter. Since the meter draws current, it disturbs the circuit enough to permit location of the defective section and stage; at the same time, the meter indication can often be used to locate the defective circuit or part directly. We will describe the complete test procedure for the a.c.-d.c. set shown in Fig. 8. The same general method can also be used to test a straight a.c. receiver if you wish.

First, take the receiver out of its cabinet. Be sure the speaker is plugged in, then turn on the receiver and turn up the volume control completely. If it is a multiband set or a phono-radio combination, see that the switches are set for standard broadcast reception.

Next, turn the set upside down and touch your finger to the grid terminal of the 12SQ7 tube (or to the center terminal of the volume control). Either disturbance should cause a buzz in the speaker. (If it is not safe to put your finger in, use a test lead. Touch the probe to the terminal while holding the other end of the test lead in your hand.) If the disturbance comes through, the audio section and its power supply are O.K.; the trouble is in the r.f. section. However, if the disturbance does not come through, the trouble is in the audio section.

Let's first assume that the disturbance does not come through the loudspeaker (the trouble is in the audio or power sections). To check the power supply, measure the voltage applied to the screen grid of the 50L6 power output tube. Place the positive voltmeter probe on the screen terminal, and the negative probe on B— (in this case the receiver chassis). If voltage is obtained, the power supply is O.K., so proceed to test the audio section as follows:

Move the positive probe of the meter to the plate of the output tube. At moment the probe touches, the meter starts drawing current through the output trans-
former. Also, when the meter probe is removed, the circuit current goes back to that drawn by the tube. These momentary changes in the current cause a.c. pulses through the transformer, so you should hear a click from the speaker and should find voltage. If there is no click, suspect a defect in the output transformer or an open in the speaker voice coil. (A meter having a sensitivity greater than 5000 ohms-per-volt may not draw enough current to cause a click in this test, but a less sensitive meter should. Any meter will be all right for most of the tests to be described next.) Lack of voltage indicates an open in the primary of the output transformer or a short in plate-to-cathode by-pass condenser C10.

If the click is heard and voltage is found, move your positive voltmeter probe to the plate of the 12SQ7. (Keep the negative probe on the chassis for all screen and plate voltage tests.) You should find voltage and hear a click as you make or break contact. If there is no voltage, R1 may be open, or C1 may be shorted. If you find normal voltage but hear no click, the trouble is between this point and the plate of the 50L6 tube (since a click was heard when the 50L6 plate voltage was measured). In this latter case, the next thing to do is to disturb the control grid circuit of the 50L6 tube. To do so, put the negative voltmeter probe on the grid socket terminal of the tube, and momentarily tap the positive probe on B+. (The screen of the 50L6 will do.) As shown in Fig. 4, the meter will allow current to flow through R4, producing a voltage across it. This will cause the
plate current of the tube to change, and should make a click in the speaker.

Notice that since the negative voltmeter probe connects to the grid side of \( C_{10} \), this click signal does not go through \( C_{11} \). If you hear the click on the grid side of \( C_{17} \), it did not when you checked the plate circuit of the 12SQ7 tube, you may be certain that \( C_{17} \) is open and is the cause of the trouble.

On the other hand, if you do not get a click at the grid of the 50L6, the trouble must be between the grid and plate circuit of this tube. Almost certainly the 50L6 is defective, or \( R_8 \) is open.

\>

Assuming your original test shows that the audio and power supply sections are all right (that is, you hear a buzz when you touch the 12SQ7 grid), use the voltmeter to check in the r.f.-i.f. section. Using Fig. 2 as our example again, touch the positive voltmeter probe to the plate of the 12SK7 i.f. tube, and the negative probe to the chassis. You should find plate voltage and hear a click signal. No voltage indicates an open primary in \( T_5 \). If you find voltage but fail to get a click, the trouble is between this point and the volume control \( R_8 \). Transformer \( T_5 \) may have an open or shorted secondary, \( C_5 \) may be shorted, or the diode section of the 12SQ7 may be defective.

If you get a click, introduce a grid-voltage change in the 12SK7 by placing the negative voltmeter probe on the control grid socket terminal and momentarily touching the positive probe to some point in the B+ circuit, as shown in Fig. 5. (You can use the screen of the 50L6 or the screen of the 12SK7, since both connect to B+.) If the 12SK7 tube is good, you will hear a click. A voltage reading shows there is continuity from the grid to B—, but is otherwise meaningless.

Next, move the positive voltmeter probe to the plate of the 12SA7 mixer, and touch the negative probe to the chassis (B—). You should find plate voltage and hear another click. No plate voltage reading indicates
an open in the $T_3$ primary. However, a voltage reading but no click might mean that condenser $C_{16}$ is open, that $C_8$ or $C_1$ is short-circuited, or that $C_{23}, C_3, C_4$, and $C_5$ are incorrectly adjusted. (Methods of adjusting these and other condensers in tuned circuits are taken up in another RSM Booklet.)

If you get a click signal through from the plate of the 12SAT7, introduce a grid-circuit pulse by placing the negative voltmeter probe on the control grid, and momentarily touching B+ with the positive probe. The voltage measured here shows only that the grid circuit is not open, but the click produced should travel through to the loudspeaker. If you don’t hear a click, the tube may be at fault. However, if you hear a click (and the receiver is still dead), the oscillator may not be working.

Oscillator failure may be caused by a bad 12SAT7 tube, a change in value of $R_s$, a short in oscillator condenser $C_b$ or a defect in $T_x$ (the oscillator coil assembly). Try shorting the rotor and stator of $C_2$ with a screwdriver; if you hear a click, the oscillator is probably working, so the trouble is in the loop antenna or in the tuned circuit adjustments. (More definite methods of checking for life in local oscillators are taken up elsewhere.)

Notice—although this voltmeter disturbance test is basically a way to find the defective stage, very often the tests may show the defective circuit and part as well. It may have appeared a little complicated at the first reading, but if you go back over it you will quickly see that there are only two main steps in it. First you measure the plate voltage of a tube, then you feed a signal into its grid. This procedure is followed for each tube in the defective section, starting with the tube nearest the speaker. As long as you hear a click, the stages, circuits, and parts between your point of measurement and the speaker must be all right. When you no longer hear a click, the voltage reading, or lack of it, may show you the defective circuit or part at once.

Now let’s study still another method of localizing the defective stage.

**Localization with a Signal Generator.** The signal generator is particularly useful for tracing through the r.f. stages—it is not as handy for the audio section as are other methods. For this reason, most servicemen touch the grid of the first audio tube to determine whether the trouble is in the audio or power supply sections. If so, they proceed to the voltmeter or other disturbance methods.

However, if the above test shows the audio section and power supply are in working order, then the signal generator may be used to check the r.f. section.

To use this method, you must know your signal generator—how to change its frequency band, how to adjust it to the desired frequency, and how to control its output. Set its controls so that its output is modulated in order to provide an audible signal. Determine whether it has a condenser in series with its output, to block the flow of direct current; if not, insert a condenser (any capacity from, say, .002 mfd. to .006 mfd.) in series with the “hot” (ungrounded) lead.

⚠️ The signal generator can be used to test any receiver. For a specific example, let’s take the a.c.-d.c. receiver shown in Fig. 3. Prepare the receiver for testing in the manner described earlier for the voltmeter tests. Be sure to turn it on. For the first test, connect the signal generator (s.g.) ground lead to the chassis of the receiver, and connect the other s.g. lead or probe (known as the free or hot probe) to the plate socket terminal of the i.f. tube. This injects a signal into the primary of the second i.f. transformer (see Fig. 3), whence it is
induced in the secondary of the transformer and is applied to the second detector. Set the s.g. to the i.f. value of the receiver (456 or 465 kc. in most modern a.m. receivers), and advance the attenuator (volume control) of the s.g. to maximum output. If no tone is heard, transformer Tₖ or the diode section of the 12SQ7 tube is defective. (Condenser C₄ or C₅ may be shorted.) If the tone is heard from the loudspeaker when the s.g. is connected to the plate of the i.f. tube, the second detector and the audio section are good. Next, move the hot probe of the signal generator from the plate of the i.f. tube to its top cap (if it has one) or to the plate of the preceding tube. (This is the first detector in Fig. 3. However, in many sets there are two i.f. stages, so you would move back to the first i.f. stage in these sets.) The signal from the loudspeaker should remain the same volume as before, or become louder. If it disappears or becomes considerably weaker, the i.f. stage is defective. Test the tube and check the voltages applied to its electrodes, particularly the screen-grid voltage.

If the i.f. stage is all right, check the mixer (first detector) stage. First, tune the receiver to the low-frequency end of the dial to reduce the shorting effect of the tuned input circuit on the signal. Then, with the signal generator still tuned to the i.f. value, move the hot probe to the grid of the mixer tube. If the signal disappears or is greatly reduced in strength, the mixer stage is at fault. Check the tube and its voltages.

If the signal can be heard, the mixer stage is at least capable of amplifying. In this case, check the frequency conversion and the local oscillator. To do so, change the signal generator to some frequency in the broadcast band, and tune the receiver to the same frequency. If the local oscillator in the receiver is working properly, the signal generator signal (still applied at the input of the mixer tube) and the local oscillator signal will combine to produce an i.f. signal, and the modulation tone will be heard in the loudspeaker. If you hear no tone, probably the oscillator is dead. (The mixer may not be acting as a detector tube, but this is unlikely if the preceding test was normal.)

You can make an additional check for a defective oscillator by tuning the receiver to the frequency of a local station, then tuning the s.g. (connected to the input of the mixer) to a frequency that is above or below the local station frequency by the i.f. value of the receiver. For example, if the receiver is tuned to a 1200-kc. station, and the i.f. value is 465 kc., set the s.g. either to 1665 kc. or 735 kc. If you hear the program of the local station mixed with the s.g. tone, you know that the local oscillator is defective.

If these tests show that the local oscillator is functioning, set the s.g. to the same frequency as the receiver, then touch the free s.g. probe to the antenna terminal of the receiver. Since everything else has been normal to here, the tone in the loudspeaker should stop at this point. Failure of the signal to come through at the antenna post is most likely due to an open in the primary of the antenna coil.

SIGNAL TRACING

A signal tracer can be used to follow the signal from the input of the set to determine where it is interrupted. The signal tracer method is perhaps not quite as fast as some of the others if the defect is a common one, but it is much faster when some unusual trouble exists. Let's see how to use it. We'll assume you have a tracer that uses a meter or magic-eye indicator, and also has a loudspeaker so that you can hear its output. Also, we'll use the circuit shown in Fig. 3 as an example again.

The input signal may be either that of a local broadcast station or the modulated output of an s.g. Turn on the receiver and tune it to the point where this signal would be received if the set were working, then connect the ground clip of the signal tracer to the set chassis.
or ground terminal. You can now use the hot probe to trace the signal.

As you become expert in the use of a signal tracer, you will probably eliminate as much testing as possible by making rather large jumps in following the signal—jumping from grid to grid, say, or even from section to section. At the beginning, however, it is best to trace the signal at each grid and plate circuit.

In this example, start with the hot probe on the control grid of the 12SA7 tube. Tune the signal tracer to the frequency of the incoming signal, and retune the set, if necessary, to give maximum indication on the signal tracer. If the signal is picked up at the grid of the 12SA7 tube, the input circuits of the receiver are in good condition.

Next, move the hot probe to the plate of the 12SA7 tube, and tune the signal tracer to the i.f. frequency of the set. No signal here may mean that there is no B supply voltage, that at least one section of the 12SA7 tube is not working, that $C_n$ is short-circuited, that the primary of i.f. transformer $T_s$ is short-circuited, or that the oscillator is misaligned.

You can check the oscillator with the signal tracer by applying the hot probe to the first grid of the 12SA7 tube. Tune the signal tracer over its band and see if you can pick up the oscillator signal. If not, then there is trouble in the oscillator circuit. If you do pick it up, notice the frequency at which you find it on the signal tracer dial. This frequency should be equal to the incoming signal frequency plus the i.f. frequency of the set. If it is far different from this, then the trouble may be that the oscillator circuit is out of alignment.

Assuming that you hear a signal at the i.f. frequency at the plate of the 12SA7 tube, you can now move to the grid of the 12SK7 tube. Lack of a signal here indicates trouble in transformer $T_s$ or in its trimmers $C_n$ and $C_l$.

If you find the signal at the grid of the 12SK7 tube, move back to its plate. The signal tracer must still be tuned to the i.f. frequency. Lack of a signal here indicates a defective 12SK7 tube, improper operating voltages, or trouble in the primary of $T_s$ or condenser $C_n$.

Next, move back to the diode detector of the 12SQ7 tube, leaving the tracer tuned to the i.f. frequency. No signal probably indicates an open in the secondary of $T_n$, or a short in $C_n$. If you find the signal, change to the audio tracing probe of the signal tracer and apply it to the grid of the 12SQ7 tube. No signal here probably means an open in $C_{18}$ or a short in $C_{15}$. There is also the possibility that the volume control is defective.

If you find the signal at the grid of the 12SQ7 tube, move back to its plate. Lack of signal here indicates a short in $C_n$, an open in $R_s$, or a defective 12SQ7 tube.

You can then move to the grid of the 50L6 tube. If you find no signal here, but did get a signal at the plate of the 12SQ7, then coupling condenser $C_{17}$ must be open.

Finally, if you find a signal at the 50L6 grid, move the probe to the plate of the 50L6 tube. No signal here means a defective 50L6 tube, an open primary of the output transformer, or a short-circuited condenser $C_{15}$.

As you can see, the signal tracer is used by moving successively from grid circuit to plate circuit throughout the receiver until you find the point at which you hear no signal. At that point, you can stop and resort
to your ohmmeter and voltmeter to find the defect. The signal tracer has the advantage of finding not only the defective stage but also the defective circuit.

As we mentioned earlier, it is a waste of time to check and follow the signal through the entire receiver just to find that the trouble is at the output stage. For this reason, most servicemen first make some circuit disturbance test or otherwise assure themselves that the audio amplifier is working and that the power supply is normal, before using the signal tracer. Therefore, you will find the signal tracer will be of greatest use in locating troubles in the i.f.-r.f. section of the receiver.

Locating the Defective Part. Regardless of the section and stage localization procedure you follow, your job is incomplete until the defective part is found. Reasoning may point to the part once the trouble has been partially localized, but, if not, your voltmeter and ohmmeter can be used to find the open or short circuit that causes the set to be dead. Follow the test procedures you have studied in other RSM Booklets to find the defective circuit and part.

The signal tracer (and the voltmeter disturbance test) will indicate directly an open coupling condenser. This is important to remember—an open coupling condenser will not upset any circuit voltage nor will it affect the continuity. If you are using other methods of localization, always remember to suspect an open coupling condenser if you have localized the trouble to a stage using one, and can find nothing else wrong.

NRI PRACTICAL TRAINING PLAN

You have now reached a point where you can introduce a number of defects into the receiver you are using for experiments. If you have not yet obtained this receiver, get one as soon as possible, and go back over all the steps given in earlier RSM Booklets. Then carry out the following steps in order.

Step 1. Check Performance of Receiver. Tune in local and distant stations at different points on the tuning dial while the set is connected to a good outdoor antenna, so you become familiar with the sensitivity and selectivity characteristics of the receiver. Become familiar with the receiver controls—try them all.

Step 2. Make a Circuit Disturbance Test. With the receiver in operation, carry out the circuit disturbance test as used for locating the defective stage in a dead receiver. Do this first by pulling out and replacing each tube in turn while the receiver is tuned between stations. (Work from the loudspeaker back toward the input in these tests.) Next, touch the control grid terminal of each tube in turn with your finger. Make the test once more; this time removing and replacing each top cap connection. Notice that sometimes you get clear-cut clicks, sometimes there is a squeal. Repeat the procedure, using your voltmeter.

Step 3. Make a Defective Stage Isolation Test with a Signal Generator. With the receiver operating but the aerial disconnected, make a defective stage isolation test with your signal generator, just as you would for a dead receiver.

Step 4. Follow the Signal. If you have a signal tracer, practice following a signal from the input toward the output.

Step 5. Create a Dead Receiver. Study your receiver diagram to see what defects could cause your receiver to be dead. Then study the list in the table given on page 21 of this RSM Booklet. All the troubles EXCEPT those given with a star (*) may be safely introduced into the receiver. WARNING: Those marked with a star (*) may cause damage to other parts, so don't try them. Create these defects, one at a time (instructions are given below); then use all the methods of localization that you have learned, to find the trouble. When you have localized it in each case, restore the receiver.

BENCH HINTS

The easiest way to remove a hollow rivet is to drill it out with a hand drill. Sometimes, however, the rivet will begin to turn with the drill after you have gotten started. If this happens, place a chisel across the pinched (bead-over) end of the rivet and strike it two or three times with a hammer. This will usually jam the rivet in place firmly enough for you to be able to drill it out.

18
to normal and introduce another defect.

- To simulate a burned-out tube filament, unsolder one of the filament power leads at the socket. (Should there be two wires, leave them fastened together—disconnect both from the socket terminal—so that you will be interrupting only one filament supply at a time.)

- You can simulate an open resistor or condenser by unsoldering one terminal from the circuit wiring. Be sure the wires you unsolder cannot touch the chassis or another terminal. If necessary, use tape over the free wire ends.

WARNING: If you unsolder the cathode bias resistor for the output tube, be sure to disconnect also its by-pass condenser to avoid damage to this condenser.

Not all open resistors or open condensers will make the set dead. It is a good idea to unsolder a number of each to see just what effect is produced.

- Unfortunately, short circuits cannot be readily introduced into supply circuits, as resistors or other parts may be damaged. However, you will get experience with these cases when you begin to service radio receivers.

---

**DEFECTS COMMONLY CAUSING A DEAD RECEIVER**

<table>
<thead>
<tr>
<th>Cause</th>
<th>How to Test</th>
<th>Usual Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burned out tube filament</td>
<td>Ohmmeter or tube tester</td>
<td>Any stage</td>
</tr>
<tr>
<td>Loss of emission in tube</td>
<td>Tube tester or substitute good tube</td>
<td></td>
</tr>
<tr>
<td>Open resistor</td>
<td>Ohmmeter</td>
<td>Any stage</td>
</tr>
<tr>
<td>Shorted by-pass* condenser</td>
<td>Ohmmeter</td>
<td>Screen and plate circuits</td>
</tr>
<tr>
<td>Broken connection</td>
<td>Ohmmeter or visual inspection</td>
<td>Any screen or plate circuit</td>
</tr>
<tr>
<td>Tube not firmly in socket</td>
<td>Push down on tube</td>
<td>Any stage</td>
</tr>
<tr>
<td>Top cap connector off tube</td>
<td>Visual inspection</td>
<td>Any section</td>
</tr>
<tr>
<td>Top cap shorting to tube shield</td>
<td>Visual inspection and wiggle grid lead</td>
<td>Any section</td>
</tr>
<tr>
<td>Shorted electrolytic condenser</td>
<td>Ohmmeter</td>
<td>Power supply</td>
</tr>
<tr>
<td>Open electrolytic condenser</td>
<td></td>
<td>Input filter in power supply</td>
</tr>
<tr>
<td>Open field coil</td>
<td>Hold screwdriver to field to sense magnetic pull</td>
<td>Loudspeaker (power supply)</td>
</tr>
<tr>
<td>Open line cord</td>
<td>Ohmmeter</td>
<td>Power supply</td>
</tr>
<tr>
<td>Burned out a.f. transformer</td>
<td></td>
<td>Audio section</td>
</tr>
<tr>
<td>Loudspeaker* unplugged</td>
<td>Visual inspection</td>
<td>Audio section</td>
</tr>
<tr>
<td>Open coupling condensers</td>
<td>Shunt suspect with another con- denser</td>
<td>Audio section</td>
</tr>
<tr>
<td>Open voice coil</td>
<td>Visual inspection or ohmmeter</td>
<td>Loudspeaker (audio section)</td>
</tr>
<tr>
<td>Phone-radio switch</td>
<td>Turn switch to other position</td>
<td>a.f. section</td>
</tr>
<tr>
<td>Open r.f., i.f., or oscillator coil</td>
<td>Ohmmeter</td>
<td>r.f. section (usually a plate winding)</td>
</tr>
<tr>
<td>Tuning condensers shorted</td>
<td>Scraping sound when tuning</td>
<td>r.f. section</td>
</tr>
</tbody>
</table>
No. 22  How To Fix a Receiver That Hums

RADIO SERVICING METHODS
Dear Mr. Smith:

It was truly a turn in the right direction for me when I enrolled in your school. I started earning money after the tenth lesson. After graduation I carried on a successful spare time business. Then, because of my training, I was selected from many applicants for a position as a technician with a large electrical manufacturer. I am still employed by this company. The door to interesting work with good pay was opened to me through the training I received from NRI.

F.W., Illinois

Copyright 1947 by National Radio Institute Washington, D.C.

How to Fix a Receiver That Hums

Hum is one radio defect that cannot be cured completely. It is always present to some extent in any receiver operating from a power line or from a vibrator power supply. Therefore, your aim in servicing a set with hum is to reduce the loudness of the hum to an unobjectionable level rather than to remove it altogether.

In this RSM Booklet, you are going to learn what causes excessive hum, and how it can be reduced. In addition, the practical experience section at the end of the Booklet will show you how to learn to recognize hum when you hear it. We shall deal primarily with receivers operated from a power line, because vibrator-operated receivers (amplified sets and farm receivers) will be covered in another RSM booklet. However, much of what we say can be applied to these receivers as well.

First, let's see what causes excessive hum. Fortunately, this defect has relatively few causes; once you have learned what they are, you will very often find it possible to locate the source of the hum without bothering with any elaborate localization procedures.

Causes of Hum

Hum occurs when a low-frequency a.c. voltage gets into the signal circuits of a set. The two most common paths through which hum voltage enters the signal circuits are through a defective filter section of the power supply and through a leak between the cathode and the heater in a tube. There are also a few less common paths that we will take up later.
Since the hum voltage is an a.c. voltage, it can be amplified just like any other signal once it gets into the signal circuits. And, naturally, the more amplification it gets, the more noticeable it becomes. For example, a fairly large hum voltage could get into the power output stage without being very noticeable, but even a small hum voltage introduced in the input of the audio amplifier would receive enough amplification to be annoying by the time it reached the loudspeaker. Therefore, whether or not the hum voltage reaches an objectionable level depends to a great extent upon where it is introduced.

Now, let's study in detail the ways in which excessive hum can enter a signal circuit.

**FILTER TROUBLES**

At least 75% of hum complaints are caused by a defect in the power supply system. As you know, the filter is intended to smooth out the ripple voltage in the rectifier output to an acceptable level. It is this ripple voltage that causes hum. If the filter becomes defective, more hum or ripple voltage than normal will be applied to the tube elements in the set, and the hum level of the set will increase.

You have learned of the difficulties that may upset filtering, but let's review them briefly.

Fig. 1 shows two typical filter systems. An a.c.-d.c. set is shown in A, and a straight a.c. set in B, but the filter circuits could be used in either receiver. Condensers C₁ and C₂ are electrolytic condensers, connected with the polarities indicated.

Condenser C₁ is not likely to cause much hum. If this condenser loses capacity, develops a high power factor, or opens, there will be a slight increase in the a.c. ripple voltage, but the d.c. voltage will be dropped to such an extent that the receiver gain will be sharply reduced. Thus, although some hum may be heard, the chief complaint will probably be weak reception or a dead receiver. (If C₁ develops leakage or short-circuits, the rectifier tube will probably be ruined, and the result will be a dead receiver.)

Most hum troubles are caused by condenser C₂. When this condenser loses capacity or develops a high power factor, its ability to act as an a.c. voltage divider with the choke decreases, so a greater proportion of the ripple voltage is passed on to the tube electrode. If C₂ opens, the hum will become very strong.

Leakage in condenser C₂ (or leakage in any condenser or circuit in parallel with C₂ at some point farther on in the receiver) will cause excessive d.c. current to flow through the choke. This will reduce the inductance of the choke coil, making it less effective as a filter component, and so causing greater hum. If C₂ shorts altogether, the set will become dead.

Condenser C₁ and C₂ are frequently in the same condenser block. If leakage occurs between these condensers, there may be a shunting resistive path across the choke coil. Such a path will reduce the effectiveness of the choke and may cause hum. A similar shunting resistive path across the choke may exist in the circuit of Fig. 1B if leakage develops from the negative side of condenser C₁ to the chassis. This, too, may cause hum.

Of course, hum may also be caused by short-circuited turns in the choke coil, but such a defect is rare.

**Unbalanced Full-Wave Rectifier Tubes.** Hum is occasionally caused by unbalanced rectification in a full-wave power supply. In this case, the hum is a result of
the design of the filter. In a full-wave circuit like that shown in Fig. 1E, the filter is designed to remove the 120-cycle ripple that is normal for full-wave rectification. If anything happens to windings S1 or S2 of the transformer, or if one-half the tube becomes defective, the tube will still deliver d.c. because one of its plates will conduct current, but the frequency of the ripple will now be 60 cycles* instead of 120 cycles. This lower frequency is much harder to filter than is the 120-cycle ripple, and the filter system may not be capable of doing a good job on it. Therefore, there may be hum even though the filter is in good condition.

CATHODE-TO-HEATER LEAKAGE

Most hum complaints that are not the result of filter troubles are caused by cathode-to-heater leakage in tubes. This is an odd trouble because it has to occur in a certain way before it can cause hum, and then may cause hum only in certain stages.

Fig. 2A shows the filament and cathode connections of a typical modern triode circuit. One side of the filament is grounded to the chassis, and the cathode is connected to the chassis through self-bias resistor R1, which is by-passed by C1. (As you know, any voltage existing between the cathode and ground is also between the grid and the cathode, so the voltage across R1 is the d.c. bias voltage for the tube.)

However, let's suppose that some part of the cathode (marked B) shorts to the ungrounded end of the filament (marked D). This will create a path from D to the chassis through the cathode and resistor R1. This path and the filament are now in parallel, so some part of the a.c. voltage applied to the filament will also appear across R1. The exact amount across R1 will depend on whether a complete short or just leakage exists between B and D.

Whether this a.c. voltage across R1 causes hum depends on the capacity of C1. If this by-pass condenser has a high capacity, it may prevent any hum. However, if the capacity is insufficient, or if there is a considerable amount of amplification between the grid circuit of this stage and the output, even a small amount of hum voltage developed across R1 will be amplified sufficiently to cause hum.

On the other hand, if a short or a low resistance develops between E and F, there will be no hum because R1 and the filament will not be in parallel, so there will be no a.c. voltage across R1. (However, the low-resistance path between B and ground will be in parallel with R1; this may upset the bias and cause distortion or oscillation.)

If the filament connections are as shown in Fig. 2B, then a short circuit between B and either E or D may cause hum, but a short circuit between B and A will not, because the a.c. potential between A and ground is effectively zero.

Finally, with the connection shown in Fig. 2C, no hum will develop regardless of how much cathode-to-heater leakage may exist, or to what points it occurs, because the cathode is directly grounded, and there is no way for the a.c. filament voltage to get between the grid and the cathode.

Therefore, cathode-to-heater leakage can exist in some stages without causing trouble and may have to exist in a special manner in other stages before it can cause trouble. (Even so, cathode-to-heater leakage is a
very common source of hum in radio receivers.) You can save time by examining the wiring diagram to see which stages may have this trouble—there is no need for checking the tubes in stages that cannot cause hum.

The greater the voltage across the filament terminals of the tube, the greater the likelihood of hum, because then there will be a larger a.c. voltage placed across the bias resistor if leakage or a short develops. For this reason, cathode-to-heater leakage causes more trouble in a.c.-d.c. receivers than in a.c. sets. As shown in Fig. 3, the potential difference between the tube filaments and ground increases as one progresses down the filament string from the grounded end (as one moves from $V_T$ toward $V_{T_1}$). To compensate somewhat for this, some manufacturers arrange the tube filaments so that the least filament-to-ground voltage is applied to the tube that is least likely to cause trouble if it develops cathode-to-heater leakage. Then the next largest filament-to-ground voltage is applied to the second most trouble-some tube, and so on.

Almost always, therefore, tube $V_T$ is the first audio tube. Tube $V_{T_1}$ may be the first detector-oscillator, $V_{T_2}$ may be the i.f. tube, $V_{T_3}$ the output tube, and $V_{T_4}$ the rectifier tube. This odd order of connecting the tube filaments tends to minimize the possibility of hum.

Even though tube $V_{T_2}$ is the power output tube, this arrangement of filaments results in such a large filament-to-ground voltage that leakage between its cathode and filament may cause a considerable amount of hum. In fact, output tube leakage is the second most probable cause of hum in a.c.-d.c. sets. (A defective filter, of course, is the most probable cause.)

**MISCELLANEOUS CAUSES OF HUM**

Defective filter condensers, and cathode-to-heater leakage account for 90% of the hum troubles you will meet. The rest have unusual causes—the kind that baffle the radio mechanic but are readily found by a man with professional training.

One reasonably frequent cause of hum is a defect in a decoupling filter. In the filter shown in Fig. 4, $C_1$ and $R_2$ act as a voltage divider to reduce any hum voltage coming from the B supply. If condenser $C_1$ loses capacity or develops a high power factor (this condenser is frequently an electrolytic condenser), it will no longer act as an effective filter element, and hum voltage will be applied to the plate circuit of tube $V_T$.

**Inductive and Capacitive Coupling.** A.C. electromagnetic fields exist in and around the chassis of any power-line-operated radio receiver. These fields will cause no trouble in a well-designed receiver, but hum may result if anyone tampers with the position of critical leads or removes shielding.

Most trouble of this kind is caused by misplaced grid leads. Unless you notice where a repair has been made in which some critical lead may have been moved, you
will first have to use the methods described later to determine which stage the hum enters. Then you can try moving the leads in that stage with an insulated stick or alignment tool while the receiver is turned on. If you find a position where the hum disappears, you have solved the problem. Examine the set carefully to see if there is any evidence of shields missing. Also, if the control grid lead should be brought up inside a shield, be sure it is so placed.

Sometimes a receiver owner will tuck lengths of the a.c. power cord “out of the way” inside the radio. The strong a.c. field from this cord may induce hum in some grid circuit. Always pull the cord out to see if the hum decreases, then fold it or tie it up away from the chassis (but off the floor).

Although less common than electromagnetic coupling, electrostatic induction also may cause hum. Electrostatic induction is the result of capacitive coupling between points. If stray coupling exists to a grid lead, for example, and the grid circuit contains a high resistance, then even a small electrostatically induced hum current will cause an appreciable voltage to develop across the resistance between the grid and the chassis. However, since stray capacities are small, only high-resistance grid circuits are much affected. In practically all cases where high resistances are used, the manufacturer minimizes this difficulty by keeping the tube grid leads short and placing them so that they are not easily disturbed. However, if anything happens to increase the resistance of the grid resistor, there may be appreciable hum induced in the circuit. Of course, any change in the grid resistor may also cause overloading of the tube or enough change in the bias so that distortion occurs. You may find that you have a combination complaint rather than a simple case of hum in such cases. This is often an aid in locating the defect, rather than an obstacle.

**Hum Caused by Replacement Parts.** Improper replacement of parts can sometimes cause hum. A typical example is a loudspeaker cone replacement. If the hum level is normal before the replacement but excessive afterwards, very likely the speaker has a hum-bucking coil that has been improperly connected. This coil should be connected, as shown in Fig. 5, so that any hum voltages induced by the speaker field in both the voice coil and the hum-bucking coil will oppose and cancel each other. If the voice coil leads are connected backwards, the voltages will add, and hum will be increased. Unsoldering the voice coil leads and interchanging them will remedy this condition.

Sometimes a replacement choke or power transformer does not have the complete shielding of the original part. This may allow strong hum fields to escape from the part if it is a power transformer or choke, or to get into the part if it is an audio transformer. In such cases, it is best to get a more nearly exact duplicate if possible.

**EFFECT-TO-CAUSE REASONING**

Effect-to-cause reasoning is a very valuable aid in the case of hum. You can use it right away to localize the section where the hum originates.

As you know, hum is a low-frequency a.c. voltage. Therefore, the hum voltage picked up by an r.f. stage cannot pass through the tuned circuits unless it modulates the incoming signal. On the other hand, hum originating in the power supply or in the audio amplifier can be heard whether or not an r.f. signal is being received.

To locate the section in which the hum originates, then, just tune the set so that no station is picked up, and turn the volume control to minimum volume. If the
hum is still audible, it must be originating in the power supply or in the audio amplifier. If you hear no hum, turn the volume control back to a normal volume level, and tune the set to a station. If you hear hum now, it must be originating in an r.f. stage and modulating the incoming signals. A hum of this sort is called modulation hum or tunable hum. Thus, effect-to-cause reasoning plus simple tests will enable you to locate at once the section in which the hum originates.

**Effect-to-cause reasoning can be brought into use in some sets for a second time once you have learned to recognize hum frequencies. In practically all a.c. receivers that use power transformers, the rectifier tube is a full-wave rectifier. The fundamental frequency of the hum or ripple produced by this rectifier is twice the frequency of the line voltage. (For a 60-cycle line, this ripple is 120 cycles.) Therefore, if you hear a hum that has a fundamental frequency of 120 cycles, you know that the filter is not removing enough of the rectifier ripple.

On the other hand, hum caused by cathode-to-heater leakage, an unbalanced rectifier, or electrostatic or electromagnetic pickup from the power line will have the same fundamental frequency as the power line (60 cycles). Therefore, in a standard a.c.-operated receiver with a power transformer, 120-cycle hum indicates a filter defect, and 60-cycle hum indicates other troubles.

In a.c.-d.c. sets and others that use half-wave rectifiers, the fundamental hum frequency is the same as the power-line frequency, regardless of the defect.**

---

**BASIC TESTING**

As we said, 90% of hum complaints (plain hum—not modulation hum) are caused by defective filter condensers or by cathode-to-heater leakage in an audio tube. Therefore, it is logical to check these suspects first, before making any further localization tests.

The simplest and quickest test for a suspected open or high power-factor electrolytic condenser is to try another one across it. Be sure that the test condenser has a working voltage rating at least as great as that of the condenser under test (450 volts or higher for a.c. receivers, 150 volts or higher for a.c.-d.c. receivers).

The capacity of the test condenser should be near that of the one across which it is connected, but this is not of extreme importance.

To make tests, first turn on the receiver (which must be connected to its speaker). If you can conveniently locate the output filter condenser, shunt your test condenser across it. Watch polarity—the positive terminal of your test condenser must go to the positive terminal of the original, and the two negative terminals also must go together. If it proves difficult to tell which is the output filter condenser, check each of the two or three electrolytic condensers, one at a time, with the test condenser.

If the hum clears up when you shunt the suspected condenser with the test unit, the condenser under test is defective and must be replaced.
The easiest way to connect a test electrolytic condenser across a filter condenser is to clip test leads to the terminals of the test condenser, as shown above, and touch the probes on the other ends of the leads to the terminals of the filter condenser. **CAUTION:** Be careful not to let your fingers touch the power supply circuits—you can get a severe shock.

▶ Frequently only partial hum reduction is observed when the output condenser is shunted with one of like capacity. This may mean the input condenser is also defective. If you wish, shunt both condensers simultaneously. Of course you can't hold all four leads at the same time, but you can temporarily solder in one test condenser and hold the other.

Make sure you test between the terminals of the original condenser. As we said in discussing Fig. 1B, the negative terminal of condenser C₁ is above ground potential. Therefore, you cannot consider that ground is one terminal of this condenser; to shunt it, you must locate both terminals of C₁ and connect your test condenser to them.

▶ If the hum is not greatly reduced when you shunt the test condenser across the output filter condenser, then the output filter condenser may be leaky. Shunting it with another will not be a test at all in this case. You must disconnect the original condenser and check it for leakage—either with an ohmmeter or by temporarily placing another condenser in the circuit in its stead.

Leakage between condensers is not easily checked except by disconnecting both condensers and trying others in their places. (An ohmmeter check is not reliable if the two have a common lead, because a check between the other two terminals will give you a reading whether or not leakage is present.)

If the capacity of the test condenser is far below that of the original condenser, the hum may not entirely disappear. However, any considerable reduction in hum shows that the original condenser should be replaced by one of the proper capacity.

▶ Cathode-to-heater leakage in a tube can easily be found by checking the tube for shorts or leakage in a tube tester. Be sure to check the rectifier tube to see that both halves have approximately the same emission, particularly if it is a full-wave rectifier and the receiver exhibits 60-cycle hum. In this latter case, also use an a.c. voltmeter to find out if the power transformer is delivering voltage to both plates of the rectifier.

Modulation hum is usually caused by the introduction of a hum voltage into an r.f. stage that has been forced off the straight portion of its characteristic. If such a stage is over-biased by some defect in the bias supply, for example, it will operate in a non-linear manner; this may permit even a fairly small hum voltage to cause modulation hum. Strong signals or a high hum voltage level may also cause the stage to operate off the straight portion of its characteristic. Cathode-to-heater leakage is the most usual way for the hum voltage to enter the stage.

**LOCALIZING HUM**

If you find that the trouble is not caused by a defective filter condenser or by cathode-to-heater leakage in a tube, it is best to determine where the hum enters the signal circuit. The procedure to use depends upon whether you have steady hum or a modulation hum.

**Localizing Modulation Hum.** Let's see how you could go about locating the stage in which hum modulation starts. Fig. 6, a typical a.c.-d.c. receiver, will serve as our example. At the start you know that the modula-
tion hum originates in the r.f. section—between the loop antenna and the volume control.

Either a signal tracer or the signal injection method may be used to locate the defective stage. If a signal tracer is used, it must be one of the kind with an audible output (one with a loudspeaker), because you want to hear the signal.

1. If you have a signal tracer, first tune the receiver to a broadcast signal, and listen to the modulation hum to learn its characteristic sound. Then, turn down the receiver volume control so that it will be easier to hear the signal tracer output. Fasten the signal tracer ground lead to the set chassis. Touch the hot probe to the control grid of the 12SA7, and tune the signal tracer to the incoming signal. Listen to the tracer signal. If it has the modulation hum, the hum is coming in with the signal or is being modulated on the signal in the antenna or in the 12SA7 grid circuit.

2. If no hum is heard here, move the probe to the plate of the 12SA7. Hum now indicates trouble in the mixer or oscillator. If there is no hum, move to the grid of the 12SK7. By proceeding this way, you will eventually reach a point where the signal is modulated by the hum. The trouble will then be between that point and the last preceding point of test.

3. A somewhat similar procedure is followed in the signal injection method. For this, you need a signal generator (abbreviated s.g.).

Set up the s.g. to give a modulated signal. Connect its ground lead to the receiver chassis. Place a .05 to .1 mfd. condenser in series with its hot lead (unless this condenser is built into your s.g.), and connect the hot lead to the control grid of the input tube (the 12SA7).

Next, tune the receiver to some point where a station is not picked up, and tune the s.g. to the same frequency. When the modulation tone of the s.g. is clearly heard, switch the s.g. to deliver an unmodulated signal and increase its output to maximum. The hum will be modulated on this signal and will be heard. Now tune the s.g. to 455 kc. (the i.f. frequency), and touch the hot s.g. probe to the plate of the 12SA7 tube. If the hum is no longer heard, the trouble is in the 12SA7 mixer or os-
collator circuits. Check the tube, the continuity of the mixer control grid return circuit, and the oscillator grid resistor (if this latter has increased markedly in value, it may be causing self-modulation, which will sound like hum). Experiment with the position of the mixer and oscillator grid leads.

If the hum is still heard with the hot probe on the 12SA7 plate, move it to the plate of the 12SK7 tube. If the hum stops, the trouble is in the 12SK7 circuit; test the parts, the tube, and the wiring in it. If the hum continues with the hot probe on the 12SK7 plate, the trouble lies between this point and the volume control. Check the parts and the wiring involved. Also, try another 12SQ7 tube.

Localizing Steady Hum. Now suppose the hum is in the power supply or the a.f. section of the receiver shown in Fig. 6. First check the 20-mfd. and 12-mfd. sections of the filter, and test for cathode-to-heater leakage in the 12SQ7 and 35L6 tubes.

If this does not reveal the defect, an audio signal tracer, or the stage blocking procedure, can be used for localization. To use the signal tracer, first tune the receiver to a quiet point (no signals) so that the hum is all that is heard. Then, trace with the hot audio probe at the following points in order: grid of 12SQ7 triode, plate of 12SQ7 triode, grid of 35L6, plate of 35L6. When you first hear the hum coming from the signal tracer as well as from the set speaker, you have found the point where the hum is getting into the signal path.

► In the stage blocking method, the signal path is blocked at some point. If the hum is still heard, it is getting in between this point and the speaker. Otherwise it is getting in farther back toward the input. To use this method, proceed as follows:

Begin by shorting the primary of the output transformer with a test lead or a .5-mfd. condenser. (Connect the shorting lead or condenser across the terminals of the primary.) This prevents any signals from being fed from the 35L6 to the loudspeaker. If the hum is still heard, the hum-bucking coil (marked B.C.) is probably reversed, or else the power supply is defective. If the hum disappears when the output transformer primary is shorted, remove the shorting lead (or condenser), and short across the 470,000-ohm 35L6 grid resistor. If hum is heard, it is originating in the 35L6 stage.

If you do not hear hum in this test, remove the shorting lead and short the 10-meg. grid resistor of the 12SQ7 tube. If hum is now heard, either it is originating in the 12SQ7 stage, or the grid of the 35L6 is picking it up.

If you don’t get hum with the 10-meg. grid resistor shorted, remove the shorting lead, and turn the volume control to minimum volume. Any hum now heard is being picked up by the grid circuit of the 12SQ7. If turning the volume control up and down varies the strength of the hum signal, the control may be defective, or some of its wiring may be picking up hum from electromagnetic or electrostatic fields.

► This method of circuit blocking can be used on any type of receiver, a.c. or a.c.-d.c. However, in an a.c. set using a power transformer, it is often simpler to block signals by removing the tubes one at a time while the receiver is turned on. (Of course, this cannot be done with an a.c.-d.c. receiver.)

Thus, if you have an a.c. set, pull out the power output tube. If hum is still heard, investigate the hum-bucking coil and the power supply. If the hum stops, reinsert the tube into its socket and pull out the first audio tube. If you hear hum, it is getting into the power output stage or in the plate supply circuit of the first audio tube.
Remember that hum will be louder when the set is in its cabinet than when it is on your bench. This is especially true when the set has a console cabinet, which usually reinforces low notes considerably. Always check the hum level with the set in its cabinet before delivering it to the customer.

no hum is heard with the first audio tube removed, the trouble is probably cathode-to-heater leakage in this tube or is an open grid circuit.

Points to Remember. Any a.c.-operated receiver will have a certain amount of hum that cannot be eliminated. If you listen carefully, you can hear this hum from practically any receiver. We suggest you listen to a number of receivers that are in good condition to become familiar with the amount of hum that is considered acceptable to the average radio listener.

Hum is always more pronounced when the loudspeaker is in its cabinet, for the cabinet improves the response to low-frequency notes. Sometimes, when a receiver (and loudspeaker) is on the workbench, it is almost impossible to hear hum that would be objectionable with the chassis and speaker mounted in the cabinet. You can get an idea of the intensity of the hum with the set out of the cabinet by tuning away from a station and barely touching the speaker cone with the end of your finger. If hum is present, you will feel a vibration of the speaker cone. Whenever you service a set for hum, be sure to notice the loudness of the hum with the chassis in and out of the cabinet. This will give you a good idea of how much difference the cabinet makes.

NRI PRACTICAL TRAINING PLAN

Hum is one of the easiest of the service complaints to introduce into a radio receiver. Carry out the following suggestions on the set that you are using for the NRI Practical Training Plan. This should be a standard a.c. receiver with a power transformer and a full-wave rectifier.

To learn the difference between 60-cycle and 120-cycle hum, locate the output filter condenser, and temporarily unsolder it from the circuit. When you do this, there will be a strong hum from the loudspeaker. If everything else is normal, this hum will have a 120-cycle fundamental frequency plus higher harmonics.

When you think you can recognize this hum, resolder the filter condenser and introduce a 60-cycle hum. There are several ways of doing this; one of the best is to connect a small condenser (.01 to .05 mfd.) from the ungrounded side of a filament to the control grid of the first audio tube. This will introduce a strong hum with a 60-cycle fundamental frequency and higher harmonics.

Much depends on the response characteristics of the receiver as to whether you can at once tell the difference between these two hum frequencies. If the set does not respond very well to low frequencies, you may hear only the higher harmonics of the two, which would sound much alike. Listen to the two hum frequencies carefully, one after the other, until you think you can recognize the difference between them.

Now proceed to introduce various defects. The test we have just described (opening the output filter condenser) has the same effect as a loss of capacity would have. Make the same test on the input filter condenser by reconnecting the output condenser and disconnecting the input condenser. The hum level will increase, but the d.c. voltages will all drop radically, and you may have weak reception or even a dead receiver. Try out the set to see how it works with the input filter condenser disconnected.

High power factor in either electrolytic condenser will have the same effect as opening the condenser, so there is no necessity for demonstrating this condition. Leak-
age is important only when it occurs in the output filter condenser. You can simulate leakage by connecting a 5000-ohm 10-watt resistor in parallel with the output filter condenser so that it draws extra current through the filter choke. This will probably increase the hum, but it will cause a lower-than-normal plate voltage on most of the tubes, and this may prevent the hum level from becoming much more noticeable.

- Cathode-to-heater leakage can be simulated by connecting a resistor of about 5000 ohms between the cathode terminal of a tube and an ungrounded filament terminal on that tube socket. This will not cause hum in certain stages, but in others there will be a strong hum. Try this on audio stages in which the cathode is not directly grounded—that is, stages that have bias resistors. Try it in r.f. and i.f. stages as well, and see if you can cause modulation hum.

- You can take off tube shields and introduce other conditions we have described earlier in this RSM Booklet, to see just what effect they have in your receiver. Try bringing the power cord close to the grid lead of the first audio tube. Finally, create excessive hum in your set while the speaker is in its cabinet, then remove it from the cabinet, and notice the hum level. Compare this level with the first one to learn how different the hum level may be when the set is on the workbench. Lightly touch the cone with your fingers to feel the vibration caused by the hum (no signals should be tuned in), then cure the hum and feel the cone again. You can frequently feel the difference as well as hear it.

### COMMON CAUSES OF HUM

<table>
<thead>
<tr>
<th>SEVERE</th>
<th>Cause</th>
<th>How to Test</th>
<th>Usual Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open or high p.f. output filter condenser</td>
<td>Shunt with a good condenser</td>
<td>Power supply</td>
</tr>
<tr>
<td></td>
<td>Leaky output filter condenser</td>
<td>Replace with a good condenser</td>
<td>Power supply</td>
</tr>
<tr>
<td></td>
<td>Cathode-to-heater leakage</td>
<td>Test tube</td>
<td>Audio section</td>
</tr>
<tr>
<td></td>
<td>Leakage through case of condenser</td>
<td>Disconnect ground strap from chassis</td>
<td>Power supply</td>
</tr>
</tbody>
</table>

### ANNOYING

- Open or high p.f. input filter condenser
- Half of rectifier tube defective
- Power cord near audio tube grid
- Hum-bucking coil reversed

Shunt with a good condenser
Test tube
Visual examination
Reverse connections

Power supply
Power supply
Audio section
Speaker
No. 23 How To Fix a Receiver That Squeals and Motorboats

RADIO SERVICING METHODS
Dear Mr. Smith:

Before I enrolled with you I thought radio was a subject that required a college education to understand. But I did enroll, even though I thought it was a gamble. Soon I discovered that with your method of teaching not only did I begin to know radio, but I was making side money. I am now operating a full time radio business. My future and that of my family is assured, thanks to NRI.

P.J.P., New Jersey

Copyright 1947 by

National Radio Institute
Washington, D.C.

OSCILLATION is the technical name for the defect that causes a receiver to produce squealing or whistling sounds along with the desired program. Although it is not as common a complaint of modern receivers as it was of older sets, you will still meet it at least once in a while in your service work.

The customer whose set oscillates may say that it is noisy or hums. However, you will find it easy to distinguish oscillation from these other defects when you confirm the complaint. The characteristic whistle or squeal of oscillation is not at all like the popping, crackling, frying sounds we call noise, and is too high pitched to be classed as a hum. Most of the whistles will be rather high in frequency, although they may vary in both pitch and intensity as the receiver is tuned. Whenever low-frequency oscillation occurs, it produces a "putt-putt" sound that is similar to the exhaust sound of a motorboat—in fact, low-frequency oscillation is popularly called "motorboating."

Before you can say definitely that a set is oscillating, you must be sure that the whistle is actually caused by a receiver defect and is not the result of some external condition. We will describe several of these external conditions briefly in this RSM Booklet and will give you
more complete descriptions of them elsewhere in your Course. The most important thing to remember is the fact that external causes generally produce whistles on only a few stations (sometimes only on one), whereas a receiver defect causes interference with many station signals. When the oscillation is severe, you may hear nothing but the whistle or motorboating sound.

You must not confuse the receiver defect "oscillation" with the action of the local oscillator in a superheterodyne. The local oscillator tube, of course, is supposed to oscillate; oscillation is a defect only when it occurs in an amplifier or a detector stage.

Before we describe the tests used to localize oscillation, let's first see just what causes it; then we will know what we are looking for when we have this complaint.

CONDITIONS FOR OSCILLATION

Before oscillation can occur, three conditions must exist in the set:

1. A feedback path must exist that will allow energy to get out of some circuit and get back into another one in an undesired manner.

2. The feedback energy must have the proper phase relationship so that, at the point where it gets back into the signal path, it will aid the signals coming through that circuit, rather than oppose them.

3. The feedback energy must be sufficiently large to overcome the losses in the circuit into which it is fed.

As a matter of fact, it is impractical and too costly to try to eliminate ALL feedback. The receiver designer merely keeps it small enough to allow the set to be stable and reliable in its operation. Therefore, whenever oscillation occurs, something has happened that provides another or a better feedback path (one that was not present originally or was suppressed), or the phase of the feedback is shifted, or the amount of feedback is increased.

Feedback is a very descriptive term. It means just what it says—energy is "fed back" from one circuit in the receiver to another circuit nearer the antenna. In other words, signals travel in the wrong direction through the receiver over feedback paths. This reversal of the normal direction of signal movement can occur only when there is an undesired coupling between circuits in the same stage or in different stages. This coupling may be inductive coupling, or may be stray capacity between circuit wires or within tubes.

The example of capacitive coupling. When a signal is passing through this stage, there will be a signal voltage across the plate load coil $L_2$. If there is any capacity coupling between the plate and the grid circuits, as shown by the dotted lines and condenser $C_{op}$, then the voltage $e$ will be applied, through $C_{op}$ and $C_3$, across the tuned circuit. This is shown in Fig. 2. Since the voltage $e$ is the amplified signal voltage across the load, it is always considerably greater than the input signal. The amount of this voltage that appears across the resonant circuit $L_2-C_3$ depends on the $Q$ of the resonant circuit and on the reactance of the capacity $C_{op}$.

If the capacity $C_{op}$ is small, there will not be enough voltage fed back to cause trouble. Therefore, every effort is made to keep this stray capacity down to a low level. Today, the triode tube is rarely used as an r.f. amplifier; instead, as shown in Fig. 3, pentode tubes are used al-
most exclusively as r.f. amplifiers in broadcast-band receivers because the screen grid acts as a shield between the grid and the plate within the tube, and reduces the capacity between these two elements. However, there is still stray capacity between the grid and the plate circuits outside the tube, so the grid and the plate leads are kept as short as possible and are well separated to minimize this capacity.

Energy can get back just as well if the magnetic field of the plate load coil (L₂) happens to link with the grid coil (L₁). Therefore, as Fig. 3 shows, these coils are shielded from each other, or are kept separated, and are so placed that their fields have as little inter-action as possible.

Even the tube is shielded to minimize stray coupling between the grid and plate circuits. (Incidentally, schematic diagrams may not indicate tube and coil shields, but these shields are normally used, whether shown or not.)

DEFECTS CAUSING OSCILLATION

Because of the design precautions we have just described, the single stage circuit shown in Fig. 3 is not likely to oscillate unless certain defects occur. For example, when a pentode tube is used, the screen grid will be an effective shield as long as the screen by-pass condenser C₁ is in good condition. If this by-pass condenser opens, however, energy fed back from the plate to the grid may set up enough signal in the input circuit to control the plate current and cause the stage to become an oscillator. In addition, if the shield is left off the tube, stray coupling between the grid and the plate circuits may cause oscillation. Improper voltages may be responsible, too—excessive screen grid voltage (because of an open bleeder resistor R₃) or a lack of bias (caused by a shorted C₂) may cause the stage to be unstable. Finally, an amplifying tube with a higher-than-normal B₁ may cause trouble because it develops a higher-than-normal load signal voltage. These last two possibilities—improper voltages or a high B₁ tube—can cause oscillation only if some feedback path to the input circuit exists that permits a fraction of the output voltage to be applied to the input. Since these defects tend to raise the output voltage, their effect is to increase the amount of energy fed back to the input. Of course, if there is no feedback path, or only a very poor one, then even a large increase in output voltage will not cause oscillation.

Therefore, in a single stage, if the circuit wiring has not been disturbed so as to provide a better-than-normal feedback path, there are four possible causes of oscillation: 1, an open screen grid by-pass condenser; 2, lack
of shielding; 3, improper voltages; 4, a high $g_m$ tube. The last is not common.

**By-Pass Condenser Troubles.** While we are discussing conditions that may cause oscillation, it is well to learn about some conditions that will *not cause* oscillation. We can make use of this knowledge in the effect-to-cause reasoning process, because it will enable us to rule out at once defects that cannot cause the complaint.

For example, in Fig. 3, regeneration cannot be caused by an open in condenser $C_3$. In this case, a portion of the plate signal voltage will be developed across resistor $R_1$ by the plate current. But, although this signal voltage will then be in the grid circuit, it will be out of phase with the grid signal voltage. To see why this is so, consider what happens in the circuit. When the grid signal swings in the positive direction, the plate current increases. The increased plate current in turn increases the voltage across $R_1$, thus driving the grid in the negative direction (opposite to the signal swing). Therefore, an open condenser $C_3$ causes degeneration, the opposite of regeneration; oscillation can never develop from this defect.

However, oscillation may occur if an open develops in a by-pass condenser that is used in more than one stage. For an example, see Fig. 4. Here the cathodes of both tubes use a common bias resistor $R_1$, which is by-passed by $C_3$. Should $C_3$ open, the plate current of $VT_1$ flowing through $R_1$ would develop a signal voltage across $R_1$ that would be in *phase* with the signal applied to the input of tube $VT_1$. Therefore, when there is a circuit common to two or more tubes, an open cathode by-pass condenser may cause trouble that would not occur if the condenser were used across the bias resistor in a single stage.

As you have already learned, a defective screen grid by-pass condenser may cause oscillation. Thus, if $C_4$ in Fig. 4 opens, then both stages are likely to oscillate because their screen grids are no longer effective as shields between the plate and grid circuits.

Condenser $C_4$ is the r.f. by-pass for the B+ circuit of the two stages. If it opens, the r.f. components of the plate currents can get into the power supply leads and be coupled to other circuits in the right phase to cause oscillation. Although $C_4$ is in parallel with the output filter condenser, the filter condenser cannot assume the function of $C_4$ because electrolytics have higher power factors than do paper condensers, and also they are inductively wound; both conditions make them poor r.f. by-passes.

Of course, you know that a short circuit in either condenser $C_5$ or $C_6$ will remove operating voltages and so kill the receiver. Therefore, you won't worry about shorts in these condensers when oscillation is the complaint.

In Figs. 3 and 4, we have shown standard r.f. stages, but i.f. stages could be substituted just as well by using i.f. transformers. The same conclusions hold in either case.

**Audio Section Troubles.** Now, let's look at the typical audio amplifier shown in Fig. 5. There are two condenser troubles that may cause oscillations in this circuit.
If condenser \( C_6 \) opens, there is some possibility that oscillation will develop in the audio amplifier. This by-pass condenser prevents the power output tube from acting as an r.f. oscillator. It may seem impossible for this tube to be an r.f. oscillator, since there are apparently no circuits in the stage that are tuned to radio frequencies. However, you must remember that even a short piece of wire has inductance, and the transformer leakage inductance is added to this. In addition, there is capacity between wires, and distributed capacity in the transformer. Therefore, it is possible for the grid and the plate circuits in an output tube to have just the right inductance and capacity to form resonant circuits at some high radio frequency. Oscillation then may occur, because a power output tube has such high power sensitivity that it will provide considerable feedback at the slightest opportunity.

The by-pass condenser \( C_2 \) is frequently important in preventing oscillation. As you know, the plate current of the output tube \( VT_1 \) has a high audio frequency (a.c.) component. Since the a.c. plate circuit of this tube is completed by output filter condenser \( C_6 \) from B+ to ground (and through \( C_2 \) to the cathode), there will be an a.c. voltage across \( C_6 \) that depends on the a.c. plate current and the condenser reactance. The high a.c. current of \( VT_1 \) causes considerable a.c. voltage to exist across \( C_6 \) even when the condenser is in the best of condition, and there will be a greater drop if this condenser loses capacity or develops a high power factor. If this a.c. voltage is applied to the plate circuit of \( VT_1 \), it will be fed through \( C_2 \) back into the grid circuit of \( VT_1 \) and will be in proper phase to support oscillation. Oscillations produced in this way will usually cause the "motorboating" noise we referred to earlier. Condenser \( C_2 \) and resistor \( R_4 \) are used both to prevent such motorboating and to help eliminate hum. The low reactance of \( C_2 \) causes most of the a.c. variation in the plate supply voltage to be dropped across \( R_4 \), rather than to be applied to the signal circuits of \( VT_1 \). An open in \( C_4 \) can, therefore, permit both motorboating and hum.

The filter condensers are another possible source of oscillation that you should not overlook. In some of the less expensive receivers, the output filter condenser must act as a by-pass for all plate supplies—the B circuits of all the tubes are brought directly to this condenser with no intervening R-C filters.

As we have said, an electrolytic condenser is a rather poor r.f. by-pass condenser at best, and an even worse one when it develops a high power factor. It is easily possible for this condenser to become so ineffective as an r.f. (or a.f.) by-pass that it will permit coupling between stages.

When this condition is suspected, and the receiver hum is not abnormal, you will probably find that a small paper by-pass condenser (.05 to .1 mfd.) connected in parallel with the output filter condenser will clear up the trouble. (In fact, many receivers have such paper by-pass condensers.)

Of course, if the hum level is abnormal, the filter condenser must be replaced as well.

**Shielding Troubles.** We have mentioned that a lack of shielding may cause trouble. Let's investigate this problem a little more closely, because there are several possible conditions.
A quick glance over the receiver while looking for surface defects will show you whether tube shields are missing or not, because you can see where shielding bases or shielding clamps are installed on the chassis. Naturally, if you see a base or clamp with no shield over the corresponding tube, you know the shield is missing.

In addition, you should always check the original tube list to make sure a metal tube originally used in the receiver has not been replaced by a glass tube. Receivers that are designed specifically for metal tubes will have no provision for shields, because metal tubes are self-shielding. However, if some serviceman has replaced a metal tube in the i.f. or r.f. stages with a glass tube, it is possible for feedback to occur. There are two possible cures here—you can either install a metal tube, or shield the glass tube.

Sometimes, even when the shielding is present, a poor electrical contact between the shield and the chassis makes the shield ineffective. Always suspect this possibility if the shield base is held to the chassis by rivets, because corrosion at the rivets may destroy the electrical contacts between the shield and the chassis. (A good check for this condition is to ground the shield to the chassis with the blade of a screwdriver. This should not affect the operation of the receiver; if it does, the shield-chassis contact is poor.) If the shield base does not make good contact with the chassis, it is advisable to drill out the rivet and use a bolt, a nut, and a lock-washer. This applies to shields used over r.f. or i.f. transformers as well as to those used over tubes.

Where the shield makes contact to the chassis through a spring, be sure that the spring presses tightly against the shield and that there is no corrosion between the spring and the shield.

Incidentally, while we are considering poor contacts—sometimes a poor contact at the rotor shaft of the tuning condenser gang is responsible for oscillation. As you know, the only contacts between the rotor shaft and the chassis are made through the end bearings and through the spring wiping contacts. Actually, the wiping contacts are depended on for most of the electrical continuity. If one of these contacts weakens, or if dust or corrosion collects under it, it will not make good contact to the shaft of the condenser. As you learned in your course, this will force the current that would normally flow through the contact to travel along the rotor shaft and flow through the other contacts instead. The linkage thus produced between the various tuned circuits may cause oscillation.

**Circuit Wiring.** One of the circuit stabilizing procedures of the receiver designer is to find the proper position for critical leads. This "lead dress" is frequently important—even a slight shift in lead position may increase feedback enough to cause oscillation. A serviceman may move one of these critical leads out of position when he replaces a part. Examine any oscillating receiver for evidence of previous repair. If it has been serviced before, check the manufacturer's service information; these often give instructions for proper lead positioning.

**Alignment Troubles.** Oscillation in a circuit may sometimes be the fault of improper alignment. We mentioned earlier that the Q of a resonant circuit has much
A missing shield is often the reason why a set goes into oscillation. Whenever you remove a shield from a tube, be sure to replace it before considering the repair finished. Do not depend on the operation of the set to tell you whether a shield is missing; it is entirely possible for a set to work properly for a while with a missing shield, only to go into oscillation later on because, say, the characteristic of some tube changes.

to do with the ability of a circuit to oscillate (the higher the Q, the greater the feedback voltage developed across the circuit when the feedback path is caused by stray capacitive coupling—see Fig. 2). This Q, in turn, depends upon the adjustment of the resonant circuits, and it is possible for there to be such a misalignment that the Q is affected. Also, the circuit may be adjusted so that the plate circuit is highly inductive, so that the feedback is in the right phase to cause oscillation if its path is through grid-plate capacity. In either case, realigning the receiver will frequently clear up the trouble. Since you have not yet studied alignment, this is something to remember for future reference.

Conditions Not Due to Receiver Defects. There are a number of conditions that are not receiver defects but will cause squeals. For example, there may be radiation from the local oscillator of some nearby receiver. This condition is obvious because the whistle will either "pass through" the signal to which the receiver is tuned, or, if it happens to remain on that station frequency, it will interfere only with that one station until the radiating receiver is again retuned. On the other hand, practically any case of receiver oscillation will cause a whistle on most (or all) received signals.

It is always possible that there will be a squeal or oscillation at the frequency on the broadcast band dial that is twice the i.f. frequency of the set. Thus, if the i.f. frequency happens to be 455 kc., there may be a squeal if you try to tune to a station at 910 kc. Again the condition is an obvious one because it occurs at only one frequency—not on all stations over the broadcast band.

There are several other conditions that may cause squeals when you tune to one or two stations, but do not cause squeals on all of them. For example, an excessively long antenna may feed in interfering station signals to such an extent that the preselector cannot cut them out. Also, when you tune to certain stations, harmonics of the receiver oscillator may beat with other stations to produce the i.f. frequency, and so may cause a squeal at some one or two points on the band.

Remember—squeals caused in any of the ways just given cannot be eliminated by repairing the set, because the set is not defective. You can shorten an antenna if it is the cause of squeals, and the i.f. setting may be changed somewhat (when you learn about alignment) when the second harmonic interferes with the desired station signal. Otherwise, there is little you can do but explain the reason for the squealing to the customer.

LOCALIZING OSCILLATION

Oscillation is not always as easy to localize as are some of the other troubles, because more than one stage may be involved. That is, feedback may go from one stage to a preceding stage one or two positions back toward the antenna. Making tests in one of these stages may kill the oscillations temporarily, as you will learn
a little later on, but this does not necessarily mean that you have found the defective stage. It may be that a defect in the other stage is really the cause, so you may have to locate both stages to cure oscillation permanently.

While you are confirming the complaint, determine whether oscillation can be heard at all times, whether or not a signal is tuned in. If it can, then the trouble is probably in the audio amplifier, although it may be in the i.f. stages. Turn the volume control on the receiver to the minimum volume position. If the oscillation is still audible, then it is definitely in the audio amplifier. However, if it disappears, either the feedback is through the volume control circuit, or the actual source of oscillation is in the i.f. stages of the receiver.

If the oscillation or squealing is audible only when stations are tuned in, but it occurs on all stations, the probable location of the difficulty is in the i.f. stages.

On the other hand, if the squeals are heard only when stations are tuned in, but they occur mostly at one end of the tuning band, the trouble is more likely to be in the r.f. or preselector stages of the receiver.

If the trouble appears to be in the audio section, you should first check for defective filter or by-pass condensers, since these are the only common sources of difficulty in the audio section of the receiver. The best test is to try other condensers across those you suspect (with the receiver turned on) to determine if the squealing or motorboating will stop while the test condenser is in place. If so, and the receiver then plays normally, replace the condenser across which the test condenser is being held.

If the trouble appears to be in the i.f. amplifier, check the screen-grid by-pass condenser and be sure the shielding is in place. However, if these obvious sources of oscillation are O.K., then it will be best to localize the trouble to a stage before making other tests.

Signal Tracing. A signal tracer can often be used to localize the stage that is oscillating. However, there is always a possibility that the tracer will stop the oscillation when the probe is brought near the section you wish to check, so do not expect the instrument to work in every single case.

The place to start with the signal tracer depends on where you have localized the oscillation. If the oscillation can be heard all the time, regardless of the position of the volume control, start your signal tracing at the first audio stage. On the other hand, if it can be heard all the time except when the volume control is turned down, start in the i.f. stages. Finally, if the oscillation is audible only when a signal is tuned in, start in the r.f. stages.

When you are tracing in the i.f. or audio stages, tune the set to some point on the dial where you do not hear a station. Start tracing at the first grid in the section and move back through succeeding grid circuits toward the loudspeaker. When you first hear the oscillation from the signal tracer as well as from the receiver, your probe is touching a stage that is involved in the oscillation.

If you are tracing in the r.f. section, follow the same procedure with a signal tuned in. Work from the input of the receiver toward the loudspeaker, tracing at each control grid in turn.
Remember that a metal tube is shielded by its own outer shell—
in other words, a metal tube is equal to a glass tube plus a shield.
Oscillation sometimes occurs because a serviceman replaces a
metal tube with its glass equivalent and neglects to shield the
latter. Always keep this possibility in mind when you service an
oscillating set. The tube complement list in the manufacturer's
service information will tell you which tubes should be metal.
Often this list is also on a label pasted to the chassis or cabinet.

➤ When you do not have a signal tracer, you must rely on other methods. Of these, stage blocking and signal injection are best for localizing the defective stage.

*Stage Blocking.* If the squeal or motorboating is audible all the time, even when a station is not tuned in, the stage blocking method of locating the trouble can be used. The procedures are like those used in localizing hum. That is, you can pull out tubes one at a time, moving from the output back toward the input, if the set is an a.c. receiver or an auto set with the tube filaments connected in parallel. As an alternative procedure, you can hold a .1 to .5 mfd. by-pass condenser across the grid input in a stage-by-stage test procedure. (When the chassis is connected to B—, the condenser is held between grid and chassis; otherwise the B— or grid return circuit must be located, and the condenser must then be held between the grid and B—.)

➤ Let's suppose you have an a.c. receiver and can pull out the tubes. Start with the first audio tube. If the oscillation disappears when this tube is pulled out, the trouble is either in this stage or in some stage nearer the input of the receiver. If it continues, however, the power output stage is oscillating.

If the oscillation stops when the first audio tube is out of its socket, re-insert this tube, and pull out the second detector if it is a separate tube. If the second detector is in the same tube envelope as the first audio tube, then pull out the last i.f. tube instead. Continue moving in this manner back toward the input until you find a tube that can be pulled out without killing the oscillation. The stage next toward the loudspeaker is then the one in which the oscillation is occurring.

➤ The by-pass condenser method of stage blocking can be used in almost exactly the same manner and will work on a.c.-d.c. and battery receivers as well as on standard a.c. sets. Try the condenser first from the grid of the power tube to the chassis (or to B— if the chassis is not connected to B—). This should kill the oscillation unless it is occurring in the power stage.

If it does kill the oscillation, then move back to the grid circuit of the first audio tube, and again try your condenser across the grid input. If this kills the oscillation, connect the condenser across the load of the second detector. If the oscillation is killed, use your condenser across the grid input of the i.f. tube. By moving back in this manner, you will eventually reach a grid circuit where the oscillation is not affected. When you do, the stage next toward the loudspeaker is again the guilty one.

Remember at all times, however, that more than one stage may be involved. If you can find no defect in the stage you believe to be at fault, or if repairing whatever defect you do find does not put an end to the oscillation, make a careful check for defects in each of the other stages between the suspected stage and the loudspeaker. Start with the stage next to the suspected one. Incorrect placement of leads, stray magnetic coupling, or a defect in a by-pass condenser used in both stages are the most common causes of this inter-action between stages.

*Signal Injection.* If the oscillation can be heard only when a signal is tuned in, it may be possible to use a
signal generator to localize the defective stage. To do this, tune your s.g. to the same frequency as that to which the receiver is tuned, and connect the s.g. to the input terminals of the set. Connect the s.g. ground lead to the chassis, and the “hot” lead to the antenna post. You should now hear the squeal along with the signal generator modulation tone. If you wish, you can use the signal generator unmodulated and allow just the r.f. signal to come through; in this case, you will hear only the squeal.

When you are sure that you are hearing the oscillation, move the s.g. back toward the output. In other words, move the hot lead from the antenna terminal to the grid circuit of the first detector. If you still hear the squeal, change the signal generator setting to the i.f. frequency, and move the hot lead to the grid of the first i.f. tube. Continue in this manner to the input of the second detector. There is no need to check in the audio section, because you know from the fact that the squeal occurs only when a signal is tuned in that the defect must be in the r.f.-i.f. section.

This test shows you the opposite of what the blocking test reveals. When you connect the generator and fail to hear the oscillation, the trouble is in the next stage back toward the antenna or in the stage to which the signal generator is connected. The latter is a possibility because the signal generator detunes and loads the circuits across which it is connected, so it can actually kill oscillation when it is connected to the defective stage.

Once you have found the defective stage, shunt its by-pass condensers with others to see if a condenser is open, and check the operating voltages. Also, check the shielding to see that it is in place, and check its grounding by touching it and the chassis firmly with a screwdriver blade. Examine the circuit for evidence that someone has tampered with the wiring. If you do not have any instructions for lead positioning, try moving the grid and the plate leads in the oscillating stage with an insulated probe or pencil. Have a signal tuned in, and watch for a change in pitch of the squeal. If a change in pitch occurs, try to find a wire position that will cure the

Two major requirements for becoming a professional serviceman are good training and determination to get ahead. Given these, even a serious physical handicap is no bar to success. This graduate is an inspiring example. Although he is confined to a wheelchair, NRI training and his own will-to-win have allowed him to build a very successful radio servicing and merchandising business for himself.
oscillation. In general, grid and plate leads should be kept short and should be separated as much as possible. If the trouble persists, try another tube and realign the circuit. (A later Booklet will show you how.)

NRI PRACTICAL TRAINING PLAN

Introducing oscillations into the receiver you are using for practical training may or may not be easy. Many radio receivers are so stable that you can change the bias or remove shielding without causing oscillation.

Of course, disconnecting a screen-grid by-pass condenser will almost invariably cause the trouble. Also, deliberately increasing the length of the grid and the plate leads in an r.f. or i.f. stage will usually produce squeals.

You can try these, one at a time, to introduce oscillation and to get practice in isolating this defect. Then, try creating the other conditions described in this Booklet. However, don't upset the alignment in your efforts to introduce oscillation; wait until you have learned to align receivers before taking this step.

COMMON CAUSES OF OSCILLATION

These causes of oscillation are listed according to the symptoms they produce, with the most common first.

1. Oscillation audible whether or not a station is tuned in and regardless of position of volume control.
   The defect is in the audio stages. Possibilities: open filter or by-pass condenser.

2. Oscillation audible whether or not a station is tuned in, but affected by position of volume control.
   The defect may be in the i.f. stages, in the second detector, or in the first a.f. amplifier. Possibilities: open filter or by-pass condensers; shielding missing or making poor contact; alignment off; excessive screen grid voltage; leads improperly placed.

3. Oscillation audible only when station is tuned in, occurs on all stations.
   The defect probably is in the i.f. stages, but may be in the r.f. Possibilities: open by-pass condensers; shielding missing or making poor contact; alignment off; excessive screen grid voltage; low bias; leads improperly placed.

4. Oscillation audible only when station is tuned in, occurs primarily at one end of tuning band.
   The defect is in the r.f. stages. Possibilities: open by-pass condensers; shielding missing or making poor contact; poor contact at tuning condenser rotor shaft; excessive screen grid voltage; low bias; alignment off; leads improperly placed.
No. 24 How To Fix a Noisy Receiver

RADIO SERVICING METHODS
NRI TRAINING PAYS...

Dear Mr. Smith:

When I enrolled with NRI I was a cotton mill hand, making only $8 to $10 per week. I even had to put off a bill I owed to make my first payment. The Course soon more than paid for itself, and my income rose steadily. In four years I have reached an income of over $3000 a year. I owe it all to NRI.

C.W.H., Georgia

COPYRIGHT 1947 BY
NATIONAL RADIO INSTITUTE
WASHINGTON, D.C.

HOW TO FIX A NOISY RECEIVER

WE say a radio is noisy when it makes popping, cracking, sputtering, frying, or rushing sounds. The crashing static heard if you attempt to listen (with an a.m. receiver) to a radio program during or just before a thunderstorm is a good example of noise.

Like hum and oscillation, noise is the result of adding interfering voltages to the signal voltage. Noise may be caused by a defect in the set, but it may also be caused by external interferences—atmospheric conditions, for example, or "man-made" interference resulting from arcing or sparking in electrical equipment.

Since noise may be caused by some external condition over which you have no control, it is not always possible for you to stop the noise. Therefore, the first step in servicing a receiver for noise is to find out if the set is defective or if some outside interference is to blame. Let's see how this is done.

LOCALIZING THE NOISE TO THE SET

Noise impulses can get into the receiver from an outside source through the antenna-ground system or through the power line. Also, if the receiver is in a powerful noise field, the chassis itself (and exposed wiring on it) may pick up noise voltages directly. Therefore, to determine whether the noise is being picked up or is originating within the set, you will have to block these paths to prevent the noise voltage from getting into the set.

Disconnect the Antenna. The first step is to discon-
nect the antenna from the receiver. (If the set has a built-in or loop antenna, follow the directions given later.) With the antenna disconnected, connect a short piece of wire between the antenna and ground posts on the receiver. This effectively prevents noise pickup by the antenna system. If a ground is used on the set, leave it connected temporarily, but connect the antenna itself to the ground, or move it well away from the receiver.

With the volume control turned full on, listen to the receiver. If the noise has decreased greatly or has disappeared altogether, probably the noise source is outside the set.

If the receiver has a loop antenna, try rotating the loop (or the entire receiver cabinet). Since loop antennas are rather directional in their receiving characteristics, any change in noise level as you rotate the loop indicates that the set is picking up the noise from some external source.

When a built-in antenna “hank” (a length of wire permanently fastened to the set) is used, roll the wire up so as to reduce its effectiveness as an antenna. If this reduces the noise level, the antenna is picking up the interference.

If the noise is still strong, continue the tests to determine whether the noise is originating in the set, or is coming in over the ground or power line.

Disconnect the Ground Lead. If the noise level remains the same when the ground lead is disconnected, the receiver is at fault, or the noise signal is coming in over the power line. However, if the noise decreases, you may have a poor ground. If it increases, the noise signal is probably coming in over the power line.

Filter the Power Line. You should have a power line filter — various commercial ones are available — for checking for noise coming over the power line. Fig. 1 shows how the filter is installed; you plug the filter into the wall outlet, and then plug the radio into the filter. This filter, which consists of by-pass condensers and r.f. choke coils, reduces the amount of r.f. energy traveling down the line to the receiver. If the filter reduces the noise, the noise voltage is coming in over the power line.
On the other hand, if the noise remains the same for all these tests, either the receiver is noisy, or it is picking up noise directly because of exposed wiring or because of its location.

**Using a Test Receiver.** Sometimes these tests will not be conclusive. If you are not sure whether the receiver is defective or whether the noise is of external origin, you can try another receiver in the same location as the suspected one. A small three-way portable receiver is excellent for this purpose. To make a test with such a portable, proceed as follows:

Turn on the customer’s receiver so that the noise can be heard and identified. Then, disconnect the antenna from the customer’s receiver, and connect it to the aerial post of the test receiver. Plug the power cord of the test receiver into the outlet, turn on the test set, and tune it to see if the same noise is picked up. If the noise is heard on the customer’s receiver but not on the test receiver, the customer’s set is probably defective. If noise is heard on both receivers, the noise is probably being picked up.

If the noise is apparently being picked up, try the test receiver on its built-in battery supply, unplugging its cord from the wall outlet. If the noise disappears, it was coming in over the power line. If it is still present, it is being picked up by the antenna. In the latter case, disconnect the antenna from the test receiver. If the noise decreases greatly, it is definitely being picked up by the antenna.

If you have no test receiver, you can take the customer’s set to your shop. If the set is noisy in this new location, it is probably defective. On the other hand, if the set plays normally and quietly on your work bench, but is noisy in the home of the customer, then the noise signal is being picked up.

**Procedure for External Noises.** When you find that the noise originates outside the set itself, the exact procedure to take will depend upon just what you think is causing the noise. If the trouble is atmospheric disturbances, explain to the customer that the noise will go away as soon as any nearby thunderstorms clear up. (Incidentally, f.m. receivers have very little trouble with atmospherics, but they do pick up interference from automobile ignition systems and other man-made sources.) Man-made interference arises from poor contacts in heating pads, arcing between sections of neon signs, sparking commutators on motors, sparking at switches, etc. It can be removed only by installing special filters on the offending device. However, man-made interference is too broad a subject to be covered here. We shall limit ourselves in this RSM Booklet to a discussion of defects within the receiver or associated with the receiver installation.

**INSTALLATION DEFECTS**

Once you discover that the noise voltage originates outside the set, examine the installation carefully, because a defective antenna or ground system or a loose connection at the wall outlet may be the source of noise.

For example, if the noise disappears when the antenna is disconnected, reconnect the antenna lead-in to the receiver, and then shake the lead-in both near the receiver and outside the home to see if this causes the noise to appear and disappear. If the noise varies as the antenna lead-in is moved, there is probably a broken connection or another defect in the antenna system; go over it carefully.
Similarly, shake the ground wire. Many people wrap the ground wire loosely around a radiator pipe. After a time, corrosion will set in between the wire and the pipe, or the wire may oxidize because of the heat. Either condition will partially insulate the wire from the pipe; then any movement of the wire may make and break contact between them, and cause noise.

If you find such conditions, see if it is possible to connect the ground wire to a cold-water pipe. Also, use a ground clamp to make good contact between the ground wire and the pipe to which it is connected.

Sometimes the noise is caused by a poor joint in the heating system. Kick the pipe leading to the radiator to which the ground wire is connected. If this causes noise, but a good connection is maintained between the ground wire and the pipe, there is probably a poor electrical contact somewhere in the pipe. Plumbers use a paint or dope in the joints between pipes to seal them and prevent the escape of water and steam. This seal prevents a good electrical contact, and as corrosion develops and joints loosen, the contact becomes poorer.

Sometimes the noise will occur or increase when you move about the room near the radio. Once in a while this means the receiver is defective, and you are jarring it enough to set the noise off. However, it often indicates that the pipes in the plumbing system under the flooring are barely touching each other and are making and breaking contact as you move about. This changes the effectiveness of the grounding system and will cause noise. The remedy is to locate the pipes, and then either use two ground clamps and a piece of wire to make permanent connections between the pipes, or separate them permanently by placing a wooden wedge between them.

Shake the power cord going to the receiver, also, because a poor contact can develop at the wall outlet—particularly if cube taps are used to allow a number of devices to operate from the same outlet. These taps rarely make good contact and can cause considerable noise to develop. If you suspect this, disconnect everything from the wall outlet except the radio. Plug it in carefully; if necessary, bend the prongs on the radio plug to make a better contact. If the junction is still poor, the wall outlet itself may be worn and in need of replacement; try plugging the radio into another outlet to see if the noise disappears.

**WHAT CAUSES NOISE IN A SET**

Noise is produced by a voltage pulse of irregular waveform. When a noise voltage gets into a signal circuit, it is amplified and passed on just like any other signal. A single noise pulse causes the loudspeaker to emit a single thud, bang, or click; when the noise pulses are close together, a continuous noise results.

Unlike hum, a noise voltage will pass through r.f. stages without being modulated on a station carrier. In other words, noise may enter the r.f. section though the receiver is not tuned to a station. This is possible because the noise pulse has sufficient energy to shock-excite a tuned circuit and cause it to oscillate at its resonant frequency, thus generating a small r.f. pulse that will carry the entire noise pulse with it through the stage.

These sudden voltage surges (noise pulses) are usually caused by a poor connection. For example, a poorly soldered joint in the plate supply lead of some tube may open intermittently. Each time it opens, the plate current will drop suddenly, and a noise pulse will be produced; each time it closes again, the current will rise.
A carbon control should not be used in a circuit where 
d.c. current flows; the current produces sparking where 
the contact arm touches the resistance strip, burning 
the strip and causing it to wear out rapidly. Even so, 
you will frequently find a carbon control used as a diode 
load as in Fig. 2A. When you replace such a control, you 
can lengthen the life of the new control considerably by 
isolating it from d.c. as shown in Fig. 2B. The only 
change involved is the use of a resistor $R_a$ as the diode 
load, and the use of $C_a$ as a coupling condenser to the 
control. The resistance of resistor $R_a$ should be between 
50,000 ohms and 250,000 ohms, and as near to the resi-
dance of the original volume control as possible with-
in this range. The new control should have the same 
taper as the original and should be about 500,000 ohms. 
The condenser $C_a$ can be from .05 mfd. to .1 mfd.

Wire-Wound Resistors. Wire-wound resistors are 
apt to cause noise, especially in older sets. (They are 
not widely used in modern receivers.) If pulling on wires 
going to the taps of a wire-wound resistor causes noise, 
you can be sure the resistor is defective. If the resistor 
is a Caddock type (a wire-wound resistor enclosed in a 
metal can) riveted to the chassis, you can test it by
springing out the resistor unit enough to subject it to a mechanical strain. (Insert a screwdriver blade between the resistor can and the chassis, and twist it to cause this strain.) If this causes a sudden appearance or disappearance of the noise, the unit is defective. A defective wire-wound resistor of any type should be replaced.

**Transformers.** We shall discuss several kinds of transformers in this section, because the same methods of localization and cure are used for each.

Noise originating in a transformer is normally caused by electrolysis (electro-chemical corrosion) at a soldered joint or terminal of the transformer (sometimes, also, between layers of windings). This corrosion will eat through the fine wire of the transformer and thus break the connection. However, the ends of the wire are so close together that arcing occurs across the break. Thus, the circuit is intermittently and rapidly opened and closed, producing sharp changes in the current. This causes machine-gun-like bursts of noise, often so loud they drown out the program.

This form of electrolysis occurs most commonly in a coil that carries d.c. current. Therefore, you can expect the primary windings of transformers to be more affected by this trouble than the secondaries. It is also more apt to occur in a damp climate; in fact, if you live in such a climate, you may find that transformers are a very common source of your noise complaints. In modern receivers, the i.f. transformer is the one that causes the most trouble. The output audio transformer is next, and the r.f. transformer is third in this respect. It is seldom that noise is caused by a power transformer winding, probably because the wire used is so large that electrolysis cannot readily eat all the way through it.

You can check a suspected transformer with your ohmmeter or voltmeter. An ohmmeter test is not always conclusive, because there is at times only a partial open, or the circuit may be completely rejoined at the moment the ohmmeter is used. If you do not find an open at once, hold the ohmmeter test probes on the winding for a few moments to see if the resistance reading changes. If it does, the transformer is defective.

Since the primary winding (in a plate circuit) is the one most affected, the noise will occur while the set is in operation and the tube is in the socket, but should disappear when the tube is removed from the socket. As a further test (with the tube removed), measure the plate-to-cathode voltage. The voltmeter draws current through the transformer, and the noise may reappear when the meter is connected. Also, the voltmeter reading will vary erratically if the transformer is defective.

If you can see green corroded spots on the winding, you have definite proof that electrolysis is at work. Either the transformer is defective, or it soon will be.

![Image](https://example.com/image.png)

**Use a test lead equipped with probes to short from a tube plate socket to the chassis. It’s easier than getting a screwdriver into the restricted space. (For simplicity, we have shown no parts or wires connected to the socket in this illustration.)**
If you suspect a tube has loose elements, snap it with your finger. A burst of noise from the set indicates your suspicions are probably correct.

Do not consider that the defect has been repaired, because it will recur shortly.

Each of the above tests is for the primary winding. If the trouble is in a secondary winding, then the ohmmeter test can be used. Also, you can momentarily short the B supply through the secondary winding of the transformer by holding a test lead between B+ and the grid end of the transformer. This again may open the transformer, thus indicating the location of the defect.

A defective transformer must usually be replaced. Sometimes, as you learned in an earlier Booklet, it is possible to repair a winding if corrosion has occurred at only one end.

Wave-Band and Push-Button Switches. Dirty and loose switch contacts in signal and voltage supply circuits are prolific sources of noise. You can locate these readily, since you will hear noise when you operate the switch.

Usually, you can clean dirty contacts with a tooth brush dipped in carbon tetrachloride. You can often restore lost tension by bending the contacts with a pair of long-nose pliers. Of course, the receiver must be turned off while you are working on the switch.

If cleaning the contacts and bending the contact fingers does not clear up the trouble, then it will be necessary to replace the switch. However, it is advisable to avoid this if possible, because an exact duplicate switch is not always easy to obtain and may be difficult to install.

Tubes. Loose elements or poor internal contacts are the defects that cause tubes to make noise. You can usually locate a tube with loose elements by snapping it with your finger while the set is turned on. If this makes the noise increase, try another tube in the same socket. If the noise then decreases, the original tube must be defective. However, if the noise continues with a new tube, you probably were jarring some nearby part, or have a defective socket.

A certain amount of hissing and frying noise heard when the set is not tuned to a station may be caused by irregularities in the electron emission in tubes. This is not really a defect, however, because the noise will be swamped by the incoming signal when a station is tuned in.

When you find a noisy tube, be sure you destroy it so that it cannot possibly get back into use and cause trouble again. This is necessary because the tube may still test O.K. in a tube tester.

Tuning Condensers. Dirt between the plates, warping or shifting of the plates, or poor contact to the rotor may cause a tuning condenser to produce noise. Usually the noise will become much worse as the tuning dial is rotated, and the set may be dead over a portion of the low-frequency end of the tuning range.

When you meet this condition, examine the condenser carefully. If the plates all seem to touch, the stator section has probably shifted its position. This can occur only if the stators are held to the insulating strips by screws. To make a repair, loosen all the screws, re-space the stator plates, and tighten the screws firmly.

If only one or two of the plates touch, they are probably bent or warped. Straighten them with a thin-bladed knife, a putty knife, or a spatula.

You can clean out dust and dirt from between the
plates by blowing between them with compressed air or by passing a pipe cleaner (obtained at tobacco stores) between each set of plates in turn.

**Poor Contacts.** Various other kinds of poor contacts can cause noise. Poorly soldered joints are frequent offenders. Always be sure you do a good soldering job yourself—and examine any noisy receiver for evidence of poor soldering by some other serviceman. If solder appears to be lumped or cracked, pull on the leads, and wiggle parts to see if you can make the noise start or stop. Sometimes you can locate a defective joint by pushing on the joints with a wooden stick. When there is any doubt, resolder the connection.

Watch out for drops of excess solder that hang down from a joint and cause a partial connection to the chassis. Remove any you find.

➤ A poor contact can also exist at a bias cell. These bias cells are held in small holders that depend on spring tension for contact. Sometimes it is necessary to clean the cell or to strengthen the contact.

➤ Once in a while a shield over a tube or over another part will be a source of noise because it makes a poor contact to the chassis. Normal speaker vibration will shake the shield and thus vary the contact. To improve the contact, tighten the screws holding the shield to the chassis, or bend the shield if it is a pressure fit. If the shield is fastened by rivets, drill them out, and use machine screws, lock washers, and nuts in their places.

**Leakage Paths.** Sometimes arcing occurs across a dirty or moist bakelite part, producing a charred path of low and varying resistance. Leakage current flowing along this path will also vary, causing noise.

This sometimes happens to tube sockets, particularly those of rectifier tubes. In this case, you will hear a sizzling sound, and, with the lights turned off, you may be able to see the arcing. It is best to replace the socket. Sometimes you can make a repair by scraping away all the carbonized material and painting the spot with speaker cement. This should be considered a temporary repair, however, although it will often last a long time.

**Less Common Noise Sources.** There are several other

---

![Diagram of R.F.-I.F. Section, Volume Control, A.F. Section](image)

Always remember that the volume control separates the r.f.-i.f. section from the a.f. section in modern sets. This fact lets you locate the defective section very quickly when the complaint is hum or noise. Just turn the volume down—if doing so affects the hum or noise, the complaint is originating in the r.f.-i.f. section.

less common causes of noise. For example, some small receivers use a Hank antenna—a flexible wire that is laid on the floor under a rug or around the room. If walking back and forth over it breaks the wire, noise may result because of the intermittent contact.

Wet electrolytic condensers sometimes cause noise because of internal arcing. This trouble is not common today because wet electrolytic condensers are not widely used.

Fixed resistors of the carbon or composition type are rarely at fault unless there has been a complete break. If the resistor element does break, however, an intermittent contact may produce noise.

**LOCALIZING THE NOISE SOURCE**

Certain clues will lead directly to the noise source. As we have already said, a change in noise level when you operate the wave band or a push-button switch, the volume control, the tone control, or the tuning condenser, indicates that the device is at fault. Even if you do not have any of these clues, the noise can be localized to a section rather simply. (We are assuming that the noise has been localized to the receiver.)

In the modern receiver, the volume control is either the diode load or is in the input circuit of the first a.f. tube. Therefore, the volume control separates the r.f.-
i.f. section from the audio section. If you turn the volume control to the minimum volume position and the noise disappears, its source is in the r.f.-i.f. section of the receiver; if it remains, its source is in the audio amplifier or in the power pack. (This is not always true—severe changes in current, such as may be caused by a plate circuit defect in an r.f. or i.f. tube, may affect the power supply to the audio amplifier even when the volume control is turned to zero volume. However, in such cases, turning down the volume control will decrease the noise intensity greatly.)

LOCALIZING NOISE TO A STAGE

Noise signals pass through the stages in the same way as other signals do. Their source can be located with a signal tracer, or stage blocking can be used.

To use a signal tracer, tune to some quiet point on the dial. Trace from the first stage of the defective section towards the set loudspeaker. When you first hear the noise coming from the signal tracer speaker, you have located the defective stage.

> Remember that noises caused by defects in common power supply circuits may feed into a number of stages, so it is possible to pick up a noise signal in the plate circuit of one tube when the noise is actually originating in a later stage. This can occur only when the noise signal is unusually strong, or in sets in which there is insufficient by-passing of the supply leads.

Once the defect has been isolated to a stage, check the voltages in that stage to determine which voltage seems to be varying. This may provide an additional clue to the defective circuit.

If you use the stage blocking method, start from the second detector. Work toward the loudspeaker if the trouble is in the audio section, toward the antenna if the trouble is in the r.f.-i.f. section.

When the receiver is a standard a.c. receiver with tube filaments in parallel, it is possible to pull out tubes to block stages. For example in Fig. 9 let's assume first that the noise is in the a.f. amplifier. In this case, you can pull out tube Vf5. If the noise stops, but continues when this tube is in the socket and the volume control
is turned to minimum volume, it must be originating in the first a.f. circuit. Assuming that the volume control is good, the most likely source of noise in this circuit is the tube itself.

If the noise continues with tube VT2 out of the socket, it is originating in the output tube stage. Here, a defective output transformer or tube is the most likely cause.

► If, instead, the noise is in the r.f.-i.f. section, turn the volume control to maximum volume and remove tube VT2. If the noise continues with this tube removed, it must be originating in the diode detector stage; tube VT1 and the volume control are the most likely suspects.

If the noise stops when VT2 is removed, replace this tube and pull out VT1. If the noise continues, it is probably originating in the VT1 stage. I.F. transformer T3 and the tube are the most likely source of trouble here.

Of course, if the noise ceases when VT1 is pulled out, it must be originating in that circuit. I.F. transformer T3, the tube, the oscillator transformer T1, the loop antenna L1, or either of the tuning condensers (C1 and C2) could be at fault. Examine each carefully.

To determine whether the noise is in T3, leave VT1 out of the socket, and connect a voltmeter between the plate terminal of the VT1 socket and the chassis. The voltmeter current will then be drawn through the primary of T3. If the noise occurs now, but does not with the voltmeter disconnected, the primary of T2 is defective.

► Of course, if the receiver is not a standard a.c. set, you can’t pull out the tubes. In this case, block the grid or plate circuits. It is easiest to block grid circuits, and the simplest way to do so is to connect a large by-pass condenser (.25 mfd. to .5 mfd.) across the input device.

condenser (.25 mfd. to .5 mfd.) across the input device. If the chassis is connected to B — this is rather easy — you can connect the condenser between the control-grid terminal of the tube, and the chassis. Otherwise, you must find B — and perhaps use a test lead to connect one terminal of the condenser to B — while the other end is held to the grid terminal of the tube.

To use this method, first hold the condenser across the grid resistor of the output tube, (Using Fig. 3 as our example, this would be VT1) If the noise stops, the trouble is nearer the antenna; if it continues, it must be originating in the output stage.

If the noise stops when the grid of VT1 is blocked, move back to the grid of VT3. If the noise now continues, it is originating in VT3 or in the coupling between VT3 and VT1.

You can move through the r.f.-i.f. section of the receiver in a similar manner. Blocking the grid of VT3 will eliminate any noise originating nearer the antenna, so, if the noise continues, it is arising in the VT1 plate circuit or in the diode detector circuit.

Since a large condenser is not too good as an r.f. bypass condenser, use a smaller condenser (say .05 mfd.) between the grid of VT1 and the chassis. If the noise stops, it is originating in the L1-C2 circuit. However, if the noise continues, it may be originating either in the plate circuit of VT1 or in the oscillator circuit. The oscillator circuit can be eliminated by temporarily short-circuiting condenser C1 with a screwdriver. If this kills the noise, the oscillator circuit is at fault.

► It is possible to block plate circuits by the same method. However, there is always danger of getting a shock. Furthermore, the condenser will charge or discharge each time you use it; in some low-voltage plate circuit, there may be a heavy enough discharge current to weld the defective connection temporarily. This may leave you without a clue to the defective part until the noise returns later. Blocking the grid circuit does not have these disadvantages.

► Almost the only other quick stage localizing test besides stage blocking (when the only test equipment is a
signal generator and a multimeter) is to strike the chassis with your palm. If this intensifies the noise, or changes its volume, try jarring different places about the chassis. Usually one part of the chassis (or a certain tube) will appear more sensitive to jarring than the rest. You should then wiggle leads and pull on parts in the nearby stage or stages. Very frequently this will localize the noise.

**THE NRI PRACTICAL EXPERIENCE PLAN**

It is not possible to duplicate all the parts defects described in this Booklet on your test receiver. However, this is not important. In servicing a noisy receiver, the real job is in localizing the noise to a stage, and that is what you should learn to do now.

Try to make a poor connection that will cause noise when the receiver is jarred. Hold your soldering iron tip on the plate socket terminal of one tube, and grasp the lead going to this terminal with your pliers. When the solder melts, remove the iron, and wiggle the lead while the solder hardens. This will cause a loose connection. Next turn on the receiver, and when it warms up, jar the chassis with your hand. Noise should result. If it does, proceed to localize the trouble by the procedures we have described. Try this on several tube socket terminals. Be sure to resolder carefully these connections when you have finished.

When you service a receiver—for noise or for any other complaint—try several different localization tests after you have found the defect. For example, you may find a noisy tube almost at once. However, leave the tube in the set and try other localization tests to see how they work out. Do the same for other defects. In this way, you will learn the method that works best for you for each particular kind of difficulty.

---

**COMMON CAUSES OF NOISE**

<table>
<thead>
<tr>
<th>Type of Noise</th>
<th>When Noticed</th>
<th>Parts to Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scratching</td>
<td>Tuning set</td>
<td>Condenser gang</td>
</tr>
<tr>
<td>Scratching</td>
<td>Adjusting volume or tone control</td>
<td>Control adjusted</td>
</tr>
<tr>
<td>Crashing</td>
<td>Changing wave band</td>
<td>Wave band switch</td>
</tr>
<tr>
<td>Steady or intermittent rushing</td>
<td>Between stations and on weak stations</td>
<td>Antenna, antenna coil, mixer tube</td>
</tr>
<tr>
<td>Steady crackling</td>
<td>Always</td>
<td>L.F. or a.f. transformer primary</td>
</tr>
<tr>
<td>Intermittent crackling</td>
<td>If chassis is jarred</td>
<td>Tube or connection</td>
</tr>
</tbody>
</table>
No. 25 How To Fix a Receiver That Distorts

RADIO SERVICING METHODS
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

DISTORTION 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 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 possible 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 C7 in Fig. 1. When this condenser becomes leaky, it acts like a resistor; the B supply voltage then divides between R5, C8, and R9. The polarity of the resulting voltage across R9 is shown in the diagram. As you can see, the R9 voltage subtracts from the normal bias voltage developed across R4, decreasing the negative voltage on the control grid of VT2, and in some cases actually making the control grid positive with respect to the cathode. As a result, the grid of VT2 draws current and may cut off the peaks of the signal, thus causing distortion.

The same result will also be produced if tube VT2 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 VT2 in Fig. 1 becomes gassy,
current will flow in the control grid circuit. Electrons will flow through $R_4$ to the control grid where they will join with positively charged gas ions. The current flow through $R_4$ 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 $R_4$, 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 $R_4$. If the receiver is a.c.-operated and has a power transformer, pull VT2 out of its socket. If the voltage across $R_4$ disappears, the tube is gassy, and a new one must be installed. If the voltage is still present with VT2 removed, $C_3$ 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 VT2 from its socket. Instead, with the power turned off, unsolder one lead of $C_3$, then turn on the receiver again. (The voltmeter should still be connected across $R_4$.) If a reading is obtained with $C_3$ disconnected, the tube is gassy; but if no reading is obtained, $C_3$ is leaky.

Once in a great while you will find $C_3$ leaky and VT2 gassy at the same time. In this case the voltage will drop when $C_3$ 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 6S7 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 VT1 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 $R_1$) 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 $C_b$. This latter defect allows the a.v.c. voltage developed across $R_1$ to be applied to the control grid of $VT_b$, thereby increasing the negative bias on this tube and causing it to operate on the lower bend of its $E_C-I_C$ curve. When the volume control is adjusted to give louder reception, more of the a.v.c. voltage is applied to $VT_b$, 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 $R_1$ 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 $C_b$.

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 cause distortion. The condition we just described (a leaky condenser $C_b$ 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 $R_1$ (the bias resistor for $VT_a$) may open. The leakage resistance of condenser $C_b$ will then complete the plate circuit, but this leakage resistance is far higher than the resistance of $R_{25}$, which is normally a few hundred ohms. Therefore, there will be a rather large voltage drop across the leakage resistance of $C_b$. Of course, this means that a high bias will be applied to the grid of $VT_b$, so distortion will occur. (If $C_b$ has a very high leakage resistance, the set will be entirely dead.)

At the other extreme, condenser $C_b$ 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 $R_{16}$, $VT_b$ is biased by the drop across resistor $R_{10}$, and the voltage across both $R_{16}$ and $R_{15}$ acts as the grid bias for $VT_b$. 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 $C_n$, or tube $VT_2$ becomes slightly gassy. Either defect will cause the voltage across $R_4$ 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 $R_4$ and $R_{10}$) will also increase. (Of course, a large amount of leakage in $C_n$ 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 $R_4$, $R_5$, and the resistance of your hand to the 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 $R_4$, $R_5$, 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 $C_n$ 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 correct 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 VT1 in Fig. 5, distortion occurs if the plate voltage drops even slightly. For example, let's suppose condenser C8 becomes leaky. This effectively connects a resistance (the leakage resistance of C8) between the R3-R4 junction and the chassis. This leakage resistance acts as a voltage divider with R4, so the plate voltage of VT1 is lowered. The bias on VT1, however, remains normal, because the bias is determined by the voltage drop across R20, which in turn is determined mostly by the plate current of VT2. 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 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 C8 or gas in VT7; the second condition (normal bias, low plate voltage) can be caused by leakage in C8 or C9. To find out which condition you have, see if you can find a d.c. voltage across R6. If no voltage exists across it, C8 and VT7 are probably all right, and you should check C9 and C8 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 VT1 from its socket and then measure for voltages across resistors R5 and R6. There should be no voltage drop across either resistor when the tube is out of its socket. If there is a drop across R5, then the tube is leaky. If a drop exists across both resistors, then C8 is leaky.

In receivers where VT1 cannot be pulled from the

**FIG. 5.** This circuit is the same as that in Fig. 3. It is repeated here for your convenience in reference.
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 receiver 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
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 C1 or a gassy tube VT2 does not cause distortion in the grid circuit of VT1—the signal across R9 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 C2 in Fig. 1. To give the effect of leakage in the condenser, connect a 50,000-ohm, 1/2-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 C2 will increase the distortion. Do not use too low a value—VT2 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 R9, the positive meter probe going to the grid of VT2, and the negative
probe to the chassis. The meter will read upscale, showing that d.c. is flowing through \( R_2 \). Leaving the meter in place, unsolder one lead of \( C_2 \) and one lead of the shunting resistor. Note that the voltage across \( R_2 \) 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 \( C_4 \) 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 \( R_4 \) 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 \( C_2 \) is leaky. Remove the shunting resistor across \( C_4 \).

**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 install 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 \( C_5 \) 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 \( R_5 \) 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 \( C_5 \).

**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 hear 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 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.
Dear Mr. Smith:

I commenced to repair radios three months after starting the Course. By the time I graduated I had made a net profit of $657 from spare time work. I am still in spare time work, making something every week and at times turning down jobs because I get too many to handle. You will never know how glad I am that I took your Course, for if anything should happen to my job I won't have to worry; I have something to fall back on.

J.C., New York

How To Align Simple One-Band Receivers

ALIGNMENT is the name applied to the process of adjusting the tuned circuits of a receiver to give the set maximum sensitivity and selectivity and make stations come in at the right points on the dial. This is a part of most service jobs. There are many service complaints, particularly those involving weak reception (low sensitivity), that are caused chiefly by poor alignment. In addition, in the great majority of radio jobs in which an overhauling is involved, the set must be realigned to restore it to maximum performance.

Provisions for alignment are found on practically all radio receivers. Set manufacturers know that the natural aging of coils and condensers in the tuned circuits, or changes in the electrical values of these parts caused by vibration and temperature variations, throw even a perfectly aligned set out of adjustment after a period of time. And, of course, the manufacturer provides adjusters for his own convenience in aligning the set in the first place.

As you know, a resonant circuit can be tuned to a desired frequency by varying either its capacity or its inductance. In modern radios, the variable tuned circuits are ganged—that is, they are tuned simultaneously by moving a single shaft (the tuning shaft). In capacity-tuned sets, this shaft operates an air condenser
having two or more sections; in inductance-tuned sets, the shaft varies the position of powdered iron cores in two or more coils (thus varying their inductance). Alignment adjustments are usually made in capacity-tuned sets by varying the capacities of trimmer condensers that are connected in parallel with the sections of the main tuning condenser. No extra trimmers are used in inductance-tuned sets; instead, alignment adjustments are made by turning screws or nuts that change the positions of the powdered iron cores in their coils. (In some capacity-tuned sets, also, low-frequency adjustments are made by varying the inductances of coils in the tuned circuits.) Fig. 1 shows an adjustable inductance.

The resonant circuits used in the i.f. stages of a superheterodyne are also adjusted by varying either their capacity or their inductance. Adjustment of these circuits is part of every alignment job.

The alignment of t.r.f. sets and simple one-band superheterodynes by setting these adjustments is a fairly simple matter. The complete procedure for these receivers will be covered in this booklet; the alignment of multi-band, high fidelity, and FM sets will be taken up later. First, we’ll see what symptoms indicate that a set needs to be aligned.

**WHEN IS ALIGNMENT NEEDED?**

You can generally be sure a set needs alignment if it has both poor selectivity and poor sensitivity. If the sensitivity is poor, but the selectivity is good, or vice versa, the alignment is not to blame; some part or circuit is defective, or else the receiver design may be at fault.

Alignment is also needed if the set does not track properly with the tuning dial—that is, stations do not come in at the proper point on the dial. With superheterodynes, improper tracking or low sensitivity may be spotty: stations may be received well at one end or in the middle of the dial, but not at the other end.

These symptoms may not be extremely noticeable if the poor alignment is caused by natural aging of the receiver, but they may be very pronounced if someone has tampered with the adjusters. In fact, it is easily possible for a receiver to be altogether dead if the adjusters are turned far enough from their correct positions.

Now let’s see what equipment you will need to align a set.

**EQUIPMENT NEEDED**

For all ordinary alignment jobs, only three pieces of equipment are required—a signal generator, an output indicator, and alignment tools.

**Signal Generator.** Although it is possible for an expert to align a simple receiver satisfactorily using broadcast signals, you should use a signal generator (s.g.) while you are gaining experience. Even when you are expert, you will use an s.g. when you want to get maximum performance out of a set. The s.g. must be accurately calibrated and capable of being tuned from 550 to 1600 kc. (the broadcast band r.f. range) and from 170 to 480 kc. (a range that includes all the commonly used i.f.’s). The s.g. should have a control for varying its output voltage, and there should be a way to modulate its output with a tone signal when desired.

A typical signal generator is shown in Fig. 2. This
instrument has a dial knob, by which the frequency of the instrument can be varied. The circuit-selector knob lets you select the kind of output you want (modulated or unmodulated). The range-selector knob is used to select the proper range of frequency from the six available. The strength of the signal is controlled by turning the attenuator knobs. The signal is fed out of the instrument through a shielded cable; the shield has a ground clip, and is used as the ground lead. It is always clipped to the chassis or ground of the receiver being aligned. The lead inside the shield ends in a probe through which the output signal of the a.g. is fed into the set. This is generally called the "hot" lead of the a.g.  

Output Indicator. The output indicator may be the tuning eye of the radio, or it may be a part of a multimeter. We will discuss this in more detail a little later on.  

Aligning Tools. Any ordinary screwdriver or hex nut driver could be used for alignment except that there is liable to be considerable capacity between your body and the circuits of the set. If a metallic screwdriver or wrench is used, your body capacity may affect the alignment. To minimize this capacity effect, alignment tools are made of fiber, bakelite, or other insulating material. This insulation is also desirable to prevent shorts, since there may be considerable voltage difference between the adjustment screw or nut, and the chassis.

The usual set of alignment tools includes a rod having a screwdriver bit on one end, and a hex wrench on the other, together with a larger hex wrench. A typical set is shown in Fig. 3. The smaller wrench will take care of practically all jobs, but there are a few for which the larger wrench may be needed.

A few manufacturers specify special alignment tools for their sets. It is usually possible to align them with ordinary tools, but you may find it will speed up your work to use the special tools recommended.

Manufacturer's Instructions. You should have the manufacturer's alignment instructions whenever possible. They will speed up the job by telling you exactly what to do for that particular set and by showing you the positions of the trimmers.

OUTPUT INDICATOR CONNECTIONS

We won't discuss signal generator connections until later, since they differ in different types of sets. However, the same output indicator connections can be used for any kind of set, whether it is large or small, t.r.f. or superheterodyne.

An output indicator is used to indicate when the adjustment being performed has reached the point of maximum output. If the set uses a tuning indicator, such as a meter or magic eye, it is not necessary to use anything else as an output indicator. Proper alignment will be indicated when maximum closure of the eye occurs, or when maximum meter swing is obtained.
If there is no magic eye or tuning indicator on the set, then you can use the a.c. voltmeter of your multimeter in the audio system, or you can use the d.c. voltmeter across the diode load.

One of the most common connections for the output meter is that shown in Fig. 4. (The OUTPUT jack of the multimeter is used, because there is a blocking condenser in series with it. Although there is no d.c. voltage to block out when the connection shown in Fig. 4 is used, it is advisable to be in the habit of using the blocking condenser always so that you will never forget it when it is needed.) Effectively, this connection puts your a.c. voltmeter across the voice coil. The a.c. voltage here is low, and it is possible that the multimeter will not have an a.c. voltage range sufficiently low to give readings. If so, you can use one of the connections shown in Figs. 5 and 6, which connect your meter across the plate circuit of the output tube. Here, the audio voltage is much higher—on the order of 15 to 75 volts. Any standard multimeter can measure voltages this large.

In all three of the above connections, the a.c. voltmeter measures the audio output voltage. When you use a signal generator, this will be the output voltage produced by the modulating tone of the signal generator.

Another popular connection is that shown in Fig. 7. Here, a d.c. voltmeter is connected across the diode load, and is used to measure the a.v.c. voltage. This voltage varies directly with the strength of the carrier of the signal. The d.c. voltmeter used must have a sensitivity of 5000 ohms-per-volt or more, so that it can be connected directly across the diode load without upsetting the circuit too much.
There is an advantage to the connection in Fig. 7—the volume control can be turned down to where the output from the loudspeaker is at a comfortable level, without affecting the reading on the d.c. voltmeter. In the other methods, the loudspeaker output may have to be rather high to give a reasonable indication on the a.c. voltmeter.

As we said earlier, your effort in aligning a set is to find the circuit adjustments that will produce a maximum voltage indication on the output indicator. Except in high-fidelity band-pass receivers, this is true no matter which of these methods you use for connecting the output indicator.

Now that you have a general idea of what equipment is used, let’s see exactly how to align various kinds of one-band receivers. We’ll start with the t.r.f. set.

**T.R.F. ALIGNMENT**

In recent years, the only t.r.f. receivers manufactured have been some of the very inexpensive a.c.-d.c. midget receivers. A typical example is shown in Fig. 8. These sets are quite simple and have but a single r.f. stage, which feeds into a detector circuit.

Many of the older t.r.f. receivers are still in existence, however, and these, too, need alignment. The following instructions will show you how to align any kind of t.r.f. set that uses screen grid or pentode tubes in the r.f., stages. However, an old receiver that uses triode tubes may be a neutrodyne, which requires an additional adjustment; this will be described later in this booklet.

➤ Almost every t.r.f. radio you will meet will have a set of trimmer condensers, one in parallel with each section of the main tuning condenser, so that each tuned circuit can be adjusted to give maximum output at the same signal frequency. The adjustment is always made near the high-frequency end of the band, because small circuit changes have the greatest effect at this end. If no over-all equalizing adjustment is provided, the rest of the tuning band may not be in adjustment for maximum response, but will usually be satisfactory.

Since few t.r.f. receivers have diode detectors or a.v.c. circuits, you will probably connect your output meter between the plate of the output tube and ground. Next, disconnect the antenna wire, and connect the hot (un-grounded) lead of your s.g. cable to the antenna terminal or wire of the receiver. Connect the ground lead of your s.g. to the ground post of the receiver (or to the chassis if there is no ground post).

To make the alignment, tune your s.g. to some frequency around 1400 kc. at which no station is heard. Tune the set dial to exactly the same frequency. Turn on both the s.g. and the set, and allow them to warm up for a few minutes so that they will become stable in operation. Then adjust each trimmer, in turn, until the output indicator gives maximum reading. (You will usually find these trimmers mounted right on the tuning condenser gang.) The set is aligned when you cannot adjust any trimmer further without causing a drop in the output indication.

**Receivers Without Trimmers.** A few of the very early t.r.f. receivers did not have trimmer condensers. Although in some of these sets it is possible to make a rough alignment by varying the position of the gang tuning condenser rotor plates on their shaft, or by moving the leads of the tuned circuits closer to or farther from the chassis (thus changing the stray capacities in the circuits), we don’t advise you to fool with it. The customer needs a more modern receiver.

**Receivers Having Trimmers and Split Rotors.** A few of the better early t.r.f. receivers were designed to be selective and sensitive over the entire broadcast band.
Alignment Pointers. If there is any question in your mind about the alignment procedure at any time, be sure to consult the manufacturer's information on that receiver. If you don't have a t.r.f. receiver, be sure that first you give it a thorough overhaul, clean out all dust and grime from the r.f. coils and the tuning condenser, and blow out all dust and dirt from the chassis. Don't align any receiver until all shields and shield connections are in place, and don't adjust any trimmer condenser until you know its purpose. An important rule to remember is that the trimmers you are to adjust will always be connected in parallel with the main tuning condensers and will usually be on the gang itself. Don't touch any trimmer not connected in parallel with the gang tuning condenser; it is in the circuit for some purpose other than alignment.

HOW TO NEUTRALIZE

At one time the neutrodyne receiver was extremely popular, so you may still occasionally get one to service. It was one of the first t.r.f. receivers to have high sensitivity without being prone to squeal or oscillate. However, this characteristic is produced by feeding back energy out of phase with that which would otherwise cause oscillation. Therefore, whenever such a receiver gets out of balance, or if there is any change in its tubes, it will oscillate.

You can be sure a set is a neutrodyne if it uses triode tubes as r.f. amplifiers (the screen-grid tube made the neutrodyne circuit unnecessary) and has trimmers on the chassis that are not in parallel with the tuning condenser gang. On some receivers you may have to look carefully for hidden neutralizing trimmers. An example is a series of early RCA receivers in which the neutralizing trimmers were actually underneath the tuning condenser gang. It was necessary to take the entire gang off the receiver to reach the neutralizing adjustors.

Neutralizing Procedure. The alignment procedure for a neutrodyne is the same as the one you just learned for other t.r.f. sets. However, if the receiver is oscillating or squealing, you must neutralize it before you can align it. If the set is not oscillating, you can go ahead
with the alignment procedure until you throw the set into oscillation, at which point you will have to neutralize. The general neutralizing procedure is as follows:

1. Open the filament or heater circuit of the tube in the last r.f. stage by unsoldering a supply lead from a filament terminal on the socket.

2. Turn the receiver on. Be sure the disconnected tube does not light, then tune the receiver to a local broadcast station operating on a frequency somewhere near 1500 kc., or connect your signal generator to the antenna and ground terminals of the receiver and tune both to the same frequency near 1500 kc.

3. With no filament emission, this one tube will have no plate current. However, if the stage is out of neutralization at all, the signal to which the receiver is tuned can be heard from the loudspeaker. This means that the signal is passing from the grid to the plate (via inter-electrode capacity) inside the cold tube. This stage therefore needs neutralizing in order to cancel the undesirable feedback signal.

4. Adjust the neutralizing condenser in the stage until the signal is at minimum volume or cannot be heard, then retune the receiver for maximum volume, and re-adjust the neutralizing condenser for minimum volume. This completes the neutralizing adjustment for one stage. (IMPORTANT: Once a stage has been neutralized, do not make any changes in that stage, and, above all, do not change the tube in that stage, otherwise you will have to re-neutralize.)

5. Turn off the set, and restore operation to the tube by reconnecting the filament lead.

6. Repeat this procedure with all other r.f. stages, one by one, working toward the antenna.

When you have neutralized all the stages, the set should not oscillate at any point over the band. However, if you find it squeals at some other frequency, say at 800 kc., after you have eliminated the squealing at 1500 kc., you may find it necessary to reduce regeneration in some other way, possibly by reducing the plate voltage. One way to do this, on receivers having line voltage switches or taps, is to move the switch or tap to a setting corresponding to a higher line voltage. This will reduce plate voltages enough to stop oscillation.

Sometimes a tube cannot be neutralized properly. If you find a stage that does not respond to neutralization, and can trace oscillation to this stage, try another tube in that stage, and check the stage wiring carefully. Of course, before you can neutralize, all shields must be in place. If there is any missing shielding, it must be found or replaced by equivalent shielding.

**SUPERHETERODYNE ALIGNMENT**

You will, of course, have more superheterodynes than any other type of receiver to align. In the superheterodyne, as you will recall, a local oscillator signal is mixed with an incoming signal to produce an intermediate-frequency signal. This intermediate-frequency or i.f. signal is then amplified by the i.f. amplifier. For a superheterodyne to work properly, the preselector stage must tune to the frequency shown by the setting of the tuning dial. At the same time, the local oscillator must tune to another frequency that is exactly equal to that of the incoming signal plus the i.f. frequency. Finally, the i.f. amplifier must be resonant to the i.f. frequency. Therefore, the preselector, the oscillator, and the i.f. amplifier must be in alignment before the set will work properly.

The general procedure for aligning a superhetero-
dyne receiver is first to align the i.f. amplifier by feeding in an i.f. signal and adjusting the i.f. trimmers or coil cores to give maximum output at this frequency. Then the oscillator and preselector sections are adjusted to give maximum output and to track the dial properly.

As you have learned from your Course, producing proper tracking is somewhat of a problem in a superheterodyne. The reason is that the resonant frequency of the oscillator must stay a fixed number of kilocycles above that of the preselector at all points on the dial. Therefore, as the tuning knob is rotated, the tuning capacity of the oscillator stage must change in one fashion, and the tuning capacity of the preselector stage must change in a somewhat different manner. (We are now speaking of capacity-tuned sets; the same is true for those using permeability tuning if you substitute "inductance" where we say "capacity.") If you don’t recall the reason for this, review your Lesson on superheterodynes.

These different changes in capacity in the two stages can be produced in either of two ways. In some sets, the plates in the oscillator section of the gang tuning condenser are shaped differently from those in the preselector section. In others, both sections of the condenser gang have plates of the same shape, and the oscillator stage contains either a series-connected padder condenser (a fairly high-capacity adjustable condenser) or uses a variable-permeability coil that can be adjusted to make the stage track with the preselector at low frequencies. Usually, no low-frequency adjustment is made on a set that has differently shaped plates for the oscillator and preselector sections of the gang condenser.

**STANDARD ALIGNMENT PROCEDURE FOR SUPERHETERODYNES**

For our first example, we shall assume that the receiver has not been tampered with—that it plays, but has lower-than-normal sensitivity and selectivity.

The first step in aligning a superheterodyne is to make sure the dial pointer is properly adjusted. This is necessary because you will have to read the dial setting accurately during the alignment procedures; you can’t, of course, if the pointer has slipped from its proper position. There is usually a “calibration mark” at one or the other end of the scale; the pointer is adjusted to indicate this position when tuned to this end of the range. If you don’t have the manufacturer’s instructions, and can’t determine this mark, then adjust for equal coverage of the dial range when the tuning knob is turned in either direction, if an adjustment is required.

Next, connect an output meter to the set in any of the ways described earlier in this Booklet.

**I.F. Alignment.** For i.f. alignment, you have a choice of two possible connecting points for the signal generator. If the first detector tube has a top cap, connect the s.g. between the top cap of this tube and the set chassis; if it does not, connect the s.g. to the antenna and ground terminals of the receiver.

Many midget superheterodynes have loop antennas. If no antenna and ground posts (or leads) are provided on such a set, you can feed a signal into the loop by making a two- or three-turn loop of hook-up wire, connecting this loop to the hot s.g. lead, and bringing it close to the receiver loop. The s.g. ground lead may be connected to the set chassis.

When the proper connections have been made, turn
on the receiver and the s.g. and allow them to warm up for about 15 minutes. When the warm-up period is over, tune the receiver to a quiet point near the low-frequency end of the band (around 550 kc.) so that the preselector will not interfere too much with the s.g. signal. Then, tune the s.g. to the i.f. frequency of the receiver.

The manufacturer's instructions and the set diagram will usually give the i.f. frequency. For that matter, since the receiver plays reasonably well, you can find the i.f. frequency just by determining what frequency from the s.g. comes through loudest. If it is near one of the standard i.f. frequencies, you can use that standard frequency for the alignment. Practically all modern receivers use an i.f. frequency of 175, 282, 456, 465, or 480 kc. Thus, if the signal seems loudest at about 455 kc., use 456 kc. as your s.g. setting, and align the i.f. amplifier to that frequency.

With an ordinary single-band receiver that is not of the high fidelity or band-pass type, it makes no difference which i.f. trimmers you adjust first. Merely adjust all of them for a maximum reading on the output meter.

You will usually find these i.f. trimmers on top, on the side, or at the bottom of the i.f. transformer shield case, although there are a few early receivers in which the i.f. trimmers are separated from the i.f. transformers. (With these latter you may have to depend on the manufacturer's instructions or trace the circuit to determine which trimmers adjust the i.f. amplifier and which are used for other purposes.)

In some sets, the output i.f. transformer (the one feeding the second detector) may have only one trimmer. However, there are a few sets in which one trimmer is on the top of the can and the other on the bottom, so be sure to look carefully for two trimmers before deciding there is only one.

After you have adjusted the i.f. amplifier, connect the s.g. to the antenna-ground terminals or arrange to feed a signal into the receiver loop (if it is not already so connected). Next, adjust the preselector and the oscillator at the high-frequency end of the band, then adjust the oscillator at the low-frequency end of the band (if the set has provisions for this adjustment).

**High-Frequency Adjustments.** With the signal generator connected to the input of the receiver, tune the receiver to its highest frequency dial reading. Set the signal generator to the same frequency. Then adjust the oscillator trimmer (usually on the oscillator section of the tuning condenser gang) for maximum output.

Next, tune the receiver and signal generator to a frequency of about 1400 kc., and adjust the preselector trimmer (or trimmers) for maximum output. This trimmer is generally on the preselector section of the gang.

Some receiver instructions will tell you to adjust the oscillator and preselector together at 1400 kc. If you do so the receiver dial may not track exactly at frequencies around 1600 kc. Of course, since there are only police stations near this frequency, that won't matter much.

**Low-Frequency Adjustments.** If the oscillator uses specially cut oscillator plates, there will probably be no low-frequency adjustment, so you will be through with the alignment after carrying out the above procedure. However, if there is a padder, or if the oscillator coil core is adjustable, you should make an adjustment at about 600 kc.

You can make a low-frequency adjustment by tuning the set and the s.g. to 600 kc. (or some nearby frequency where no station is received) and adjusting the low-frequency padder or the coil core for maximum output. However, when the maximum in sensitivity is wanted, it is better to use the procedure known as “rocking.”

To make a rocking adjustment, tune the s.g. to about 600 kc. and leave it set at this frequency. Now tune the receiver to get maximum output, regardless of the dial setting. Note the exact output meter reading. Then, change the setting of the oscillator padder condenser (or of the coil core) slightly, and retune the receiver for maximum output. Notice whether the reading on the output meter has increased or decreased. If the reading increased, keep on changing the oscillator adjustment in the same direction, tuning the set each time, until you find the point at which you get the maximum output meter indication. If the second reading is less than the
first, change the oscillator adjustment in the opposite direction, and retune the set, keeping up the procedure until the highest output reading is obtained.

This rocking procedure increases the receiver sensitivity (at the sacrifice of dial tracking somewhat) by effectively tuning the local oscillator and preselector simultaneously. (Changing the receiver dial setting tunes the preselector, while the oscillator is tuned by the combination of the paddler adjustment and the dial change.)

If you make any change in the paddler or oscillator coil setting, you must go back to the high-frequency setting at about 1400 kc. and readjust the oscillator trimmer to get the dial to track properly, and to get the maximum output at this frequency. Sometimes you will then have to make the low-frequency and high-frequency adjustments again. Always wind up with the high-frequency adjustment. After one or two repetitions of these adjustments, the receiver dial should track reasonably well, and the set should have maximum selectivity and sensitivity.

Notice that this alignment procedure is not a matter of making one definite adjustment, but is rather a back-and-forth process. One adjustment affects the other, so you have to make slight changes in both to get the best possible setting of the trimmers.

**HOW TO ALIGN A SUPERHETERODYNE AFTER THE ADJUSTMENTS HAVE BEEN TAMPERED WITH**

If someone has tampered with the adjustments, you will have to consult the manufacturer’s instructions to determine the correct intermediate frequency. Then, it is possible that you can’t get the i.f. signal to go through the set at all when the s.g. is connected to the antenna or to the first detector terminals. In this case, you must connect the s.g. to the grid of the i.f. tube (the one nearest the second detector, if there is more than one), thus forcing a signal through the last i.f. transformer alone. (Usually some signal will travel through just one transformer no matter how badly mis-aligned it is.) Once you have brought this transformer to alignment, move the s.g. back to the next i.f. stage if there is more than one, and align the middle i.f. transformer. Finally, connect the s.g. to the first detector or to the antenna ground post and align the remaining i.f. transformer. You can now make a final adjustment of all the i.f. trimmers to bring the transformers into precise alignment.

Once the i.f. amplifier is aligned, you can usually get the set back into alignment by tuning the receiver dial to, say, 1400 kc. and then varying the s.g. dial until a signal comes through. When you get the signal through, adjust the oscillator trimmer condenser for maximum output. Next tune the s.g. toward the correct frequency (toward 1400 kc., in this case) until you can just barely hear the signal, and readjust the oscillator trimmer for maximum output. Continue this process of tuning the s.g. toward the proper frequency, then readjusting the oscillator trimmer, until the s.g. is at the same setting as the receiver dial. If you can do so before the oscillator trimmer condenser is screwed all the way in or out, your high-frequency alignment has been made; you can then make the paddler adjustments we described earlier.

Sometimes, however, you will find that the oscillator trimmer does not have enough range to let you make the high-frequency adjustment this way. If so, go to the low-frequency end of the dial and make a rocking paddler adjustment, then try the high-frequency adjustment again. You may have to make both adjustments several times, but eventually you will get the set aligned.

**MISCELLANEOUS ADJUSTMENTS**

In a few sets you will find an extra trimmer on the chassis, that is connected as is C₁ in Fig. 10. This trimmer and the coil L₁ form a wave trap that is used to prevent an interfering signal from entering the input of the receiver. Generally these wave traps are designed to
work at the intermediate frequency of the receiver, since code stations operating at this frequency can cause a great deal of interference.

If such interference actually exists when you are aligning the receiver, simply adjust $C_1$ for minimum interference. If you do not hear any interference at the moment, but want to guard against it anyway, connect your s.g. to the aerial and ground posts of the receiver and tune it to the intermediate frequency, then adjust $C_1$ until a minimum signal is heard in the loudspeaker.

**Regenerative Superhet.** Fig. 11 shows the superheterodyne part of a widely used midget receiver circuit. Receivers using this circuit are unique in that they have no i.f. amplifier tube. The output of the first detector feeds into an i.f. transformer. The output of this transformer feeds directly into the second detector. Sensitivity is obtained by making the second detector regenerative.

The trimmer condenser marked "REGENERATION CONTROL" in Fig. 11 determines the amount of feedback from the plate to the grid circuit of the second detector. To align this set, proceed as you would with any other superheterodyne, aligning first the i.f. stage (which consists of the i.f. transformer only, in this case), then the preslector and oscillator. The set may go into oscillation as you align it; if so, tune in a signal near the high-frequency end of the dial, and turn the screw of the regeneration control trimmer counterclockwise (thus reducing the feedback) until the oscillation ceases. When the alignment is finished, turn this screw clockwise until the set oscillates; then turn it counter-clockwise until the oscillation ceases and continue turning it counter-clockwise for one-half to one turn more. This procedure sets the amount of feedback at a value that is just short of enough to make the receiver oscillate, and so give it maximum sensitivity.

**Looking Ahead.** We have not included any Practical Experience section in this Booklet because we prefer that you read the next Booklet before practicing set alignment. This next Booklet will show you how to align all-wave superheterodynes. It will contain all sections of the Practical Experience Plan relating to alignment.
No. 27 How To Align All-Wave Superheterodynes

RADIO SERVICING METHODS
Dear Mr. Smith:

I am employed by the local power company. Since taking the NRI course I have been placed in charge of all radio service and interference complaints in this district of eleven towns. Although I have not had much time for extra radio work, my spare time radio earnings have paid for my home and for a well equipped repair shop. The NRI course has been very interesting and profitable for me.

G.O.S., Iowa

How to Align
All-Wave Superheterodynes

Basically, the procedure followed in aligning an all-wave receiver is similar to the one that you have already learned to use in aligning a one-band superheterodyne. The major difference is that there are additional short-wave bands that have to be aligned in the former. In some all-wave sets, also, there are special circuits, such as automatic frequency control or variable-selectivity i.f. amplifiers, that make alignment more complicated.

In this RSM Booklet, you will learn how to align all-wave a.m. receivers, including those having special associated circuits. The alignment of f.m., television, and high-fidelity receivers is discussed elsewhere in your course.

Basic Procedure

The alignment order is the same for an all-wave superheterodyne as it is for a one-band super: the i.f. amplifier is aligned first, then the preselector and oscillator are made to track. Before going into the specific details of how to make these adjustments on various kinds of sets, let's see in general how they are made.

Align the I.F. Stages. To align the i.f. stages, connect the signal generator to the input of the first detector (or to the antenna-ground post if sufficient signal can be forced through the preselector). Connect an output meter to the set. Tune the signal generator to the i.f. frequency of the receiver, then adjust the i.f. trimmers for maximum gain (maximum output).

Align Preselector and Oscillator. Connect the signal generator to the antenna and ground post of the receiver (or couple it to the loop antenna, if one is used). Set the band-change switch on the receiver to the highest
frequency (shortest wave length) band, and tune both the receiver and the signal generator to a frequency near the high-frequency end of the band being aligned. (Be sure that the receiver dial reading is exactly the same as the frequency to which the signal generator is tuned.) Adjust the oscillator high-frequency trimmer associated with this band for maximum output, then adjust the preselector trimmers similarly. If the band has a low-frequency padder, tune the signal generator and the receiver to a frequency near the low end of this band, and make a rocking adjustment on the padder. Repeat the high-frequency adjustment after making a low-frequency adjustment.

Proceed now to align the next lowest frequency band in exactly the same manner. Continue to align band after band until all bands have been aligned, including the broadcast band.

Now let’s consider each of these steps in more detail to see what problems may arise in carrying them out.

I.F. ALIGNMENT

If the receiver does not have variable-selectivity controls, you can align the i.f. amplifier in exactly the same manner as you would a single-band set. The output meter may be: 1, an a.c. type, connected across the voice coil or connected from plate to chassis of the power output tube; or 2, a d.c. meter, used to measure the a.v.c. voltage. (Of course, if the set has a tuning eye or meter indicator, you can align for maximum closure of the eye or for maximum meter swing; in this case, you do not need an output meter.)

Identifying the First Detector. The signal generator is normally connected to the input of the first detector for i.f. alignment. This brings up the problem of finding out which tube is the first detector. If you have the manufacturer’s instructions for the set, this will be easy, because the tubes will be identified. However, if you do not have the manufacturer’s instructions, you can frequently find the right tube by noticing the types of tubes in the set. A tube such as a 6A7, 6A8, 6SA7, 6K8, 12SA7, or 6L7 is generally used as the first detector.

If you do not find one of these tubes in the radio, it will be necessary to identify the stage from its connections. The plate of the first detector tube is connected to the primary of the input i.f. transformer, which is usually rather easy to identify, and the grid of this tube is generally connected to r.f. tuning circuits. (In a few all-wave receivers that use an r.f. stage and a loop antenna, the input circuit of the first detector is not tuned.)

Coupling the S.G. to the Set. You will frequently find that the manufacturer’s instructions recommend the use of a blocking condenser in the hot lead of the signal generator for i.f. alignment. (This may be listed under “dummy antenna” in the instructions.) The blocking condenser is used to prevent the s.g. input circuit from short-circuiting the a.v.c. supply of the first detector.

You should know whether your signal generator already has such a blocking condenser. Many do. If it has, you can clip the s.g. hot lead to the grid terminal of the first detector stage, and then connect the ground lead of your s.g. to the set chassis.

If your s.g. does not have a built-in blocking condenser, then it is desirable to connect one in series with the hot lead. The capacity of this condenser is not critical. You will find that the
values recommended by manufacturers differ widely, but actually any condenser from .01 to .1 mfd. is satisfactory.

- If the first detector is a single-ended tube, such as a type 6SA7 or 12SA7, you may encounter some difficulty in making connections to the control-grid terminal underneath the set chassis. Sometimes you will find it possible to connect the hot s.g. lead to the tuning condenser stator plates in the section that is used to tune the first detector input. However, if this connection is difficult too, it may be easiest to connect the s.g. to the antenna-ground terminals, or to couple it to a loop antenna, if one is used. In most instances it is possible to force the i.f. signal through the preselector when the wave-band switch is set to the broadcast band and the set is tuned to the low-frequency end of the broadcast range.

Finding the i.F. Value. When the s.g. is connected, it must be tuned to the i.f. value of the receiver. The manufacturer's information can be consulted to learn what this is. However, if you do not have the manufacturer's instructions, and the receiver is in playable condition, it is probable that the i.f. section is adjusted to a frequency not far from the correct one. Starting at 500 kc., tune your s.g. downward over the i.f. range until you encounter a frequency that will pass through the receiver with the greatest volume. If this frequency is near one of the standard i.f. values of 262, 456, 465, or 480 kc., then use the nearest standard frequency for the alignment.

- A word of caution—you may get a signal through the set with the s.g. tuned to some frequency that is not the i.f. frequency. This will occur if the s.g. signal (or some harmonic of it) combines with the local oscillator output of the receiver to produce an i.f. signal. You can always tell whether you have a spurious signal by changing the setting of the receiver dial. This shifts the oscillator frequency, and so will cause a spurious signal to disappear. However, changing the receiver dial setting will have little effect if the proper i.f. frequency is being fed in from the s.g., even when it is being fed through the preselector.

It is customary to allow the set to warm up for ten minutes to half an hour before aligning it, and if the signal generator is a.c.-operated, to allow it to warm up, too. This assures that both will be stable and that the alignment will hold after it is made.

Adjusting the i.F. Trimmers. When you are ready to align, adjust the i.f. trimmers for maximum output. Repeat the adjustment to eliminate the effects of interaction between trimmers.

In an ordinary all-wave set, this adjustment is made simply by turning the two trimmers associated with each i.f. transformer. There are three forms of high-fidelity receivers, however, that require different methods of aligning the i.f. amplifier.

- One of those has the standard two trimmers, but also has a variable-selectivity control on the front panel of the receiver. This control shifts the i.f. amplifier from a band-pass, high-fidelity characteristic to the usual sharp-selectivity characteristic. To align the i.f. amplifier in such a set, turn this control to the sharp-selectivity position, and adjust the two trimmers for peak response. When this is done properly, turning the selectivity control to its other position will provide just enough additional coupling to give a broad-band response when higher fidelity is desired.

- Another kind of high-fidelity receiver has a third trimmer on each i.f. transformer. This type of set also has a variable-selectivity control switch, but the alignment method used is generally different from the one just discussed. Often the trimmer going to the center set of coils is adjusted first for minimum response, then the other two are adjusted for maximum response, and finally the center one is again adjusted, this time for maximum response. However, all receivers of this type cannot be adjusted in exactly the same way, so you will have to consult the manufacturer's instructions to be sure you make the adjustment correctly.

- The true high-fidelity receiver is not usually all-wave; rather, it is a single-band set designed for local station reception. Such a set is designed only for band-pass i.f. response; the trimmers are therefore adjusted to give broad-band response instead of peak response. Essentially, this is done by adjusting one trimmer on
each i.f. transformer to give maximum response at a frequency a few kc. above the i.f. frequency, and by adjusting the other trimmer to give maximum response the same number of kc. below the i.f. frequency. For maximum fidelity, it is usually necessary to use additional equipment—a cathode ray oscilloscope and a wobbled signal generator—to align such receivers. However, it may be possible to make the band-pass adjustment reasonably well by tuning a standard s.g. carefully the proper number of kc. above and below the proper i.f. frequency. If it is possible to use this latter method, the manufacturer’s instructions will usually tell you just what to do.

As we said before, the details of aligning high-fidelity receivers are given elsewhere in your Course. We have mentioned the various methods that may have to be used on them only to point out the fact that you should not attempt to align such sets by the ordinary procedures.

ALIGNING THE PRESELECTOR AND OSCILLATOR

Once the i.f. amplifier is aligned, you can turn to the preselector and oscillator. The all-wave receiver has, of course, a number of preselector and oscillator circuits—one of each for each wave band. There are two major systems of providing these circuits. In one, each circuit has its own set of coils, trimmers, and padders. In a set of this sort, the bands can be aligned in any order—that is, you can adjust the broadcast band first if you want to, then skip from short-wave band to short-wave band.

The other system utilizes a single set of coils for all bands; the coils are provided with taps, and as much of each coil is used for each band as is needed to give the necessary inductance. For example, the highest frequency band uses one section of the coil; the next highest frequency band uses that section plus another section, and so on. A set with this arrangement, known as the series coil connection, MUST be adjusted from the highest frequency band downward. The setting of the trimmers in each circuit affects the capacities in the other circuits, and it is impossible to compensate for this unless the highest frequency band is aligned first. Proceeding this way, band by band, you will align the broadcast band (or low-frequency weather band, if the set has one) last.

Naturally, if you have the manufacturer’s instructions, you won’t have any trouble no matter which system the set uses; these instructions will list the adjustments in the order in which they should be performed if the order is important. However, when you do not have the manufacturer’s instructions, you must either

This is a typical use of a series coil connection in a preselector circuit. The shorting switch is part of the wave-band switch. When this switch is turned to position 1, it touches the contact of position 2 also; coils L2 and L4 are then shorted, leaving only L1 to be tuned by condenser C5. When the switch is turned to position 2, coil L2 is shorted; coils L1 and L3 are then in series and tuned by C5. When the switch is in position 3, all three coils are in series and tuned by C5. To align this set, you must turn the switch first to position 1 and adjust trimmer C1, then to position 2 and adjust C2, and finally to position 3 and adjust C3.
examine the set carefully to determine which type it is, or follow the general rule of aligning the highest frequency band first in all cases, working downward through the lower frequency bands.

**Dial Pointers.** Before adjusting the preselector and oscillator, make sure that the dial pointer tracks over the dial properly; if it does not, it will be impossible to get the oscillator and preselector to track. The manufacturer's instructions will tell you of any calibration marks to which the pointer should be adjusted when the gang tuning condenser is fully open or fully closed. If you have no such instructions, determine whether the pointer covers the entire scale as the tuning condenser is turned from the open to the closed position. If it seems to cover the scale, with about the same amount of overlap at each end, you can usually be sure that the pointer is in adjustment.

If the scale is circular, like the one shown in Fig. 1, usually the pointer should be adjusted to be perfectly horizontal—in line with the center horizontal line—when the tuning condenser is fully open or fully closed.

If the pointer has slipped, you can usually loosen the screw holding the pointer, or disconnect the pointer from the dial cord, and slip it to the proper position. Once it is in position, fasten it securely.

- In some of the older radio receivers the dial scale is attached to the tuning-condenser assembly, and a fixed indicator is attached to the cabinet. When one of these sets is removed from the cabinet, there is no means of indicating the frequency to which the set is tuned. Before you remove such a set from the cabinet, turn it to some frequency that is clearly marked on the dial. Take it from the cabinet carefully, so as not to disturb the tuning. Then make a marker from a piece of wire, attach it to the chassis, and adjust it so that it indicates the same frequency as the pointer did in the cabinet.

- On more modern receivers, the dial scale may be attached to the cabinet so that it remains in place when the set is removed. On most sets like this, the tuning condenser dial drum (a part of the receiver) has on it an auxiliary scale, calibrated from zero to 100 or from zero to 200, that is intended to be used for alignment purposes. The manufacturer's instructions give the numbers on this scale that correspond to the main dial frequency settings.

**Identifying the Adjusters.** Once you have found that the pointer is in adjustment, or you have adjusted it, you are ready to align the receiver. Your first problem is to identify the many trimmers and padders that may be on the receiver. Once again, the manufacturer's alignment instructions are very desirable. These instructions give a sketch of the trimmer layout, and tell you which trimmer should be adjusted for each wave band and for each band setting. Typical examples are given in Fig. 2 and Fig. 3.

If you do not have the manufacturer's instructions, there are two ways of finding out which band each trimmer is used in. One way is to tune in a signal from the a.g. and then adjust the trimmers, one at a time, to see which ones affect the response. When a trimmer adjustment causes a change in the output meter reading, you know that this trimmer is used in the wave band cor-
action between the various trimmers in all-wave receivers that use the series connection of coils for all bands. For this reason, always start with the highest frequency band when you are identifying trimmers by the method just described. When you have located the trimmers for that band, switch the set and the s.g. to

FIG. 2. As part of his alignment instructions, a set manufacturer usually supplies a diagram similar to this of trimmer locations.

responding to the signal generator setting.

Sometimes just touching the screw with a metal screwdriver will be sufficient to produce a change in the output meter reading if the trimmer is active at the frequency being tuned in. Or, in the case of a book-type trimmer, pressing down on the top plate of the trimmer with an insulated alignment tool will cause a large change in capacity, producing a considerable change in the output meter reading if the trimmer is active.

As we said earlier, there is a certain amount of inter-
the next highest frequency band, and repeat the identification tests (but do not make tests on the trimmers already identified). Continue through the other bands in descending order of frequency. Making tests in this order will reduce the chances of causing a response in one band when you adjust a condenser that belongs in another.

The other way of identifying trimmers is to trace the various circuits to determine where each trimmer is connected. This is not easy, particularly in sets in which the trimmers are scattered over the chassis. However, in most receivers the trimmers are collected into groups; once you have identified the order in which the groups are connected to the wave band switch, you can then determine the band in which each is used.

The problem is additionally complicated by the use of padders in the oscillator section of the receiver. As you know, padder condensers are used to obtain equal tracking. A system of padding must always be used in an all-wave receiver. However, this does not mean you will always find an adjustable padder in each band—the higher frequency bands are frequently padded by means of fixed condensers. If you can find no variable padder in a high-frequency band after making a careful search, you can assume that a fixed condenser is used.

Alignment Procedure. Let us suppose that you have the manufacturer’s instructions, or have identified the trimmers, and that the dial pointer is properly adjusted. To align the preselector and oscillator sections, proceed as follows:

Connect the signal generator to the antenna and ground terminals of the receiver, or couple it to the loop antenna. When a loop antenna is used, you can couple to it either by placing a single piece of wire around the loop, as shown in Fig. 4, or by clamping the hot lead from the signal generator to the form on which the loop is wound (Fig. 5).

Set the band-change switch to the highest frequency band. Tune the s.g. to the proper frequency near the high-frequency end of the band being aligned. Then adjust the oscillator trimmer and the preselector trimmers associated with this band for maximum output.

---

**FIG. 4.** A wire looped loosely once around the loop-antenna form and connected to the s.g. leads will provide sufficient coupling for your s.g. signal.

If this band has an adjustable padder, tune to the low-frequency end of the band and make a rocking adjustment of the oscillator low-frequency padder. (Of course, no low-frequency adjustment is possible if a fixed condenser is used as a padder.) If you make this adjustment, go back to the high-frequency end of the band and re-adjust the oscillator high-frequency trimmer.

When the highest frequency band is aligned, tune to the next highest frequency band, and align it in the same manner. Proceed band by band until all have been aligned.

**ADJUSTING THE ALL-WAVE RECEIVER THAT HAS BEEN TAMPERED WITH**

If someone has tampered with the adjusters on an all-wave receiver, your first problem is to get the receiver to play at all. It is usually best in this case to get the receiver to play on the broadcast band by aligning this band first. The reason for doing so is that the broadcast band is less critical in its adjustment than are the short-wave bands, so it is easier to make the set play on the former.

If the set has separate coils for each band, you can then proceed to align the short-wave bands in any order you wish. If, however, the set has series-connected coils,
you must start aligning with the highest frequency band once the broadcast band has been made to work. Frequently, in the latter case, you will have to re-align the broadcast band after the higher frequency bands have been properly adjusted. In fact, since the adjustments made in one band affect those in the others, it may sometimes be necessary to go through the whole alignment procedure a second time, band by band, to get maximum response from the set.

ALIGNMENT NOTES

You may find the manufacturer recommends a dummy antenna for aligning the short-wave and broadcast bands. The purpose of the dummy antenna is to simulate the effect of the standard antenna on the preselector. A 400-ohm resistor is usually recommended for the short-wave bands, and it is simple to connect a 400-ohm resistor in series with the s.g. hot lead when the maximum results are desired.

The manufacturer may recommend a more elaborate L-C-R coupling for broadcast band alignment. However, unless you make instrument measurements, it is difficult to tell the difference between the results obtained with such a coupling, and those obtained without it. If you do not care to set up the network, then you can readjust the preselector trimmers when the receiver is returned to the customer and the set is connected to the customer's antenna.

You may find conflicting recommendations in regard to the s.g. output to be used. If you keep the output low, the automatic volume control (a.v.c.) circuit will be less effective, and the gain of the controlled tubes will be high. As a result, the input capacities of the tubes used in the various tuned stages will differ somewhat from those the tubes would have if a stronger signal were used. (As you learned in your Course, the input capacity of a tube depends upon the stage gain.) Therefore, if you use a low-level signal from your s.g. for alignment, the set will be slightly detuned when a signal of average strength is received. Conversely, if you use an s.g. signal of average level for alignment, the set will be slightly detuned when a low-level signal is received. In any case, the detuning will be too slight to produce an appreciable effect except on the upper short-wave bands, and even on them the effect will not usually be very noticeable.

In general, it is best to align with an output from the signal generator that will approximate the average incoming signal. Therefore, keep the output from the signal generator at a reasonable level—one that will give you a good reading, but not necessarily a very high one, on the output meter.

You may encounter some difficulty in aligning a short-wave band if you make an improper adjustment of the oscillator high-frequency trimmer. As you know, a superheterodyne should be aligned so that the oscillator frequency is above the preselector frequency by the amount of the i.f. frequency. If any band is aligned so that the oscillator frequency is below the preselector frequency by the amount of the i.f., the set will still play at the high-frequency end of the band, but it will be impossible to make it track properly at the low-frequency end.

Such a misalignment cannot usually occur in the broadcast band, because the average oscillator trimmer cannot be tuned over a wide enough range at broadcast frequencies to cause this difficulty. However, the oscillator trimmer has a much wider tuning range on the short-wave bands—for example, a shift of 900 kc. can be ob-
tained on the 18-megacycle band by turning the trimmer screw less than half a turn. Therefore, in a short-wave band, it is often possible to set the oscillator by accident to a frequency that is under the preselector frequency by the amount of the i.f.

To avoid this difficulty, do not turn the oscillator trimmer very far when you are making a high-frequency adjustment on a short-wave band that is reasonably well aligned. However, if the set has been tampered with, or if you accidentally turn the oscillator trimmer far away from the correct setting, you had better make sure that the oscillator frequency is above the preselector frequency. To do so, adjust the set and your s.g. to a frequency near the high end of the band, and run the oscillator trimmer adjusting screw out slowly, being careful not to bring it out so far that the condenser comes apart. If the trimmer has a wide enough tuning range, you should pick up the signal at two different screw positions as you back the screw out. If you do, leave the screw at the outer position (the position that gives the trimmer less capacity). This will make it certain that the oscillator is above the preselector in frequency.

**MINIMUM OUTPUT ADJUSTMENTS**

There are two circuits in which a trimmer should be adjusted for minimum output rather than maximum. The more common of these is a wave trap in the antenna circuit, adjusted to the i.f. frequency.

To adjust an i.f. wave trap, proceed in the normal manner to align the i.f. circuits of the set. Then, with the s.g. connected to the antenna-ground posts (or coupled to the loop antenna), locate the i.f. wave-trap adjuster. Next, with the s.g. tuned to the i.f. frequency, adjust this trimmer to give minimum output. When thus adjusted, this trap will tend to block out any code signals or other interfering signals that may try to come in at the i.f. frequency of the set.

- The second minimum adjustment is found only in some receivers manufactured in the early 1930’s. In these, the a.v.c. circuit is of the “amplified” type and has its own i.f. transformer. Usually there is but one trimmer on this transformer, although occasionally there are two. Since this transformer feeds the a.v.c. network, it is necessary to adjust the trimmer to produce minimum output for the set. (The fact that the set output is minimum means that a maximum a.v.c. voltage has been developed.) Therefore, after aligning the i.f. amplifier in the usual manner, leave the s.g. connected as for i.f. alignment, and adjust the a.v.c. transformer trimmer or trimmers for minimum output.

A typical circuit of this kind (which, as we have just mentioned, will be found only on fairly old receivers) is shown in Fig. 6. Usually there will be three i.f. transformers in a set that has this feature, but not all three-transformer sets are of this kind—some use a third transformer because they have two i.f. stages.

**A.F.C. CIRCUIT ALIGNMENT**

The automatic frequency-control circuit, used in a number of radio receivers made in the late 1930’s, is intended to pull the oscillator into alignment even though the set is not perfectly in resonance. (You will learn the details of the operation of this circuit later in your Course.) It was used chiefly to assure accurate tuning in push-button receivers. Fig. 7 shows a typical discriminator section.

When you encounter a set having a.f.c., consult the manufacturer’s instructions if they are available. If
not, follow this procedure:

First, connect an a.c. output meter, as usual, to the voice coil, or from the plate of the power output tube to ground. Or, if a d.c. meter is used, connect it to measure the a.v.c. voltage (between point 2 and chassis in Fig. 7). Next, turn the a.f.c. switch to the O.F.F position to eliminate this feature. Align the set in the usual manner—the i.f. amplifier first (including trimmers $C_1$ and $C_2$ in Fig. 7), then the preselector and oscillator trimmers and padders for all bands—with the a.f.c. switch off throughout the procedure.

After completing the alignment, tune the set to some frequency near 1000 kc., and tune the s.g. accurately to this same frequency. Be sure they are exactly in resonance, as indicated by a peak in the reading of your output meter.

Now, connect a high-sensitivity voltmeter (10,000 ohms-per-volt or better), or a vacuum-tube voltmeter, across the output of the discriminator circuit. In Fig. 7, this is from points 1 to 3. Turn on the a.f.c. switch, and adjust condenser $C_0$ (Fig. 7) until the high-sensitivity voltmeter reads exactly zero voltage. (The voltage can reverse in polarity. To make sure you have zero voltage, reverse the voltmeter connections to points 1 and 3. Your voltmeter should still indicate zero voltage.) This adjustment is very critical. Make extremely accurate voltage readings, and make them with the adjusting tool removed from condenser $C_0$. (Leave $C_1$ and the other i.f. trimmers alone—only $C_0$ is re-adjusted.)

When this adjustment is properly made, snapping the a.f.c. switch off and on should make practically no difference in the reading of your output meter. However, don't attempt to use the output meter to make the adjustment; only a sensitive d.c. meter connected as we have described will give the necessary precision.

THE NRI PRACTICAL TRAINING PLAN

You must have a signal generator and a multimeter (to be used as an output indicator) before attempting to gain experience in aligning sets. When you have this equipment, we suggest that you go through the following procedures twice on your set—one with an a.c. voltmeter connected across the voice coil (or from the plate of the output tube to ground), and once with a d.c. voltmeter connected to measure the a.v.c. voltage. This will teach you how to use both types of output meters. It is a good idea to know how to use both kinds, for then, in your future work, you can use the one that is easier to connect to the receiver you are aligning.

First, study carefully the alignment instructions furnished with your receiver. After you are sure you understand them, go through the alignment procedure, step by step.

Since your receiver is in good playing condition, it is probably not in need of alignment. However, go through the procedure anyway, just to be sure that the set is giving its maximum performance.

Then, deliberately misalign the i.f. amplifier by turning the i.f. trimmers a quarter- to a half-turn away from their proper settings. Operate the receiver to learn what effect this had on its selectivity and sensitivity. Now go through the procedure of realigning the i.f. amplifier.

Next, with the i.f. amplifier aligned properly, misalign the oscillator and the preselector section of the broadcast band. Again notice the effect on the selectivity and sensitivity of the receiver, then realign it.

After you have become thoroughly familiar with the procedure of aligning the i.f. and broadcast bands, practice aligning the short-wave bands if your set is an all-wave type.
Next, deliberately turn all of the trimmers to simulate a set that has been tampered with. Usually anyone tampering with a set will tighten the adjusters, so screw them down until they are all reasonably tight. Try out the set now. You will probably find that nothing whatever can be received. Finally, re-align the set completely.

After you have finished all the practical training in alignment suggested above, you will be reasonably quick about making your adjustments on your own set. Now all you need is the experience of working on other receivers that have trimmers in different locations, so you can become familiar with the problems of locating trimmers and of following different procedures.

Each time you deliberately misalign a set, be sure you notice the effect your action has on both the sensitivity and selectivity. This is very important—the response of a set is one of the few clues you will have that show that re-alignment is needed.
No. 28  How To Fix a Weak Receiver

RADIO SERVICING METHODS
Dear Mr. Smith:

I took your Course in a depression year at a time when I was scarcely making enough to live. I am now engaged in full time service work with steadily increased earnings. I might add that the Course has paid for itself several times this year. Let me say that the NRI Course is the most thorough I have ever seen and that your school is the most friendly I know of.

H.E.R., North Carolina

Weak reception is a complaint that may be completely baffling to the "radio mechanic." But the man who has a professional knowledge of radio circuits can often locate the defective section almost at once by observing how the set acts, and can usually run down the defective stage in a matter of minutes.

This Booklet will teach you the quick, professional ways to find out why a set plays weakly. We'll follow our usual plan of study: first, we'll see what can cause the complaint, then we'll see how the defect can be located. The last section of the Booklet is a continuation of your NRI Practical Training Plan; it will show you how you can gain experience in tracking down the causes of weak reception.

CAUSES OF WEAK RECEPTION

When you confirm the complaint, make sure that the weak reception is real and not just in the customer's imagination. Sometimes a customer will suddenly decide that he wants to pick up a distant station that he has never heard before—one that his set, even when brand new, could not receive. Or, if he has recently moved, perhaps he enjoyed better reception at his last home because of a better antenna-ground installation, or because of a better location. Furthermore, the customer may not realize that because of atmospheric conditions, he may not be able to get stations in the summer that he receives well in winter.

Weak reception exists when stations that have been
heard normally no longer come in at a satisfactory volume level. The cause may or may not be a defect in the receiver—often the antenna-ground system is to blame. In fact, you should always check the antenna-ground system first when the complaint is weak reception. Look for breaks, short circuits, and accidental grounds—any of these can cause weak reception.

If a receiver defect is the cause of the weak reception, you will always find that the defect has: (1) interfered with the signal path through the receiver, or (2) caused the gain in one or more stages to fall below normal. The first condition is caused by such things as open antenna coils or open coupling condensers. The second condition, low stage gain, occurs if something reduces the tube gain (improper operating voltages or loss of emission), or if the load impedance decreases. A drop in load impedance can be caused by short circuits across the load, reduced Q factor in tuned circuits, or improper alignment.

Before we go on to localizing the defective section and stage, let’s see in more detail what part and circuit defects are most likely to cause weak reception.

**Tubes.** Many complaints of weak reception are caused by tubes that have lost their emission. This may have happened suddenly (a break in the filament or an open in the cathode lead could do this), or it may be the result of gradual deterioration of the tubes. In the latter case, more than one tube may be involved. Since defective tubes are such a common cause of this complaint, it is a good idea to check all the tubes with a tube tester early in the test procedure, and to replace any that are below normal in emission.

**Improper Voltages.** Lower-than-normal plate or screen grid voltages are sometimes the reason why the stage gain is below normal. Usually a leaky or shorted by-pass condenser is to blame for the voltage drop, although shorted by-pass condensers are more likely to cause a completely dead set than weak reception.

► If the input filter condenser \(C_1\) in Fig. 1 opens or develops high power factor, the B supply voltage will drop considerably. This is particularly important in a.c.-d.c. receivers; since such sets operate on low voltages anyway, any drop is quite noticeable.

► Excessive grid bias is another possible cause of weak reception, although distortion is a more usual result. Excessive bias may be caused by excessive current through a bias resistor in the power supply circuit, or by an open bias resistor in the cathode circuit.

**Condensers.** An open grid-plate coupling condenser in an R-C coupled amplifier will usually make the set dead. However, a powerful signal from a nearby station may get by the condenser to some extent; you will then get weak reception from this station, and none from others.

► An open cathode by-pass condenser used in only one stage (like condenser \(C_1\) in Fig. 2), may cause weak reception because of degeneration. On the other hand, when a cathode by-pass condenser is common to more than one stage, opening of the condenser may cause regeneration. This may cause oscillation but not neces-
sarily weak reception. Keep this in mind when you are servicing for weak reception.

- An open plate by-pass condenser in the power output stage may cause weak reception indirectly. For example, if condenser C₁ in Fig. 2 opens, the power output stage may oscillate at a frequency too high to be heard. The tube may then draw so much current from the power supply that the B+ voltage is reduced sharply, causing weak reception. (This is an interesting example of a multiple cause for a complaint; the weak reception is caused by a low B supply voltage, which is caused by oscillation in the power output stage, which, in turn, is caused by an open condenser.)

- An open a.v.c. filter condenser, such as C₁ in Fig. 3, can also cause weak reception. Normally, the signal applied to the grid of tube VT₁ reaches ground through condenser C₁—a relatively low-impedance path. If C₁ opens, however, the signal must reach ground through resistors R₂ and R₃. These form a high-impedance path, over which much of the signal is dropped; consequently, the signal output of tube VT₁ is seriously reduced.

**Resonant Circuit Defects.** There are two possible defects in a tuned circuit that can cause weak reception—(1) misalignment of the circuit, and (2) a reduction in the circuit Q factor. Loss of Q may be caused by the addition of resistance in the circuit (a high-resistance connection, for example), by absorption of moisture in a coil form, or by shorted turns in a coil winding. Lowered Q is one of the important reasons for weak reception in an old receiver; look for this if you have found that the tubes are normal.

**Loudspeakers.** If the field coil is not used as a choke, it can open without interrupting the supply voltage. An open field coil will cause very weak reception mixed with distortion. An open voice coil may also cause weak reception, though it is more apt to make the set dead altogether. A voice coil that cannot move freely will cause weak reception plus a loss of bass notes.

These are the most important causes of weak reception. Now let's see what techniques will locate these defects quickly.

**LOCATING THE DEFECTIVE SECTION**

You can generally locate the defective section by using effect-to-cause reasoning while you are confirming the complaint. There are several possible symptoms the receiver can exhibit, each of which can tell you much about what the trouble is. We'll take up each symptom in turn.

**Distant Stations Weak — Locals Normal.** In summer, it is normal to receive only local stations during the day, although there should be some distant-station reception during the night. However, reception of this sort in the wintertime is a sure indication of trouble in the r.f.-i.f. section or in the antenna system. In this case, weak signals receive so little r.f. amplification before reaching the second detector, that the audio section cannot bring them up to normal volume. The signals from powerful local stations are heard well enough because they are so strong when they reach the receiver that they do not need much r.f. amplification.

If the set is a superheterodyne, and the amount of first detector noise (a hissing sound) is above normal when you tune in a distant station, either the antenna system is at fault, or there is a break in the primary of the antenna coil (if the set has one). If the set uses a loop antenna, you might try changing its position to see if that helps matters.

**Weak Reception of BOTH Distant and Local Stations.** The fact that you hear both distant stations-
Circuit Disturbance Tests. Of course, if you wish to find the defective stage first, you can use a circuit disturbance test. The best way is to use a voltmeter, because you can kill two birds with one stone—you can measure supply voltages and create the disturbance at the same time. Let's use Fig. 2 as our example.

To use this method, start by measuring the plate voltage of the output tube. If you find normal voltage here, then in all probability the power supply is all right.

However, if the plate voltage in this stage is abnormally low, the power supply is defective—or the output tube is improperly biased because of a leaky coupling condenser, gas in the tube, or a short-circuited C1—or the output tube is oscillating because of an open C2. Check the bias from cathode to ground, and check for current through the grid resistor Rg. If the bias is normal, and there is no current through Rg, then the trouble must be caused by an open condenser C1, or by a power supply defect.

If the plate voltage is normal, touch the voltmeter probes between the screen grid and control grid terminals of this tube. Have the positive voltmeter terminal go to the screen grid. The sudden current surge as you make and break the contacts with the voltmeter will cause a sharp click from the loudspeaker if VT2 is capable of amplifying, and if the speaker and output transformer are in good condition.

If you get a normal click, measure the plate voltage of tube VT1. You should hear a click when you touch the positive voltmeter probe to the plate of VT1, and another when you remove it. No click and a low voltage reading, indicates trouble in the plate circuit of VT1. No click, but a normal voltage reading, indicates an open coupling condenser C1.

If you get a normal click, check the VT1 stage by touching the voltmeter probes between B+ and the control grid of VT1. Weak clicks usually indicate a defective VT1, or a short-circuited grid circuit.

An open in either C1 or C2 would cause degeneration and a loss of output. Ordinary voltage readings will not show up either of these conditions, so if everything is normal up to now, check these condensers by shunting them with good ones.

Signal injection could also be used to locate the defective stage, except that there is practically no source of audio voltage readily available to the average serviceman. However, the circuit disturbance test just described will usually work. Its greatest drawback lies in the fact that you must judge the loudness of the clicks. You will have to have experience with this before you can tell when a click is below normal in loudness.

Signal Tracing. A signal tracer is ideal for locating the defective stage in either the a.f. or the r.f.-i.f. sections. Since much the same technique is used in both sections, we shall describe how to use a signal tracer for both a little farther on.

Locating the Defective Stage in the R.F.-I.F. Sections

Locating the defective stage in the r.f.-i.f. section is somewhat more complicated both because there are more stages than in the average a.f. section, and because there may be a defect that affects a number of stages at the same time—for example, improper alignment or change in coil Q.

If you have a clue that makes you suspect improper alignment, such as weak reception only on certain bands or only at one end of a band, then try re-aligning as the next step. However, assuming for the moment that you
and locals indicates that the r.f.-i.f. section is all right; the defect is probably in the second detector, the a.f. section, or the loudspeaker. If the set has a tuning eye, notice if it closes the usual amount when you tune in a station. If it does, the r.f.-i.f. section, the second detector, and the a.v.c. circuit are working properly; the a.f. section or the speaker must be to blame.

**Local Stations Weak—No Distant Stations Heard.**
Reception of this sort does not tell you quite as much about the defective section as do the two kinds previously discussed. It may mean that some r.f. stage is very weak—practically dead—or that some power supply defect has reduced the voltage supply to all tubes below the value at which they can work properly. You will have to make a localizing test before you can be sure which section is defective.

**Receiver Weak at One End of Dial.** This is a sure indication of trouble in one of the tuning circuits. It is caused by improper alignment.

**All-Wave Set Weak on Certain Bands—Normal on Others.** This can only be an r.f. preselector defect. Suspect misalignment, a defective band-change switch, or open coils on the weak bands.

**Weak When Lights Are Turned On or Off.** This shows that the trouble is in the antenna system rather than in the receiver itself. The signals from some stations may be affected more than others. Usually the cause is a poor ground. If the set uses an indoor antenna, you should recommend the installation of a good outside one.

**Localizing Tests.** You can almost always localize the trouble to the r.f. section or to the a.f.-power supply sections with the familiar circuit disturbance test made by touching the top cap of the first audio tube with your finger. (If this tube has no top cap, you can make this test by turning the volume control up full, and touching the hot, or ungrounded, terminal of the control with your finger.) If a loud hum or buzz is heard from the speaker, the a.f. section and the power supply are all right; the defect is in the r.f.-i.f. stages. If the hum or buzz is very weak, the a.f. section or the power supply is to blame.

**Locating the Defective Stage in the A.F. Section**

The audio section of most modern radio receivers contains two stages—a first audio stage and either a single-ended or a push-pull output stage. (A phase inverter or some other special tube may also be used.) Since the audio section contains so few stages, there is little need for stage localization tests for weak reception. If the defect is apparently in the audio section, first test the tubes in this section, and then, if the tubes are good, measure the supply voltages in the stages.

Abnormal voltages usually indicate trouble in the power supply or a by-pass condenser breakdown, either of which you can quickly find in the usual manner with a voltmeter and an ohmmeter.

If the tubes are all right, and the voltages are normal, probably the coupling condenser (C2 in Fig. 2) is open, or there is something wrong with the loudspeaker.

You can quickly check the coupling condenser by trying another one across it. If the set is instantly restored to normal operation, replace the original condenser.
do not have a clue like this, let's see how it is possible to locate the defective stage in the r.f.-i.f. section.

Only three of the localization techniques can be used — circuit disturbance, signal injection, and signal tracing. Signal tracing is by far the best method. Neither circuit disturbance nor signal injection is very useful unless some stage is the source of trouble, and that stage is nearly dead. However, we shall describe all three methods, as usual.

**Circuit Disturbance.** Let's use the typical r.f.-i.f. section shown in Fig. 4 to show how to locate the defective stage. If the tubes in the r.f.-i.f. section have top caps, make the circuit disturbance test by removing and replacing the top caps on the tubes, one at a time, starting with $VT_4$ and working back to $VT_1$. If everything is in good condition, you should hear a fairly loud click or thump when you remove and when you replace each top cap. If you do not hear the click, the stage you are testing is defective.

If the r.f. tubes do not have top cap grid connections, you can disturb the circuits either by pulling out and replacing the tubes or by using a voltmeter. Pulling and replacing tubes should have the same results as making and breaking top cap connections. Of course, tubes can be pulled only in sets such as straight a.c. receivers or auto radios, in which tube filaments are connected in parallel to a source that supplies the exact filament voltage. A voltmeter, however, can be used to disturb circuits in any kind of radio.

To make voltmeter tests in the circuit of Fig. 4, first check the voltage between the plate of $VT_4$ and the chassis (connecting the positive voltmeter probe to the plate terminal of the tube). If you measure normal voltage, but do not get a click of normal intensity in the loudspeaker, the defect must lie between the plate of $VT_4$ and the volume control. If you do not measure normal voltage, very likely there is a defect in the plate circuit of the tube. Next, measure between the plate of $VT_1$ and the chassis. A click should be produced. Finally, measure the voltage between the plate of $VT_1$ and the chassis; again, a click should be produced. No click means that the defect is between the plate of the tube being tested and the plate of the tube next nearest the loudspeaker.
If you find a defective stage by this means, and the tube tests O.K., probably the difficulty will be lack of plate or screen grid voltage, improper alignment, lowered Q in one of the tuned circuits, or perhaps an open a.v.c. bypass condenser. Rarely, you may find an open bypass condenser across the bias resistor in the cathode circuit of an r.f. or i.f. stage.

Of course, if you get clicks from all stages, and none of them appears abnormally weak, then you may have an over-all defect—such as improper alignment, or low Q, in more than one circuit.

**Signal Injection.** Signal injection with a signal generator will give you a rough idea of the gain of each stage, and at the same time let you check the alignment as you go along. Before you can get the most out of this method, you must have had considerable practical experience in alignment. You must be able to judge whether the Q of a tuned circuit is normal by noticing whether the trimmer tunes as sharply as it should. If a trimmer should tune sharply, but instead is rather broad in its tuning (that is, you can turn it quite a bit without affecting the output much), the circuit has lower than normal Q. Only experience will teach you how sharply the trimmers should tune in specific sets—receivers differ in this respect.

As a practical pointer—you will find that circuits using variable-inductance tuning (a fixed condenser and a variable-inductance coil) always seem to tune much more broadly than do the fixed-inductance variable-trimmer types.

- If your signal generator does not already have an isolating condenser in the hot lead, isolate the lead as shown in Fig. 5 by connecting a condenser to its tip. You can then use the lead of the condenser as the probe.

To make tests on the receiver circuit shown in Fig. 4, connect an output meter to the set, turn on the receiver, set the volume control for maximum output, and set the a.g. attenuator for maximum output. Clip the ground lead of the a.g. to the chassis.

Tune the a.g. to the i.f. amplifier frequency, and touch the hot probe to the plate socket terminal of VT3. You should hear the modulating tone of the a.g. in the loudspeaker, but the reading on the output meter may be small. If you do not hear the modulating tone, or the level is far below normal, there is a defect in the plate circuit of VT3, or in the circuits of the second detector VT2. (We are assuming that the trouble is in the r.f.-i.f. section.)

If you hear the tone at normal volume, move the hot a.g. probe to the control grid of VT3. The tone should be considerably louder, and you should get a reading on the output meter. If the output does not increase satisfactorily, look for trouble in the VT3 stage. Try adjusting trimmers C13 and C14 to see if the alignment is off or if there is broad tuning, indicating low Q.

- If the output is satisfactory, peak trimmers C13 and C14 (that is, adjust them for maximum output with the hot a.g. probe touching the control grid terminal of VT3). Next, move the hot a.g. probe to the control grid of VT2. (Be sure you get the control grid, not the oscillator grid.) You should get a large increase in output over that obtained at the grid of VT3, both in sound and in the meter reading. If you do not, the defect is in the detector-mixer portions of the VT3 stage. Adjust i.f. trimmers C11 and C12 to see if perhaps alignment or low Q is responsible.

Next, tune the receiver to the high-frequency end of the dial, choosing some point at which no station is received. Switch the a.g. to its r.f. range, and tune it carefully to the receiver dial setting. Touch the hot probe of the a.g. to the plate of VT3. If you don't hear the signal, adjust the oscillator high-frequency trimmer C14 until you do. Next, adjust trimmer C11 for maximum output. If VT3 is acting satisfactorily as a mixer, the output meter reading should be about the same as the one you got when you fed the i.f. signal into the control grid of VT3. If you find a loss in output, the defect is between the plate of VT3 and the control grid of VT3.
If this test is satisfactory, move the a.g. hot probe to the antenna post, and adjust trimmer condenser for maximum output. There should be a marked increase in the output meter reading. If there is none, the defect is in the VT₁ stage.

* Notice that we have done nothing to check the oscillator part of the VT₁ stage. The reason is that the oscillator is never involved in a weak-reception complaint. True, the oscillator signal voltage can decrease below its normal value—but the oscillator usually will cut out, either at all frequencies or at one end of the dial, long before its signal voltage can drop enough to cause weak reception. The complaint would then be a dead set, not just a weak one.

* The signal injection procedure is as good as the circuit disturbance test for localizing a stage that is almost dead, except that it takes somewhat longer. In addition, it is considerably better as a means of localizing over-all difficulties, since it makes it easier for you to judge the increase in output and to notice the effect of the various trimmers as you go along.

**USING A SIGNAL TRACER**

Although the signal generator and output meter will enable you to get some idea of the relative gain of the stages in the radio, the signal tracer is far better in that it allows you to measure the gain fairly accurately. For simplicity, instead of determining the exact amount of signal, you get a comparison by determining how much greater the signal is at one point than it is at another point. This gives the gain of the section or stage, and tells you at once whether or not things are normal within that portion of the radio.

Of course, you must know what gain to expect in each portion of the radio. Many manufacturers now include gain measurements in the information on their sets. Some do not, however; for their sets, you will have to go by average gain values.

Table 1 gives the manufacturer's gain figures for the set shown in Fig. 6, and Table 2 lists what are considered to be average gain values. As you can see by comparing the two, some of the values in Table 1 are within the average, but others are somewhat outside. Therefore, you can't rely on average values absolutely—you will have to supplement them with what you learn from experience with specific receivers. Even when you get a reading that is within the average limits, you will have to be careful. It may be below normal for that particular radio. That is, if you get a reading near the minimum value of Table 2, you won't always know whether this is natural for the receiver, or whether the gain for this particular stage should be near the maximum and is actually far below normal. Be guided in cases like this by the value you get in the rest of the receiver. If the manufacturer has designed one section to have fairly low gain, then another section must make up for this by having a higher gain.

* Now, let's see how to make gain measurements on the set shown in Fig. 6.

As you know, the basic signal tracer is a vacuum tube voltmeter with a tuned input for checking r.f. sections, and an untuned input for a.f. section measurements. The output indicator on the signal tracer may be either a magic eye tube or a meter. A calibrated volume control, also called an attenuator, on the signal tracer is used to adjust the amount of signal fed in.

To use the signal tracer, you must have a signal, either from a local broadcast station or from a signal generator, to feed into the set. The signal generator is

### Table 1

<table>
<thead>
<tr>
<th>Gain between points</th>
<th>Tuned to</th>
<th>Approximate gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>600 kc.</td>
<td>2.5</td>
</tr>
<tr>
<td>2 and 3</td>
<td>600 kc.</td>
<td>1 (A) or 7 (B)</td>
</tr>
<tr>
<td>3 and 4</td>
<td>455 kc.</td>
<td>70</td>
</tr>
<tr>
<td>4 and 5</td>
<td>455 kc.</td>
<td>0.7</td>
</tr>
<tr>
<td>5 and 6</td>
<td>455 kc.</td>
<td>60 (A) or 125 (B)</td>
</tr>
<tr>
<td>6 and 7</td>
<td>455 kc.</td>
<td>6.7</td>
</tr>
<tr>
<td>7 and 8</td>
<td>400 cycles</td>
<td>30</td>
</tr>
<tr>
<td>8 and 9</td>
<td>400 cycles</td>
<td>15</td>
</tr>
</tbody>
</table>

(A) with a.v.c. voltage applied.
(B) with the a.v.c. voltage shorted out.
preferable, particularly when you expect to make measurements in the audio section of the receiver, because there a steady audio signal of unvarying amplitude is necessary. Let's suppose you are going to use a signal generator.

The gain of the r.f. and i.f. stages depends on the a.v.c. voltage. Hence, most manufacturers recommend that the a.v.c. voltage be killed—in this case by shorting a.v.c. condenser C. Grounding the a.v.c. lead this way permits the set to operate with a maximum and fixed sensitivity. Notice that the r.f. stage gain varies from 1 to 7, depending on whether or not the a.v.c. is working.

Let's prepare the set by shorting the a.v.c. condenser C.

Table 1 shows that the signal strength is increased 2.5 times (the gain is 2.5) between the input of the receiver and the grid of the r.f. amplifier. The measurement, as the table also shows, is to be made with a 600 kc. signal input. Therefore, tune the receiver, the signal generator, and the signal tracer to 600 kc. Connect the signal generator to the aerial and ground posts of the receiver. Attach the ground lead of the signal tracer to the receiver chassis, and touch its hot probe to the antenna post. Adjust the calibrated attenuator of the tracer until the indicator eye of the signal tracer just closes. (For convenience, we will assume you are using a tracer that has a magic-eye indicator. If, instead, you are using a tracer that has a meter, adjust the e.g. output to bring the meter to the value recommended by the tracer manufacturer.)

Next, move the signal tracer hot probe to the control grid of VT. Adjust the attenuator until the indicator eye again closes. The ratio between this attenuator reading and the previous one shows the gain or loss in signal strength between the antenna post and the control grid of VT. (Thus, if the first reading was 3, and the second reading is 8, the gain is 8 ÷ 3, or 2.) If a gain of about 2.5 is found, you know that the input section of the receiver is functioning properly.

Next, move the hot probe of the signal tracer to the plate socket terminal of VT. The ratio between the new attenuator reading and the last one should be about 7 when the a.v.c. is not working.
Next, tune the signal tracer to 455 kc., the frequency of the i.f. amplifier, and touch its hot lead to the plate of \( V_T \). Adjust the attenuator until the tuning eye of the signal tracer closes. The attenuator setting should show a gain of about 70.

Next, touch the hot probe to the control grid of \( V_T \), and adjust the attenuator gain. The "gain" should be about 7—actually, this represents a loss, which is to be expected in a double-tuned i.f. transformer.

Next, move the hot probe to the plate of \( V_T \), and adjust the attenuator. There should be a gain of about 125 when the a.v.c. is not working (about 60 if it is).

In this case, the first reading may be 20 (adjust the a.g. output until the signal tracer eye closes at some convenient attenuator setting), and the second reading may be 2500. The gain is 2500 ÷ 20, or 125. (The attenuator is calibrated to cover a range of from 1 to 10,000.)

Finally, touch the hot probe to the ungrounded diode plate of \( V_T \), of the volume control. This should show a "gain" of 7—the loss in the second i.f. transformer. This completes your check of the r.f.-i.f. section of the receiver.

To check stage gain in the a.f. section, adjust the signal tracer to receive audio signals, and check the level at the volume control. Next, touch the hot probe to the triode plate of \( V_T \), and adjust the attenuator; the gain should be about 50. Finally, touch the hot probe to the plate of \( V_T \), and adjust the attenuator; this gain should be about 15. This completes your check of the gain of each stage of the receiver.

Naturally, if the gain in any stage is below normal, then that stage is the defective one.

**LOCATING THE DEFECTIVE CIRCUIT AND PART**

You will seldom carry out completely any of the isolation procedures we have described. When you locate the defective stage, you will proceed to check the circuits and parts involved, following the same methods you have learned to use to locate other defects most likely to cause weak reception; these were discussed in the first part of this Booklet.

---

**TABLE 2**

<table>
<thead>
<tr>
<th>SECTION</th>
<th>GAIN</th>
<th>MIN</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.F.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antenna to 1st grid</td>
<td>2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Antenna to 1st grid, auto sets</td>
<td>10</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>R.F. amplifier, super, broadcast</td>
<td>10</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>R.F. amplifier, ex.f., broadcast</td>
<td>40</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>R.F. amplifier, super, short wave</td>
<td>5</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>MIXER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converter grid to 1st i.f. grid (single i.f. stage)</td>
<td>30</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Converter grid to 1st i.f. grid (2-stage i.f.)</td>
<td>5</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>I.F. AMPLIFIER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.F. stage (single stage)</td>
<td>40</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>I.F. stage (2-stage i.f., per stage)</td>
<td>5</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>DETECTOR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biased detector, 57, 6J7, 6C6, etc. (depends on % modulation)</td>
<td>5</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Grid leak detector, square law</td>
<td>5</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Diode detector (a loss—depends upon % modulation)</td>
<td>0.2</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>AUDIO AMPLIFIER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triode (low gain)</td>
<td>5</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Triode (high gain)</td>
<td>22</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Pentode</td>
<td>50</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>POWER OUTPUT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triode</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Pentode and beam</td>
<td>6</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

One defect that you have not previously had experience in isolating is low Q in a coil. As we said earlier, this defect is indicated if the associated trimmer condenser resonates very broadly. It is also a definite possibility if you can find no other defect in a stage. When you suspect a coil of having low Q, it is worth while to go over all soldered connections with a hot soldering iron to remove any high-resistance connections. If this does not correct the difficulty, it is best to replace the coil. If the coil has a lowered Q because it has absorbed water vapor, it is sometimes possible to drive out the vapor by baking the coils in an oven. Immediately after-
wards, you should coat the coil with coil dope to prevent re-absorption of moisture. If loss of Q is caused by an internal short in one of the coil windings, no repair can be made; the coil must be replaced.

**NRI PRACTICAL TRAINING PLAN**

In servicing a weak receiver, the most important thing is to localize the trouble by its symptoms or through one of the localization techniques. Because of this, you should introduce defects in your receiver that will cause weak reception, note any of the identifying symptoms mentioned at the beginning of this Booklet, and practice the localization techniques that can be made with the test equipment at your disposal. Following is a list of defects, and suggestions as to how they can be introduced in a receiver.

**Open Cathode By-Pass Condenser.** Look at your diagram, and note which r.f. or a.f. amplifier tubes use an individual cathode resistor by-pass condenser. Unsolder one lead of this condenser and tune in a station. Now touch the unsoldered lead back in place and note how the volume increases. With the condenser disconnected, try out localization tests. You will find that considerable patience is required to localize the trouble.

**Open Antenna Coil Primary.** This trouble can be demonstrated if your receiver uses an antenna. It is not necessary to unsolder the primary leads of the antenna coil. Simply remove and ground the antenna lead. Now connect about 5 feet of insulated hook-up wire to the antenna post of the receiver, and lay the wire on the floor. Tune for both weak and local stations. Notice the characteristic hissing when weak stations are tuned in.

**Low Q in Resonant Circuit.** This defect may be duplicated quite easily. Simply unsolder the lead from the coil to the condenser in a resonant circuit, and insert a 100-ohm resistor in the circuit. If you find that the receiver is dead, use lower values of resistance until strong locals or the full output of your s.g. will cause the loudspeaker to produce weak signals. Now peak the trimmer of this modified tuned circuit. Note how broad the adjustment of the trimmer in the low Q circuit has become. Compare this broadness to its normal sharpness after you have removed the resistor from the circuit. Try this in several circuits, both in the preselector and in the i.f. circuits. Before you restore the circuit to normal, tune in both weak and distant signals and try all localization procedures.

**Weak Stage Localization.** Simulate the effect of a low emission tube in each stage, one at a time. (You can do this readily only in an a.c. set.) To lower the emission of a tube, place a resistor in series with its filament. This will reduce the voltage across the filament, thus lowering the cathode emission. A 5- to 10-ohm, 2-watt resistor will be satisfactory. Tune in weak and distant stations, and note the results when the weak stage is located in different sections. Watch the action of the tuning eye if one is used. Practice the localization procedures.

**Misalign the Set.** You have had practice in alignment before, but try throwing the set out of alignment again, to notice particularly the symptoms of weak reception.

**Measuring Stage Gain.** If you have a signal tracer, practice measuring stage gain. Many servicemen check the gain of all sets they service, and prepare tables for themselves for future reference.
No. 29 How To Fix an Intermittent Receiver

RADIO SERVICING METHODS
Dear Mr. Smith:

In the year since I graduated, I have earned enough money so that my course, tube checker, multi-meter, signal generator, signal tracer, and a nice stock of tubes and parts are completely paid for out of these earnings. There is also a bank balance of about a hundred dollars left over. All of this work was done in my spare time.

E.J.G., New York

INTERMITTENT defects are defined as those defects that are not present all the time. The complaints are the same as the usual ones except for this characteristic, but it very often happens that they are present for such short periods of time that they disappear before one has a chance to localize them. Also, the situation is made more complicated by the fact that attempts to locate the defect will often shock the receiver back into normal operation. This requires somewhat different tactics in localizing the trouble, as we will show. On the average, an intermittent defect will take somewhat longer to localize than a similar permanent defect.

Aside from the fact that they appear and disappear, instead of being permanent, intermittent defects are no different from those you have already studied. A receiver may be intermittently dead, noisy, or weak, or may have intermittent oscillation, hum, or distortion. Always remember this important fact about intermit-
tents—THE SAME GENERAL DEFECTS THAT CAUSE PERMANENT COMPLAINTS ALSO CAUSE THE CORRESPONDING INTERMITTENT COM-
PLAINTS. Armed with this fact, and with modern service techniques, you can expect to have far less trouble with intermitents than did the "old timers."

Before we study the procedures for locating the causes
of intermittent complaints, let's see why they occur.

**What Causes Intermittents.** All intermittent defects are produced by temporary shorts, opens, or leakages. Very often thermal (heat) expansion is responsible for these defects. For example, a metal part in some circuit may be almost touching another part or the chassis; when the receiver is turned on, the chassis and parts become warm, and may expand enough to touch and produce a short. Or there may be a defective connection—a poorly soldered joint, for example—that remains connected as long as it is cool, but opens when the passage of current through the metal heats it enough to cause a slight expansion. Tube electrodes may move slightly when they become warm, perhaps shorting to one another or opening some circuit that should be closed.

Mechanical and electrical actions can also cause intermittents. A jar caused by a passing truck, or even by someone's walking near the set, may open a connection or cause two parts to touch. Sometimes a very small gap exists in a circuit, a gap so small that an arc forms and completes the circuit as long as all voltages are normal. A momentary drop in the supply voltage may quench this arc, producing an open circuit that will close again when the voltage returns to normal or when the receiver is shocked by having the power switch clicked on and off. (Of course, any temporary defect of this latter kind will eventually become permanent, because the arc will eat away the wires at the ends of the gap.)

As you can see, defects that occur in any of the ways just mentioned can often be cured temporarily by the reverse of the effect that causes them. A part that expands when heated will contract when it becomes cool; a part that can be mechanically or electrically jarred loose can be just as readily jarred back again by a succeeding shock; a defect that appears because of some outside influence will disappear when the outside influence is no longer felt. Therefore, it is perfectly possible for an intermittent defect to appear and disappear at frequent intervals—although, in the long run, any such defect will usually become permanent.

Now, let's learn something about how specific parts become defective.

**INTERMITTENTLY DEFECTIVE PARTS**

**Fixed Condensers.** Defective paper condensers are the most common causes of intermittent complaints. As you know, usually these condensers have only a pressure connection between their leads and the condenser plates. The ends of the leads are bent into a spiral shape and pressed against the edges of the plates, and are held in this position by the wax that seals the ends of the condensers. Obviously, the connection has little strength and can readily be broken by mechanical jars. Further, heat may soften the wax enough for a lead to move away from the plate with which it should be in contact.

When such a break between a lead and a condenser plate appears, the gap will be very small. It can, therefore, be closed or opened very easily, so an intermittent open in such a condenser can be expected to occur rather often. On the other hand, it is virtually impossible for a paper condenser either to short intermittently, or to change in capacity.
Almost any complaint can be produced by intermittent defects in a paper condenser—dead set, weak set, distortion, oscillation, etc. The complaint caused depends on where the condenser is used in the circuit.

Many electrolytic condensers, in cardboard containers, are held in place by metal brackets. Sometimes leakage will develop between the condenser and the bracket through the cardboard. If this leakage varies intermittently, it will cause intermittent hum.

Intermittent defects in other kinds of condensers are very rare.

Tubes. A defective tube is the second most common cause of intermittent receiver operation. As you might suspect, the filament is most often to blame. A filament gets hot in normal operation and may undergo considerable expansion. If it is broken, and the broken ends are touching, this expansion may cause the filament wires to pull apart at the broken point. This will open the circuit and shut off the filament current; consequently, the filament will cool off again and shrink back to its normal position. When the broken ends come together again, filament current will again flow, and the process will be repeated. Often it will be as regular as clockwork. Of course, the tube is dead for the length of time the filament stays open.

Improved manufacturing techniques have largely eliminated this trouble in tubes with low-voltage filaments. It is still quite common, however, in the tubes with higher-voltage filaments now used in a.c.-d.c. receivers.

Heat expansion may also cause partial shorts in tube filaments, with one section of the filament touching another. High-voltage filaments are likely to have this trouble because of the many closely spaced loops of the filament.

The effect of a shortened filament is to produce weak reception. This defect is not always a regular on-and-off affair like an open filament, because the filament loops may remain shorted until the set power is turned off. However, the filament will then return to its normal state, and the tube will be good for a while after the set is turned on again.

Intermittent cathode-to-heater leakage sometimes occurs in a tube. Again, the defect is the result of movement of the filament as it becomes hot. This intermittent leakage can cause any of the defects usually caused by cathode-to-heater leakage — intermittent distortion, hum, or oscillation.

Tubes also exhibit other and more mysterious intermittent defects. These can usually be blamed on a defective weld between one of the tube electrodes and its lead. The heat of operation of the tube may cause the weld to open; the effect of this, of course, depends upon which electrode is at fault.

In general, an open filament is the only tube defect that is genuinely intermittent in the sense that it occurs at regular intervals while the set is playing. Other defects usually occur after the tube has become warm and do not cure themselves until power has been removed from the tube.

Coils. An open is the most common intermittent defect in a coil. An air-core coil may open up because the coil form expands, stretching the wire near a lug until it breaks. This may create a permanent defect, or con-
tact may be re-established if the chassis is jarred or the coil form returns to its normal size. The set will usually be dead while the coil is open. This defect occurs only with air-core coils—iron-core coils are not wound so tightly on their coil forms, and therefore do not break when the coil form expands.

When electrolysis attacks the coil winding, the result is usually a tiny break in the winding. The break may be so small that it opens and closes rapidly, in which case the receiver will be noisy. If the interval between opening and closing is somewhat longer, the receiver will be intermittently noisy; if the interval between opening and closing of the coil is rather long, the set will be intermittently dead. This defect usually occurs mostly in i.f. and audio transformers; power transformers are seldom affected.

**Resistors.** Defective potentiometers with carbon elements frequently cause intermittent complaints. Pitting of the carbon element causes imperfect electrical contact between the slider arm and the element; the slightest jar may break the connection. If the potentiometer is used as a volume control, any of several defects may occur, depending upon the circuit in which the control is used. Usually the complaint will be weak reception, noise, or hum.

Wire-wound variable resistors seldom become intermittently defective. Occasionally one will become dirty, permitting an intermittent contact to develop between the slider arm and the coil.

Fixed resistors may develop internal breaks that will make them intermittently defective, especially if they have been overheated. The intermittent complaint produced will, of course, depend upon the circuit in which the resistor is used; however, the most usual complaint is intermittent noise.

**Tuning Condensers.** A tuning condenser may be intermittently defective if a variable high-resistance connection develops in series with the rotor and stator plates. Usually this is caused by wiper spring contacts that are dirty or have lost tension. Many older receivers made the connection to the stator plates through bolts that held these plates properly centered between the rotor plates. Oxidation of the threads on these bolts sometimes causes a variable resistance that produces intermittent operation. Metal particles sometimes peel off the plates of the older types of condensers, causing intermittent shorts between the plates. However, this defect no longer exists in modern condensers. Intermittent noise that occurs only as the tuning knob is being rotated usually indicates some defect in the tuning condenser gang.

**Connections.** Poorly soldered joints may open intermittently; sometimes, also, a bad soldering job will leave a drop of excess solder hanging from the connection and coming close enough to some other part of the set to cause an intermittent short. Any of several defects can be produced by a poor soldering job; intermittent noise or a dead set are two of the more common.

**Installation Defects.** Poor joints in the antenna or ground system are fairly frequent causes of intermittent reception. The poor connection may occur anywhere in this system, but the lead-in strip and the ground clamp are particularly common locations. The power connection may also be at fault, especially if the customer has plugged the power line into a cube tap along with several other appliances. A fault in the antenna or ground connection will usually cause intermittent noise or a dead set; a poor contact between the power cord plug and its receptacle will, of course, make the set intermittently dead.

Whatever possible, plug the power cord of a receiver directly into a wall outlet. Avoid using a cube tap if you can— they have a tendency to loosen inside and create poor contacts.
CONFIRMING THE COMPLAINT

Now that you know something about the more common defects that can cause intermittent operation, you are ready to learn how to isolate the trouble.

When you confirm the complaint, be sure to question the customer carefully. Remember—the radio may be playing all right at the time you come to examine it, so you can find out about intermittent defects only by careful questioning. When you discover the customer is complaining of a defect that comes and goes, determine just what does happen when the radio plays abnormally. That is, does the receiver fade out completely (become dead), does it distort, or have a hum, or just what does occur?

While you are listening to the receiver to try to hear the trouble yourself, try to find out how frequently the trouble occurs. Ask whether it happens as soon as the set is turned on, or only after the set has operated for a period of time.

Be particularly careful to inquire further into complaints that seem to occur at fairly definite times during the day or that seem to be related to the operation of household devices. These complaints may be caused by some external influence—an unshielded diathermy machine in a nearby doctor’s office, for example, might be the cause of noise that occurred only during the doctor’s office hours. Or a noise that occurs only when an oil burner or a refrigerator is operating probably means that the electrical system of the device is feeding noise into the power line.

As another example, the customer may complain of fading out of medium-distant stations. Further questioning may show that this fading occurs only at the hours near sunrise and sunset. It is entirely natural to find severe fading on medium-distant stations at this time—even on stations that may be heard satisfactorily earlier and later—because of shifts in the ionized atmosphere layers that serve to reflect radio waves.

This initial questioning is necessary to determine whether the trouble is actually within the set. It is particularly necessary with intermittent noise and intermittent hum, both of which may be caused by man-made interference of an intermittent type. Atmospheric conditions may account for intermittent fading in and out of signals, and in some instances for distortion and perhaps station interference, which may be described to you as noise.

Once you are reasonably sure that the complaint is caused by the receiver or its installation, the next step is to be certain that the installation is not at fault. A break or a poor contact in the antenna system, or a poor electrical contact at the power plug, may cause severe noise or sharp changes in the volume. The set may even go intermittently dead because of such defects.

It is well to examine the antenna system carefully. Shake the lead-in wire to see if this makes the receiver act up. Be particularly careful in your examination of window lead-in strips.

In some cases of intermittent reception or intermittent noise, you may find that walking around in the room causes the trouble to appear and disappear. This can mean that the receiver is being jarred by your movements and thus shocked into and out of normal reception. However, don’t overlook the fact that the installation itself can be at fault—walking around the room may make pipes touch under the floor in such a way that there is a better ground than normal (or in some instances a poorer ground than normal) for the radio.

Sometimes you will find that turning on or off electric switches causes sharp changes in the volume level of the receiver. This may mean that the operation of the switch is shocking the receiver back into normal operation. On the other hand, it may indicate that the set has a defective antenna and is depending for its operation on signals picked up by the power line. If so, opening or closing the switch will change the effective length
of this power-cord antenna and so cause the set output to vary.

From what we have said, you can see that some judgment is needed to determine whether the set is at fault. Sometimes the only real test is to take the receiver to the shop and try operating it there. Naturally, if it continues to operate improperly in another location, the receiver must be defective. On the other hand, if the trouble clears up, there is a good possibility that the location or installation is at fault.

However, let’s suppose that the customer’s description of the defect, or the operation of the radio, leads you to believe the set itself is at fault. The logical procedure for you to follow is the same as for any other trouble—try to localize the defective section, stage, circuit, and part. In each instance, you will be looking for a defect that could cause that same symptom more permanently—if the complaint is intermittent hum, for example, you would look for things that would cause hum, not for troubles that would cause distortion.

Now for some general rules. The greatest difficulty with intermittent reception is the fact that a mechanical jar or an electrical shock may temporarily restore the set to normal. Therefore, your attempts to test and localize the trouble may shock the set back into normal operation, thus forcing you to wait for the next occurrence of the trouble before you can continue your tests. This makes it practically impossible to perform any kind of circuit disturbance test, because such a test is almost certain to restore normal operation, whether the defect is in that stage or not. Therefore, either you must follow a brute force technique of trying to make the trouble occur, or you must use test procedures that will not shock the set back into operation. We will describe both methods, brute force first.

**BRUTE FORCE LOCALIZATION**

The brute force method is given that name because it is the application of physical force to the set in an attempt to make it act up. To use it, you wiggle the various by-pass condensers, pull on leads, snap tubes with your finger, and jar the chassis. Naturally, you must use some discretion—don’t yank leads or parts hard enough to break them, but use enough force to open up any connection that is already loose.

If the set is sensitive to jarring, so that striking the chassis causes the intermittent action to show up, then rap more lightly in different places on the chassis. If you find that one end of the chassis is much more sensitive to this jarring than the rest of the chassis, very likely that is the end where the defect is; concentrate on jarring the individual parts there until you are led to a logical suspect.

When the trouble is an intermittent contact in a tube, you will find that rapping lightly on the tube, one at a time, will disclose the offender. Of course, always keep in mind the possibility that the jarring you introduce by doing so may actually be moving a defective part or connection somewhere else—a loose connection at the tube socket, for example. For that matter, there is always a chance that you are unknowingly jarring some remote part or connection when you use any brute force technique. However, if you find that moving a
part or pulling on a lead lets you make the intermittent condition appear and disappear at will, then you should first suspect the part or circuit you are touching. Replace the part, or resolder connections, to see if the intermittent operation disappears. If it does not, you should then consider the possibility that your actions jarred the set at some other point.

If you cannot force the trouble to occur easily by the brute force method, go on to other methods of testing that we will now describe. We will show how to locate the defect in an intermittently dead or intermittently weak set first, because these are the most common intermittent complaints.

**LOCALIZING THE TROUBLE IN A RECEIVER THAT IS INTERMITTENTLY DEAD OR WEAK**

When you are called upon to service a receiver that is intermittently dead or weak, the first thing to notice is the tuning indicator, if the set has one. Any changes in the signal level up to the second detector will be shown by a change in the closure of the tuning eye, or by movement of the tuning meter pointer. Any such changes at once indicate that the trouble is in the r.f. section of the receiver, or in the power supply.

If, on the other hand, the tuning indicator indicates that the signal volume level remains constant, but the set becomes weak or goes dead intermittently, the trouble must be in the audio amplifier.

In the latter case, coupling condensers and tubes are the most logical suspects. However, if the trouble could be in either the r.f. stages or the power supply, you should measure the power-supply voltage first. If it does not vary, tubes are the next most likely suspects.

- If the set has no tuning indicator, provide one. The quickest and simplest means of doing this is to connect a d.c. voltmeter so that it will indicate the a.v.c. voltage. Connect the meter, and allow it to remain connected until the set has had a chance to act up. (It is not a good idea to take a reading, then disconnect the meter and come back and take another reading when you think the signal level has changed. If you try this, connecting the voltmeter may draw sufficient current to provide the

---

This diagram shows two points to which you can connect a meter to indicate a.v.c. voltage in a set that uses the volume control as the diode load, as do most modern receivers. It is usually simpler to connect your meter from point X to ground (that is, across the volume control). However, doing so will affect the tone and the output of the set; also, you must be sure your meter will not indicate a.c. Either a high-resistance or a low-resistance meter can be used. Connecting your meter from point Y to ground will not affect the performance of your set, and it does not matter whether the meter indicates a.c.; however, you must use a high-resistance meter. In either case, the positive meter terminal should go to ground.

needed shock to start the receiver operating again. You won't know then where the trouble might be.)

With the d.c. voltmeter connected to the a.v.c. circuit, allow the receiver to operate. When the fading occurs, notice whether the d.c. voltage reading has changed. If it has, the defect must be in the r.f.-i.f. section or in the power supply. Otherwise, it is in the audio amplifier.

When you have located the defective section in this way, you may decide to revert to the brute force method of finding the trouble, or you may go to what you consider the most logical suspect for the particular complaint. If you find it necessary to make further tests to locate the defective stage, remember that you cannot use circuit disturbance techniques.

**Using a Signal Tracer.** If you have a signal tracer, the problem is not so difficult. You can connect the sig-
nal tracer and leave it connected until the fade occurs. If the volume drops in the signal tracer output as well as in the set output, you know the trouble is between the antenna and the point where the signal tracer is connected. On the other hand, if the signal tracer maintains normal volume but the set output drops, then the trouble is between the signal tracer connecting point and the loudspeaker.

Because a signal tracer indicates the amount of signal at the point of connection, it is an ideal instrument to use when the complaint is an intermittently dead or intermittently weak set. You have your choice of methods—start with the signal tracer somewhere near the middle of the set and work towards the end containing the defect, or start at either end of the set and work back towards the other. From a logical standpoint, it is best to locate the defective section first, so the signal tracer is normally connected at the input of the audio amplifier. Any change in the amount of signal at this point indicates trouble in the r.f. stages or in the power supply.

There is one important fact you should consider before you start to use a signal tracer—or, for that matter, any other piece of test equipment—to locate an intermittent defect. You must leave it connected until the set acts up. Therefore, your test equipment is tied up to this intermittent receiver. You cannot use it to service other sets while you are waiting for the defective one to act up. For this reason, be sure to learn how often the intermittent defect occurs before you even accept the job. If it is relatively infrequent, it may be best to advise the receiver owner to keep his set until the trouble occurs more often. Point out to him that, at the moment, the repair will cost him more than it is worth because of the time you will have to spend looking for the defect. However, if the intermittent occurs several times an hour, then it is becoming frequent enough to consider tying up equipment to locate the defect.

Of course, in between cut-outs, you need pay little attention to the set. Service other receivers, or attend to other shop duties, as long as you stay within hearing distance of the intermittent set. When you hear the set act up, a glance at your indicator will show you how much progress you are making in locating the trouble.

**Signal Injection.** If you do not have a signal tracer, you will undoubtedly depend mostly on the brute force method when the defect is in the audio system or in the power supply. R.F. troubles, however, are sometimes difficult to locate by force. If you have a signal generator that operates from the a.c. power line, you can use the following method of signal injection to locate the defective stage:

Tune the set to a quiet point on the dial (no signals), connect the signal generator to a signal circuit in the set, and tune the s.g. to a frequency that will pass through the set at that point. Turn down the s.g. output so that it approximates the strength of a normal signal at the particular point where the s.g. is connected to the radio.

Allow the s.g. to run until the set acts up. (Unfortunately, this means that you must listen to the very monotonous tone of the signal generator for some time—one good reason for not accepting an intermittent that
does not act up reasonably often.) If the s.g. signal fades, then the defect must be somewhere between the point where the s.g. is connected and the output of the set. On the other hand, if the signal remains constant, the defect is in some stage nearer the antenna.

To make sure you will hear the fading, start with the signal generator connected to the antenna terminal. Then, advance your s.g. toward the loudspeaker a stage at a time. When you finally reach a point where the fading no longer occurs, you have just crossed over the defective stage.

**OTHER INTERMITTENT COMPLAINTS**

Fading and weak reception are the most common intermittent complaints, but hum, oscillation, noise, and distortion also occur intermittently. In each of these complaints, you can again use the brute force method, concentrating on the particular parts that are most apt to be at fault. Table I lists the most common causes of these intermittent complaints.

Intermittent hum is almost always caused by intermittent cathode-to-heater leakage in a tube, or by a leaky electrolytic filter condenser. Once in a great while, a grid circuit may open intermittently, and there may be cases of intermittent modulation hum. However, you should concentrate first on tubes and filter condensers.

Because of the intermittent nature of the trouble, the standard tube test is not always satisfactory. A much better test is to substitute tubes for those in the set. Some servicemen make a practice of putting in an entire new set of tubes, then putting back in the old tubes one at a time until the trouble reappears. Other servicemen work the other way, replacing the tubes one at a time with new ones until the intermittent operation stops; then the last tube replaced was defective. Either method will show you which tube is bad. However, the latter method may be somewhat quicker if you concentrate on first replacing the tubes that are most likely to cause the trouble. For example, in intermittent hum complaints, replace the audio and power output tubes first, since they are the ones that are likely to be at fault.

Intermittent distortion is an audio defect in most cases. This trouble is most likely to be caused by gassy tubes, intermittently leaky coupling condensers, and intermittent short circuits that change supply voltages.

These conditions can be checked for with a d.c. voltmeter. Make the same tests that you would make for a permanent defect, but leave the voltmeter connected until the distortion occurs, and then check to see whether the voltage has changed. You can leave the d.c. voltmeter connected across the grid resistor, for example, to determine whether a gassy tube or leakage in the coupling condenser is to blame. (With a signal tuned in, you may observe small variations in the voltmeter reading. Ignore these—when the distortion occurs, the reading will be radically different.)

Similarly, you can connect a d.c. voltmeter and see whether there is any change in the supply voltage when the intermittent defect shows up.

- Intermittent noise and intermittent oscillation can be run down by brute force methods, by signal injection, or by the use of a signal tracer. The last is generally the best. Just listen to the signal through your tracer; as long as it has the oscillation or noise voltage added to it, the trouble is between the antenna and the point where your tracer is connected.

### ADDITIONAL CLUES TO THE SOURCE OF TROUBLE

We have already mentioned the tuning indicator as

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complaint</strong></td>
</tr>
<tr>
<td>Hum</td>
</tr>
<tr>
<td>Distortion</td>
</tr>
<tr>
<td>Noise</td>
</tr>
<tr>
<td>Oscillation</td>
</tr>
</tbody>
</table>
a means of localizing the trouble when the complaint is intermittently dead or intermittently weak reception. The tuning indicator may sometimes also indicate when noise occurs in the r.f. section or the power supply, because the meter needle or tuning-eye shadow may quiver in step with the noise pulses. However, this is not very reliable, because a serious trouble in the amplifier may pass a noise voltage through the power supply to the r.f. stages. Always remember that such interconnections exist—they cause some of the most baffling defects.

Another important fact is that the rapidity with which the defect repeats itself is often a clue to its nature. As we pointed out earlier, heat is frequently the cause of intermittent operation. If a part is made defective by heat, and can heat and cool quickly, the time interval between periods of improper operation may be short. On the other hand, if the part is a large heavy one, it may take some time for it to heat up. In this case the trouble won't occur until some time after the receiver has been in operation, and then may not recur very rapidly.

For example, when the defect is an intermittent open in the filament of a tube, the filament heats quite rapidly when the connection is made, and cools equally fast when the break occurs, with the result that the interval of time is short. If, on the other hand, the defect is an intermittent open in a power transformer winding, there is so much metal in the vicinity to be heated and cooled that the defect will take longer to appear and longer to disappear. Table 2 indicates several probable causes of trouble when the intermittent occurs at regular, definite intervals of time.

Sometimes a serviceman is baffled by the fact that the set plays intermittently while in its cabinet, but plays rather satisfactorily, with far fewer cut-outs, when it is placed on his bench. This is almost always an indication that for the trouble to occur, the set must be enclosed so that enough heat is trapped. You can frequently get around this by enclosing the set on your work-bench in a cardboard box. This will cause it to heat up much faster, and the trouble will therefore occur sooner.

### Table 2

<table>
<thead>
<tr>
<th>Time</th>
<th>Probable Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 minutes</td>
<td>Defective connection.</td>
</tr>
<tr>
<td>3-5 minutes</td>
<td>Defective resistors, especially cathode bias resistors which heat up after tubes are warm, and other parts that dissipate heat rapidly; loudspeaker fields are in this classification.</td>
</tr>
<tr>
<td>3-5 minutes</td>
<td>(A.C.-D.C. receivers.) Series filament resistors and heavy duty bias resistors that sag and touch the chassis.</td>
</tr>
<tr>
<td>Over 5 minutes</td>
<td>Defective power transformers and large resistors.</td>
</tr>
</tbody>
</table>

### NRI Practical Training Plan

It is perfectly possible to introduce defects that will make a receiver dead, weak, noisy, distorted, or will cause it to hum. However, it is not practical to make these defects occur intermittently, since it is not possible to create the same types of intermittent shorts or opens that occur naturally in receivers. Because of this, wait until you have an intermittent receiver to service to get your practice.

When you have such a set to service, try every means of localization at your command. Get your practical experience on the job. Then, when you have learned all you can from this set, repair the trouble and go on to the next one. Remember, however, always to destroy any intermittent tube or other part you remove from a radio receiver. This will eliminate the possibility of its ever getting into another set.

If you have followed the NRI Practical Training Plan faithfully up to now, you have received, in a few weeks, the practical training that would otherwise have taken you months or even years to acquire. You are certainly ready to cope with any ordinary receiver trouble.

Except for a few suggestions here and there in later RSM Booklets, this is the last of the sections on getting practical experience. If you wish to experiment further, it is advisable to repeat this entire Plan on another
To make a set heat up on your bench, simply place an ordinary cardboard box over it. Make sure the box is large enough to rest on the bench all around the set.

entirely different make of receiver. This will help greatly, because you will find that receivers do not sound exactly alike when they have distortion, and hum has different characteristics in different radios. Practical experience on more than one set is therefore desirable.

Looking Ahead. With this RSM No. 29 you have reached another milestone; this is the last of the series dealing with servicing for particular complaints. You will next receive RSM Booklets on servicing particular types of receivers, such as a.c.-d.c., auto, etc. Then you will finish the RSM series with No. 35 on "How to go into Full-time Servicing." There are no RSM Booklets beyond No. 35. However, if you have chosen the Lessons specializing in Radio Servicing, you will continue your education in this field by studying the advanced service methods in your regular Lessons.
ity, making it better able to pass the high current that flows when the set is first turned on.

► A few a.c.-d.c. receivers use a resistor in place of the filter choke, as shown in Fig. 8. (In modern receivers using this circuit, the speaker is invariably a p.m. dynamic.) The resistance of $R_1$ must be at least 10 times the reactance of condenser $C_3$ to provide sufficient filtering. If all the current drawn by the set were allowed to flow through the resistor, too much voltage would be dropped across it; therefore, the plate current for the power output tube $VT_1$, which needs the least filtering, is taken off ahead of the filter resistor. All other plate and screen-grid currents flow through $R_1$.

► Another possible filter variation is the use of a choke coil in the negative side of the filter circuit. The purpose is to use the voltage drop across the choke as bias for the output tube, as shown in Fig. 9.

► The screen grids and the plates are supplied with the same d.c. voltage in a.c.-d.c. receivers, with the exception of the screen grid of a C-bias detector in t.r.f. sets. The reduced screen voltage it needs can be obtained as shown in Fig. 1. Another method is shown in Fig. 10, where the detector screen grid is connected to the cathode terminal of the output tube. This applies the output tube bias voltage, developed across bias resistor $R_1$, to the screen grid of the detector tube. As it happens, this bias voltage is about the right value for the screen voltage of this detector circuit.

It is important to recognize this last variation, because, in making continuity checks, you won't find continuity between the screen grid of this detector and B+. Instead, the continuity will be from the screen grid through the low resistance $R_2$ to B-. (Of course, if the speaker field is connected from B+ to B- as in Fig. 7B, you can find continuity through $R_1$ and the speaker field back to B+.)
Dear Mr. Smith:

After having spent several years in spare-time radio work, I am in business for myself 100% now. I also have service contracts with several radio and appliance dealers who do not maintain service departments of their own. I make as much in one week as I used to in a month of nights.

N.P.K., Missouri

PRACTICALLY all modern midget and small table-model sets, and many of the low-priced console receivers, are a.c.-d.c. sets (able to operate from either an a.c. or a d.c. power line). Generally speaking, these sets have simpler signal circuits than standard a.c. receivers, and are inferior to the latter in selectivity, sensitivity, and fidelity. However, their compact construction and low cost have made them very popular in spite of these shortcomings.

Your earlier RSM Booklets have discussed the servicing of all kinds of receivers, both straight a.c. and a.c.-d.c. Here we are going to concentrate on the servicing problems that are peculiar to a.c.-d.c. sets, showing you what changes you must make in your general servicing procedures to adapt them for use on sets of this sort. As the first step, let’s see how the circuits of a.c.-d.c. sets differ from one another and from straight a.c. sets. (This is important, because service information is frequently not available on these sets. Many are “orphans”—their manufacturers are out of business by the time they come in for servicing.) We’ll start with the signal circuits.

BASIC SIGNAL CIRCUITS

Tuned-Radio-Frequency Type. Today, the t.r.f. circuit is used only in the smallest and least expensive of the a.c.-d.c. receivers. In practically all cases, this circuit uses the fewest possible parts, so that the receiver can be manufactured at a low cost.
A.C.-D.C. Superheterodyne. The a.c.-d.c. superheterodyne is also essentially a simple receiver. The most common kind uses 6 tubes (including the rectifier) in the basic circuit shown in Fig. 2. Here we have a simple frequency converter, an i.f. stage, a combination second-detector-first-a.f. stage, and a power-output stage.

In the set shown in Fig. 2, an antenna coil is used to feed the signal from the hank antenna to the control grid of the first tube. Often a loop antenna is used instead, with the loop winding replacing the secondary of the antenna coil. Some manufacturers provide a single turn of wire around the loop to be used to couple the loop to an outside aerial and ground.

The r.f.-i.f. section of a variation of the superheterodyne circuit is shown in Fig. 3. Notice that there is no i.f. tube, but an i.f. transformer is used to couple the first detector to the second detector. This is essentially a superheterodyne circuit, since an i.f. signal is produced. Although there is no i.f. tube to amplify this signal, some i.f. gain is provided by the transformer. More is secured by making the second detector regenerative. This particular variation makes a four-tube set. It was rather popular several years ago, so you may still occasionally get one for servicing.

In general, the a.c.-d.c. superheterodyne has less signal output but almost as good sensitivity and selectivity as a straight a.c. receiver using a similar number of tubes. However, using an outdoor antenna with such a set may permit considerable image interference and cross-modulation to occur, particularly during the evening and in the winter months.

Now, let's turn to the power supplies, where the greatest difference between the standard a.c. and the a.c.-d.c. sets exists. The one great difference is that you will never find a power transformer in an a.c.-d.c. receiver. The power pack of an a.c.-d.c. set must rectify the a.c. line voltage and deliver the maximum possible B supply to the plates and screens of the tubes. (When the set is operated from a d.c. power line, the power pack serves only to filter out power-line noises and ripple.) Furthermore, since no power transformer is used, the filaments of the tubes must be operated directly from
FIG. 2. The tubes used in a set of this kind depend on the age of the set. In the following, the tubes used in earlier sets are given first. The first detector-oscillator is a 5A7, 6A8, 12A6, or 125A7. The i.f. amplifier is a super-control pentode such as the 78, 6D6, 6K7, 12K7, or 12SK7. The second detector-first a.f. tube is usually a dual-diode-triode such as the 75, 6Q7, 12Q7, or 12SQ7. The power output tube may be a type 43, 2SL6, 3SL6, or 50L6 tube.

the power line. Let's first see how power is supplied to the filaments, then study the plate or B power supply.

FILAMENT POWER SUPPLIES

In all a.c.-d.c. receivers, the tube filaments are operated in series so that they get their operating power directly and economically from the power line. It is standard practice, therefore, for all the tubes in any particular receiver to have the same filament-current rating.

The filament string, as it is called, consists of the tube filaments in series and whatever limiting resistor may be necessary to cause the proper current to flow. The earlier sets used 6.3-volt and 25-volt tubes rated at .3 ampere. More modern sets use 12-volt and 35- or 50-volt tubes rated at .15 ampere.

Fig. 4 shows a typical string using .3-ampere tubes. The two r.f. tubes have filaments rated at 6.3-volts, and the power and rectifier tubes have filaments rated at 25 volts each. Adding up the filament voltages, you will find that they total 62 volts. Since the line voltage is considered to be 115 volts, the difference between the line voltage and that required by the filament string is 53 volts, which must be dropped in the series resistor.

Replacing the Series Resistor. The series resistor may be a wire-wound power resistor, a ballast tube, or a special resistance element contained in the power cord. (The latter is called a Cordohm.) All types open frequently and must be replaced.
As you know, the resistance of any resistor is equal to the voltage drop across it divided by the current flowing through it. To figure out the proper resistance for a replacement series resistor, first add up the filament voltage drops and subtract their total from 115 volts. The difference is the voltage that must appear across the series resistor. Then, determine the filament current of any of the tubes in the string, and divide the value of the resistor voltage by this current value. In Fig. 4, for example, the resistance should be about 178 ohms. Actually, a resistor between 170 and 180 ohms would be entirely satisfactory as a replacement.

If the series resistance is a power resistor mounted on the set, its wattage must be figured carefully. This is done by multiplying the voltage by the current. The resistor in Fig. 4 dissipates about 16 watts, which means a resistor rated at about 25 watts should be used.

You do not need to figure the wattage rating of Cord-ohms; they have a standard rating of about 35 watts.

If the resistor is a ballast tube, replacement won’t be much of a problem, since the ballast tubes are numbered by a system like that used for regular tubes. Simply replace the defective ballast with another having the same marking. However, some ballast tube manufacturers have their own marking codes, so you will have to refer to replacement charts issued by the manufacturer of the type you use to be sure you have the right replacement. (Incidentally, ballast tubes become very hot; always use a handkerchief or pad to pull one out of its socket.)

**Low-Current Strings.** Modern sets, using .15-ampere tubes, may not require any series filament resistance.

---

**FIG. 4**

---

**FIG. 5.** Notice the arrangement of the tube filaments in this typical filament string. To prevent hum, it is desirable to have the least potential difference between the filament and the cathode. Therefore, the tube most likely to cause hum—the first audio tube—is always the tube nearest the ground or B—end of the filament string, because this brings this tube’s cathode and filament closer to the same potential. The next tube up the string, the first detector, is the one that is next most likely to cause the hum. The high-voltage tube filaments are in all cases closest to the hot side of the power line. Of course, this means that the filament wiring must skip properly from tube to tube.

A typical string of this type is shown in Fig. 5. Adding up the filament voltages (12 + 12 + 12 + 50 + 35) gives a total of 121 volts. This string will work across the standard 115-volt a.c. or d.c. power line without any limiting resistor. The filament voltage on each tube will be slightly below its rated value, but the set will operate satisfactorily.

If a 35L6 tube is used instead of the 50L6, the voltage required by the filament string is reduced by 1.5 volts. In this case, a series resistor is used to limit the current to the correct value.

**Pilot Lamps.** Practically all a.c.-d.c. receivers use pilot lamps. A few of the very early ones used 110-volt bulbs, connected directly across the power line, but today it is standard practice to use a 6.3-volt pilot lamp in series with the tube filaments. These pilot lamps are rated at .15 ampere, or .2 ampere, or .25 ampere. To use one of these lamps in series with 3-ampere tube filaments, it is necessary to shunt it with a resistor. The value chosen for this resistor is such that the voltage across the pilot lamp will be 4.25 volts when the tubes are drawing normal current. This is done to protect the lamp against the rather high surge of current that oc-
curta when the set is switched on when the tubes are cold. The shunting resistor carries a current equal to the difference between 0.3 ampere and the current rating of the pilot lamp. The resistance can be found by dividing 4.25 volts by this current value.

When you replace a pilot lamp, use a 6.3-volt bulb having the same current rating as the original. The current rating is not marked on these bulbs, but it is shown by the color of the glass bead that supports the filament. In the 6.3-volt bulbs, a brown bead indicates a .15-ampere bulb, a white bead a .2-ampere bulb, and a blue bead a .25-ampere bulb.

If the pilot lamp burns out as soon as it is installed, the wrong lamp has been used, or a circuit defect exists. The shunt resistor may be burned out, in which case the pilot lamp is called upon to carry too much current. However, if the shunt resistor is normal, and the pilot lamp is used only in series with the filament string as in Fig. 6, then there is probably a short circuit in the filament string somewhere.

Incidentally, the shunt resistance across the pilot lamp may be a separate resistance or a section of the series resistor. If a ballast tube or a Cordohm resistor is used, it is tapped to provide the shunt resistance. If a shunting resistor of the latter sort is open, replace the entire ballast or Cordohm. However, if it is a separate resistor, or a section of a power resistor, then just the single section needs to be replaced.

PLATE POWER SUPPLIES

The B power supply of an a.c.-d.c. receiver is quite simple. There is no step-up transformer, so the rectifier tube is operated directly from the power line. The rectifier output is filtered in the usual manner, and then is used as the plate and screen-grid supply.

Some early a.c.-d.c. sets used magnetic speakers, and many modern ones use p.m. dynamos. In these sets, of course, the power supply does not have to energize the speaker field. In sets using electrodynamic speakers, there are several ways in which the speaker field may be energized. Since the rectifier output voltage is limited, a field used as a choke has to be a special low-resistance type—300 to 450 ohms—to keep the drop low.

More commonly, the speaker field is connected directly across the output of the rectifier. Some early sets use the circuit shown in Fig. 7A, in which one cathode is connected to supply the B voltage, and the other is used to supply the speaker field. The field coil in this case is usually about 2500 ohms, and the filter condenser connected in parallel with it furnishes all the filtering needed.

Usually, however, the rectifier cathodes are tied together, and the field is connected directly across the B supply, as shown in Fig. 7B. This connection has several advantages: it eliminates a filter condenser; there is less voltage drop in the rectifier, because its resistance is halved; and the rectifier has greater current capaci-
The recent a.c.-d.c. receivers generally use .15-ampere tubes and the 35Z5 rectifier tube in the circuit shown in Fig. 11. As you will notice, the rectifier tube has a tap on its filament. This tap is arranged so that a portion of the filament can be used as a shunting resistor across the pilot lamp, and, since the plate of the tube is connected to this tap, the rectifier plate current flows through the pilot lamp and its shunting filament section. (This makes the lamp light brilliantly at first when the tube filaments are cold, dim down to a low brilliance as the filaments warm up, then light up more brightly again as rectifier plate current flows through it.) This peculiar connection is used as a protection for the rectifier tube.

An important difference between the usual rectifier and those used in a.c.-d.c. sets is that all the latter have cathodes with links, or connectors, from the cathode to the prong lead that are made of "fuse" material. This "fuse" will open on any overload, so that any short in the B supply will open the rectifier cathode instead of blowing the hose fuses. Also, this serves to protect the receiver from excessive damage. At the same time, this means that current surges will at times open the tube's fuse link, thus ruining the rectifier.

To avoid this, the circuit shown in Fig. 11 has the pilot lamp arranged so that, if too high a plate current surge occurs, the lamp will burn out, effectively increasing the resistance in the rectifier plate circuit. This will often prevent the tube from burning out, too.

A fairly high plate current surge occurs while the input filter condenser charges when the set is first turned on; a considerably larger one—large enough to burn out both the pilot lamp and the rectifier—may result if you snap the set off, leave it off long enough for the charge on the input filter condenser to leak off, then snap the set back on while the rectifier is still warm. Remember—NEVER snap an a.c.-d.c. set off and on.

On a set of this kind, if you find the pilot lamp is burned out, replace it. If the replacement burns out, either there is a short circuit across the B supply, or the tapped section of the rectifier filament is open. If the lamp burns normally, then the original was probably burned out by one of these current surges.

Except for the tapped filament, and the fact that the tubes are chosen so that their filament voltage values add up to the line voltage value, the circuit in Fig. 11 is much like those previously shown.

Incidentally, some of the earlier sets have 25- to 50-ohm resistors in series with the plates of the rectifier, as shown in Fig. 12. These resistors protect the rectifier; if the surge current is high, the voltage drop across the resistors lowers the rectifier plate voltage to such an extent that the cathode links are not likely to open.

**REPLACING FILTER CONDENSERS**

Electrolytic condensers are more likely to become defective than any other part in an a.c.-d.c. receiver. Because of space limitations, they are usually grouped in
a single block or container. When one condenser in such a unit becomes defective, replace the entire unit; the other sections are very likely to fail soon.

Of course, if you obtain an exact duplicate condenser, its replacement is simple. Often, however, these condensers have no identifying markings, and there may be no service information for the set. You must then find out what is in the block before you get a replacement.

First, make a sketch of the old condenser block, showing all of the leads. Trace each of these leads in the receiver and determine what power pack circuit is used. Then draw in what you believe to be the internal connections for the condenser block, and mark the polarity of each lead. Next, determine the approximate capacity values from the following list:

**Input Filter Condenser.** Any value between 10 and 20 mfd., rated at 150 volts or higher. Values up to 40 mfd. are used, but only if there is a protective resistor of some sort in the rectifier plate circuit.

**Output Filter Condenser.** Any value between 16 and 40 mfd., rated at 150 volts or higher.

**Loudspeaker Field-Coil Filter Condenser.** Any value between 4 and 10 mfd., rated at 150 volts or higher.

**Output-Tube Cathode By-Pass Condenser.** Usually between 5 and 25 mfd., rated at 25 or 50 volts.

With these suggestions for possible values, you can try to get a single replacement block. If you cannot find such a replacement, you may be able to get a block to replace some sections and use individual midget electrolytics for the rest. However, be very careful to get condensers that will fit the available space.

In many cases, the two filter condensers are in a common unit, and the by-pass condenser for the cathode of the output tube is a separate unit. When ordering a dual replacement condenser for the filter, remember that they are made in three different types. The ones shown in Figs. 13A and 13B have a common lead from the two sections. That shown in A has a common negative lead, that in B has a common positive lead. These condensers are not interchangeable, but either can be replaced by the unit shown in Fig. 13C, in which all positive and all negative leads are brought out.

**FIG. 13.** The dotted lines represent the condenser cases. In the types shown at A and B, the two condensers are tied together inside the case so that a “common” lead is obtained. You can replace these with exact duplicates, or else you can use the general replacement type, shown at C, by connecting together the proper pair of leads.

**CHASSIS GROUNDS**

In some a.c.-d.c. receivers, the chassis is connected to B—, and thus to one side of the power line. However, most sets do not have this connection, because, if the power cord wire (that connects to B—) happens to be plugged into the hot (ungrounded) terminal of the wall receptacle, the chassis will then be above ground potential. If you touch the chassis while you are grounded, you will get a shock; if the chassis itself becomes grounded, the house fuses will be blown. (For this reason, never connect a ground to an a.c.-d.c. receiver, and be sure these receivers never touch a ground accidentally.)

To avoid this trouble, many a.c.-d.c. receivers have the arrangement shown in Fig. 1. Here, all points shown as “grounded” are connected by wire to B—, which is connected to the chassis only through condenser C1. (The chassis, in this instance, has the special symbol you will find at the lower center of the diagram.) In some sets, the connection between B— and the chassis is made through the resistor-condenser combination shown in Fig. 14.

When the chassis is not used as B—, the tuning condenser may or may not be insulated from the chassis.
If not, the connection between the tuning condenser and B— is completed through the by-pass condenser that connects the chassis to B—.

Remember, then, that you will often be unable to use the set chassis as the B— test point when making voltage and continuity tests in an a.c.-d.c. set. For continuity tests, you can always use one side of the power line for your B— reference point. To do so, unplug the power cord, hold one test probe across both prongs of the plug, and turn ON the on-off switch. This will connect your probe to B—. Your other test probe can then be used in the usual manner for making continuity tests in the radio.

If you are making voltage measurements, the set will be turned on anyway, so locate any point in the B— circuit that is convenient. A filter condenser terminal, or either side of the on-off switch, is usually the most convenient point to use.

Either the cathode of the rectifier or the screen grid of the power tube can be used as the B+ reference point.

GENERAL SERVICE INFORMATION

Now that you know the main features of a.c.-d.c. sets, let's see how to service them.

Remember that these sets are almost always very simple, so there is not much that can go wrong with them. In practically all cases, operating defects can be traced to a faulty electrolytic filter condenser, tube, or audio coupling condenser. If the complaint could be caused by any one of these, check it before trying the usual localizing procedures.

Now, let's see what to look for in specific complaints.

Dead Sets. First, determine if the pilot lamp lights. If it does not, the filament string may be open because of a burned-out tube, a burned-out pilot lamp (and its shunt resistor), or an open in the a.c. cord. Check each of these possibilities.

If the pilot lamp lights normally, and the set is dead, the cathode of the rectifier tube may be open—or there may be a short circuit across the supply terminals, such as would be caused by a leaky or shorted filter or by-pass condenser.

This sketch shows one way of holding a test probe on both prongs of a power cord plug. This method leaves the other hand free for making continuity tests.

The voltage at which an a.c.-d.c. receiver operates is low—between 90 and 120 volts. A defect that causes a drop of only 10 volts in the B supply voltage (a change that would go unnoticed in a 250-volt power supply of a straight a.c. set) may definitely affect the operation of an a.c.-d.c. receiver. For example, the lowered voltage may stop the oscillator, and thus kill the set.

A common cause of a lowered B supply voltage is a high power factor or an open in the input filter condenser. As you know, you check for either defect by shunting the suspected condenser with another of about the same capacity. If the symptoms clear up, the original condenser is defective and must be replaced.

However, be careful when you make this test. An a.c.-d.c. rectifier tube can be ruined if you connect an uncharged test condenser across the input filter condenser with the set turned on. To prevent this, make a practice of charging the test condenser at the output of the filter, by connecting it across the output filter condenser, before you move it to the input terminals. The resistance of the choke will prevent an excessive surge current from flowing during this charging process, and if you place the condenser across the input filter con-
denes to discharge, it cannot draw a very high current in charging up to the full voltage across the input of the filter. Always remember this trick so you won’t open the cathode of the rectifier.

- If you have d.c. power in your district, always watch for a reversed power plug. The rectifier tube will prevent current from flowing if the line polarity is wrong. The owner may be unaware of this. Try reversing the plug in the wall outlet before making other tests, particularly if the pilot lamp lights.

**Distortion.** A defective filter condenser that causes a drop in the B supply voltage is a common cause of excessive distortion. Other possibilities are an off-center voice coil, an unglued speaker cone, a leaky coupling condenser in the resistance-coupled amplifier, or gas in the output tube.

As you know, you can check for gas in the output tube and for leakage in the coupling condenser by measuring the voltage across the grid resistor $R_1$ as shown in Fig. 15. Normally no d.c. voltage exists across this resistor. If you get a reading across $R_1$, the tube is gassy or the condenser is leaky. Unsolder one end of the condenser; if the voltage disappears, the condenser is leaky. Otherwise the tube is gassy.

If the distortion is accompanied by very low volume, suspect an open field coil. When the field is shunted across the power supply as in Fig. 7, an open in the field will not affect the voltages applied to the tubes. However, the very low field excitation will cause distortion and low volume.

**Low Volume.** Defective filter condensers, open speaker field, improper alignment, and a poor antenna system are the common causes of low volume in an a.c.-d.c. receiver.

If the antenna is one of the bank varieties, wound on a card, be sure it is completely unrolled and stretched out.

A more obscure trouble, peculiar to a.c.-d.c. sets, is the possibility of a partial short in a tube filament. The high-voltage filaments are made by folding the resistance wire back and forth a number of times. If one or two of these folds short together, the filament string will still be complete, but that one tube will not have its cathode sufficiently heated to give normal plate current. This may reduce the volume. At the same time, it will raise the filament voltages on the other tubes in this string—some other tube in the string may even burn out as a result of the excessive filament voltage across it.

- If a set has a history of frequently burning out tubes, carefully measure the filament voltage across every tube in the string, watching particularly for one that has a voltage drop lower than normal for that kind of tube. If you find such a tube, be sure to replace it. Incidentally, a tube tester will not always show up a defect of this kind.

**Oscillation.** A certain amount of oscillation at high volume level is normal in some t.r.f. receivers. If turning the volume control to a lower setting stops the oscillation and allows the signals to come through clearly at normal volume, nothing should be done to the set for this condition. The regeneration is introduced to give better sensitivity. Of course, if the oscillation cannot be controlled, or if the volume must be reduced too much to eliminate it, look for a defect. The most common are an antenna that is not properly uncoiled, a misplaced control-grid lead, an open by-pass condenser, missing tube shields, or an open output filter condenser.

- If the complaint is that a superheterodyne whistles and squeals, check to see if an outside antenna is being used. Too long an antenna will load the preselector, reducing its selectivity, so that excessive station interference is heard.
Two styles of Cordohms are shown here. The standard is at A, and one tapped for a pilot lamp is shown at B. Occasionally, you will have to replace a Cordohm. If you have no information as to the resistance value, calculate it as you would a series filament resistor. As you know, the Cordohm was developed to dissipate the heat (that is, the result of the power loss in its resistance) into space. You are liable to get calls from alarmed receiver owners who have happened to touch the Cordohm and have found it warm. You can explain that this is natural. If you find the Cordohm "tucked away" inside a receiver cabinet, unfold it and pull it outside the cabinet so that it can properly dissipate heat. Warn the customer about this. You may even find that some owners have tried to shorten the cord by cutting it off. As they are usually unaware of the third wire, they rarely make the proper connections, so the set is usually dead. This cord cannot be shortened, because this will reduce its resistance, even if the proper connections are made.

**Intermittent Reception.** Experience has shown that the most common cause of intermittent trouble is a defective audio coupling condenser or a defective output tube.

**Hum.** As in standard a.c. receivers, the most frequent causes of hum are defective filter condensers and cathode-to-heater leakage. Be particularly careful about cathode-to-heater leakage in the output tube. High-voltage filaments are rather subject to this trouble.
No. 31 How To Service Three-Way Portable and Battery Receivers

RADIO SERVICING METHODS
Dear Mr. Smith:

I thought I knew a few things about radio before I started studying your Course, but found out that I was mistaken. I am Parts Manager for a large automobile dealer here and do my radio repairing in my home at night. I repair automobile radios for eight auto concerns and fix home sets too. I get more work than I can do. The NRI Course has really shown me the right way to service radios — it’s all that you claim and more, too.

R.B.R., Kentucky
A TYPICAL THREE-WAY PORTABLE SET

Fig. 1 shows a diagram of a typical three-way portable receiver. This set is designed so that for battery operation, the tube filaments are connected in parallel to a single 1 1/2-volt A battery. For power-line operation, the tube filaments are connected in series and draw their current from the B supply. Notice this important fact—these are battery-type tubes, so their filaments must be supplied with d.c. They cannot operate directly from a.c.

Battery Operation. Fig. 2 shows a simplified sketch of the filament connections for battery operation. When the change-over switch is thrown to the "battery" position, it connects the filaments as shown here, so that they are in parallel across the 1 1/2-volt A battery. Notice the 3Q5 tube. This tube has a 3-volt filament if terminals 2 and 7 are used alone. However, the filament is tapped, connecting the two halves in parallel, as shown here, permits the filament to be operated from 1.5 volts. For simplicity, the change-over switch connections have been eliminated from this figure.

The B supply for battery operation is obtained from a 90-volt B battery. No C battery is used. The only tube requiring bias is the 3Q5, and its bias is obtained from

FIG. 2. When the change-over switch is thrown to the "Battery" position, the filament circuit in Fig. 1 is as shown below. Notice that one terminal of each filament is grounded, and that the other terminal is connected to A+, so the filaments are in parallel. ON-OFF switches SW1 and SW2 are ganged together, and they open both the A and the B circuits when turned off. Opening the A circuit would be sufficient to stop set operation, but the B circuit is also opened to prevent draining the B battery through leakage paths. (The "ground" symbol here represents a connection to the set chassis.)
the drop across $R_{14}$, as you can see by tracing the grid return circuit of the 3Q5 tube in Fig. 1. All plate currents flow from B— to chassis through this resistor.

**Power-Line Operation.** Fig. 3 shows a simplified sketch of the connections for power-line operation. Now the tube filaments are in series. (The rectifier tube has a 117-volt filament, which is connected directly across the a.c. power line.) Resistor $R_{14}$ drops the B-supply voltage to about 7.5 volts, the amount required by the other tube filaments. The rectifier tube must have a high current capacity, for it must supply a filament current of 50 ma. for these tubes in addition to the normal B-supply current.

Resistor $R_{14}$ and condensers $C_{12a}$ and $C_{12b}$ act as a filter to smooth out the filament supply.

Notice the other shunt resistors and condensers in this filament circuit. Resistor $R_{14}$ is in parallel with the filaments of the 1H5 and 1A7 tubes, $R_{14}$ is in parallel with the filament of the 1N5, and $R_{14}$ is in parallel with all the tube filaments except section 8-7 of the 3Q5. This arrangement is necessary because the filaments of these tubes are also the cathodes; consequently, both plate current and filament current must flow through them. Since the tubes are in series, all the plate current for, say the 1N5, would have to flow from ground through the filaments of the 1H5 and 1A7 if $R_{14}$ were not in the circuit. This current flow through these filaments would increase the voltage drop across them above the desired value. To prevent this from happening, $R_{14}$ is included in the circuit as a shunt resistor; if its value is properly chosen, $R_{14}$ carries most of the plate current for the 1N5 (and for the 3Q5), and little of it flows through the 1H5 and 1A7 filaments. Similarly, $R_{14}$ shunts most of the plate current of the 3Q5 past the filament of the 1N5, and $R_{14}$ shunts half of the plate current of the 3Q5 past all the filaments.

The resistances of $R_{14}$, $R_{14}$, and $R_{14}$ must be very carefully calculated by the set manufacturer. When you replace a resistor in a filament string of this sort, be sure you use a value that is close to the original.

Incidentally, on power-line operation, the voltage drop across the other three tube filaments furnishes the bias for the 3Q5 tube. As you can see from Fig. 1, the 3Q5 grid is connected to ground through $R_4$ and $R_{15}$. (There is no voltage across $R_{14}$ on power-line operation, since current flows through it only when batteries are used.) This is the same as connecting the grid to the ground terminal of the 1H5 tube, the most negative point of the filament string. Consequently, the voltage drops across the 1H5, 1A7, and 1N5 filaments supply the bias for the 3Q5.

Condenser $C_{11}$ in Fig. 3 is a high-capacity electrolytic. It acts as an a.f. by-pass condenser, preventing the a.f. components of the 3Q5 plate and screen-grid currents from flowing through the filaments of the other tubes.

This receiver will operate from a d.c. power line as well as from a.c., provided the power plug is connected to the power line so that the plate of the rectifier tube is made positive. Otherwise, the rectifier tube will block the passage of current. On a.c. operation, the line polarity is usually unimportant, although sometimes noise
and hum can be cut down somewhat by reversing the line plug in the wall outlet.

THREE-WAY PORTABLE VARIATIONS

Fig. 4 shows a somewhat different filament arrangement for a three-way portable. Here, the tube filaments remain in series at all times. On power-line operation, they are supplied by the B supply; on battery operation, they are supplied by a small 6-volt dry-cell battery. To change from battery to power-line operation, the ganged switches \( SW_1 \) and \( SW_2 \) are thrown. Switches \( S_1 \) and \( S_2 \) are the on-off switches, and they are ganged with the volume-control shaft.

Incidentally, some sets use a 35- or 50-volt rectifier tube, plus a series filament resistance, as shown in Fig. 4. More generally, however, a tube with a 117-volt filament is used, so that its filament can be connected directly across the power line.

Fig. 5 shows another important type of three-way portable. This set is unique in two ways—it uses two power-output tubes and has an unusual method of changing from battery to power-line operation.

Notice that the control grids of the 3Q4 and the 117N7 power amplifier tubes are in parallel, and their plates are connected to the same output transformer (the 117N7 is connected to a tap on the transformer for a better impedance match). Therefore, either can be the output tube; the power supply used determines which one operates.

Fig. 6 gives more details of the filament circuit, and of the method of changing from battery to power-line operation. On the back of the receiver chassis, there is a polarized receptacle—one into which the receiver power plug will fit, but only in one way, because the receptacle openings are a different size, and the plug prongs are specially shaped.

When battery operation is desired, the line plug is inserted into the receptacle. When properly placed, the plug prong marked \( Y \) connects \( B \) and \( A \) through the on-off switch \( SW_1 \) to the set chassis. (The other side of the plug, \( X \), does not connect to anything in this receptacle.) By tracing the filament circuit in Fig. 6, you will see that this completes the \( A \) battery circuit through \( SW_1 \) and through the filaments of the 3Q4, 1T4, 1R5, 1T4, and 1S tubes. Therefore, on battery operation, all these tubes operate from the \( A \) supply, and, of course, the 117N7 tube filament is not energized.

When power-line operation is desired, the plug is withdrawn from this receptacle (thus disconnecting the batteries from the set chassis) and plugged into a wall outlet. The filament of the 117N7 tube now is energized by the power line. All other tubes except the 3Q4 are connected, through \( R_{ib} \), in parallel with the 117N7 bias resistor \( R_{ib} \). Therefore, a portion of the d.c. plate current of the 117N7 amplifier section passes through these tube filaments and provides the necessary filament current. However, none of this current can flow through the 3Q4 filament, because its circuit is broken at the
FIG. 5. The use of a different power output tube for power-line operation greatly improves the output power and the tone quality of this type of portable. Notice the condenser symbols used here. Some manufacturers have adopted the special "curved line" symbol shown here to represent fixed by-pass and filter condensers. A careful examination will show that the trimmer condenser "curved plate" symbol has an arrowhead, and that the tuning condenser symbols have a straight arrow drawn through them.

Receptacle—the power plug is not in this receptacle on power-line operation.

In Fig. 6, condensers C24, C26, and C28 by-pass the a.c. components of the plate currents, and R12 reduces the current flow through the filaments to the desired value. Resistors R11 and R4 are filament shunt resistors.

Going back to Fig. 5, we see that resistor R4 is the power-tube grid resistor. On battery operation of the 3Q4, the bias for this tube is obtained from the filament-voltage drop across the IT4, IR5, and IT4 tubes. Since R4 connects to terminal 7 of the IS6 tube, the drop across this latter tube filament is not used as bias.

Inverse feedback, a feature that improves the fidelity, is obtained on both power-line and battery operation, because resistor R12 is connected so as to feed energy from the grid of the output tube back to the grid circuit of the IS6 tube. Since the IS5 tube inverts the phase of the signal, this feedback is out of phase with the grid input signal to this tube, so inverse feedback is obtained.

Recharging Batteries. In some receivers, the batteries are connected in the circuit at all times. To see how
such a set works, imagine that we connect together all three terminals of switch SW; in Fig. 4, and do the same for the terminals of SW₂. Now, when the power plug is not in a wall outlet, the set will operate from the batteries. When the power plug is connected to a line, the power-supply voltage will be a little higher than the corresponding battery voltages, especially if the batteries have begun to run down. Therefore, the set will operate from the power line, and a small reverse current will flow through the batteries. Dry batteries cannot be recharged by this reverse current, but the polarizing film of hydrogen gas that forms around the positive pole can be dissipated by it, thus lowering the internal resistance of the battery and prolonging its life. You may find some manufacturer’s literature that states that this is a recharging process, but it is not; it is a depolarization of the battery, rather than a true charging such as could be carried on with a storage battery.

A STORAGE-BATTERY PORTABLE

The development of low-filament-drain tubes has led to the production of one portable using a special 2-volt lightweight storage-battery cell. A diagram of this set is shown in Fig. 7.

The tube filaments are connected in parallel, and operate directly from the 2-volt storage cell. The cell also operates a vibrator power supply of the synchronous vibrator type, which furnishes the necessary B-supply voltage.

The set operates from the storage battery all the time. However, when the set is connected to an a.c. power line, the a.c. supply is stepped down by a transformer and applied to a copper oxide rectifier unit that charges the storage battery. The power selector switch has four positions, marked “off,” “battery,” “a.c. line,” and “charging.” When the switch is thrown to the charging position, the set does not operate, but the power line charges the battery. In the a.c. line position, the battery charges from the line while the set operates from the battery.

This receiver differs in several ways from other portables. It is not a true three-way type, because it does not
operate from d.c. power lines—the power line must be a.c. However, in appearance it resembles the three-way types previously described, and its total weight, with battery, is only 16 pounds. Thus, it is portable.

**BATTERY SETS**

Battery sets are of several major types. In one, all power comes from A, B, and C batteries. In the past, 5-volt, 3.3-volt, and 2-volt tubes were used in these sets; now, 1.4-volt tubes are generally used.

Many of the larger console receivers, particularly those found where there are no power lines, operate from 6-volt storage batteries, and use a vibrator power supply like that in an auto set to furnish the B and C voltages. Such a set is shown in Fig. 8. Notice that a synchronous vibrator is used, rather than a rectifier; this is usual in these sets, and is done to keep battery drain as low as possible. The 6-volt storage battery is kept charged by a wind charger, a gasoline-engine-driven generator, a 32-volt Delco power plant, or by having it charged at a service station (and using a rental battery while the original is being charged). The servicing of these receivers is basically like that of auto sets, which you have already studied, except, of course, you do not have ignition interference to worry about.

Since battery sets are designed primarily for use in outlying communities, they are usually both sensitive and selective. The tone quality may not be remarkable, because they are strictly limited in their power output, but it will be at least acceptable in the better sets.

Now let's see how to service these receivers. We'll devote most of our attention to the three-way portable, since the troubles that occur in this set on battery operation are much the same as those that occur in all battery-operated sets.

**PRELIMINARY SERVICE PROCEDURES**

Before you start to service a three-way portable, determine just how the faulty operation occurs. If it occurs on both power-line and battery operation, the trouble is probably a defective signal circuit, a bad tube, or an electrode supply defect. If the defect occurs only
on battery operation, the trouble is in the batteries or in the circuits that are used only for battery operation. When there is trouble on power-line operation only, it lies in the a.c.-d.c. power-supply system or in the circuits that are active only on power-line operation.

When the trouble occurs on both power-line and battery operation, use the usual methods of localization. Usually it is simplest to operate from the a.c. power line and treat the receiver as you would an a.c.-d.c. set. Remember—you cannot pull tubes out of these sets in your localization procedures.

➤ As a matter of fact, it is dangerous to pull out tubes in a three-way portable; you might burn the tube out when you put it back in. For example, in Fig. 9, condenser C₃ is a high-capacity electrolytic condenser. If you pull out a tube, this condenser will charge up through R₁ to the full 30-volt output of the B supply. Then, when you put the tube back in, the high current flow that results from discharging this condenser through the low-resistance filament string is practically certain to burn out a filament. Always keep this fact in mind.

Furthermore, be careful when you replace a burned-out tube. Before installing the replacement, make sure that the set is turned off and that the electrolytic filter condensers of the filament string are discharged—otherwise the effect just described may occur.

➤ Don’t be alarmed if you cannot observe any filament glow in modern battery tubes. The very low power used by these tubes means that there will be little visible light, so don’t depend on observation to tell you whether tubes are good or not. Check them in a tube checker if in doubt.

➤ The replacement batteries used in three-way portable sets must usually be exact duplicates, physically and electrically, of the originals, to provide the proper voltages and fit the space allotted to them. Sometimes these batteries are not easily obtained, or the receiver owner may not want battery operation any longer. In all cases except that of the storage-battery set described earlier, the batteries can be removed and the set used as a power-line-operated receiver. If you do this, be sure the battery cables are clearly marked so that in the future, replacements can be easily put in, and be sure the leads are taped or positioned so that they cannot short to each other. Incidentally, it is always advisable to remove exhausted batteries, for the zinc cases of the cells may be punctured and allow the electrolyte to leak out and damage the case of the receiver.

Now let’s see what to do about specific receiver defects.

**SET DEFECTIVE ONLY ON POWER-LINE OPERATION**

In this section, we will assume that the receiver operates on its batteries, but is defective when you try power-line operation.

**Dead Receiver.** Check to see if the rectifier tube is good. Since this has a high-voltage filament, you should be able to see whether it lights up. If it does not, check it in a tube tester. Be on the lookout for a broken lead.
in the power cord near the power cord plug. Usually a portable is connected to and disconnected from the power line rather often, so its power cord gets much more wear than does that of the standard receiver.

If a line-cord resistor is used (the rectifier tube is not a 117-volt type), check it also for an open.

If the rectifier tube lights, check the output voltage of the power supply. Check the B supply first. If the 1.4-volt tubes have their filaments in series with the cathode of the power output tube, be sure this tube is getting plate voltage. An open in its plate circuit will kill all operation.

Since the set plays on batteries, the 1.4-volt tubes must be good. However, there is always the possibility that a defect in the switching system used to switch over to power-line operation is preventing these tubes from receiving the proper filament voltage.

If the power line is d.c., watch for improper polarity of the power plug. Try reversing it in the wall outlet if the rectifier tube lights but there is no B voltage.

Oscillator Failure. A rather common defect of these receivers is failure of the oscillator stage to function. Fig. 10 shows the oscillator-first-detector section of the receiver in Fig. 5. As you know, you can readily determine if the oscillator is working by measuring the d.c. voltage across the oscillator grid resistor \( R_2 \). A high-resistance d.c. voltmeter should be used, and the negative voltmeter probe should be placed on grid terminal \( g \) of the oscillator section of this tube. A reading of 10 volts or more indicates that the oscillator is working, but no reading or very little reading shows that it is not.

If it is not, first check the operating voltages, particularly the filament voltage. Low filament voltage is the most common cause of oscillator failure, when battery operation is normal. Check the line voltage, since low line voltage will reduce all the filament voltages. (Frequently you will find that low line voltage is the cause of the trouble when a receiver works all right in your shop but not in the customer’s home.) If the line voltage is low, and is found to be always below normal, the filament voltage may be increased slightly by arranging for more current to flow through the filament.

If the line voltage appears normal, but the voltage across the 1.4-volt tube filaments is low, check their supply. If they get their voltage from the plate current of the power output tube, check to see if you have a weak output tube. Below-normal plate current will naturally reduce the voltage drops across the 1.4-volt tube filaments. Incidentally, this tube filament rating indicates the average voltage at which they will work. They are supposed to operate on any voltage between 1.2 and 1.65 volts. However, the oscillator-first-detector tube is somewhat critical in this respect, and some tubes will fail to work if the voltage drops below 1.3 volts.

If the filament voltage is below normal, and the drop is provided by a series resistor such as \( R_1 \) in Fig. 9, then this resistance value may have increased slightly, or condenser \( C_1 \) may be somewhat leaky. Also, the B-supply voltage may be somewhat below normal because of a defect in condenser \( C_2 \), leakage in \( C_3 \), or low emission in the rectifier tube. If there are filament shunting resistors, one or more of these may have decreased in value. Any of these conditions will reduce the filament voltage.

Should you find the filament voltage to be normal on this tube, and it still does not function, try another tube.
If voltage measurements prove this to be the case, you can try to make the oscillator work at the reduced voltage by changing its grid resistor or by using a new tube; if you don’t succeed, there is little you can do except call the matter to the attention of the power company.

Sometimes the trouble will be caused by operating the receiver from an outlet that is already heavily loaded by lamps or other home devices. Try the set on another outlet, on a different branch of the electric circuit of the house.

► A trouble such as intermittent oscillation may be caused by the reverse of the above condition—the oscillation may occur when the line voltage rises above normal. Other intermittent conditions usually have the same causes as their more steady counterpart troubles, so we will describe them in the following sections.

**Distortion.** If distortion is present only on power-line operation, check the voltages at the various tube-socket terminals in the audio amplifier. You will probably find some abnormal voltage on the power-line operation. Bear in mind that the voltages on power-line operation are usually somewhat higher than those for battery operation. Compare both battery and power-line voltages to find the one that is radically different.

Check also for a gassy output tube, particularly if the set is so designed that a different output tube is used for power-line operation. More gain is obtained from the higher d.c. voltages available on power-line operation, and there may be distortion caused by overloading if the volume control is turned up too high. This is not a receiver defect if the distortion clears up satisfactorily when the volume control is turned down somewhat.

Improperly centered voice coils and loosened cones may show up only when maximum volume is used. You will recognize these forms of distortion and can, make the proper repair or replacement.

**Hum.** This trouble occurs only on a.c.-power-line operation. Usually defective filter condensers are to blame; also be on the lookout for cathode-to-heater leakage in the rectifier tube, since this will inject a high-voltage a.c. ripple into the circuit.

---

### Table: Batteries

<table>
<thead>
<tr>
<th></th>
<th>Burosse</th>
<th>R.A.O-WAC</th>
<th>General</th>
<th>Master</th>
<th>Usalite</th>
<th>Advance</th>
<th>Brophy</th>
<th>Star</th>
<th>Winchester</th>
<th>Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>A' BATTERIES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4F</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>1F</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>2/3F</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
</tr>
<tr>
<td>2F</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
</tr>
</tbody>
</table>

| B' BATTERIES |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
| 4H | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 |
| 1H | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 |
| 2/3H | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 230 |
| 2H | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 |

Charts like this show which batteries of one manufacturer correspond electrically and physically with those of another. Battery manufacturers also publish lists of the batteries used in the better known receivers. From such lists you or your parts supplier can choose a satisfactory replacement battery when an exact duplicate is not available.

regardless of the way the original tests in a tube checker. Also, sometimes the oscillator can be made more reliable by reducing the value of Rg in Fig. 10 by 10% to 20%.

(Write for cases where this resistance has increased above its rated value.)

If the above suggestions do not lead at once to the source of trouble, proceed to the usual localization tests. For a dead set, you can use signal tracing, signal injection, or the circuit disturbance steps made by touching tube top caps or measuring voltages.

**Intermittent Reception.** If the set is intermittently dead on power-line operation, but plays normally on battery operation, then the trouble must be in some portion of the power supply. Check to determine if the intermittent operation occurs at definite times in the day. If so, the trouble may be the result of line-voltage fluctuation.

At certain times of the day, particularly in the early morning and early evening hours, the electric lines may be so heavily loaded that the voltage drops considerably.
SET DEFECTIVE ON BATTERY OPERATION ONLY

For this section, we will assume that the receiver plays normally on the power line, but does not play satisfactorily when operated from its batteries.

Dead Set. If the set works O.K. from the power line but is dead on batteries, probably the batteries are at fault. Always check battery voltages with the set operating—batteries that test normal when the set is turned off may drop in voltage when it is turned on and a load is placed on them.

If you find it necessary to replace the batteries, you can get the right replacements by ordering duplicates of the originals. The factory manual for the receiver will generally give battery type numbers of several different battery manufacturers. Your jobber can also suggest the right replacement from charts furnished by the battery companies, if you will tell him the make and model number of the set and the types and number of the tubes used in it.

Intermittent Reception. Intermittent reception on battery operation only also indicates battery trouble, particularly when the set plays at first and then gradually fades out. Make a careful check of the battery voltages after the set has faded out. If any have dropped appreciably, replace the batteries.

Noise. Noise on battery operation and not on power-line operation may indicate defective batteries, but probably indicates loose connections to some battery. Check over the battery connections carefully, and go over the switch that changes the operation from the battery to the power line.
No. 32
How To Service
Auto Receivers

RADIO SERVICING METHODS
Dear Mr. Smith:

I am now doing radio servicing, full time. I own my shop (Radio Hospital) which is equipped with the best up-to-date instruments. Believe me, I am making more money now than I ever made before. I owe all this to NRI and I advise all young men interested in radio to take your Course.

C. S., Iowa

HOW TO SERVICE AUTO RECEIVERS

SERVICEMEN differ in their attitudes toward servicing auto sets. Some never handle them, others specialize in them, and still others service them occasionally. The choice is up to you. This Booklet will show you what the jobs are like, so that you can more easily make up your mind. Also, if you decide to do auto-radio servicing, then this information will be sufficient to get you started.

Although an auto receiver is basically much like a home receiver in its principles and operation, the fact that it is designed to be used in an automobile makes it subject to special difficulties that do not bother home receivers.

Most of these special difficulties come from the power supply used and from the actual installation in a car. The set must be properly placed and securely fastened, the right kind of antenna must be installed, and precautions must be taken to eliminate interference from the auto ignition. We will treat power-supply problems in this Booklet, but will not consider the problems of installing a set, as these are covered elsewhere in your Course. Here, we will concern ourselves primarily with servicing auto radios that have been properly installed and were once operating satisfactorily.

However, it is impossible to ignore the installation completely when you are servicing an auto set, for it is always possible that some of the precautions that were
These are rarely found in private cars. The earliest auto radios used bulky and expensive B batteries as power sources, but no modern set does so.

A second important difference is the fact that an auto set must have extremely high sensitivity because the antenna used with it will be, at best, only a short one. For this reason, auto sets have high-Q circuits throughout their r.f.-i.f. sections. In addition, some sets have a tuned r.f. amplifier ahead of the oscillator-mixer stage, and others deliberately include a certain amount of regeneration. These features, which, as we will see, can complicate your servicing problems, are sometimes found in home receivers, but not nearly as often as in auto sets.

There are two other ways in which auto and home receivers differ electrically. An auto radio must have a fast-acting a.v.c. system to counteract variations in signal strength as the car is driven from place to place. And, since the set normally works in an intense interference field, special shielding and filtering are required.

Apart from these four factors, an auto set does not differ electrically from a home receiver. Notice how closely the circuit diagram of a typical auto set in Fig. 1 resembles the diagrams with which you are now familiar.

**Mechanical Differences.** Since an auto set must usually be mounted in a rather small space under the dash of a car, it is far more compactly constructed than most home receivers. It is frequently equipped with mechanical remote controls worked through a flexible shaft. Further, it is always ruggedly built to withstand shock and vibration.

The extreme compactness of the set often makes it quite a problem to replace a part. Also, it is frequently necessary to use exact duplicate parts; it may be impossible to use universal replacement parts because of the space limitation and the need for particularly strong construction.

► Now that we have established the major differences between home and auto receivers, let's see what you need in the way of special equipment for servicing the latter.
EQUIPMENT NEEDED FOR AUTO SET SERVICING

The first requirement for servicing auto sets is a place in which to work. You should never try to work on a radio in a car that is parked on the street; it may be dangerous to do so, and it is almost always inconvenient. The best arrangement is to have your customer drive his car right inside your shop, if you have a location that will permit this, or at least into a private driveway or parking area beside the shop. This will let you work in safety, with your tools near at hand. If you are doing work for a car dealer, work in his garage.

Next, you will need a 6-volt power source. You can use a storage battery, or a power pack—sometimes called an A battery eliminator—that will furnish 6 volts d.c. from 115-volt a.c. power lines. Several firms make these power packs especially for auto radio servicing. If you get a storage battery, you should also get a trickle charger so that you can keep the battery in good condition.

For convenience, you should mount your storage battery or power pack behind or underneath your bench and bring a cable up to the bench from it. This cable should be No. 10 wire and should be as short as possible—remember, a battery is a low-voltage source, so even a relatively small voltage drop in your leads may prove troublesome. If you use a battery and trickle charger, use the circuit shown in Fig. 2 to connect them. This arrangement will keep the battery fully charged at all times.

You will need a certain amount of other special equipment also. For one thing, you will need a pair of thin, strong, adjustable end wrenches for removing the receiver from the car. (A set of box or end wrenches can be used instead.) You will also need a supply of tinned copper braid to be used either to shield wires or to bond parts of the car together, some lock washers of various sizes, some type 3AG auto fuses with different ratings (between 5 and 20 amperes), and a few universal vibrators. These, of course, are in addition to the usual supply of radio parts, tools, and equipment. Your regu-

FIG. 1. This is the manufacturer's circuit diagram of a typical small auto radio, the Motorola 405. Notice that it uses permeability tuning in the r.f.-i.f. section.
lar servicing instruments—multimeter, tube tester, and signal generator—will be sufficient to locate defects.

**Localizing the Trouble.** As we said earlier, an auto set that is not operating properly may not itself be defective; the installation in the car may instead be to blame. Therefore, the first step in servicing an auto set is to find out whether the installation or the set is at fault. The tests you make to determine this depend on what the complaint is. Let’s take up the most common complaints in order, showing you in each case how to tell whether the installation or the set is to blame.

**NOISY RECEPTION**

Noise is one of the most common complaints in auto sets. It is more apt to be caused by the installation than by the set, so you should check very carefully before assuming that the set is to blame.

The receiver itself may have any of the defects that produce noise in home receivers—broken wires, corroded shielding, bad tubes, defective resistors, bad condensers, and loose connections. In addition, the vibrator power supply of the auto set can cause a “hash” when the vibrator is defective or the filtering system used with it breaks down.

Noise resulting from installation may be caused by a car’s ignition system, by static interference produced when the car is running, or by poor bonding. (Bonding is the process of making good electrical connections between the various metal parts of the car with strips of flexible braid. For example, the hood of the car is usually bonded to the body, and the body to the frame; when this is done properly, the receiver is effectively shielded from the ignition system of the car.)

Ignition noise, or interference, is produced by the ignition system of the car. It may originate in the generator or in the regulating relays in the low-voltage section of the car’s electrical system, or it may be caused by the distributor or spark plugs in the high-voltage section. When the engine is running, small electric arcs produce pulses of energy at each of these locations and set up r.f. noise signals on the associated cables. If the ignition system is not properly shielded, the radiation from these points may produce noise in the set. Of course, this noise cannot occur when the car engine is not running.

Static discharges, on the other hand, are not dependent upon the electrical system of the car. They result from friction between moving and stationary parts. For example, static charges are built up on the tires as the car rolls over the road; these static charges may discharge suddenly when they have built up far enough, thus producing a miniature lightning flash that may create a burst of noise in the set. The car must be moving to produce static interference of this sort, but the engine does not have to be running.

Another possible source of noise in the installation is the connection between the antenna and the receiver. The vibration of the car as it moves may create a loose connection between the lead-in and the antenna or between the lead-in and the set. Either of these conditions can cause noise.

**Localizing Noise.** A few simple tests will show whether or not the set or the installation is to blame for the noise. First, turn on the radio with the antenna disconnected, the car engine not running, and the car stationary. If you hear noise under these conditions, you can be sure that the set itself is causing the noise, since
all other possible sources of noise have been eliminated.

Reconnect the antenna, and wiggle the antenna leadin. (The motor should not yet be running.) If this causes noise, install a new lead and see if the noise disappears. Don't attempt to fix the old one, since it probably can't be done.

If you hear no noise, start the engine and allow it to idle. If you hear noise now, it is caused by the car ignition system, and the set can be considered to be all right. If you do not hear noise, speed the engine up somewhat; some ignition difficulties do not occur until the engine is moving at fairly high speed.

If the noise has not yet appeared, give the car a road test. Coast down a hill with the engine turned off. Noise under these conditions probably means that there are static discharges.

➤ This series of tests should tell you whether or not the set is to blame. There is a slight possibility of making a mistake: it may be that there is a loose connection within the set that will produce noise when the car engine is running, because of the vibration produced. In this case, you may think that the noise is caused by the installation rather than by the set, since there will be no noise when the car is stationary, and the engine is not running. In some sets, you can check for loose connections by slapping the side of the set—have the engine turned off and the car standing still. If doing so produces noise, you can be sure that there is some loose connection within the set.

**WEAK RECEPTION**

Weak reception may be caused by receiver defects, by defects in the installation, or by natural conditions over which you have no control. Before making any localizing attempts, you should question the owner carefully to find out if the set is weak all the time, or only in certain locations, or only at specific times. This will often show you whether or not natural effects are the real cause of the complaint. For example, it is normal for the signal of a distant station to be weak in a city because of the shielding effects of steel-framed buildings. Also, a certain amount of weak reception is to be expected in

![Steel-framed structures, such as buildings or bridges, act as shields for radio waves. Reception on a car radio is naturally poor when the car is in the vicinity of such structures. If the car passes through a shielded area in a short time, the signal will appear to fade; if it stays in the area for some time, the set will seem to be weak.](image)

country driving because of the erratic way in which radio waves vary in strength in certain locations (in mountainous or valley regions, for instance). However, if the set is weak on local stations that other auto receivers in the same location bring in strongly, it is reasonable to suppose that it is defective.

Before blaming the set, however, make sure that the auto battery is in good condition. Auto receivers draw a rather high current—as much as 10 amperes—so a battery that is running low may be unable to supply enough power to keep the set working well. If the set is weak when the engine is idling but improves when the engine speed is increased, check the storage battery with a hydrometer to make sure it is reasonably near full charge. If it is not, the charging rate of the generator may need adjustment. It is always worth while to check the battery when the complaint is weak reception, especially in the winter time, when the combination of cold weather and increased power-demand may run down a car battery rather quickly.

A poor antenna installation can often be the cause of weak reception. Check for leakage from the antenna to
the car chassis with a high-range ohmmeter. Also, be on the lookout for poor connections between the antenna and the set.

FADING

As we have already said, the antenna of a car set is so short that very little signal is supplied to the input of the receiver. When this small signal is further reduced because the car comes near some natural shield, such as a steel bridge, it is only normal that the volume of the receiver should decrease. Car radios are equipped with fast-acting a.v.c. systems to compensate for some of the natural fading caused when the car moves from a region of high signal level to an area where the signal level is low, but the compensation that the a.v.c. system can introduce is limited. You can expect the signal to fade considerably, or even vanish completely, when the car comes close to any large steel framework.

However, the signal should not fade appreciably when the car is standing still and the set is tuned to a local station. If it does do so, you can be sure that something is the matter with the set. A further check of this is to try a portable radio in the same location. If it shows no sign of fading, but the car radio you are testing does, you can be sure that the car radio needs repairs.

DEAD SET

When a car set is dead, the very first thing you should do is check the fuse in the power lead of the set. This lead, called the hot "A" lead, is usually connected to the electrical system of the car at or near the car ammeter. (Only one lead is used to supply power to the set in all modern cars; one terminal of the car battery is grounded to the car body, and the return lead from the set to the battery is made by grounding the set to the body also.) There is always a fuse in this power supply lead; it may be inside the set, or, more commonly, in a fuse holder that forms part of the lead. If this fuse is blown, insert another fuse of the same rating in the fuse holder, and try the set. If this fuse blows, you can be sure that something is wrong with the set.

Other tests you should make include a visual check to be sure there is a good connection between the hot "A" lead and the car's electrical system. Make sure the car battery is fully charged, also. A low battery will usually cause a weak rather than a dead set, but it is worth making the check anyway.

The vibrator of a car radio makes a distinctive humming sound that you will quickly learn to recognize. If you hear no hum from the vibrator when you turn the set on, almost certainly there is something the matter with the power supply to the set. If you hear the vibrator hum when the set is turned on, yet the set does not play, check the antenna lead to make sure it is not broken and that it makes a good connection to the set. If you are not sure about the antenna lead, disconnect it from the set completely, and connect a 10-foot length of insulated copper wire to the set as an antenna. If the set now plays, there is something the matter with the antenna connection; if it does not play, the defect is in the set (assuming that you have already made the tests described in the preceding paragraphs).

SERVICING THE SET

From what we have said, you can see that you should make very careful tests before you pull the set out of the car to check it. One good reason for doing so is that it is
often rather difficult to take an auto set out. For this reason, practically all auto sets are made so that you can remove the top or side and pull out the tubes without having to take the set out of the car. You should always check all tubes in a tube tester before removing the set, no matter what the complaint. Also make sure that all tubes are seated properly in their sockets; the vibration of the car may sometimes work a tube loose.

If testing the tubes does not point out the cause of the complaint, you will be forced to remove the set from the car and take it to your bench for testing. It may be difficult for you to remove the set alone—you may need a helper to hold the set while you loosen the holding bolts. (Some sets are hung on simple hangers and can be lifted out easily.) If manufacturer’s instructions are available, by all means read them carefully for hints on installation and removal. Be sure to notice exactly how the remote-control cables are fastened to the set, if they are used, and to tag them so that you will know which goes where when you put the receiver back in.

Once you have the set on your bench, the tests you will make will be much the same as those you would use if you were servicing a home receiver with the same complaint, except that the vibrator power supply used in an auto set will require special treatment. To refresh your memory on the subject of vibrator supplies, let’s review the operation of the two common types before we learn how to service the sets that use them.

**HOW VIBRATORS WORK**

There are two main kinds of vibrators, known as the “synchronous” and the “non-synchronous” types. Figs. 3 and 4 show diagrams of typical power supplies using each type.

Essentially, the chief working part of a vibrator is a flexible reed that is moved by an electromagnet. This reed vibrates in a gap between sets of contact points. As it moves, it alternately makes and breaks contact with these points. This intermittent switching action does two things: 1, it keeps the vibrating reed going, because the circuit is so arranged that the switching alternately energizes and de-energizes the electromagnet; and 2, it produces sharp changes in current flow, chopping up the d.c. current from the battery into pulses, so that the a.c. components can be fed through a transformer.

The non-synchronous vibrator shown in Fig. 3 has only one pair of fixed contacts. If you trace the circuit from the battery you will see that when switch S is closed, current flows through L1, L2, P2, and L5 (the coil of the electromagnet) to ground. The coil then attracts the vibrating reed R, pulling it down until it hits contact A. This permits full current to flow through P2 and also shorts L5, causing it to release the reed. The reed then flies back, striking contact B, and completing a circuit through P1. Then coil L2 again attracts the reed, repeating the cycle.

The pulsing current flow first through P2 and then through P1 induces an a.c. voltage in the secondary of transformer T. This voltage is then rectified by tube VT and passed on to the filters. Since the voltage produced across the secondary by this system has very high, sharp peaks, the buffer condenser C1 is connected across the secondary. This condenser tends to smooth out the peaks to some extent. Even so, the rectified output contains considerable “hash” (that is, it has an irregular wave shape caused by the presence of many high harmonics). That is why the elaborate (high- and low-frequency) filter system C1-L1-C2-L2-C3 is used in the power supply.

*The synchronous vibrator power supply, shown in*
Fig. 4, uses a mechanical system to rectify the secondary voltage of the transformer, thereby making it unnecessary to have a rectifier tube in the set. It is not as popular as the non-synchronous vibrator already described, chiefly because it is more complex, and therefore more prone to failure.

As you can see from the circuit diagram, the synchronous vibrator is similar to the non-synchronous in the method used to connect its operating electromagnet to the car battery. Notice, however, that two sets of contacts are used in the synchronous vibrator, one connected to the primary of the transformer, the other to the secondary.

The contacts connected to the secondary of the transformer provide mechanical rectification of the secondary output. As you can see from Fig. 4, the B—terminal of the vibrator output is grounded, as is also the vibrating reed. Therefore, the two ends of the secondary of the transformer are alternately connected to the B—terminal through ground as the reed touches the secondary contacts. If the proper connections are made between these contacts and the secondary of the transformer, each end of the secondary will be connected to B—during the half-cycle that it is negative with respect to the other end of the secondary. This will produce rectification, for the vibrator output will then always be negative at the terminal marked B—and positive at the terminal marked B+.

However, reversing the connections to the battery will reverse the polarity at the B+ and B—terminals of the vibrator output. If this were to happen, the electrolytic filter condenser C+ across the vibrator output would be quickly ruined. Therefore, it is important to make sure that a synchronous vibrator is connected to the car battery with the proper polarity. As we shall show in a moment, this means you must be more careful when you are making bench tests on a set that uses a synchronous vibrator.

Vibrators, like tubes, wear out and must be replaced. After a while the vibrating reed loses its springiness, and the contacts become pitted and worn. This will happen even if no defect exists in the receiver. In addition, if there is leakage or shorts in the B supply circuits of the receiver, more than the normal current will flow through the vibrator contacts, and their useful lives will be further shortened.

The easiest way to test a vibrator is to insert one that you know is good in its place. Most modern vibrators are equipped with a plug-in base that fits a socket resembling a tube socket; such vibrators can be removed as easily as a tube for testing. In some of the older sets, however, it is necessary to unsolder connections to the vibrator to make tests.

If you do a great deal of auto receiver servicing, you will find it worth while to get a vibrator tester. This is an instrument that resembles a tube tester in its operation. The vibrator is plugged into the proper socket, and measurements are made of the voltage output and the current drain while the vibrator is furnishing power to a load. The vibrator is satisfactory if it delivers a rated voltage with a minimum current drain.

Whenever you must replace a vibrator, you should always check the buffer condenser (C+ in both Fig. 3 and Fig. 4). These condensers have high voltage ratings—1200 to 2000 volts—but they frequently break down as a result of continued high-voltage surges. If you must replace a buffer condenser, remember that its capacity and voltage rating were originally selected by the manufacturer to match the vibrator and the transformer with which it is used. Therefore, a replacement buffer condenser should have exactly the same capacity as that
of the original, and a voltage rating at least as high.

You should always suspect a power supply defect if an auto set draws excessive current or if the vibrator rate of operation seems to vary. Excessive current does not always mean that the vibrator itself is defective, for there may be some defect in the set that is causing the abnormal current drain; however, all the current drawn by the set must pass through the vibrator, and, if too much current flows, the vibrator will usually be damaged. Therefore, although the vibrator may not be the original cause of the excessive drain, it may very well become defective after the drain has continued for a while. At the very least, its future useful life will be shortened.

Now that we have reviewed the subject of vibrator power supplies, let's see how to go about testing an auto set after removing it from the car. Remember, we know that the set itself is defective, because we have already checked the installation.

PREPARING THE SET FOR TEST

You will need a short antenna to test an auto set at your bench. Use an auto antenna or four or five feet of wire. Don't make the mistake of using a long antenna; the set will be overloaded and may even oscillate.

When you connect the set to your battery, connect one battery terminal to the "hot" lead, and the other to the receiver chassis (or the enclosing case). We pointed out earlier that it is important to connect a battery to the set with the proper polarity if the set has a synchronous vibrator. This is not necessary if the set has a non-synchronous vibrator, for the latter type uses a rectifier tube that maintains the proper polarity on the output of the power pack. However, if you don't know whether the set uses a rectifier tube, play safe and connect the set to your battery or bench power supply with connections of the same polarity as those used in the car. You can then be sure that the output of the power supply will have the correct polarity whether or not a synchronous vibrator is used in it.

If you have a set with a synchronous vibrator, and you are not sure how the battery was connected to the set in the car, check the polarity of the vibrator power supply output by connecting the set to your test battery, then pulling out the output tube and connecting your d.c. voltmeter between the output tube plate terminal socket and the receiver chassis (positive lead of your voltmeter to the plate terminal). Turn on the set. If the meter reads upscale, connections have been made to the set with the proper polarity. If it reads downside, disconnect the set at once from the battery and reverse the connections. If you get no reading at all on the voltmeter, the set power supply is defective.

When you use an ohmmeter to check the B supply circuit of a set that uses a synchronous vibrator, be sure to disconnect or remove the vibrator before making continuity measurements. The vibrating reed may rest against one set of contacts when the receiver is not operating; this will ground one end of the secondary of the transformer and give incorrect measurements. It is unnecessary to do this in a set that uses a non-synchronous vibrator, for the power-supply output of such a set is isolated from the vibrating reed, and your ohmmeter measurements will not be affected whether or not the reed touches a contact.

LOOKING FOR SURFACE DEFECTS

You should always look for surface defects in an auto set, just as you do when you service any other type of set. Make an even more thorough examination than usual on an auto set, however, for the vibration to which the set is subjected when it is in a car makes it much more probable that the set will have some mechanical defect.

For example, make sure that all tubes fit tightly in their sockets. (Many auto sets use local tubes that are supposed to fit tightly at all times; however, even with these types, it is always possible that something has gone wrong with the locking arrangement on a tube or that someone has inserted a tube in its socket incorrectly.) You should make this test while the set is in the car whenever possible, but it is wise to check it again when the set is on your workbench.

Look carefully, too, for bolts, nuts, and lock washers
that have been worked loose by the vibration and have become lodged underneath terminal strips, resistors, or condensers. Loose hardware of this sort can cause shorts. Make sure, also, that all wire connections, tube top cap connections, and shield cans are tight.

The general servicing procedures for an auto set, once you have it on your workbench, are the same as those you would use for a home receiver. In the following sections on specific receiver complaints, we will not go into the tests with which you are already familiar, but will instead describe tests that apply specifically to an auto set.

SERVICING A DEAD SET

If the set is dead, listen for the vibrator hum. If no sounds at all come from the speaker, and you cannot hear any sound directly from the vibrator, the vibrator is defective or is not getting power. (Look for a blown fuse, or a break in the A lead.) On the other hand, if the vibrator buzzes, but no sound comes from the speaker, the defect is in the rectifier-filter section of the power supply, or is caused by a short circuit across the B+ and B− terminals. (Remember, if the vibrator is of the synchronous type, to remove it before making ohmmeter tests in the power supply.) If the sound the vibrator makes is unsteady, check the vibrator itself and the buffer condenser. If the vibrator buzzes, and you hear a slight hum from the speaker, proceed to locate the defective section and stage as you would in any set.

SERVICING A SET THAT HUMS

Because it uses a vibrator, an auto set is an a.c.-operated device (even though its original power comes from a battery) and is therefore subject to hum. Vibrators usually operate at a frequency around 115 cycles (some go as low as 85 cycles, some as high as 165 cycles, but most are at or near 115 cycles) so the basic hum frequencies for an auto set will be either 115 or 230 cycles, rather than the 60 or 120 cycles that you find in sets operating on power lines.

Cathode-to-heater leakage cannot normally cause hum in an auto set, because the filament supply is d.c. This leakage is more likely to upset the bias and cause distortion, or to permit the vibrator hash (noise) to be increased.

Remember that the vibrator may be fairly noisy in its operation. Do not mistake the normal buzz of the vibrator for hum in the set. (Of course, if the vibrator is excessively noisy, it may be well to replace it even though it operates satisfactorily.) Also, remember that the vibrator noise and hum may be rather noticeable on your bench in your quiet shop, but may be masked entirely when the set is in a car.

SERVICING A NOISY SET

An auto set can be noisy for any of the reasons that a home receiver is. In particular, it is subject to noise caused by loose connections because of the mechanical strain to which it is subjected in a running auto. You can be rough with the set when noise is the complaint.
Don’t be afraid to drop it an inch or so onto your bench to see if you can cause the noise to appear. An auto set should be strong enough to withstand much greater shocks than this, and it may be necessary to vibrate it rather strongly before you can make a noise appear with the set out of the car.

There are two possible sources of noise in an auto set that you will not find in home receivers. One is the cold-cathode rectifier tube used in some sets. Such a tube is subject to gas oscillation, which will cause noise. The easiest way to check this tube is to substitute a good one in its place. If you find this stops the noise, you can, if you wish, leave the good tube in. However, since this tube may also become noisy later on, many servicemen make a practice of substituting a heater-type rectifier with a similar rating (if the ear battery does not have too many gadgets to power). Usually the only change you have to make to use a heater-type tube is to wire in the filament circuit; in some sets, you will find this has already been done by the manufacturer.

Another source of noise in auto sets is vibrator hash. The buffer condenser is designed to reduce the high surge peaks, and to reduce the sparking at the vibrator contacts, that cause this noise. However, if the buffer condenser becomes defective, the wave form of the vibrator output will change, and the filters may not be able to remove the a.c. components of the altered wave. This will usually cause a rasping noise from the speaker. Remember that the capacity of a replacement buffer condenser should be very close to that of the original. Watch the voltage rating too—values of 1200 to 2000 volts are used for the buffer.

Vibrator hash may also be caused by defects other than a defective buffer condenser. Worn vibrator contacts may be at fault, or the power supply shielding may have loosened. Watch for corrosion around the screws holding the shielding in place.

SERVICING A SET THAT OSCILLATES

An auto set is more prone to oscillation than is a home receiver, because it is far more sensitive. Some very slight defects may cause trouble. Look for loose shield-

ing, and for corroded shield mountings. You may have to be very careful about how the leads are positioned. The alignment will have to be checked carefully. Look for poor connections, too.

Some sets use regeneration to increase their sensitivity. In such a set a change in the characteristics of a tube can cause excessive regeneration and, therefore, oscillation. You may be able to cure this with another tube, or you may have to adjust the position of the feedback coil if such an adjustment is possible.
No. 33 Recognizing Complaints Not Caused by Receiver Defects

RADIO SERVICING METHODS
Dear Mr. Smith:

At present I am operating a part-time radio business, but my friends and people for whom I have fixed radios say I should go on a full-time basis in a shop of my own. I have more than paid for my course and I have about $200 worth of equipment which has paid for itself with the aid of the NRI. I owe it all to you.

R. H., Illinois

Recognizing Complaints

Not Caused by Receiver Defects

Perhaps, now that you have had more technical radio training, you find it a little hard to realize that most people are completely ignorant of how and why a radio works. Yet it is a fact. Generally speaking, it is a fortunate fact for you—after all, if everyone were thoroughly familiar with the workings of a set, servicemen would find it hard to make a living. But there will be times in your servicing career when you will wish a customer knew a little more about his set—times when you will make a long trip to his home only to find that he is complaining about something that is perfectly natural and simply can’t be helped.

Such fruitless calls come to every serviceman. They are irritating and profitless—since you are not usually justified in charging more than your minimum service charge—but you must learn to expect them. In fact, very often you can get some benefit from them in the way of customer good will, just by taking a few minutes to explain carefully and courteously what the trouble is and why it cannot be remedied.

The complaints to which we refer are those that are not caused by a defect in the receiver. An example is the complaint, fairly common in the summer, that “my set doesn’t pick up the stations I used to get last winter.” As you know, this is not the fault of the set; reception
is naturally poorer in the summer, and there is nothing you can do to change that fact. But many customers, lacking your technical knowledge, are not aware of the differences in reception at various times of the year; consequently, you will get service calls to fix "weak" receivers that are actually in perfectly good condition.

Others of these complaints will be caused by the customer's misunderstandings of the capabilities of his set. For example, you know that the selectivity and tone quality of a five-tube midget set are far inferior to those of a ten-tube console receiver, if both are properly designed. The average set owner realizes this only vaguely, if at all. To him, both sets are simply radios; therefore, both should bring in both local and distant stations with ample volume and clarity, and with a minimum of interference from other stations.

This Booklet discusses the common complaints of these kinds that you are apt to meet. They are treated under the usual headings of dead set, weak reception, and so forth. However, this Booklet differs from most of the preceding ones in one respect: very often there is no service information on the complaints, since there is no way of servicing them. Instead, in such cases, we have pointed out what the causes of the condition are, so that you can, in turn, explain them to your customers. Although this is not service data, it is none the less valuable information; you are going to have to make such explanations fairly often.

DEAD RECEIVER

When you are called upon to service a dead receiver, find out first just how dead it is. Determine whether the set is absolutely and completely dead—no sign of life whatsoever, no sounds from the loudspeaker, and no lights in any of the tubes or the pilot lamp.

If so, you will do well to check up on the installation. It is rather rare for a set defect to make the set absolutely lifeless. Rather, some defect in the installation that has interrupted the supply of power to the set is most often to blame—such things as the power cord's being out of the wall outlet, the wall outlet's being dead because of a blown house fuse, etc. (You can check the wall outlet by plugging a lamp into it.)

If you live in a district that has both a.c. and d.c. power lines, make sure the receiver is connected to the kind of power for which it is designed. You may find that an a.c. receiver has been plugged into a d.c. outlet. Naturally, the set won't work; in fact, you will probably find that the primary of the power transformer has been burned out.

Set Shows Some Life. On the other hand, if the set has some degree of liveness—some slight operating noise and hum from the speaker, lights visible in tube filaments or pilot lamps, or some bands alive while the others are dead—it is probable that some defect exists in the receiver. However, there is a possibility that one of the following outside conditions is to blame.

Occasionally a complete loss of reception occurs on
one or more short-wave bands because of natural phenomena, such as ionospheric disturbances caused by sun spots. When these spots occur, the ionic layers that reflect radio waves often shift up and down and thus change the reflection pattern. Also, at certain times, magnetic storms of sufficient intensity to block all reception on certain short-wave bands may occur.

When a customer complains that one or more short-wave bands are dead, check carefully to see whether other bands are alive. If they are, and the noise level and the fading on these bands appear unusually intense, it is quite probable that ionospheric disturbances are to blame. In this case, just wait for an hour or so. Usually the bands will start to come back to life in that length of time, thus indicating that the trouble is not in the preselector or oscillator stages of the set. Also, noise on the supposedly dead bands is a further indication that the set is probably all right.

Sometimes a customer believes his set has gone dead because he cannot get some local station, when actually the trouble is that the station has gone off the air temporarily. Always suspect this if a set plays on most stations, but does not pick up a local. It is possible for a set to go dead on just a part of its tuning range, but the chances are that the station is off the air instead. To make a quick check, try to pick up the station on another receiver. If you can't tune it in on either set, you can safely assume that the station has had a breakdown.

When a receiver is located in a well shielded place, such as within a steel-framework building, an outside antenna may be necessary for reception. If something should happen to the antenna, the receiver owner may believe his set has gone dead. Usually, careful tuning over all wave bands will disclose some slight pickup on some bands, which should lead you to think that the antenna system may be defective.

**WEAK RECEPTION**

A defective antenna system can cause weak reception rather than a dead set, and, of course, there are a number of set defects that must be considered. However, sometimes a set owner complains that reception is weak when he tries to pick up distant stations under adverse conditions, or with a radio not designed for this reception. In these cases, the customer's complaint of weak reception is not really justified; true, reception is not good, but it is as good as can be reasonably expected. When you get a complaint of this sort, your task will be to explain why the reception is poor rather than to try to correct it.

When the owner tells you that he once picked up a distant station satisfactorily, but no longer does so, you should of course make sure the set is up to normal in sensitivity. However, before you go to any great trouble to check sensitivity, consider carefully the conditions under which the change in reception occurred. Reception of distant stations is always better at night than in the daytime. Therefore, if the owner's complaint is that he receives a station at night and not in the daytime, or that he heard it well last winter and does not hear it so well in the summer time, then the normal limitations of reception are probably responsible for the change. (Once in a great while, he may be unable to get a station any more because the station has made some change in the directivity of its antenna system or in its power.)
In this connection, remember that reception on different short-wave bands varies not only with the season of the year but also with the hour of the day. For instance, the 19-meter band (16 megacycles) works best during the daytime, and even then stations that are less than about 1500 miles away may be difficult to pick up. On the other hand, the 24- and 31-meter bands will give fairly good reception for stations over 2000 miles away both day and night. For good daylight reception over comparatively short distances, the 39-meter band is more reliable. Most short-wave stations broadcast simultaneously in several bands, so the set owner can try tuning for the desired station in the band that is most favorable at the listening time.

Furthermore, if the receiver owner is a short-wave enthusiast, he must realize that many of the short-wave programs are beamed in specific directions. If a station is broadcasting a program intended for a country or a location in a direction far removed from that of the receiver, then he should not expect to pick up that station very well, if at all, during those hours. On the other hand, when the station shifts to an antenna system beaming the program in his direction, he may find the same station coming in with practically the same strength as a local.

Sometimes you will find a radio plugged into not just one, but a combination of cube taps. This is almost sure to cause trouble—eventually, if not at the moment. Plug the set directly into the wall outlet and advise your customer to connect the other devices elsewhere.

> Fairly often, you will find that the trouble is that the receiver owner expects too much. He may suddenly have decided to listen to some distant station that his receiver is incapable of getting satisfactorily. There may be many reasons why his set can't bring in the particular station he wants. The power of the station to which he wants to listen may be inadequate for the distance, even with the best of receivers and antennas. There may be something about his location that prevents good reception from that particular station. The receiver antenna system may be entirely inadequate for long-distance reception. Finally, the set itself may be too insensitive because of its design limitations. Naturally, a small receivers that has been manufactured to sell for a low price does not have the number of stages required for high sensitivity.

> When you are attempting to judge how much sensitivity a set can reasonably be expected to have, remember that the number of tubes in a receiver is not as important as is the way that these tubes are used. Such tubes as tuning-eyed indicators, phase inverters, a.v.c. tubes, noise-squelch tubes, and tone-control tubes, do not amplify the signals; neither do rectifiers and diode detectors. In determining what a receiver should be capable of doing, you must consider only those tubes that amplify the signal. Even this is not a perfect guide, because manufacturers follow different design practices. One manufacturer may make his sets highly sensitive, another may sacrifice sensitivity for better tone quality, still another may reduce the gain in his set to prevent oscillation—yet all may use the same number of amplifying tubes. These design factors are hard to explain to a customer, and you must be familiar with the receiver before you can be absolutely sure about them.

Naturally, if you find every receiver of a particular make and model operates at about the same level, then they must be designed to work that way. But don’t make snap judgments after hearing only one or two sets. Remember that radio receivers are production devices—they are allowed rather wide variations in their response characteristics. You may find one that has unusually high sensitivity, far more than others of this same
model. Therefore, don't jump to the conclusion that, because one was extra peppy, all should be that way. That one set could have been the model in which all the tolerances added in the proper direction to give extra pep.

Another design factor that can affect the sensitivity of a set is the kind of antenna intended to be used with it. Quite a number of modern receivers use loop antennas, some of which are rather directional in their characteristics. For this reason, many of the larger console sets are arranged so that the loop antenna may be rotated for best reception from a particular direction. Perhaps the receiver owner is unaware of this, or someone may have changed the loop position. When you meet a set of this sort, always try rotating the loop to see if you can improve the response from the desired station.

In midget receivers, the loop antenna is generally fastened to the cabinet in such a manner that the cabinet itself must be rotated to turn the loop. Try this anyway. If you find a particular position that gives much better results, demonstrate this fact to the owner, and then let him see if he can find a better location in the room for the radio. Incidentally, the directional characteristic of the loop may be the reason for the complaint of weak reception, because the receiver may have been moved to a position in which reception is poor.

A loop antenna receives poorest when it is turned at right angles to the direction from which the signal is coming.

FAADING SIGNALS

Since practically all sets now have a.v.c. circuits, receiver owners have become accustomed to hearing local stations come in without fading. A customer who happens to turn on a distant station may believe that something has gone wrong with his set if the station fades in and out. This is a natural condition, however, not a set defect. The a.v.c. circuit cannot do anything about a signal that fades below the threshold level. Therefore, it is entirely natural for signals from distant stations to fade in and out as reception conditions vary. Interference between the ground waves and the sky waves is a common reason for fading in the broadcast band, and shifting of the Heaviside layer accounts for much of the short-wave fading.

Interference between ground and sky waves is more pronounced with stations from 50 to 150 miles away than it is from more distant stations. This is because this is the point where the ground wave (radiation that travels close to the earth’s surface) and the sky wave (radiation that travels outward from the earth, then is reflected back) happen to be about the same strength, but out of phase with each other. Therefore, it is quite possible that some semi-distant station of this kind will be subject to severe fading, while a more distant station can be received reliably.

Two kinds of fading exist. One is relatively slow: the station is received for varying periods of time, then gradually fades out, and a few minutes later fades back in. The other kind of fading is very rapid: the station fades in and out in an extremely short period of time. This very rapid fading may completely destroy the intelligibility of the signal, leaving nothing but a hash or “monkey chatter.”

Insofar as auto receivers are concerned, you can expect the signal to fade in and out as the car passes over a bridge, travels along a street car line having an overhead trolley, or moves to a position where a tall steel-frame building comes between the car and the transmitter of the station being received. These are all normal effects; don't waste time trying to eliminate them.
INTERMITTENT RECEPTION

Intermittent reception is seldom caused by anything but a receiver defect. If you are sure that intermittency is the complaint, you can proceed to check the receiver at once without bothering to consider the possibility that some outside influence is really to blame.

However, sometimes it is hard to tell whether a set is actually intermittent. The prime example is a set that changes radically in its volume when light switches are snapped on or off. This may mean that the set has an intermittent defect, and that the line voltage surges caused by snapping the switches are shocking the receiver into and out of normal operation. On the other hand, it may mean that the antenna-ground installation is poor, and that the receiver is depending on signals picked up by the power line. If so, as you change the resistance across the power line by adding or taking away the lights and other appliances, the signal strength will naturally vary. You may have to try the receiver in another location to determine which condition exists.

INTERFERENCE

The amount of interference between signals will depend greatly upon the selectivity of the receiver and the listening habits of the receiver owner.

Signal interference may be divided into three classes: 1, interference from stations on the same frequency as the one tuned in; 2, interference from stations on frequencies adjacent to the one tuned in; and 3, interference from stations on frequencies widely different from the one tuned in.

Stations on Same Frequency. Interference from signals originating on the same frequency is practically a hopeless case. This occurs mostly when you try to listen to a low-power station at the high-frequency end of the broadcast band, where there are frequently as many as fifty or more stations broadcasting on the same frequency. In the daytime, only the nearest station is likely to be received. However, at night, particularly in winter, more distant stations on this same frequency may easily be picked up.

Most console receivers have open backs to permit the escape of the sound waves that result from the movement of the back surface of the speaker cone. If the receiver is placed too close to a wall, these sound waves will be trapped within the cabinet, usually causing rattles and hollow booming noises. To prevent this effect, the best position for a receiver is across the corner of a room, as shown above. If the customer prefers the receiver parallel to a wall, make sure that it is at least two or three inches out from the wall.

Once in a while a radical change in the antenna will prove helpful. Strangely, you will have to experiment to determine whether you need a better antenna or a poorer one! Sometimes a better antenna will provide sufficient signal from the desired station to allow the a.v.c. system of the radio to reduce the sensitivity enough to minimize reception from the more distant station. On the other hand, you may, by reducing the amount of pickup by the antenna system, sometimes eliminate pickup from the more distant interfering station. Repositioning even the same antenna may help in some cases. Antennas of the inverted L type are somewhat directional, so sometimes rotation of the antenna may tend to favor the desired signal. However, if the undesired signal originates from a station of sufficient power, or from one sufficiently close by, there is little you can do about this condition.

Adjacent Channel Interference. Interference from stations on adjacent channels is another condition about which little can be done in most cases. You are not apt to run into this difficulty with sets that are highly selective, except when the customer at-
tempts to pick up a weak, distant station that is on a
band adjacent to a powerful local. Naturally, in such
a case, the more powerful station is almost certain to
cause interference no matter how selective the set is.
Adjacent-channel interference is most apt to occur,
as you would expect, in sets that have a broad response.
A t.r.f. set, for example, always tunes broadly, and is
frequently the victim of such interference. High-fidelity
a.m. receivers are another kind that tune broadly and
are therefore subject to interference; in fact, they are
designed only for reception of local stations and for use
under conditions where the desired signal is many times
stronger than any undesired signal that is likely to
interfere.

The sensitivity of the set has a bearing on whether
it is likely to have trouble with adjacent-channel inter-
ference. Naturally, the more sensitive the set, the more
likely it is to pick up undesired signals in addition to
the one you want.

Once in a while, if only one station is causing the
trouble, you can cut down the amount of signal from
this interfering station by using a wave trap in the an-
tenna circuit of the receiver. To do so, tune the wave
trap to the interfering signal, and adjust it until the
undesired signal comes through with minimum volume.
Whether or not this method works depends mostly on
how close together the desired and undesired signals
are. If they are only 10 or 20 kc. apart, the wave trap
may reduce the strength of the desired signal almost as
much as it does that of the undesired; in that case, of
course, the wave trap is of little use.

Other Interferences. Interference from stations on
the same or adjacent frequencies can occur in both t.r.f.
and superheterodyne receivers. In addition, the super-
heterodyne (but not the t.r.f.) is subject to a number
of kinds of interference from stations on frequencies far
removed from the desired one.

Usually something can be done to clear up interfer-
ences of this last kind. Let's briefly review what they
are (you studied them in your Fundamental Course),
and see what can be done about them.

► Perhaps the most common of these interferences is
caused by a nearby code sta-
tion or long-wave weather sta-
tion that happens to be on a
frequency equal to the i.f. fre-
quency of a superheterodyne.
If the signal from this station
is strong enough to get through the preselector of the
set, it will travel directly through the i.f. amplifier and
cause interference at all points on the dial. Interference of
this kind can also be created by a
station with a frequency equal
to one-half the i.f. frequency
of the superheterodyne; in this
case, the second harmonic of
the station frequency (pro-
duced in the receiver) causes
the trouble.

The best cure for this diffi-
culty is to shift the i.f. fre-
quency 10 or 15 kilocycles, if
this can be done without seri-
ously upsetting the dial cali-
bration. Another possible cure
is to use a wave trap in the an-
tenna circuit, tuning the trap
to the i.f. frequency of the set
and adjusting it for minimum
response at this frequency.
Fig. 1 shows two ways of con-
necting wave traps for this
purpose. After installing the
trap by either method, feed a
strong i.f. signal from a signal
generator into the antenna-
ground terminal of the set,
then adjust the trap until the
output of the set is at a mini-
 mum.

► Another common trouble is
image interference. As you know, in the superheterodyne the desired incoming signal frequency is normally below the oscillator frequency by the amount of the i.f. frequency. However, if there is a strong station at a frequency above the oscillator frequency by the amount of the i.f., it may be able to get through the preselector with sufficient strength to mix with the oscillator and produce the i.f. signal. (This interfering signal is equal to a frequency twice the i.f. frequency above the desired signal.)

Image interference normally occurs only when you are very close to a powerful local station, or when the preselector of the receiver is not of the best quality. Sometimes it is caused by too long an antenna, because the loading reflected into the resonant circuit broadens the preselector response.

When you find image interference, try re-aligning the entire receiver, particularly the preselector.

If only one desired station is interfered with, it is possible to use a wave trap in the antenna circuit, tuned to the interfering signal and adjusted for minimum response. Another possible solution is to shift the i.f. value about 10 kc. This moves the interfering signal to another point on the dial, and thus lets the desired signal come through clearly.

► A complaint somewhat similar to image interference may be caused if the set oscillator generates strong harmonics. One of these harmonics may combine with some high-frequency signal to produce the i.f. frequency of the set. Interference from this source is rather unusual; for one thing, most oscillators are limited in harmonic output. For another, the frequency of the undesired signal would have to be, at the very least, over twice the frequency of the desired signal for this interference to occur; if the radio is of reasonably good quality, it should be able to keep out even a very strong signal that is so far removed from the desired one. However, if you should encounter a case of this kind, you can again use a wave trap tuned to the interfering signal. There is very little likelihood of there being more than one station in any one location powerful enough to cause this kind of trouble.

► In a few rare locations, two stations may be picked up whose frequencies differ by exactly the i.f. value of a radio. In this case, these two station signals can beat together, without using the oscillator signal in the superheterodyne, to produce an i.f. frequency capable of being amplified by the i.f. stages of the receiver. If the combining occurs outside the set, the only cure is to shift the i.f. about 10 kc. However, if the first detector stage does the combining, a wave trap may be used, tuned to either of the two station frequencies.

► Some customers may call to your attention the fact that a strong local station is received at two points on the dial. Usually, some high-frequency broadcast station is picked up at the low-frequency end of the dial. This is repeat-point reception. It occurs because, at this dial setting, the oscillator frequency is below the local station frequency by the amount of the i.f., and the local station produces a signal strong enough to get through the preselector. The low-frequency point on the dial where the high-frequency station is heard a second time is called the “repeat point.”

As you just learned, this condition is what causes
image interference if some desired station is at the same point on the dial as the repeat point of the high-frequency station. If no station comes in at the repeat points, just explain to the customer why this is so, but do nothing about it.

**DISTORTION**

Ordinarily, distortion is caused by a receiver defect. In broadcast-band reception, the only exception that is not the fault of the customer occurs when a local station is so powerful that it overloads the receiver. On the short-wave bands, a form of distortion may occur from time to time because of rapid fading of the signal. In these cases, it is even possible for different frequencies to fade at different time intervals; this form of selective fading may wipe out a portion of the side band of some signal being received, thus distorting the signal.

Sometimes the distortion that a customer complains about is caused by his mistuning of his radio. Some people seem to be unable to tune a receiver properly, even with the aid of a tuning eye or a tuning meter. If the customer complains of distortion, and none is apparent when you tune in the radio, have him tune in several stations. If you find that he is not tuning the radio exactly, point this out to him and show him how to do it properly.

**NOISE**

Noise is a complaint that may well be caused by something outside the receiver and its installation. Atmospheric disturbances cause plenty of interference on a.m. receivers, and man-made interference, such as that arising from motors, switch contacts, etc., may be heard to some extent even on f.m. receivers.

Whenever you have a complaint of noise, follow the suggestions given in another RSM Booklet to localize the difficulty. Obviously, if the noise can be cut out by disconnecting the antenna or ground, or by using a power-line filter, then it is arising outside the radio and is caused by either atmospheric trouble or man-made interference.

There are a few facts about noise, however, that you may have to explain at some time. A receiver owner may notice that the amount of noise heard between stations is much higher than that heard when a station is tuned in. He may want to know why, or may think that something is the matter with the receiver. As you know, this condition is natural: when no signal is tuned in, the a.v.c. circuit has the receiver operating at maximum sensitivity, so plenty of noise is picked up. When a signal is tuned in, the sensitivity of the set is reduced, so the amount of noise picked up is less. Furthermore, to a listener, the presence of the signal tends to mask some of the noise. Therefore, it is entirely natural to get higher noise levels between stations. (This problem of noise between stations has led to the development of inter-station noise suppression systems for many services—such as police radio—where it is necessary to listen in constantly but where there may not be a signal at all times.)

Of course, you are familiar with the noises caused by atmospheric disturbances that are heard on a.m. receiv-
The local oscillators of some receivers, portables in particular, will stop working if the line voltage drops even a few volts below normal. Suspect this when you get a complaint like that made by the customer in the sketch above. Turning on an electric iron, or any other high-wattage appliance, may cause a considerable drop in the line voltage at all outlets connected to the same circuit. This is especially apt to happen in older houses, where the wiring is often too small to carry heavy currents.

MISCELLANEOUS COMPLAINTS

There are a few other fairly common complaints that you should be prepared to meet. Since they do not fit into any of the previous categories, we have collected them into this final section.

A receiver owner may become alarmed because he notices that a spark is seen when the antenna lead is connected or disconnected from the receiver. Once in a while this is the result of a collection of static on the antenna, but more often it is caused by the design of the receiver. Many sets have a by-pass condenser connected from one side of the power line to the set chassis. If no ground is used on the receiver, and the antenna itself happens to be grounded, it is quite possible that the condenser will discharge, producing a visible spark, when the connection between the antenna and the set is made or broken. This sparking is not harmful; however, if you want to eliminate it, you can do so by grounding the chassis or by clearing up the ground on the antenna system. If you ground the chassis, the ground lead will always show a spark when it is connected or disconnected. (Of course, you cannot use a ground on an a.c.-d.c. receiver.)

➤ As we have explained elsewhere, it is easily possible to get a shock from an a.c.-d.c. set if it is one of the types in which the chassis is connected directly to one side of the power line. Most sets of this kind are well protected by a cardboard or wooden back on the receiver cabinet, but sometimes these are left off or are taken off by the customer. Should any ask you about this shock, explain why it occurs, and warn them to keep their hands away from the rear of the receiver.

➤ Watch out for a.c.-d.c. receivers in kitchens and bathrooms. Sometimes you will find that one has been set upon a refrigerator or a stove, and that some exposed mounting bolt touches these grounded objects. Once in a while, a house fuse may be blown by such a short circuit. When one of these receivers is used in a bathroom, make sure it is mounted well away from any possible ground. For the sake of safety, be particularly careful to see that the set is in such a position that it cannot be tuned or touched by anyone in the bathtub.
It is DANGEROUS to touch ANY electrical appliance when you are wet. If you find a radio in a bathroom, warn the owner not to tune it while he is in the tub. Better still, persuade him to move it to a location where a person in the tub cannot reach it.

When an owner finds that a power cord of the Cord-ohm type, or a transformer, or the speaker field of his set becomes hot, he is apt to get excited about it—particularly if he makes the discovery when the receiver happens to be in need of repair. Of course, you can assure him that it is normal for these parts to get hot. However, make sure they are not hotter than they should be. Estimating what a safe degree of heat is requires some judgment, because some receivers run hotter than others. However, you can be pretty sure that something is wrong if the set becomes so hot that smoke appears.
NRI TRAINING PAYS...

Dear Mr. Smith:

It was a lucky day for me when I sent for the Course in Radio. The only thing I regret is that I did not start sooner.

I have built up a good size radio business in my city and it is growing every day. Thanks again for getting me started in Radio and I hope others will take your Course and profit like I did.

F. H., Wisconsin

FREQUENCY modulation (f.m.) has two important advantages over amplitude modulation (a.m.)—the possibility of high fidelity, and freedom from noise. Of course, true high fidelity can be achieved only if the receiver is designed for it—an inexpensive table model set cannot give it, no matter how good the transmission is. However, freedom from noise is a real advantage, particularly in large cities where man-made interference is severe.

Because f.m. requires such wide frequency bands, it has been forced to use ultra-high-frequency broadcasting channels. Waves of these frequencies have ranges of only 30 to 50 miles from the transmitter, because they are not reflected by the ionosphere layers. For this reason, f.m. transmitters are being installed only near large centers of population—small towns and rural areas still have to depend on a.m. broadcast services.

If you operate a service business in an area that has (or soon is to have) f.m. stations, you will be expected to repair f.m. as well as a.m. receivers. Let’s turn now to the f.m. receiver and learn just what differences there are in the service procedure.

As Fig. 1 shows, the f.m. receiver is basically like the standard a.m. superheterodyne, with the exception of the limiter and discriminator stages. Obviously, since the stages and parts are similar, the f.m. receiver will have the same types of troubles as the a.m. sets. In fact, the a.f. amplifier and the power supply of an f.m. set are serviced in exactly the same manner as are those of an
THE I.F. SECTION

You will find two types of f.m. receivers: one type that receives only f.m. signals, and another that is a combination a.m.-f.m. set. Since you've already studied f.m. receivers in your course, we won't discuss the operation of the stages. However, let's take a quick look at a typical combination a.m.-f.m. receiver to learn of the switching used.

A combination usually consists of a standard a.m. receiver to which one or two f.m. bands have been added. This means that the proper i.f. section must be switched in, along with the limiter and the discriminator, when the f.m. bands are to be used. A rather elaborate switching arrangement (a part of the wave-band switch) is necessary.

Of course, it is possible to use entirely separate i.f. amplifiers, and merely switch from one to the other. However, more standard practice is to use the same tubes, with dual transformers, and a switching arrangement like that shown in Fig. 1.

Switch SW₂ directs the output of the first detector tube into the proper i.f. transformer T₁ or T₂. This signal is amplified by the tube VT₂. From VT₂, the signal path depends on the i.f. signal frequency. A 456-kilocycle a.m. signal passes easily through the primary of the 10-mc. transformer, which offers practically no impedance at these frequencies. Therefore, at 456 kc., the plate load of VT₂ is the low-frequency transformer T₁, and its condenser. On the other hand, transformer T₂, and its trimmer form the plate load when the 10-megacycle f.m. signal is present, because the condenser across transformer T₂ acts as a by-pass around that transformer at this frequency.

For the same reasons, the signal path again divides at the output of VT₂. A 456-kilocycle a.m. signal passes through T₂ to the a.m. detector tube VT₄. The output of this tube is fed (through a switch) to the audio amplifier. On the other hand, a 10-mc. signal passes through T₁ to tube VT₅, which is the limiter. From the limiter, the signal goes into discriminator VT₆. The audio output of the discriminator is then fed to the audio amplifier.

The switch SW₂ opens the cathode circuit of the limiter tube VT₅, so that the limiter stage cannot function when the wave-band switch is set for a.m. reception. Some receivers open the screen supply lead instead.

GENERAL HINTS

One general rule we can state -- don't attempt the slightest design change when you service an f.m. set. These sets are high-precision devices compared to ordinary a.m. sets. Parts have 5% or 10% tolerances, instead of the 20% (or worse) that are common in a.m. sets. The placement and lengths of wires are often critical. Therefore, disturb circuits as little as possible when you are mak--
ing repairs, and use exact duplicate replacement parts. If you must use a condenser or a resistor that is not an exact duplicate, be sure that both the value and the tolerance match those of the original.

How you service the r.f.-i.f. portion of the f.m. receiver will depend greatly upon whether the set is a combination, and if so, upon whether the trouble occurs on a.m. reception as well as on f.m.

When you find that the trouble exists on both the a.m. and f.m. bands of a combination receiver, switch to an a.m. band, and service the set just as you would any other a.m. receiver, using the standard methods of localization with which you are already familiar. When you have cleared up the trouble on a.m. reception, it should have disappeared from the f.m. portion of the receiver also.

Trouble on F.M. Bands Only. If the set is an a.m.-f.m. combination, and the a.m. section plays satisfactorily, but the f.m. section has suddenly gone bad, then the trouble must be in the wave-band switching arrangement, or in some part that is used only for f.m. reception. Referring to Fig. 2 again, it is obvious that trouble in $V_T_1$ or $V_T_2$ will kill or otherwise interfere with the normal passage of an f.m. signal, but will have no effect on the a.m. signal. Similarly, trouble in transformer $T_1$ will affect f.m. reception without affecting a.m. reception. A short circuit across one of the windings of the f.m. transformers $T_4$ or $T_5$ can also prevent f.m. reception without noticeably affecting a.m. This rarely happens, however.

Of course, you must not overlook the fact that the preselector-mixer-oscillator portion of the receiver may also be at fault. It is standard practice to change the input circuits of the receiver rather completely on the f.m. band, because of the great frequency difference between the present 88-108 megacycle f.m. band and the normal a.m. frequencies. The signal often goes through an entirely different series of r.f. and converter tubes.

The same test procedures are followed on both the straight f.m. set and the f.m. band of a combination, except, of course, that the latter has switches that must be considered as possible trouble sources. Therefore,
the following sections we will assume that you are working on a straight f.m. receiver, or have a set in which only the f.m. bands are defective.

**HOW TO LOCALIZE DEFECTS**

The first steps in servicing an f.m. receiver are the familiar ones of confirming the complaint and looking for surface defects. Then, once you decide the trouble is within the radio, proceed in the usual manner to localize the trouble to the defective section, stage, circuit, and part. You can use the same effect-to-cause reasoning you have learned to use for a.m. receivers, because, for example, any defect that can cause a dead a.m. set can also cause a dead f.m. set. In the following discussion of the various possible complaints, we will point out the methods of localization you can use.

**Dead Set.** If an f.m. receiver is dead, follow the usual procedure of making a circuit disturbance at the grid input of the first audio stage to determine whether the trouble is in the audio section or in the power supply. Touch the top cap of the first audio tube, or touch the slider arm terminal on the volume control if this tube has no top cap. In either case, you will hear a loud buzzing sound from the speaker if the a.f. section is working. If the a.f. section is not working, proceed to localize the trouble in the a.f. section and the power supply section just as you would in an a.m. set.

> If you get a normal buzz, you know that the trouble is in the r.f.-i.f. section of the radio. You can use circuit disturbance tests, stage-by-stage signal injection, or signal tracing to localize the dead stage.

At first thought, it may seem odd to make circuit disturbance tests on the r.f.-i.f. section of an f.m. receiver, since the limiter is supposed to wipe out noise. However, as you perform a circuit disturbance test on stages ahead of the limiter, there will be a change in the signal amplitude at the limiter. The limiter will wipe out all voltage changes above its saturation level, but the change from zero up to the saturation level will cause a click to travel through the receiver. The click may not be as strong as it is in a.m. sets, but it will be there.

Therefore, you can make the usual circuit disturb-

ance tests—pull out and replace tubes, use a voltmeter, or remove and replace tube top-cap clips. Start the disturbance at the limiter and work back toward the input of the receiver. As you disturb each stage, you should hear a thud or click if everything between the stage being disturbed and the input of the a.f. section is in good condition.

If you get no click when you disturb the limiter, you won't know whether the limiter stage or the discriminator is at fault. However, a few voltage readings or circuit continuity tests will point to the defective stage.

> You can also use the signal injection method, using a standard amplitude-modulated signal generator. First, feed the signal into the discriminator, then work back through the limiter and the i.f. stages to the first detector.

You will find that the discriminator input transformer tunes very broadly when you feed the signal generator signal in at the plate of the limiter. A signal anywhere within 1 or 2 megacycles of the proper i.f. value will pass through. As you move back toward the first
detector and include more resonant circuits, the tuning sharpens somewhat; however, the set is supposed to pass signals up to 100 kilocycles on either side of the i.f. resting frequency, and most sets will tune even more broadly than this.

Furthermore, when the discriminator stage is properly aligned, it will tend to produce minimum output at the resonant frequency. Therefore, you will get a stronger signal by tuning to one side or the other of the i.f. resting frequency. Thus, if the i.f. frequency is 10.7 megacycles, you may find that a signal of 10.675 or 10.725 megacycles will give greater output from the set loudspeaker than does one of exactly 10.7 mc.

Remember that the limiter stage will tend to hold signals to a fixed top level. Don't expect a great increase in signal strength as you move along through several i.f. amplifier stages. However, as long as the signal comes through, you haven't encountered the dead stage.

Tracing through the first detector or an r.f. stage may be somewhat more troublesome unless your signal generator has a fundamental, or a strong harmonic, that is within the f.m. tuning band of the set. This was not so much trouble on the older f.m. band from 42 to 50 megacycles, but the new band from 88 to 108 megacycles is harder to reach.

► A signal tracer can also be used, provided it will tune to the proper frequencies. A few types will reach at least the 10 or 11 megacycle i.f. value; these can be used for signal tracing through the i.f. portion of an f.m. set. Fortunately, most of the stages in the r.f.-i.f. section are in the i.f. amplifier, so the chances are that the trouble will be somewhere in this portion of the radio.

To use a signal tracer, you must have a signal. Its source can be either an f.m. station or an amplitude-modulated signal generator. If you use the generator, follow the signal through the i.f. amplifier the same as you would in an a.m. receiver. If you use the signal from an f.m. station, detune the signal tracer slightly. This detuning will make the tuned circuit ahead of the signal tracer detector work on the slope of its characteristic rather than at its peak, and thus give frequency discrimination. Naturally, the output won't be of high fidelity, but you don't care about fidelity when you are looking for a dead stage.

**Weak Reception.** The same methods used to service a dead receiver are used to localize a weak stage.

If you are using a signal tracer, work from the input of the receiver back toward the limiter. Tune the tracer exactly to the resting frequency of the i.f., and use the signal level indicator of your tracer as a means of indicating the gain per stage. In this way, you'll be able to tell when a signal does not increase properly as you add stages of amplification. Don't worry about the distorted signal sound.

You will find that the output of the limiter stage (or stages) will be less than that of the preceding i.f. stages. How much less depends on the degree of limiting. You cannot know just what to expect here unless the manufacturer gives gain data on his set. (Of course, if all other stages are normal, then the limiter should be suspected.)

If you plan to use signal injection (a signal generator), you cannot use the output of the set as a gain indicator, because the limiter cuts off the amplitude changes. However, the limiter grid current will vary with the
strength of the signal, so you can use a 0-100 micro-
ammeter as an output meter by placing it in series with
the limiter grid resistor. The stronger the signal fed to
the input of the limiter, the greater the amount of grid
current flow.

➤ If you have no such microammeter, you can use a
high-resistance d.c. voltmeter by connecting it across
the grid resistor of the limiter. The stronger the signal,
the higher is the voltage across this resistor.

With either the voltmeter or the microammeter con-
ected as a signal strength indicator, move your signal
generator back from the limiter through the i.f. ampli-
fier toward the first detector. As you add stages, the out-
put indicator should show that the signal increases
greatly.

➤ When we speak of weak reception, we mean recep-
tion in which something has caused the signal strength
to drop below the level formerly received. This could
be caused by a defect in either the receiver or the an-
tenna installation. On the other hand, if the receiver has
never been properly installed, the receiver owner may
describe the trouble as weak reception when he has
never had good reception for that particular station.
We'll go into the installation of a proper antenna later
in this Booklet.

_Hum_. This is normally only an audio complaint,
since any hum modulation introduced in the r.f. section
of an f.m. receiver should be removed by a properly
operating limiter. Very severe hum modulation may get
through, however, if the incoming signal is too weak
to saturate the limiter. (The low signal level may mean
that something has happened to cause weak reception,
that the receiver has not been properly installed, or that
it is at the very limits of the field of that particular
transmitter.)

_Noise_. Noise between stations is severe on f.m. re-
ceivers—it may even be worse than that found on a.m.
tuning ranges. The receiver noise level should be judged
only when a strong f.m. signal is tuned in. If the noise
level then is high, it usually means there is an audio or
power supply defect. Any noise originating in an r.f.
or i.f. stage should be wiped out through the action of
the limiter, so defects in these stages will usually not be
noticed until a permanent breakdown, and a dead or
highly distorted receiver, results.

Noise may be heard, however, if the signal strength
at the input of the limiter is insufficient to drive this
stage to saturation. This may be noise picked up by the
set, or it may indicate trouble in the r.f.-i.f. section.

Incidentally, excessive noise or modulation hum may
also be an indication of faulty limiter operation. Trouble
in this stage can be caused by changes in resistor values
or by leaky or shorted by-pass condensers.

_Distortion_. Distortion normally means trouble in the
a.f. amplifier, which may be localized with the usual a.m.
methods. However, it is also possible for improper align-
ment—particularly of the discriminator—to cause dis-
tortion in f.m. receivers.

➤ When a receiver sounds all right at first, then ex-
hibits distortion that clears up if the tuning control is
retuned slightly, oscillator frequency drift is probably
the cause. This is quite a problem at the high frequen-
cies on which f.m. signals are broadcast. The circuits
already use extremely tiny amounts of capacity and in-
ductance. Therefore, the slight changes in value of coils
and condensers caused by heat expansion may detune
the circuits considerably.

Most modern f.m. sets have built-in compensation for
temperature effects. One common solution is to use parts
with opposite temperature coefficients. For example, if
the tuning condenser increases in capacity when heated,
another condenser will be added in parallel with it that
decreases in capacity when heated. The two will counter-
act each other.

If you ever replace a temperature-compensated con-
denser, remember that the replacement must have both
the same capacity and the same temperature coefficient
as the original.

**ALIGNMENT OF F.M. RECEIVERS**

A standard amplitude-modulated signal generator
can be used to align an f.m. receiver if the s.g. can pro-
duce at least the necessary i.f. frequency. Fundamental
frequencies or strong harmonics from an s.g., or the
signal from a local f.m. station, can be used to align the r.f. section.

Now, let's run through the complete alignment procedure for an f.m. set, starting with a few general rules and precautions:

- If they are available, always read the manufacturer's instructions carefully to find out about trimmer locations, the order of adjusting trimmers, the decoupling resistors and blocking condensers to use with the signal generator, etc.

Some of these instructions call for aligning first the input of the discriminator, then the i.f. amplifier; others reverse the order. If you have the exact equipment specified by the manufacturer, it is probably best to follow his procedure.

Some manufacturers suggest you align the discriminator first, and then move the signal generator from grid to grid as you pass through the i.f. amplifier back toward the input. To do so, you must move the signal generator cable, and there is always a chance you will detune the generator. This stage-by-stage method of alignment is necessary only when the set has been tampered with to such an extent that you cannot get a signal to pass through it at all. For ordinary alignment, and for touch-up alignment, the procedure we recommend below is better.

- Before aligning an f.m. receiver, tune on your signal generator and allow it to warm up until it becomes stable in its output. A half hour is not too long for many types of signal generators. Then, once you have it adjusted, to produce the correct frequency, leave the tuning dial strictly alone. If you try to retune the signal generator, the chances are that you will not return to exactly the same frequency as before. When aligning the i.f. and discriminator stages, it isn't as important that you tune to exactly 10.7 megacycles as it is to use the same frequency for all the i.f. and discriminator adjustments. If you align the i.f. amplifier to one resting frequency and then align the discriminator to a somewhat different one, you cannot expect proper discrimination or proper fidelity.

**Output Indicator.** Because of the action of the limit-

er, you cannot tell from the output of the set when the i.f. stages have been properly aligned. Therefore, you must use an output meter in the limiter stage when aligning the i.f. stages.

Generally, set manufacturers recommend that the grid current be measured by placing a microammeter with a 0-100 microampere range in series with the limiter grid resistor, as shown in Fig. 3. Note the polarity of the meter connections. Often the set will have a terminal strip arranged for conveniently inserting a microammeter in this manner. With such, unsolder the jumper wire that normally closes the circuit, and connect the meter in its place.

You can also use a high-sensitivity voltmeter when provisions for its use are made. The voltmeter capacity would upset the alignment if it were connected across the grid resistor \( R_1 \) in a circuit like Fig. 4. However, here you can connect the voltmeter in parallel with \( R_1 \); now \( R_1 \) acts as a decoupler, preventing the voltmeter from affecting the alignment. When the grid resistor is connected as is \( R_10 \) in Fig. 2, then the voltmeter can be connected right across it.

**Aligning the I.F.** First, connect your signal generator to the control-grid terminal of the first detector tube. If the signal generator does not have a built-in blocking condenser, use a 0.01- to 0.05-mfd. condenser in series with the hot lead.

If the set is a combination, turn to an f.m. band so the proper i.f. coils will be switched into the circuit.

**FIG. 3. This is the proper way to connect a microammeter to use it as an output meter in the grid circuit of the limiter stage. Notice that the positive terminal of the meter is connected to ground; this is necessary because grid current flows in this circuit. If your microammeter has several ranges, use the one that is most convenient for reading a 50-microampere current, since that is approximately the current that should flow through the circuit during the alignment procedure to make sure the discriminator input transformer is properly loaded.**
FIG. 4. You can use a high-sensitivity voltmeter (10,000 ohms per volt or more) as an output indicator in the grid circuit of the limiter stage, but only if the manufacturer has included some provision for presenting the capacity of the voltmeter from affecting the alignment. In the circuit shown here, the by-pass condenser makes it possible to connect your voltmeter across \( R_2 \). Similarly, you can connect your voltmeter across \( R_0 \) in Fig. 2, because it is by-passed. If there is no provision for using a voltmeter, use a microammeter as your indicator.

Connect your output indicator to the grid circuit of the limiter. Then, allow both the set and the signal generator to warm up thoroughly before attempting the alignment adjustments.

Tune the signal generator to the correct i.f. resting frequency for the receiver. With most modern f.m. receivers, this is between 10 and 11 megacycles. It is standard practice to use the unmodulated output of the s.g. (You don’t need a sound output, since the output of the radio is meaningless because of the limiter action. Therefore, if the set is noisy, you can turn the volume control down during this alignment procedure.)

Adjust the signal generator output to give a limiter grid current of approximately 50 microamperes; this loads the discriminator input transformer properly. (When a voltmeter is used, the limiter grid current can be calculated by dividing the voltage by the value of the resistance across which the meter is connected—\( R_2 \) in Fig. 4.) Then, adjust the primary and secondary trimmers (or coil cores) of the i.f. transformers between the first detector and the limiter grid circuit. Make each adjustment for maximum output. If any adjustment throws the meter off-scale, reduce the output from your signal generator somewhat. This will keep the input to the limiter somewhere between 50 and 100 microamperes throughout the alignment procedure.

**Discriminator Alignment.** After you have aligned the i.f. amplifier to give maximum limiter input, you are ready to align the discriminator. Leave the signal generator turned on and connected just as before. This is important. If you turn your signal generator off and on, it may shift in frequency.

You can leave the output indicator connected to the limiter grid circuit if you have another meter to use as a discriminator indicator. However, if you are going to use the same meter, it is all right to turn the receiver off to make the change in the output indicator connection. (When you disconnect a microammeter, be sure to resolder the jumper wire so that the limiter grid circuit will be complete.)

To align the discriminator input, first connect a high-resistance d.c. voltmeter across one-half the discriminator output network, as in Fig. 5. Then, adjust the primary trimmer \( (C_1) \) on the discriminator transformer for a maximum reading on this d.c. voltmeter. Next, connect the d.c. voltmeter across the entire output network (Fig. 6) and adjust the secondary trimmer \( (C_2) \) for a zero reading, or as near zero as possible.

The output d.c. voltage from the discriminator can reverse in polarity if you carry the secondary adjustment past the proper point. To make sure this has not happened, interchange the test probes so as to reverse the meter polarity. The meter should not now read up-scale. If it does, readjust the secondary trimmer for zero output.

This completes the i.f.-discriminator alignment. Some instructions tell you to check the discriminator alignment by swinging the signal generator frequency about 50 to 75 kc. above and below the resting frequency, to be certain that the output goes to the same value in each direction. However, this test is meaningless unless your s.g. can be set very accurately, because unless the frequency change is exactly the same on each side of the resting frequency, the output reading won’t be the same. Eventually, as f.m. becomes more popular, highly precise signal generators will undoubtedly become available for aligning f.m. sets. Until then, the procedure we have given will be accurate enough.

**Aligning the R.F.-Oscillator Section.** After the i.f. and discriminator have been aligned, disconnect the s.g. from the first detector and connect it to the input
of the receiver. Follow the manufacturer's instructions carefully, because, for maximum results, the proper decoupling resistors should be used between the s.g. and the antenna terminals of the set.

Next, reconnect the output indicator in the grid circuit of the limiter stage. Tune the s.g. to the frequency required. For the 88-108 megacycle band, 100 megacycles is commonly used. If your s.g. won't produce this as a fundamental, tune it to 50 megacycles and use the second harmonic. If your s.g. will not produce a sufficiently strong harmonic, use a signal from a local f.m. station instead.

Next, adjust the r.f., first detector, and oscillator trimmers for a maximum reading at the input of the limiter. This completes the alignment procedure. As you can see, an f.m. set is aligned much as is a standard a.m. receiver. The chief difference is in the discriminator alignment, where you adjust one trimmer for minimum instead of maximum output.

F.M. ANTENNAS

A good antenna and ground must be used with an f.m. set. The antenna should deliver sufficient signal to saturate the limiter. Preferably, a noise-reducing variety should be used, because there is plenty of man-made interference at f.m. frequencies.

It is impossible to give hard and fast rules that will work in every installation. Always try the receiver first on an ordinary antenna and see how it works. If the reception is entirely satisfactory, fine—no more need be done. However, if there is excessive noise, or if the signal is weak or is interfered with by signals from another station, then a better antenna installation must be considered.

Most receiver manufacturers recommend specific types of antennas for use with their receivers. The input of the receiver is designed to match the impedance of the transmission line of the recommended antenna, and best results will be obtained through its use. Other types can be used if the proper impedance-matching transformers are used. Most of the antennas available are of the standard half-wavelength dipole style, and are sold with a matching transmission line.

It is standard practice for the f.m. transmitter to radiate a signal having horizontal polarization, so the antenna is mounted in a horizontal plane. It should be mounted securely, as high above grounded objects as is possible.

The half-wave dipole receives best from its side, as shown in Fig. 7. Therefore, the antenna must be rotated so that it is broadside to the radiation from the desired station.
If the signal pickup is still too low, as may be the case when the receiver is located at some distance from the transmitter, you may have to use an antenna that has a reflector, like the one shown in Fig. 8, or even one that has both a reflector and a director (Fig. 9). These are sold by radio supply houses.

Some of the antennas now available are tunable; their lengths may be changed by means of telescoping end sections. In such cases, it is practical to adjust the antenna to receive maximum signals from a particular station that would otherwise come in weakly.

- If the antenna you use has a different transmission line characteristic impedance from that recommended by the set manufacturer, it is desirable to use a matching transformer at the receiver. If the line has a higher impedance than that for which the set is designed, use a step-down transformer, if it has a lower impedance, use a step-up transformer. Most of the standard antennas come with such matching units, and of course the problem can be avoided altogether by obtaining an antenna system designed for the particular receiver.

- The antenna is often easier to mount than is a standard broadcast antenna, since it is mounted on a single pole or support and is rather small. The length of a half-wave dipole at the f.m. frequencies is only about 4½ to 5½ feet!

To make the installation, first get the antenna in place without anchoring it. Then rotate the system to find the point of maximum reception. This is a job for two men—one at the antenna and the other at the receiver. The man at the antenna should rotate the antenna in steps while the man at the receiver watches a tuning indicator and listens to the receiver output. When the point of
Maximum reception is reached, anchor the antenna in place.

Not much trouble occurs with the antenna itself—it is practically foolproof. However, the transmission line will eventually require servicing and, probably, replacement. All types of transmission lines are used—twisted pair, coaxial cable, and parallel wire. The coaxial line, if properly sealed against weather at the antenna end, should give very little trouble. However, it is the most expensive of the transmission lines, and cost may be a factor in some installations.

The twisted pair of wires is enclosed in a weatherproof loom, but after a certain number of years of being acted on by the elements and by city fumes, this coating may be penetrated and the line may short. When this happens, a replacement is necessary.
FOREWORD

This RSM Booklet marks an important point in your studies. You have now completed your preliminary training in radio servicing. At the same time that you were learning the fundamentals of radio theory from your Course, these RSM Booklets have been teaching you how to repair sets. First you learned to service as a radio mechanic does. Then you advanced to using the methods of the semi-professional serviceman.

If you plan to specialize in radio servicing as a career, you are now ready to learn the advanced professional servicing methods that will fit you for a successful career as a real Radiotrician.

The remaining Lessons of your Course will be devoted to teaching you these advanced methods. You will receive no more RSM Booklets. However, I advise you strongly not to consider yourself finished with your Booklets, for they are still valuable to you. In fact, they will continue to be useful throughout your servicing career. There are sections, and even whole Booklets, that you will want to read and re-read as the need for this information arises.

I suggest you skim through your Booklets from time to time to keep their contents fresh in your mind. Then, when you need some of the information they contain, you will be able to turn to it quickly.

J. E. SMITH.

COPYRIGHT 1947 BY

NATIONAL RADIO INSTITUTE
WASHINGTON, D. C.

FMIS247 Printed in U.S.A.

How To Go into Full-Time Servicing

This Booklet is written for those of our students who have chosen a servicing career, and are now about to start on their Lessons Specializing in Radio Servicing.
If you have chosen Communications as your field, the statements made here about the contents of future Lessons will not apply to you.

PreVIOUS Booklets have shown you, among other things, how to test parts, how to service receivers for specific complaints, and how to get started in a part-time servicing business. If you have made a careful study of this information, and have faithfully carried out all the suggestions for getting practical experience in our NRI Practical Training Plan, you should be well on the way to becoming a professional serviceman.

Of course, you have not yet learned all there is to know about radio servicing. In fact, if you are taking the Lessons Specializing in Radio Servicing, your regular Course will soon start to feature the advanced methods of servicing that make the NRI-trained man stand out. You need this advanced training, plus the sureness of action that comes only with experience, before you can consider yourself a master of your profession. However, if you have learned all that these RSM Booklets can teach you, you're even now better equipped for radio repairing than are many men who make their living that way.
That is why we are now going to discuss the subject of a full-time radio servicing career for you. You may not wish to go into full-time servicing at this time—indeed, you should finish your complete Course before you take such a step—but by now you know enough about the profession and its problems to be able to devote really productive thought to the subject.

In this Booklet, we shall first discuss the question of whether you should make servicing a part-time or a full-time career. Then we shall give you general advice on how to start and run a full-time business.

PART-TIME OR FULL-TIME?

There are a great many NRI graduates who are operating their own full-time servicing businesses right this minute. Many others have kept their servicing on a part-time basis. Some of the latter prefer to work at some other job during the day, and let their servicing income supplement their regular pay; some look upon servicing as a hobby, and use it as a means of relaxation rather than as a source of income; some prefer to live in very small communities that will not support a full-time servicing business; in fact, there are a great many reasons why a man who is perfectly competent to make a full-time career out of servicing may prefer not to do so.

Whether you should be a part-time or a full-time serviceman is something that you, and only you, can decide. We are not going to attempt to persuade you either way—indeed, we are going to give you practical advice, based on our experience in teaching many thousands of servicemen, so that you can have a good background for making your decision.

What factors should you consider before you make up your mind? Most important, perhaps, are your own feelings. If servicing a set gives you real pleasure—if you can't wait to get home from your regular job to start the evening's work on a set—if, in brief, fixing radios seems to you to be the most interesting profession possible—then certainly you should consider full-time work very seriously.

Another very important factor to consider is—do you have enough technical ability to be successful in full-time work? Frankly, we think the answer to this is "No" for most students at this point in their studies. However, this is no barrier to future full-time work; you should have all the technical ability you will need when you graduate.

Important as they are, interest and professional servicing ability are not by themselves sufficient reasons for choosing a full-time servicing career in preference to other work. You must also be sure you can make an adequate living out of servicing. Therefore, you should make a very careful survey of the possibilities for financial success in your locality.

If you have been operating a part-time service business (and, except under exceptional circumstances, you should not be thinking of entering full-time servicing if you have not had part-time experience), you probably have a fairly good idea of how much servicing business exists. Do you now have more sets to service than you can possibly handle on a part-time basis? If so, that is good evidence that there is enough demand for your services to make full-time servicing profitable.

Of course, this is true only if you are now turning out sets with really professional speed. If you can handle almost any job in an hour or less, and still find that
work piles up on you, then you are probably getting a sufficient volume of business to justify full-time work. However, if it takes you two, three, or more hours to service a set, then you have no very clear idea of just how much work you can handle when you have professional ability.

If you don’t have much work to do, but have never tried very hard to get any, make a real effort for a few weeks to drum up business. Doing so will help you to estimate future business more closely—and, incidentally, will give you some valuable experience in securing work.

Estimate your probable volume of business just as closely as you can—and, when doubt exists, be pessimistic. Take every factor you can into account. Estimate the number of sets in your town (or in the section in which you intend to operate, if you live in a large city). Consider how much competition you will face. Estimate the amount of business established servicemen are doing—are they swamped with work, or are they finding it hard to make a living? If some are doing well and others poorly, try to discover the reason for the difference; any information of this sort that you can get will be very helpful both in making your estimate of probable business and in conducting your business if you decide to start one.

In brief, analyze your chances for financial success realistically. If it seems unlikely that you can make the income you want, it is advisable to give up the idea of a full-time business—in that locality, anyway. You will be better off to continue in spare-time work, or to open a shop in some location where the chances for success are greater.

► Suppose that you have a deep interest in servicing, that you have completed your professional training, and that there is enough potential business to give you the income you want—is there anything else you should consider before making your decision? Yes, there is one more factor. You must be sure that you have enough capital to carry you until your shop is making money. It is sometimes possible to start a business on a “shoe string,” but usually it is not advisable to do so. More new businesses fail for lack of capital than for any other single reason.

You should have enough money to buy all the equipment and tools you need, plus enough to decorate your shop and get it ready for full-time work, plus enough to pay your business and personal expenses for at least three months. We cannot set any definite amount you should have before starting a business, for that depends on a variety of things—how much equipment and stock you already have, whether you already have a shop set up, the cost of living in your locality, etc.

If you don’t expect to have enough money to start a full-time business when you graduate, you’ll be wise to save as much as you possibly can and continue spare-time work until you have adequate funds.

► What we have said can be summed up in four questions:

1. Do you really want to be a full-time serviceman?
2. Are you technically ready for full-time work?
3. Is there enough business in your chosen locality to give you the income you want?
4. Do you have enough capital to start?
When you can answer an unqualified "Yes" to each of these questions, you are ready to start a full-time servicing business of your own. Now let's see how you can start and run such a business successfully.

LOCAL LAW GOVERNS EVEN SMALL BUSINESSES

For the protection of their citizens and all legitimate businesses, most communities have laws and ordinances governing the conduct and location of business enterprises. For example, it is often necessary to secure a license to run a business. Also, very often it is forbidden to carry on business activities in residential areas. Further, commercial enterprises often must pay special taxes that private individuals do not pay. Before you start to set up a business of your own, find out exactly what laws and ordinances affect you in your community. An official of the town or city hall should be able to tell you what the laws are. There may not be many of them—in most small communities, for example, only a license is required to start a business—but be sure you know exactly what is expected of you. Remember, ignorance of the law is no excuse.

Incidentally, speaking of law, be careful about taking the advice of your friends on legal matters. Unless the man who gives you the advice is a lawyer, what he tells you may not be worth much. Unfortunately, common sense is not always a good guide in legal matters. As a businessman, you will probably need more legal advice than does an ordinary citizen. For instance, you may accumulate some bad debts that you would like to collect; you may wish to form a partnership, instead of running your business completely by yourself; or you may even be sued by some customer who fancies he has been wronged by you. Each of these situations calls for competent legal help. Therefore, we suggest that you arrange for the services of a lawyer. Many lawyers, particularly young ones, are willing to handle small legal matters and extend advice to a beginning businessman like yourself at much less than the usual legal fee in the hope that you will eventually become a profitable client. See if you can locate such a lawyer. Of course,
amount of business you can expect is therefore restricted, probably it is best for you to plan to do work in your own home, where your business expenses will be least. If you have built up a good business among your neighbors because your location is convenient for them, it may be best to plan to remain somewhere in the neighborhood, if not in your home.

Many people consider a man working from his own home to be just a “tinkerer,” not really capable of doing professional work on a radio. Such people are far more apt to take their sets to a serviceman who has a separate shop. Therefore, if you must build up a great deal of business to make full-time servicing profitable, you’ll do well to consider moving to a shop that stamps you at once as a professional. This might be either a downtown or a neighborhood shop, but, in most cases, a downtown location will give you more business.

★ Whatever location you choose, it must serve to separate your business from your home life. As we said in an earlier booklet, this is desirable in a spare-time business; it is necessary in a full-time business, for it is next to impossible to concentrate on earning a living in the midst of household activities.

Of course, the separation of home life and business life occurs automatically if you have an outside shop. If you must remain at home, a garage in your yard is the best location for your shop. A front room or a basement location that can be completely shut off from the rest of the house and reached by a separate entrance is almost as good. It should never be necessary for a customer to enter your personal home during business hours to do business with you.

★ Very often, the rent you can afford to pay will be one of the chief factors determining where your shop will be. It is generally agreed that you should pay about 5% to 7% of your total gross income as rent. Thus, if you estimate that you will gross $5000 a year, your annual rent should be between $250 and $350—say $20 to $30 a month. Obviously, if you can pay only a small amount like this for rent per month, you’ll not be able to afford a main-street, downtown location in any but the very smallest community. You may, therefore, automatically be forced into a side street or even into remaining in your own home if you estimate an income of this size.

A location on a side street may be no hardship to you if you intend to do service work only. If you intend to sell merchandise as well, however, a location on or very close to one of the important streets in your town is almost a necessity. This is because a great deal of your business will come from people who pass by your shop, notice the merchandise in the window, and come in to inspect and perhaps to buy. The serviceman, on the other hand, gets little business from the casual passer-by; his business is built up by advertising and by word-of-mouth recommendation from satisfied customers. To him, then, the attention-getting location on a main street is not necessary.

Of course, if you do intend to sell merchandise, you can expect a considerably greater gross income than you would get from servicing only. Therefore, by our 5% to 7% rule of thumb, you can afford to pay a much higher rent for a good location than a serviceman can. In fact, since so much of the success of a merchandising
business depends upon its location, it is often considered a worth-while gamble to spend far more than 5% of
the estimated gross at first to rent an excellent location,
on the assumption that the improved location will create
a large enough volume of business to justify the high
rent. However, we are not going to attempt to give you
much information about merchandising in this Booklet;
we mention it here simply to point out that the factors
to be considered in choosing a location for a service
shop are not the same as those you must consider when
you are establishing a merchandising business.
► The location you select for your shop should, as far
as possible, make it convenient for your customers to
do business with you. For example, a location with
plenty of parking space near it is usually preferable to
one without parking space.

Remember, also, that you'll need to install an anten
na for testing sets in your shop. It is better, theref
ore, to choose a location that is not completely shielded
by tall buildings—and you should make sure that an
antenna installation will be permitted. If you must use
some other building to help support your antenna, make
sure the property owner will permit you to do so.

If your business is servicing only, you'll do well to
get a shop with a fairly small front window rather
than a large display window. (Of course, a merchan
dising business needs display space.) This will make
it easier for you to make the front of your shop attrac
tive, for there will be less space for you to fill with
display material. We'll say more about this later on.
► Perhaps the best way of settling the question of the
location you should have is to pick the best one you
can afford, taking every factor you can into considera
tion. Remember, you are not committed to one location
for life; if you must start out in a place you don't par
ticularly like, you can always move when business
justifies it.

DECORATING YOUR SHOP

A shop should have more than four walls, a floor,
and a ceiling. It should be decorated and furnished
so that it will impress your customers favorably. Dirt

and darkness have no place in a radio shop; neither
has old-fashioned ornateness. A radio shop should be
clean, orderly, and modern-looking; it should give the
customer the feeling that up-to-date methods prevail.

This does not mean that you must have glass block
walls and chromium fixtures. It does mean that your
place should be thoroughly clean and well painted, with
nothing of a makeshift appearance about it. Your bench
should have the look of something made by an expert
carpenter. A rough-and-ready, unpainted bench has no
place here.

The layout of your shop is important. It should be
designed first for your own convenience in working,
and second for the impression it will make on your
customers. The exact layout will depend, of course, on
the dimensions of your shop. Generally speaking, how-
ever, you'll do well to have your bench and other work-
ing equipment up near the front, and your storage
equipment, including shelves for finished and un-worked-
on sets, in the back.
It is important, also, to have your shop well lighted. You should provide both general illumination for the whole shop and a concentrated light for your workbench. Never use unshaded bulbs for either of these purposes; they cause eyestrain and spoil the appearance of the shop.

Many large paint, linoleum, and building material manufacturers offer valuable decorating advice. If there is a local distributor for such products in your town, find out what assistance he can offer you in planning the appearance of your shop. If he does not have this service, write directly to several manufacturers of nationally advertised products of this sort. Tell them that you are opening a radio service shop, and ask for whatever information they supply that will help you in decorating it. Such information is usually free.

Here is an example of a large shop that features its service department. The complete assortment of test equipment is made more impressive by being placed in panels at the back of the bench. Notice that the counter permits customers to see the bench, but keeps them from getting too close to it. You will do well to adopt some such measure as this to keep customers at a distance; otherwise, you will be frequently annoyed by the "sidewalk superintendent" type, who likes to see everything you do.

You should devote some thought to the problem of window decoration. Since there is little that a service business can display to attract attention, some imagination is necessary to get an attractive window. Some servicemen go so far as to put their service benches right in front of the window so that passers-by can see them at work. This is an effective attention-getter, since there is nothing that most people like to do better than to watch someone else working. However, remember that you will be leading a somewhat goldfish-like existence if you try this method of attracting attention to your shop; you may find the lack of privacy rather annoying at times.

YOUR WORKING EQUIPMENT

If you take our advice and do considerable spare-time work before starting full-time radio servicing, very likely you will have most or all of the equipment you need. You should have, as a bare minimum, the three basic test instruments—a multimeter, a signal generator, and a tube tester. Then, when you are servicing full-time, you should consider purchasing "time-savers" such as a signal tracer and a condenser tester.

In addition, of course, you must have a good bench and a variety of hand tools. You will need more tools for full-time work than for part-time: since every moment counts, you should have the tools to do every kind of job you handle, instead of having to waste time making some tool do work for which it is not well suited. As an example, you should have a wide assortment of screwdrivers and socket wrenches. Furthermore, you should keep a tool kit always packed so you will not have to waste time loading the kit before leaving for an outside job. This will mean duplicating some tools.

A good antenna is a necessary part of your shop equipment. This should be an outside antenna to give you the best possible reception. If you are in a downtown location, you may find it necessary to install a noise-reducing antenna to overcome the interference near your location.

Finally, you should have a good assortment of replacement parts. By now you should have sufficient
experience with various repairs to know what items you need. It is a good idea to have enough stock on hand so that you don't have to make daily purchases from your wholesaler or mail-order supply house. Of course, don't go overboard—it is foolish to put too much of your capital into stock.

HELPERS

You must have at least one helper as soon as you open a shop of your own. There must be someone in the shop at all times to answer the telephone and greet customers. If your shop is in your own home, it may not be actually necessary to have this assistant in your shop, since you can have an extension telephone that can be answered by someone in the house when you are out on call.

At first, at least, the services of this assistant should cost you as little as possible. For this reason, it will be very helpful if you can get some close relative to take on the job at little or no cost to you. If you must hire someone, by all means get someone who can help you with your bookkeeping as well as answer your telephone. Of course, it would be handy to have a helper who could also assist you in servicing, but it is unlikely that you can afford anyone with such technical ability when you start out.

OPENING YOUR NEW SHOP

For the sake of the success of your new business, you should get your opening as much publicity as possible. Let every potential customer know that a new service is available in your community—a modern, efficient, high-quality radio repair shop that is ready to furnish excellent radio servicing at reasonable cost.

To this end, dramatize your opening. Don't just rent a store, hang up a sign, and move in your equipment haphazardly. Instead, prepare your new shop thoroughly before making any public announcement of your business venture. Clean it up, paint it, install your lighting, your bench, your storage equipment, your test equipment, and your supplies before declaring yourself open for business. You may even find it wise to cover your window with Bon Ami while you are preparing the shop, so that it will not be open to the public view until you are completely ready. This serves two purposes—it prevents anyone from getting a poor impression while your shop is all upset by the process of moving in, and it also stimulates the curiosity of passers-by who wonder what is going on behind this opaque window. Any curiosity you can arouse in this way will serve to attract that much more attention to your shop when you finally throw open the doors.

Then, when every last bit of equipment is in place, when you are completely ready for business, do everything you can to attract attention to your shop. Advertise in your local newspaper, send announcements to your old customers, and, if possible, arrange some special feature that will make people notice your opening. You might offer a free gift to everyone coming in on opening day—perhaps a useful novelty, or a card entitling the holder to free inspection and checkup of his set for some limited time—or you might arrange to give a demonstration of the latest television or facsimile receiver. Almost anything that will attract public attention will be helpful.
CONDUCTING YOUR BUSINESS

An earlier RSM Booklet gave you advice on conducting a spare-time business. It will be worth your while to read that Booklet again, for most of the advice it gives, with one possible exception, applies equally well to a full-time business.

The exception to which we refer is the question of advertising. We said that a spare-time serviceman does not need to do much advertising; this is not, however, true of full-time technicians. It is highly unlikely that you can get enough business to be fully occupied without the help that advertising can give you.

At the very least, you should have a display ad in the classified section of your telephone directory. Very likely you will find that newspaper and mail advertising will pay for themselves. See to it that the public is frequently reminded of the services you offer. The word "often" is almost always the key to success in advertising; generally speaking, a small ad every day is much better than a large ad once in a while.

Just how much you should spend on advertising depends upon your circumstances. If the servicing field is somewhat overcrowded in your community, and is therefore highly competitive, you will undoubtedly have to spend more than you would if there were little or no competition. No one can tell you exactly what the best advertising procedure is for you; this is something you will have to learn from experience.

Since advertising is so important to you, you will do well to learn all you can about it. Probably your public library has some books available on the subject. Your newspaper will undoubtedly be glad to help you write ads (but remember, often the space salesman for a newspaper will be interested in selling you as much space as he can; don't allow yourself to be talked into spending more than you can afford).

Planning the Day's Work. If you are going to handle any real volume of business, you must plan your day's work to take advantage of every possible moment. You will have many different activities—servicing sets, picking up and delivering sets, getting parts, visiting prospects, planning advertising, etc.—and there is simply not enough time in a day to do all these things unless you set up a schedule that keeps your wasted time at a minimum.

The best way to keep from wasting time is to organize matters so that you stick at each phase of your occupation long enough to do some effective work on it. For example, it is better to service several sets one after the other than to fix one, deliver it to the customer, and then return to fix another. As far as possible, all your servicing should be concentrated in one part of the day, and all your pickup and delivery work in another part. Other business activities, such as getting parts or planning advertising, should also be done at definite, scheduled times as far as possible.

The early morning is a poor time to visit prospects or pick up and deliver sets, since housewives are generally busy with household duties at that time. Therefore, this is the best time of day for you to do your actual servicing.

The noon hour is a good time for you to buy parts, if you patronize a local distributor, or to order them if you buy from a mail-order house. After you've had some experience and have learned fairly well what your requirements of replacement parts are, you can probably buy parts on a larger scale and reduce the number of visits you must pay to your distributor. At the be-
Beginning, however, it would be better for you to buy only a few days' supply at a time.

The afternoon hours are the best time for you to pick up and deliver sets and visit prospects. If possible, concentrate these activities between the hours of 2 and 4—the time when most housewives have least to do. Of course, if your customers are not home during the day, you may have to postpone these activities until the early evening hours.

You should set aside some time of your day toward devoting thought to the improvement of your business and to planning your advertising. Never be content to let your business run itself—always be on the alert for opportunities to improve it, and spend many hours of good solid thought on its problems. Plan, also, to devote some time to your technical advancement; set aside at least one or two evenings a week to study the various servicing magazines and to review parts of your NRI Course with which you do not feel very familiar.

**Customer Relations.** We have spoken, in an earlier Booklet, of the importance of treating your customers well and making a good impression on them. Always keep one fact in mind—your business, your very living, depends upon the good opinion your customers have of you. Do every job as well as you can; charge fair prices and no more; keep your personal appearance neat and your manners friendly—such actions will help convince your customers that you are an able, honest, and courteous businessman.

**KEEPING RECORDS**

If you have a paid helper, you must pay Social Security taxes for him, and may have to pay unemployment and other taxes as well. (Check with your lawyer on your local, state, and federal tax laws.) This at once means you must keep records of time worked, salary paid, etc. As a matter of fact, these are just a few of the records you must keep when you go into business for yourself.

What we have said in an earlier RSM Booklet about the importance of keeping records of the cost of doing business applies with even greater force when you start a full-time business of your own. If your business remains fairly small, you can probably keep much of the same kind of records for full-time as for spare-time work (except that there will be more entries—the Social Security tax for your helper, for example). If you branch into marketing, and particularly if you enter into credit sales of merchandise, you will have to keep much more elaborate records for full-time work.

We shall not discuss the merits of various systems of record keeping here, since, as we've just said, the method you use will depend largely upon your volume and kind of business. If you intend to keep more than the simplest sort of records, and have no particular bookkeeping training, we suggest that you hire an accountant to set up a record system for you. You can usually find someone who is willing to do this as a part-time project—in fact, you can probably also hire him