No. 17 How Professional Service-men Repair Receivers

RADIO SERVICING METHODS

NRI TRAINING *Pays...*

Dear Mr. Smith:

Up to my fortieth year I slaved in factories. The last two years I have had my own business, thanks to your training. My business is growing all the time. There has not been a receiver which I could not repair properly, even the very old ones. I wish to thank you and all of your staff for the wonderful service and cooperation I have received.

W. S., Canada

NATIONAL RADIO INSTITUTE
WASHINGTON, D. C.

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TO the layman, it is amazing how quickly an experienced Radiotrician can locate a defect in a receiver. In 90% of the sets he repairs, an experienced man using professional methods finds what is wrong within ten or fifteen minutes after he starts working. Although occasionally he will take longer to locate some unusual defect, generally he will have finished the repair in the time it would take the "mechanic" to get well started.

Now that you have studied the basic circuits of radio receivers, and have a better understanding of the interrelation between the sections, stages, and circuits, you are ready to begin to learn how the professional works. Therefore, we shall introduce the basic professional servicing methods in this RSM Booklet. Most of your remaining RSM Booklets will show you how to apply these techniques to specific receiver complaints, such as dead receivers, receivers that distort, etc.

Also, in this Booklet we introduce the NRI Plan for Gaining Practical Experience in your own home. This is an important part of your training and will be continued in future RSM Booklets.

PROFESSIONAL SERVICING

As you know, the radio mechanic locates a defect in a set by testing parts until he finds the one that is defective. This can be, and usually is, a very slow and laborious way to service a set. The professional, on the other hand, tests very few parts. Instead, he uses two powerful tools that very quickly lead him to the one or

two parts that may be defective. These are the only ones he tests.

What are these two powerful tools that are so helpful to the professional? One is the process that we call "effect-to-cause reasoning." The other is a method of locating defects by following a logical, orderly six-step plan of "trouble isolation." Let's see just how these professional procedures are used.

Effect-to-Cause Reasoning. Effect-to-cause reasoning is the "use your head" step of radio servicing. When you turn on the receiver you are to service, you find that it operates in some peculiar manner, or else fails to operate at all. This is the *effect,* and you reason back from this effect to its probable *cause.*

Of course, much of this "reasoning" is actually pure memory—you remember having heard this particular kind of sound at another time, and you remember what the trouble turned out to be. Naturally, the more experience you have, the more likely it is that you have heard the sound before. In other words, practical experience will often help you to spot a defect almost immediately. (Later in this Booklet, you will learn how you can get this experience very quickly.)

But this reasoning process is by no means all memory. Even when you have never heard an effect just like the one in the set you are servicing, you can often use reasoning to locate the probable cause if you know enough about the actions of radio parts, circuits, stages, and sections. In fact, the only limits to your use of effect-to-cause reasoning will be how much you know about parts defects and how parts work together.

Let's take a practical example to show how you can use effect-to-cause reasoning. Let's suppose you are servicing a set equipped with a "magic-eye" tuning indicator. The complaint is that the set is dead.

First you switch on the set to confirm the complaint. You notice that the tuning eye lights up with its normal green color; this shows you that the power supply is probably all right. Then you attempt to tune the set to a station. Since the tuning eye is controlled by the output of the second detector, you can tell at once whether the defect is in the r.f.-i.f. section or in the a.f. section.

The Radiotrician hunting for a radio defect is equipped with a double-barrelled weapon — effect-to-cause reasoning and the six-step servicing method.

If the eye closes when you tune to a station, the r.f.-i.f. section must be all right, and the defect must therefore be in the a.f. section. If the eye does not close, the r.f.-i.f. section is probably at fault. Thus, in this example, your knowledge of circuit actions enables you to locate the defective section at once without even looking inside the cabinet!

Do you begin to see how your knowledge of radio circuits and parts will fit into the servicing procedure? The example we gave is only one of the many instances in which circuit knowledge can be used. There are other cases in which effect-to-cause reasoning proves to be an even more powerful tool, and also cases in which so many possibilities exist that reasoning is of only limited usefulness. All these conditions will be discussed in much greater detail in other RSM Booklets.

Now, let's learn how defects are located by the six-step method.

SIX-STEP DEFECT LOCALIZATION

No matter what the receiver type may be, nor what the complaint, it is possible to locate the trouble in a logical step-by-step manner. This process of orderly localization is one of the great "trade secrets" of the professional serviceman. Unlike effect-to-cause reasoning, it can *always* be used effectively—it cannot fail to work. Furthermore, you can use it without the intimate knowledge of exactly how parts operate that effect-to-cause reasoning requires.

The Signal Path. To understand just how a defect is located, let us briefly review the stages and sections of a radio receiver. Fig. *1* shows a layout that is typical of

both a.m. and f.m. superheterodynes. (F.M. receivers will usually have three or more i.f. stages, whereas a.m. superheterodynes will usually have only one or two, and the frequencies will differ.) All superheterodynes are considered to have three main sections—an r.f.-i.f. section, an a.f. section, and a power supply.

► The r.f.-i.f. section of the receiver includes all stages up to and including the second detector. Starting from the input, there may or may not be an r.f. stage preceding the mixer tube. The receiver oscillator feeds into the mixer, and its signal combines with the incoming signal to produce the i.f. signal. The i.f. signal passes through the i.f. amplifier and into the second detector, where the a.f. signal is separated from the i.f. signal.

The a.f. section of the receiver obtains its signal at the output of the second detector, and amplifies it through at least one audio stage, after which the signal is fed into a power output stage, which, in turn, drives the loudspeaker.

The power supply provides the d.c. operating voltage for plates and grids to all stages, furnishes the filament voltage, and, in some sets, provides power for the field of the loudspeaker.

► The method of localizing trouble is based on one important fact: the signal progresses from the antenna to the loudspeaker in a one-way direction and ordinarily never goes in the reverse direction. The solid arrows in Fig. *1* show how the signal passes from stage to stage.

There is a popular belief that when something goes wrong in a radio, the entire radio is affected. This is not often true. Usually, when a part (not in the power supply) breaks down, it affects a particular circuit and therefore a stage, but every other stage in the receiver is usually perfectly all right. The stages ahead of the defective one operate normally, and the stages after it are capable of operating.

For example, let's suppose that the i.f. tube goes dead because of an open in its filament. If the receiver is an a.c. receiver with the filaments in parallel, there will be no effect on the signal in any other tube or circuit. The incoming signal still travels through the r.f. and mixer stages into the i.f. stage, but it gets no further. However, the second detector and all stages following it are ready and willing to work if only they had a signal to put them into operation.

It is very important that you understand clearly the last several paragraphs. *The trouble in the i.f. stage has not blocked the signal in its progress from the antenna through the mixer stage.* Because of the open filament, the signal does not pass through the i.f. stage. *However, the second detector and audio stages are ready and willing to work and would operate if they had a signal voltage to drive them.*

Similarly, a defect in any other stage may block the passage of the signal partially or completely, or may add noise, hum, or squeals to the signal. Such a defect will not ordinarily affect the progress of the signal from the input of the receiver up to the defective stage. Furthermore, the stages following the defective stage will

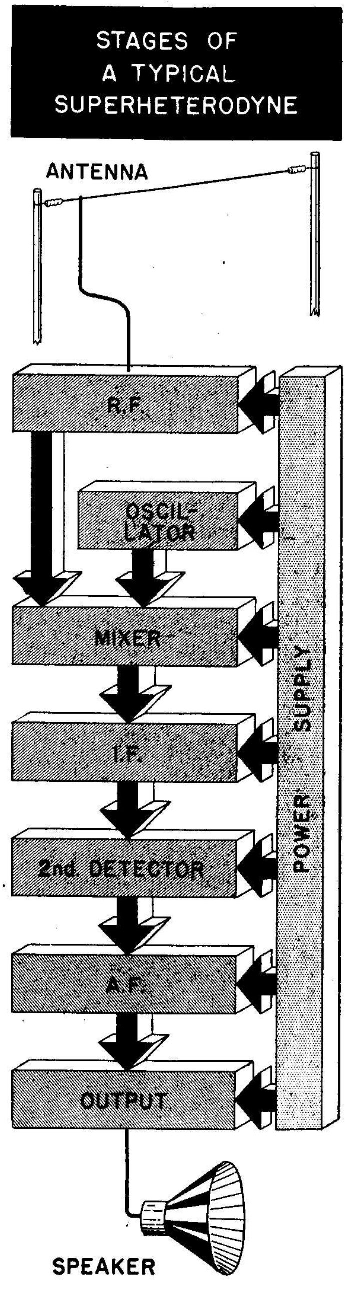


FIG. 1. This block diagram shows the basic stages of either an a.m. or an f.m. superheterodyne. An a.m. set might have an extra i.f. stage and an extra a.f. stage. Usually an f.m. set will have at least three i.f. stages, one of them known as a limiter stage. Also, the second detector stage in an f.m. set is usually called the discriminator.

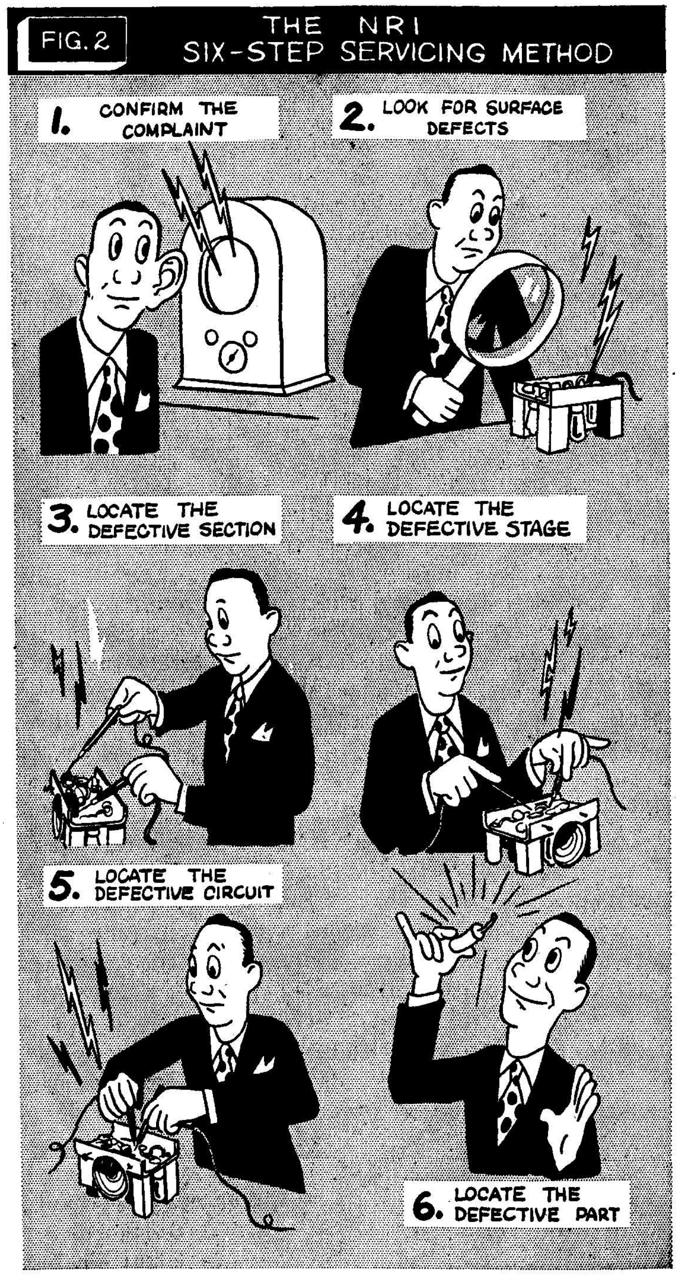
operate in a normal manner except that they will not receive the proper signal, or will receive a signal that has undesirable characteristics added to it.

The six-step plan of trouble isolation is given in Fig. 2. You are already familiar with the first two steps—confirming the complaint and looking for surface defects. In following this plan, you continue the test procedure by making one or two very simple and quick tests that will show you in which of the three main sections the defect is. Once the trouble has been localized to a section, you may have to make another test or two to determine which stage in the section is defective. Then, once the trouble is localized to a stage, the defective circuit is usually easy to find. Finally, when you have run the trouble down to a plate, grid, or filament circuit, you will almost invariably find that there are only one or two possible parts defects in that circuit that could cause the complaint. Therefore, you will have to test only the one or two parts to locate the defect.

As you can see, this professional method keeps *parts* testing at a minimum. The defect is found by making localizing tests that always take far less time than tests on even a few radio parts. Furthermore, you may not even have to make all the localization tests. Frequently, isolating the trouble to a section will show you at once which stage is defective; sometimes, too, you can locate the defective stage without bothering to make a separate section isolation test. The use of effect-to-cause reasoning will often let you skip steps in the isolation procedure this way; in fact, as you gain experience, you will find that this is one of the prime uses of effect-to-cause reasoning.

BASIC LOCALIZATION PROCEDURES

The steps of trouble isolation are logically divided into two groups—(1) section and stage localization, and (2) circuit and part localization. For group (1), there are four *basic* systems of localization. For group (2), the ohmmeter and voltmeter are used, although the methods used for group (1), or effect-to-cause reasoning, may localize the trouble to one or two parts once the defective stage is found.



Future RSM Booklets will describe the use of the multimeter in circuit testing, so let's concentrate here on the four basic methods of circuit and stage localization. They are named:

1. Signal Tracing.
2. Signal Injection.
3. Circuit Disturbance.
4. Signal Blocking.

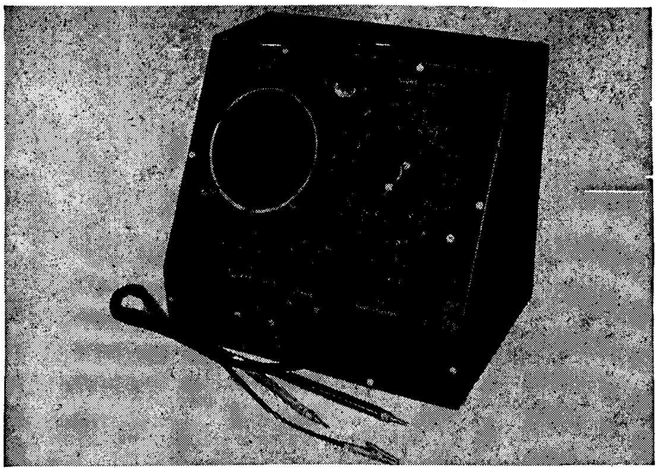
The following *brief* descriptions of these methods will make you acquainted with their general uses. Future RSM Booklets will go into more details, particularly on their uses for specific service complaints.

SIGNAL TRACING

You will recall that the signal proceeds normally through the radio until it encounters the defective stage. Hence, it is logical to follow this signal (to trace it) to see where the defect exists. A special instrument, known as a signal tracer, may be used to follow the signal from the antenna to the stage whose output is improper.

As we have shown in another RSM Booklet, the signal tracer is not one of the three basic pieces of test equipment. However, it is one that every well-equipped service shop should eventually own because of its ability to localize troubles quickly. When a signal tracer is not available, then one of the other methods must be used. (Read the sections on signal tracing here and in later RSM Booklets carefully, even if you do not have a tracer, because you probably will obtain one if you go into the service business.)

Essentially, a signal tracer is a vacuum tube voltmeter, with a selective tuned input for checking r.f. signals, and an untuned input for checking a.f. signals. With practically all forms of the signal tracer, tests are made by connecting one lead of the instrument to the r.f. ground of the receiver, and touching the other lead (which has an isolating probe) in turn to a grid or a plate terminal of the tubes in the various stages of the set. This feeds the signal of the stage into the signal tracer. The strength (level) of the sampled signal is then indicated either by the swing of a meter needle or, in the tuning-eye type, by the amount that a calibrated



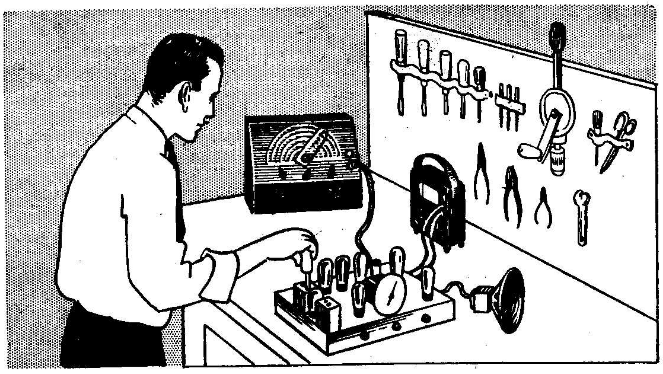
This is the NRI Model 33 Professional Signal Tracer. It has two output indicators—a tuning eye and a loudspeaker—so it can be used in locating any defect.

attenuator must be turned to close the eye. Some signal tracers also have a loudspeaker so that the sampled signal may be heard as well.

► Any type of signal tracer is useful when the complaint is a dead set or weak or intermittent reception. The types that also have a loudspeaker (so that you can hear the output) are considerably better, however, because they can also be used to locate the causes of distortion, noise, oscillation, and hum. The latter type allows you to take an actual sample of the signal at various points in a receiver, and thus gives you a direct indication of what is happening in the set. When the tracer shows that the signal output of a stage is defective (weak, distorted, etc.—depending on what the complaint is), you know that the stage is faulty. You will learn more about the technique of using the signal tracer in future Booklets.

SIGNAL INJECTION

When a signal tracer is not available, so the input signal cannot be followed, it is logical to supply an artificial signal and to work back from the audio section toward the input until the defective stage is encoun-



This man is aligning a set with a signal generator. A signal generator is one of the serviceman's three basic pieces of test equipment, for it is necessary to align most sets as a part of the repair procedure. Although the instrument was not originally intended for other uses, methods have been devised whereby it can be used to locate defects as well. You will learn these methods in later RSM Booklets.

tered. Injecting a signal into stages between the defect and the loudspeaker will produce a normal signal output. However, when the signal is fed into the defective stage, it will be inaudible (dead set) or it will have distortion, hum, or noise added to it.

One of the three basic tools of all radio servicemen is the signal generator (or test oscillator). This instrument is absolutely necessary when you align a set, as you will learn in a later Booklet. In addition, it can be used to locate defects in a receiver.

The signal generator produces a signal that can be tuned in by a radio receiver in the same way as a signal from a broadcast station. This signal is modulated by an audio voltage that will produce an audible sound from the loudspeaker when the r.f. or i.f. output of the signal generator is fed into a receiver.

The signal injection method is useful for locating defects when the complaint is modulation hum (hum heard only when the set is tuned to a station), weak reception, intermittent reception, or a dead set. It is not the *best* localizing method for any of these complaints: both the circuit disturbance and signal tracer techniques are better when the complaint is a dead set, and the signal tracer is also preferable for each of the other com-

plaints. However, if you do not have a signal tracer, the signal generator method of signal injection is useful, and is certainly faster than the procedures of the radio mechanic.

► In general, you will locate defects with a signal generator in this way:

First, with the set turned on but not tuned to a station, locate the defective *section* by feeding a modulated i.f. signal into the input of the second detector. For example, let's suppose the set is dead or weak. If you hear a normal volume of sound from the speaker, you know at once that the second detector and the a.f. section are all right, and that there is at least no major defect in the power supply. Conversely, if there is no sound, or only a very weak one, the defect is in the power supply or is somewhere between the second detector input and the speaker. Thus, you can localize the defect to a *section* at once.

The next step depends on whether the defect is in the r.f.-i.f. section or in the power supply-a.f. sections. The signal generator is of limited usefulness in tracking down faults in the a.f. section, because the signal from it cannot be fed directly into the power output stage or into the speaker. However, you can tell whether or not the second detector is all right by feeding the audio output of the signal generator into the a.f. amplifier. If a normal sound is then produced by the speaker, but not when the signal generator signal is fed into the second detector, the second detector is at fault. That, however, is about as far as you can go in tracking down defects in this section with a signal generator. You will use other methods, described in future RSM Booklets, to locate the defective stage.

► If the defect is in the r.f.-i.f. section, though, the signal generator is very useful. You can locate the faulty stage readily by proceeding toward the antenna from the second detector, injecting a signal into each stage you reach. (Of course, you must tune the generator to the proper frequency for the stage in question.) Eventually, you will find that injecting a signal into a certain stage produces the operation that the customer has complained about; that stage is then the defective one.

CIRCUIT DISTURBANCE

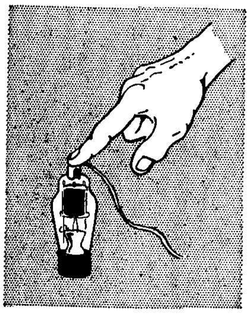
The circuit disturbance test, which is actually another form of signal injection, requires no test equipment. It is a simple, quick method of locating the defective section and stage in a dead receiver—probably the most common of the complaints. Unfortunately, it is of no use in any other complaint except weak reception, and for that it does not give uniformly good results.

In this method, the signal is produced by disturbing a circuit in some manner (whence the name of the method). This disturbance creates the electrical equivalent of a noise in the circuit, and this noise then travels through the set just as if it were a signal from a signal generator.

There are several basic methods of creating an electrical disturbance in the stage. These disturbances will be reproduced by the loudspeaker as a buzz, a thud, or a click. To create the disturbance, you can:

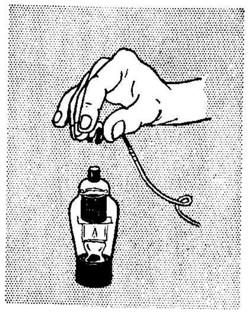
A. Touch the top cap with your finger.
B. Remove and replace the tube top cap connection.
C. Remove the tube from its socket and return it.
D. Make voltage measurements in the plate or grid circuit with a d.c. voltmeter.

► Method *A* creates a disturbance because your body capacity picks up audio voltages, which are fed into the set when you touch the top cap with your finger. However, since these voltages are rather weak, this method can be used only to locate the defective *section* by touching the top cap of the first audio tube. If you touch some other tube in the audio section, the picked-up voltage will not be amplified enough to be heard. Touching the cap of an r.f. or i.f. tube will produce no noise, since the audio voltages will not go through the tuned circuits.



Method A of disturbing a circuit—touch the top cap with your finger.

If the first audio tube is one of the type having a top cap, turn on the set, allow it to warm up, and touch the top cap with your finger. If you hear a loud hum or buzz, the audio section and the power supply must be all right—the trouble is in the r.f.-i.f. section. On the other hand, if you hear no buzz, the trouble is either in the a.f. section or in the power supply of the set.



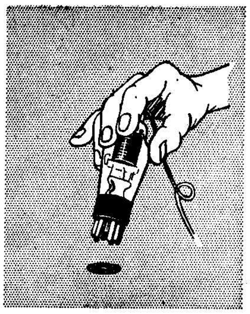
Method B of disturbing a circuit—remove and replace the top cap clip.

If the first a.f. tube is a single-ended type, with the control grid on the bottom, then skip this test and go on to methods *B. C.* or *D.*

► Method *B* can be used in any set having tubes with top caps. Removing and replacing the top-cap clip causes a sharp change in the bias, so there is a definite change in the plate current. Both removing and replacing the clip cause a plop or click that travels as a signal or noise pulse through good stages to the speaker. However, a disturbance of the defective stage in a dead set (or the stages further back toward the antenna) will cause no sound from the speaker. Therefore, you can use this method in the same manner as you would a signal generator, working back from the first audio stage toward the input.

Method *B* cannot be used on the power output tube, which never has a top cap. Also, if the second detector is a diode, there can be no click introduced in this stage, since there is no grid circuit to interrupt. In these cases, you would use one of the other methods.

► Method *C* can be used *only in a.c.-operated receivers that have power transformers,* and *certain* battery-operated sets. In all a.c.-d.c. and in some battery sets, pulling out one tube interrupts the filament circuits of all the tubes because the filaments are in series. This defeats the purpose of the test, because it blocks all amplifying stages and also causes the output tube to produce a click. Furthermore, removing one tube breaks the filament circuit, and therefore allows the full filament voltage to appear across the socket terminal of the tube that has been removed. When the tube is re-



Method C of disturbing a circuit—remove and replace the tube. This test cannot be used in a.c.-d.c. receivers nor in some battery-operated sets.

placed in the socket, this excessive voltage may be high enough to burn out the tube.

Some battery-operated receivers have their tube filaments connected in parallel and use a series resistor to reduce the battery voltage to the proper value for operating the tubes. It is not safe to pull out a tube in such a set either, because doing so will reduce the current flow through the series resistance and may allow the voltage on the other tubes to build up high enough to damage them. ***Remember this rule:*** it is safe to pull tubes in a battery-operated receiver only if the A battery furnishes the *exact* voltage required by the tube filaments. An example of a battery set in which you *can* pull the tubes in safety is an auto receiver, in which the 6.3-volt tubes operate directly from the storage battery.

Method *C*, when it can be used, provides a good test. Pulling out a tube interrupts the plate current sharply, which in turn causes a loud plop or click impulse to travel through good stages to the loudspeaker. Reinserting the tube allows the plate current to build up again and will usually provide another noise impulse.

This method can be used in the audio section as well as in the r.f.-i.f. section, since the output tube can be pulled out of its socket if others can. However, most servicemen don't make a practice of pulling the power output tube because this tube's plate current is such a large part of the total current that its interruption allows the plate voltage to rise higher than normal. This rise may sometimes damage a filter or by-pass condenser.

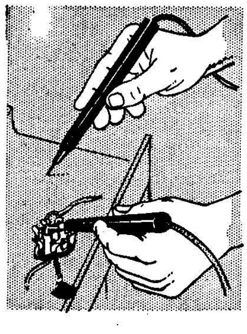
► Method *D* is the best all-around way of causing a circuit disturbance, for it is possible to use a voltmeter in *any* kind of radio. However, this is a somewhat slower method, because it is necessary to remove the receiver from its cabinet and to locate the proper measuring points.

The voltmeter method works because the voltmeter draws current when it is connected into the circuit. Thus, there is a sudden surge of current when you touch the voltmeter probes to the circuit, and an equally sudden stopping of this current when you withdraw the probes. Each of these effects usually causes enough disturbance of the circuit to produce a click or thud in the set speaker. This voltmeter method, as you will learn in a later RSM Booklet, can be used in *any* signal circuit and also is of use in the power supply.

SIGNAL BLOCKING

When the complaint is noise, hum, or oscillation, and the sounds are heard whether or not the set is tuned to a program, the defect is introducing a signal of its own, and this signal is travelling through the good stages to the loudspeaker. The origin of this signal can be found with a signal tracer, or by the procedure of blocking the path of this signal.

When a stage is blocked, the noise, hum, or oscillation signal cannot pass through it. Therefore, if the sounds stop when a stage is blocked, either the trouble is in that stage, or else it is in a stage further back toward the antenna. A stage may be blocked either by removing the tube or by shorting the stage output. The former procedure is preferable when it can be used, because it is simpler; however, as in the circuit disturbance test, tubes cannot be removed from a.c.-d.c. sets or from many battery sets, for the tubes in these are wired with their filaments in series, and removing one tube would prevent the operation of all. On the other hand, shorting the signal output is a step that can be used in any radio. Generally, a by-pass condenser or a test lead is touched across the stage load and serves to by-pass the signal. We will go into more details in later RSM Booklets; for now, let's see where this procedure is used.



Method D of disturbing a circuit—make voltage measurements in plate or grid circuit.

How to Locate the Defective Stage

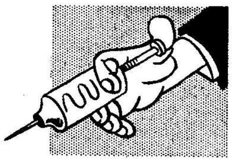
In this Booklet, you have learned something about the four possible methods a Radiotrician may use to locate the defective stage. Since it is important to remember these four methods as you read later RSM Booklets, we summarize them here to help you keep them in mind.

To locate the defective stage, you can:

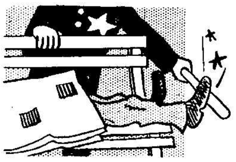
1. Trace the signal.

This is the best single method of locating the defective stage, since you can use it no matter what the defect may be. To use it, however, you must have a signal tracer, preferably one equipped with a loudspeaker.

2. Inject a signal.



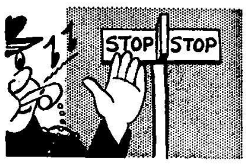
This method can be used only when the complaint is modulation hum, weak or intermittent reception, or a dead set. You need a signal generator to use it, but you will have to have one anyway for set alignment.



3. Disturb a circuit.

This method requires no test equipment except when d.c. voltmeter measurements are used to disturb the circuit. It can be used only when the complaint is a dead or weak set, however, and not always for the latter.

4. Block the signal.



This method also requires no test equipment, but can be used only when the complaint is steady hum, noise, or oscillation. In some receivers, a by-pass condenser or a shorting lead must be used to short out signals.

► Since the volume control is at the input of the a.f. amplifier in practically all modern receivers, as you will learn in your Lessons, the defective section can be easily located by turning this control to minimum volume. This blocks all signals originating in the r.f.-i.f. section. If the noise, hum, or oscillation continues as loud as before, the trouble is in the a.f. section or is in the power supply. Otherwise, if the sounds stop, they originate in the r.f.-i.f. section.

If the trouble is in the audio section, proceed to block the output of the first a.f. tube. If this stops the sounds, then this is the defective stage. But, if the hum, noise, or oscillation is still heard when the first audio stage is blocked, the defect must be in the power supply or in the power output stage (assuming that the set has only one audio amplifier stage, as is the case in most modern sets). If so, you will probably use other tests, which we will describe in later Booklets, to determine which of these two is at fault.

► If the trouble is in the r.f.-i.f. section, turn the volume control back toward full volume, so that you can hear the noise or oscillation. (Hum cannot develop in an r.f. stage as a steady hum—it can come through only as a modulation on a signal. You will study this later.) Proceed to block the r.f. and i.f. stages in turn to find the defect. You can work through the section either way—starting from the antenna end and working toward the second detector, or starting from the second detector and going back toward the antenna. If you work forward through the section (starting from the antenna end), the noise or oscillation will stop when you block the defective stage. If you work backward, eventually you will find a stage where blocking does not kill the undesired signal; then the stage next nearest the speaker must be the defective one.

LOCATING THE DEFECTIVE CIRCUIT AND PART

Once you have located the defective stage by one of the four preceding methods, you still have to find out which circuit and which part is defective. In this, a knowledge of part defects and the use of effect-to-cause

reasoning often help the professional serviceman a great deal. He knows from experience which circuits and parts are most apt to cause the given complaint, so very often he is able to guess which part is to blame, make a quick check to confirm his suspicions, and thereby locate the defective part almost at once.

Even if he has no very definite idea of what is the matter with the defective stage, the professional serviceman is able to locate the defective circuit and part very quickly by using his ohmmeter or his voltmeter in a manner that we will describe in other RSM Booklets.

Summary. You should by now have a good general idea of how a professional serviceman goes about fixing a radio—of how he uses effect-to-cause reasoning and the six-step servicing method. We have purposely made our treatment of these servicing aids rather general, for the primary purpose of this Booklet is to show you the broad picture of how a serviceman works. You will find all the details in the later RSM Booklets in which we take up specific receiver complaints.

THE NRI PRACTICAL TRAINING PLAN

The NRI Plan for giving you practical servicing experience in your own home is the result of many years of experience in training Radiotricians. We know this Plan works, because it has already helped thousands of students to become professional servicemen. We tell you this because we want you to be sure you follow every step of the Plan according to directions; make every test, and make each in just the way we describe. Doing so will give you all the experience you would get from spending a long period of time as a low-paid apprentice in some radio shop—and will give you this experience in an amazingly short time.

What the NRI Plan Is. Briefly, our Plan gives you concentrated experience in servicing all kinds of defects in one radio. In other words, you create different defects in a test receiver, then learn how to locate each defect and how to repair it. You will carry out this procedure for all kinds of defects, rare ones as well as common ones. This will quickly teach you how to locate the cause of any radio complaint.

When you learn how to service a dead receiver, for instance, you will, as part of your practical training, create defects in your test receiver that will make it dead. Then you will track down each defect just as if you had never seen the set before. Similarly, the Practical Training Plan in your Booklet on distortion will teach you to locate the defects that cause distortion, and so on for each of the Booklets dealing with specific receiver complaints. By the time you have finished these Booklets, you will have a varied experience that might have taken you months of apprenticeship to accumulate.

Your Test Receiver. Before you start the NRI Practical Training Plan, you must have a suitable receiver. Read the following description carefully; you may already have such a receiver. (You won't damage the set you use.) If you don't have one, obtain (borrow or purchase) a *five-to-eight-tube broadcast-band superheterodyne receiver* in good operating condition. If possible, get a set that operates on the broadcast band only; however, you can use an all-wave receiver if the simpler set is not available.

Like this NRI graduate, you will be able to handle test equipment with ease and sureness when you have the training your Practical Training Plan will give you.

If you have *a.c. power*, the receiver should use a power transformer. If a.c. is NOT available, get a 6-volt receiver using a vibrator; this will give you the same experience as an a.c. receiver. *Do not get* an a.c.-d.c. set, a battery set using 1.4-volt tubes, or a three-way (a.c.-d.c.-battery) portable. Many servicing techniques cannot be used on these latter sets, so you cannot get all-around experience on them.

You don't need a new set; in fact, one that is a few years old will be better suited to your needs. If possible, get a well-known make, such as RCA, General Electric, Zenith, Airline, Silvertone, Truetone, etc., for we can usually supply you with complete service information on them, often including pictorial layout diagrams.

When you have gotten a suitable receiver, write to us and tell us so. Give us the make, the model number, and the type numbers of the tubes used in it, *and state that you intend to use this set for training.* We will then send you all available service information on this set without charge.

We suggest that you get this training receiver as soon as possible. Each succeeding Booklet will continue with your NRI Practical Training Plan, and you should begin carrying out the steps of the Plan at once.