

# How to Make Extra Money FIXING RADIOS

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 1 How Radio Receivers  
Are Serviced

RADIO SERVICING METHODS



## FOREWORD

As you open this Booklet, you may well ask: "What is the purpose of these Radio Servicing Methods Booklets?" In a nutshell, we can answer: "The purpose of these Booklets is to give you what amounts to apprenticeship training—the kind of knowledge that most people believe can be obtained *only* by working for months or years at a trade!" And, this training is planned to "fit in" with your regular Course, so that your theoretical and practical training will go along hand-in-hand.

Your regular Lessons will give you all the necessary radio theory—the how-and-why-it-works knowledge. In these Lessons, you will learn what breakdowns may occur and how they affect the operation of the radio; you need this knowledge to find troubles when they occur.

Then, you will get the actual "feel" of working with radio parts in the Experimental Kits. The experiments you carry out will supplement your technical knowledge and give you practice in constructing and testing radio circuits.

Finally, these Radio Servicing Methods Booklets will show you how to use the methods actually followed by professional servicemen. You will learn how to remove the set from its cabinet, make tests, replace defective parts, and make adjustments on the complete radio. Yes, these Booklets are your *shop training*. In them, you will learn as an apprentice does—by following the tested, proven methods used by professional servicemen. You will learn *what* to do, and even more important, you will learn *why* to do it that way!

To get the most from these Booklets, plan to read one after each of your regular Lessons. Study a Lesson, then read the Radio Servicing Methods Booklet having the same number. Then from time to time review the Booklets to keep fresh in your mind all the details of how to service receivers.

J. E. SMITH.

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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**

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

## **RADIO SERVICING METHODS**

Here are the first six "Radio Servicing Methods" (abbreviated "RSM") Booklets - an original feature of NRI Training to help you start making extra money soon after you enroll.

The best plan is to read ONE Radio Servicing Methods Booklet AFTER each regular lesson. Study a Lesson, THEN STUDY THE RSM BOOKLET WHICH HAS THE SAME NUMBER.

You will get one additional RSM Booklet with each new lesson on Fundamental Radio Principles. There are THIRTY-FIVE RSM Booklets altogether in the complete series.

These Radio Servicing Methods Booklets show you how to fix Radios -- they give you the practical money-making how-to-do-it directions that are so important to practical Radio men. Here is the same type of information you would get by apprenticesing to an expert Radio Serviceman.

This is just another example of NRI's policy of giving its students the best possible practical Radio instruction.

Chief Instructor  
NATIONAL RADIO INSTITUTE



## How Radio Receivers Are Serviced

RADIO servicing is an ideal field—an interesting, profitable occupation that will give you real professional standing in your community. Almost everyone owns a radio, but relatively few people know how to fix one. The man who has this knowledge is sure of a comfortable living and the respect of his fellows.

► When you are an expert radio serviceman, what will your life be like? Well, you'll certainly find it to be varied! In a typical day, you may repair a half-dozen radios—ranging in size from a tiny midget to a large phono-radio combination—with each of them having entirely different defects. You may make service calls at several homes, meeting all sorts of people. Each day will be different from the one before it—new work to do, new people to meet—a vast improvement over the humdrum, monotonous days of which the average job consists.

Your working conditions and hours, too, will be better than those most jobs offer. You will find that radio servicing is an enjoyable combination of brain work and mechanical work-with-your-hands. The physical work almost always will be light and non-fatiguing—a pleasant relaxation, in fact, from your thinking—and generally will be carried out in a clean, well-lighted place. Your hours you will set for yourself if you have your own full-time radio business, or work part-time to get additional income. Of course, if you prefer regular hours, you may work for someone else.

All in all, being a radio serviceman is a wholly satis-

fying and *profitable* way of earning your living.

► What do you need to know to get into this field? How does the successful serviceman fix radios? Why are some radio men more successful than others?

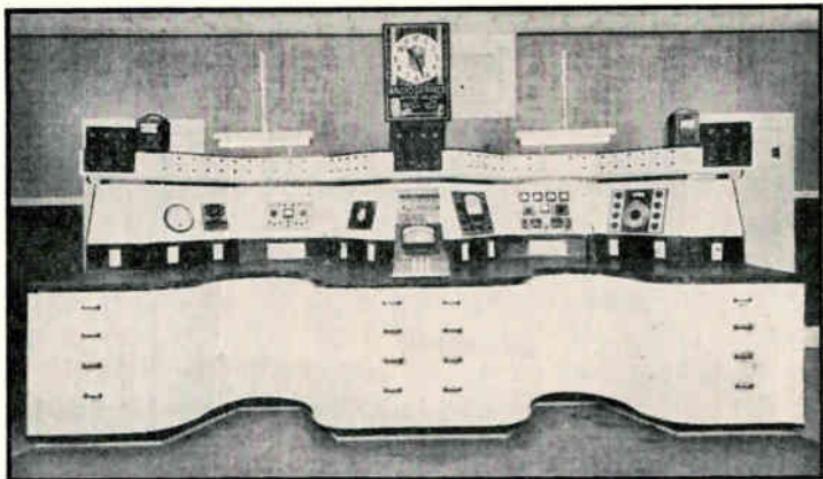
These RSM (Radio Servicing Methods) Booklets are going to answer these questions by giving you the *practical*, step-by-step procedures followed by expert radio servicemen. You may be familiar with some of these procedures—you may have tinkered with radio at some time in the past, or you may have had experience as a serviceman. However, here at NRI we do not take anything for granted. We are going to build on a rock-bottom foundation of radio knowledge, leaving nothing to your imagination. Let's start now, and see how radio troubles develop and how radio servicemen find and correct these troubles.

## WHAT A SERVICEMAN DOES

To the eye of the average person, a radio chassis is a jumble of strange-looking objects. However, the radio man doesn't worry about how the radio *looks*. Whether the set is a large phono-radio combination, a television set, or a tiny midget—whether it is an a.m. (amplitude modulation) or an f.m. (frequency modulation) type—the serviceman knows that it contains only a few general types of parts. He knows that these parts are connected in certain ways to produce certain desirable operations.

In other words, the serviceman recognizes a radio receiver as an electrical device that operates according to well-known electrical rules. To him, there is nothing mysterious about a radio that operates improperly, or goes dead altogether. He knows that some part or connection has become defective, and that he is to find and repair the fault.

Repairing a defect is simply a mechanical procedure of mending a poor connection or substituting a good part for a bad one. Almost any handyman can repair a radio, once he is shown the trouble. But it takes real knowledge of radio to locate the defect with reasonable speed. It is this *specialized knowledge* that sets the ex-



Can you imagine yourself working at a modern, fully-equipped service bench like this? Here you see an excellent example of a well-designed two-man service bench, built for an NRI graduate. This man started in business using a small desk-like bench and a limited stock (a picture of this is shown later in this Booklet). In just two or three years his business grew to such an extent that this larger bench was necessary.

pert serviceman apart from ordinary "fixers"—and it is for this knowledge that he is paid.

The quicker a serviceman can find the trouble, the more receivers he can service and the more profit he can make. Hence, you should have *two* goals as you start on your radio career: first, to learn *how to service*; and second, to learn how to service *more quickly*.

This *second* goal is the one that makes the difference in the earnings of servicemen. Many are "stuck" in a rut, having learned just enough to get by, and then having stopped their radio education before reaching the point where it would really pay dividends. Remember, it's *knowledge* for which you are paid!

Let us begin now to build up your knowledge of radio servicing by giving you some facts about the parts found in radio receivers and how they become defective.

## HOW RADIO PARTS BREAK DOWN

The basic parts of a radio receiver are tubes, coils, condensers, and resistors. Any one of these parts can become defective. Two of your first steps on the road to becoming a serviceman will be to learn to recognize

these various parts and to understand what may go wrong with each of them. Let's take a few examples, and preview some of the parts you will study in detail in your Lessons in Fundamental Radio Principles.

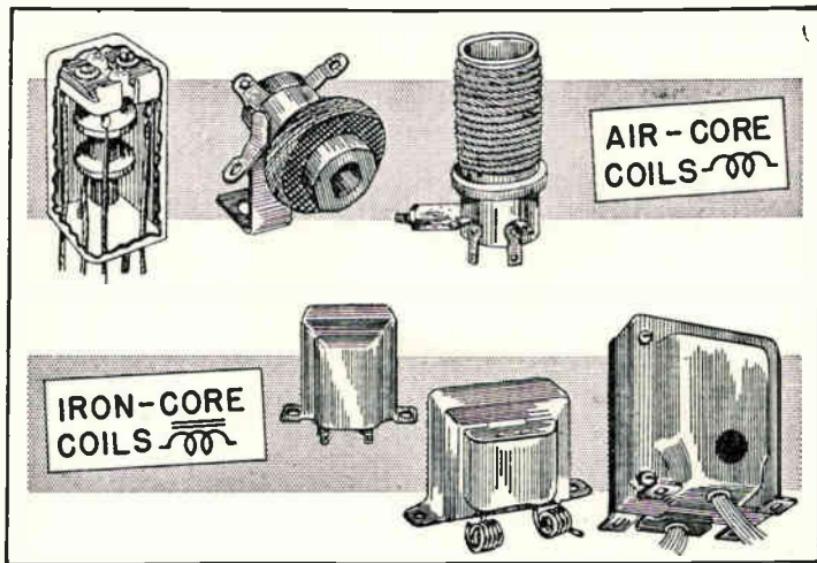
**Radio Coils.** Several typical coils are shown in Fig. 1. As the name implies, each consists of a coil of copper wire wound around a form. It may be wound in a single layer, or it may be wound in layers, like thread on a spool. The coil may be wound on a bakelite or fiber cylinder, or it may be wound on a cardboard bobbin. In some cases, thin sheets of iron may be inserted inside the bobbin, so that the coil is around the iron. Frequently two or more coils are wound on a single core of iron, bakelite, or fiber. Such a combination of coils is called a "transformer." It is used to transfer power from one circuit to another.

The wire is made of copper because copper is a good "conductor" of electricity. (Little electrical power is lost in the wire.) Silver would be slightly better, but its high cost rules it out except for special applications.

**Open Circuits.** Regardless of its appearance, a radio coil is a continuous piece of wire through which an electrical current can flow. If this coil wire breaks, the current no longer can flow through the coil. Then we say that the coil has *opened*, because the circuit is broken and no longer has "continuity."

A break of this kind may occur sometimes because the coil wire (which usually has a very small diameter) was pulled too tightly when it was first fastened to a terminal lug connector, and stretching or expansion of the coil form has snapped the wire. A more likely reason for a break in the wire is electrolysis—a kind of corrosion that attacks and eventually eats through wire that is carrying a current. Also, if too much current flows through a wire, it will overheat and melt.

Whatever the cause of the break, the circuit is opened and the radio no longer can perform normally, or it may be dead altogether. We may be able to see this break if it has occurred at a terminal. However, it is quite likely that the break is underneath several layers of wire, in some position where we cannot possibly see it. If so,



**FIG. 1.** Coils are called "iron-core" or "air-core" depending on whether or not the cores on which they are wound contain iron. The symbols that follow the names in the above illustration are used to represent the two types on circuit diagrams.

to find the trouble, we either have to substitute parts until the radio comes back to normal or have to make electrical tests to determine just which part is defective. (Servicemen make these tests by using indicating devices that show just what is happening electrically within the circuit. In your regular study Lessons, future RSM Booklets, and the Experimental Kits, you will learn all about the different methods of testing radio parts and circuits.)

**Short Circuits.** An open circuit is not the only trouble that can occur in a coil. The turns of wire in a coil may be wound close together, or there may be many layers of turns. It is important that the wire-turns be electrically separated so that there is no copper-to-copper contact between wires or layers. To prevent contact, the wire is covered by "insulation." This insulation may be a varnish, or it may be a silk or cotton "sleeve," either of which has the property of blocking the flow of current, thus forcing the current to stay within the wire.

Should this insulating material become defective, it will be possible for electric current to flow through the break to some adjacent wire, or to an adjacent layer,

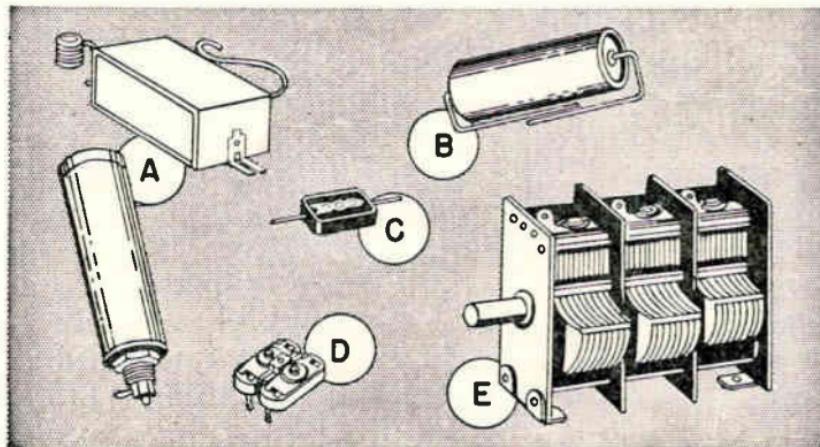
without having to follow the turns of wire. Any such path through a break in the insulation is called a *short circuit*, so named because the current is following an undesirable (and usually shorter) path. Thus, it is not flowing at its full intensity through a portion of some electrical device. Again we have a defect that probably will not be visible.

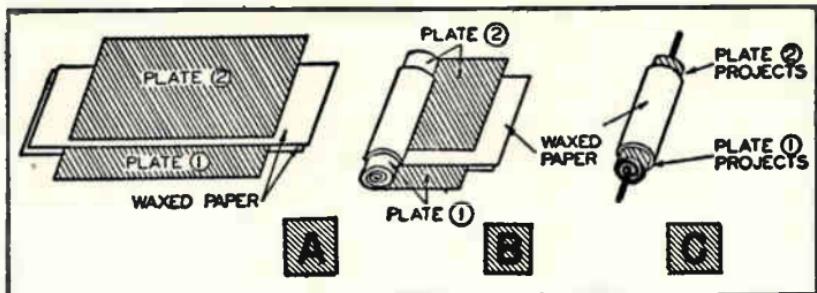
**Part Value Changes.** When you study coils in your Lessons in Radio Fundamentals, you will learn that certain electrical properties of the coil depend on the spacing between the turns of wire. Should this spacing change ever so slightly, the coil will not have exactly the same properties. Also, you will find that if moisture is absorbed by the form on which the coil is wound, another electrical value of the coil will be affected. Consequently, it is possible for the electrical characteristics of the coil to change, and for the operation of the receiver to be affected thereby, without any visible alteration in the appearance of the coil.

**Radio Condensers.** As you can see, coils are subject to a variety of possible defects. This is true also of other radio parts. Let us see how some of the condenser types, shown in Fig. 2, can become defective.

One kind of condenser is made of two metal plates

FIG. 2. The name by which a condenser is called sometimes indicates what it is made of, sometimes what it is used for. Two kinds of electrolytic condensers are shown at A, a paper condenser at B, a mica condenser at C; these names come from the materials used in making them. The trimmer condenser (D) and the tuning condenser (E) get their names from their uses.





**FIG. 3.** This is how a paper condenser is made. Sheets of metal foil and waxed paper are stacked (A) and rolled up (B). Then leads are pressed against the ends of the foil sheets (C).

separated by an electrical insulator, as shown in Fig. 3. The plates are strips of tin foil, separated by an insulator made of waxed paper. The condenser is rolled up in the form of a cylinder, and a wire is pressed against each foil plate. The condenser then is dipped in wax. On hardening, this wax holds the wires against their plates. These wires are used to connect the condenser to other parts of the circuit in which it is installed.

Should one of these wires pull away from its plate, the connection between other parts and that particular plate of the condenser will be broken, which *opens* the circuit. Since the contacts between the wires and the plates are sealed within the condenser housing, you can't see whether a wire has pulled away or not.

If the insulation between the plates breaks down, an electrical circuit will be completed between them. This *short circuit* will ruin most types of condensers. (The excess current flow may also ruin other parts as well, so more than one part may have to be replaced.)

► Another class of condenser has plates with variable spacing. One plate is made of a spring material and can be moved either closer to or farther from the other plate by a controlling screw. These condensers are used to adjust circuits so that they are exactly in step with each other. Once they are adjusted properly, the radio performance will be at its best. However, the spring tension of such a condenser may change with age so that the spacing between the plates alters. When this occurs, the *electrical value* will change also. The actual amount of space variation may be so small that it cannot be de-

tected by the eye, but it will affect the operation of the circuit.

► Another kind of condenser contains a chemical solution that causes a film to form on an aluminum plate. The film acts as an insulator between this plate and the solution. As the condenser ages, evaporation of water from the solution will reduce the amount of liquid in contact with the insulating film, which will change the *electrical value* of the condenser. Also, the liquid may become a poorer conductor of electricity, which will reduce the usefulness of the condenser. These changes will not be visible, although sometimes the escaping moisture will deposit some of the chemical in a whitish crust around the vent holes of the condenser housing.

**Resistors.** Lengths of special wire or carbon material that have the property of opposing the flow of current, but not of stopping it altogether, are known as resistors. Their electrical effects are in between those of conductors, which carry current with ease, and insulators, which prevent current flow.

Several types of resistors are shown in Fig. 4. Various defects may appear in them. For example, the wires used to connect them to the rest of a circuit may pull away from the resistance material inside the resistor, or the resistance material may break; either of these defects will *open* the circuit. *Short circuits* may occur within the resistor housing. And, as you will learn, heat may alter the characteristics of the resistance material so that it *changes in electrical value*.

**Radio Tubes.** A tube is perhaps the most familiar of all the parts in the radio. As shown in Fig. 5, it consists essentially of a glass or metal bulb, inside of which are a number of pieces of metal and wire. Heat is necessary for the operation of radio tubes, so one of the pieces of wire is arranged in the form of a filament, somewhat similar to the filament in a lamp bulb or light globe. An electric current flowing through this filament produces heat, and this heat makes it possible for the tube to operate. If too much current flows through the filament, the heat may become so great that the filament wire will melt. This *breaks* or *opens* the filament circuit, and the tube will no longer work.

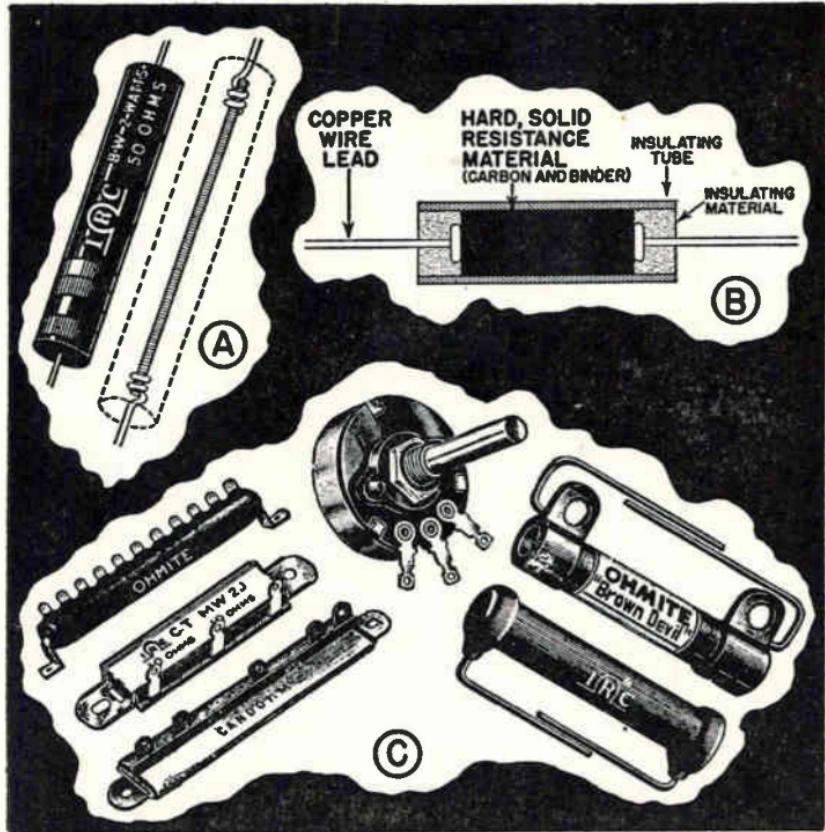


FIG. 4. Typical resistors. A and B show how some are made.

The various pieces of wire and metal within the tube must not touch each other except as intended—otherwise, a *short circuit* will exist within the tube. Should the position of some of these parts change, the *tube characteristics* will be altered.

**Connections.** Radio parts must be connected to one another by pieces of wire. Each connection is soldered to produce a good electrical contact. Although a connection is not a radio "part," a broker connection can *open* a circuit just as well as a defective part. Excess solder may drop from a connection and cause a *short circuit* to the set chassis or to another terminal or part. If dirty wires are connected, or if improper soldering lets chemical actions occur at a connection, then the resulting poor contact will oppose the flow of current like an unwanted resistor.

The manufacturer of the radio is careful to see that the proper soldering techniques are followed to avoid these troubles. However, servicemen frequently either do not know how to solder properly, or grow careless. Thus they may make defective connections which can cause much trouble later.

When you receive the Experimental Kit giving instructions and practice in soldering, *be sure to learn all you can* about this important service step. You will have to unsolder connections either to test parts or get them out for replacement; you will have to resolder the connections to the new part, so you will constantly be using a soldering iron in your radio work.

**Summary.** We have barely touched upon *some* of the types of radio parts with which you are going to become familiar. However, you can see a pattern repeating itself over and over—*regardless of the part, you know that you always look for a mechanical defect that has opened a circuit, caused a short circuit, or resulted in a change in the electrical characteristics of some part.*

It is rare to find a part that *looks* bad, although occasionally one will be found that has been overloaded so severely that it is actually burned or is otherwise visibly defective. Generally, the mechanical trouble will be inside some sealed container or will be of such a nature that it cannot be seen. *The only way we then have of finding the trouble is to observe the electrical effects produced by that particular trouble.* From a thorough knowledge of radio theory and of service procedures, it is possible to localize troubles by reasoning. However, in most cases, the test procedures soon reach a point where test equipment is needed.

As you can see, radio servicing is basically easy—you already know just what the serviceman looks for!

## TEST EQUIPMENT

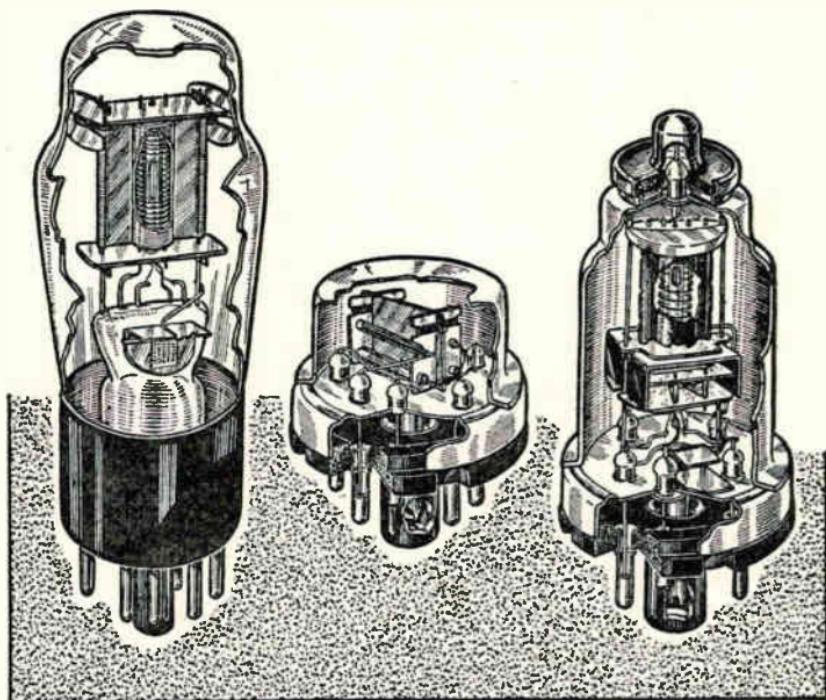
To do service work, you will need only three pieces of test equipment—known as a multimeter, a tube tester, and a signal generator. Later RSM Booklets will describe these devices in detail and show you just how to use them. For now, let's see briefly what their uses are.

**Multimeter.** This device is a combination instrument that can be used to measure resistance, voltage, or current. It is the most useful test instrument any serviceman has, for with it, he can locate open or short circuits in any part or connection. In addition, he can sometimes use it to determine whether a part has changed its electrical characteristics.

**Tube Tester.** As the name implies, this device is used to test tubes. It is a very handy instrument, since faulty tubes are one of the most frequent causes of service complaints.

**Signal Generator.** The circuits of a set must be adjusted from time to time to produce maximum performance. The signal generator is used to supply an electrical signal that allows the receiver to be adjusted properly. The instrument also proves very useful in tracking down certain kinds of defects.

► These three items are the basic pieces of test equipment that all servicemen must have and use. It is possible to carry on a large servicing business with no other



**FIG. 5. Cut-away views showing the elements within typical radio tubes.**

equipment. However, a serviceman who has a large volume of business usually acquires additional kinds of specialized testers that help him to service faster. This supplementary equipment will be described in later Booklets and in your Course.

## CLASSES OF RADIO SERVICEMEN

We cannot classify servicemen as beginners or experts solely from the length of time that they have been in the service business, because an absolute beginner may use advanced techniques that are unknown to some servicemen who have been in business for years. Instead, it is better to classify servicemen according to the methods that they use in servicing. We might split them into three classes—the radio mechanic, the semi-professional serviceman, and the professional serviceman. Let's see which methods each class of serviceman uses to locate the mechanical troubles we have just described.

**The Radio Mechanic.** The most elementary way of servicing is to test each and every radio part, in turn, until the defective part is located. The only requirements for servicing in this manner are: 1, a knowledge of the appearance and characteristics of radio parts; 2, the three basic pieces of test equipment; and 3, a lot of patience. The procedure is so mechanical that we apply the name "Radio Mechanic" to such a serviceman. He uses only his hands and his test equipment, and does not yet have the radio knowledge to "use his head."

► While this is not the *only* way to service radio receivers—nor the best or quickest way—it does require the least radio knowledge and allows one to start servicing the soonest. It is the way many servicemen start out, and it was once the way of even the expert.

In the early days of radio, even the large receivers contained no more than twenty or thirty parts. When something went wrong, it was practical to test each and every part and thus localize the trouble. Of course, if the radio man was unlucky, the defective part might be the last one tested, but eventually the trouble would be found.

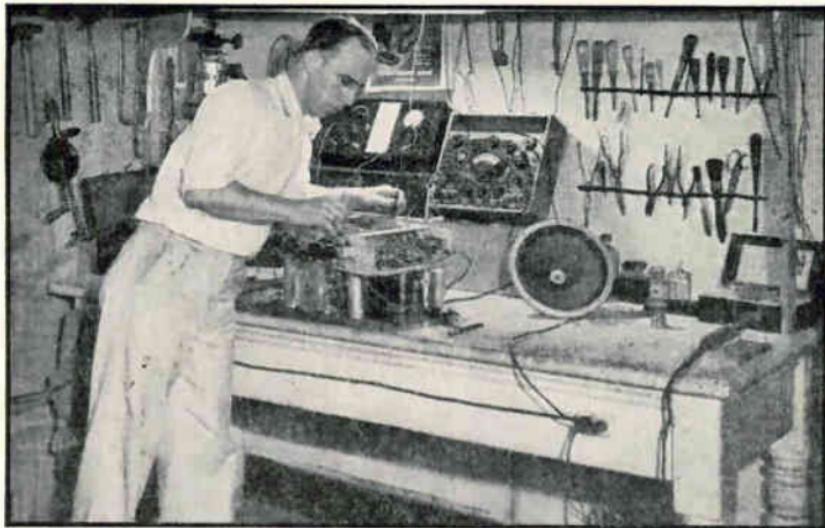


Here is the man who now owns the fine bench shown on page 3. Even here, his few pieces of test equipment are arranged for convenience and good appearance. The latter is particularly important when customers can see the workbench.

It is still possible to test radio receivers this way—but now you have seventy or eighty parts in the average seven-tube receiver, so the problem of testing all parts or trying others in their places is too time-consuming to be profitable. Obviously, if one man can service five or six receivers in the time it takes another man to service one, then the first man will have the greater income. This need for greater speed in service led to the modern, professional servicing techniques that take full advantage of a thorough knowledge of radio parts and the circuits in which they are used.

Before we describe the procedures of the real expert, however, let us discuss those of the intermediate servicemen—those men between the mechanic and the expert. We might call these the semi-professional servicemen.

**The Semi-Professional Serviceman.** The next step up the ladder to becoming a true professional serviceman is to learn the *purpose* of radio parts—why they are used in certain combinations, and what they are supposed to do. With this knowledge, it is possible to see why certain troubles are common to certain receivers, and why certain troubles produce certain defi-



A good example of how most men get started. A sturdy table for a bench, a few tools neatly held on a board, a multimeter, a signal generator, and a tube tester are all this man needs now. These basic test instruments are all many servicemen ever get for spare-time or small one-man businesses. However, it is a good idea to set aside some of your earnings to purchase additional equipment when such equipment can speed up your work.

nite symptoms of operation. For example, the semi-professional serviceman knows that a particular condenser (called a "coupling condenser") is used to pass signals from one stage of a receiver to another. Coupling condensers very frequently open, thus blocking the path for signals; this causes the signals to be extremely weak or even makes the set dead altogether. Hence, when called to service a receiver that operates in this manner, it is logical to check the coupling condensers to be sure that they are in good condition.

Or a receiver might have a loud hum or buzzing sound mixed with the desired signal. The serviceman knows that certain condensers are used as filters in the radio to remove this hum. It is natural to assume that excessive hum is caused by a failure in one of the filter condensers, so he would check the filter condensers first.

► A semi-professional serviceman, then, is able to work more rapidly than a radio mechanic. He understands the *purpose* of radio parts when used in certain particular combinations, so he can start at once to check those parts that are most likely to cause the trouble.

The semi-professional still must use the three pieces of basic test equipment, and must know how to test these parts. In addition, he has to know what purpose is served by the parts, and should pay careful attention to the way in which the receiver operates. This last often gives clues that can guide him directly to the defect.

► Parts break down more frequently in certain sections of a receiver than in others. The coil in one circuit of the radio may be subject to frequent breakdowns, while the coil in another circuit in the same kind of radio may never give trouble. There is, of course, a reason for this —radio parts in some circuits are required to handle more power than in others. The fact that certain troubles occur frequently in radios has led to the development of service charts that describe the different ways in which receivers may act and list a number of possible causes for each kind of abnormal behavior.

The difficulty with using these charts is that you must either memorize them or refer to them constantly. As soon as you develop a complete knowledge of the function of radio parts, you'll *know* what can cause the trouble, without having to memorize a list of troubles.

***The Professional Serviceman.*** The ability of the semi-professional serviceman to locate defects rapidly is limited. As soon as he is out of ideas on what may be wrong with a receiver, he must revert to the "test everything" methods of the radio mechanic.

The true professional serviceman, however, has a thorough knowledge of radio parts and circuits. From this knowledge, he first tries to reason out the most probable faults, much in the manner of the semi-professional. However, if this step fails, he does not have to test all seventy or eighty parts in the radio receiver, because he knows methods of *isolating* the trouble to a small group of parts. These processes of isolation allow him to concentrate on just the three or four items that could be causing that particular trouble; this limits the amount of testing he has to do. This excludes the element of luck, and makes it possible for him to service receivers in a minimum of time.

► The professional knows that radio parts are grouped

in arrangements called circuits. Each circuit is a complete path for an electrical current flow. Then, he knows that these circuits are grouped in units called stages, and that stages are grouped into subdivisions called sections of the radio receiver.

Even the most elaborate radio consists of only three sections, as shown in Fig. 6. Sections usually contain from one to five stages, and each stage may have five or six circuits. However, by making a few simple tests, the expert is able to isolate the trouble to a section, then to a stage, next to a circuit, and, finally, to the defective part.

For example, a test can be made at the input of the audio section that will show at once whether the a.f. (audio frequency) and power sections are working. If they are O.K., then the trouble must be in the r.f.-i.f. (radio frequency-intermediate frequency) section, so we can ignore all the parts in the a.f. and the power supply sections. A few tests in the r.f.-i.f. section will lead to the defective stage, then to the defective circuit in that stage.

Before it will be possible to isolate troubles in this time-saving professional manner, one must have a thorough understanding of the operation of radio parts and their combinations in circuits, stages, and sections. Only then is it possible to take full advantage of observable symptoms and to reason back to the probable cause of the condition.

Even the professional still has to know how to test radio parts. It is true that he tests fewer of them while locating the trouble, but he must know all about radio parts and their particular weaknesses.

**To Sum Up:** We group the methods of radio servicing according to the manner of finding the trouble. We have: 1, the radio mechanic's method of testing everything; 2, the semi-professional method whereby logical reasoning, service charts, or practical experience leads to the testing first of parts most likely to cause the defect; and 3, the professional method of reasoning, then of localizing the trouble.

► The first method requires a knowledge of radio parts,

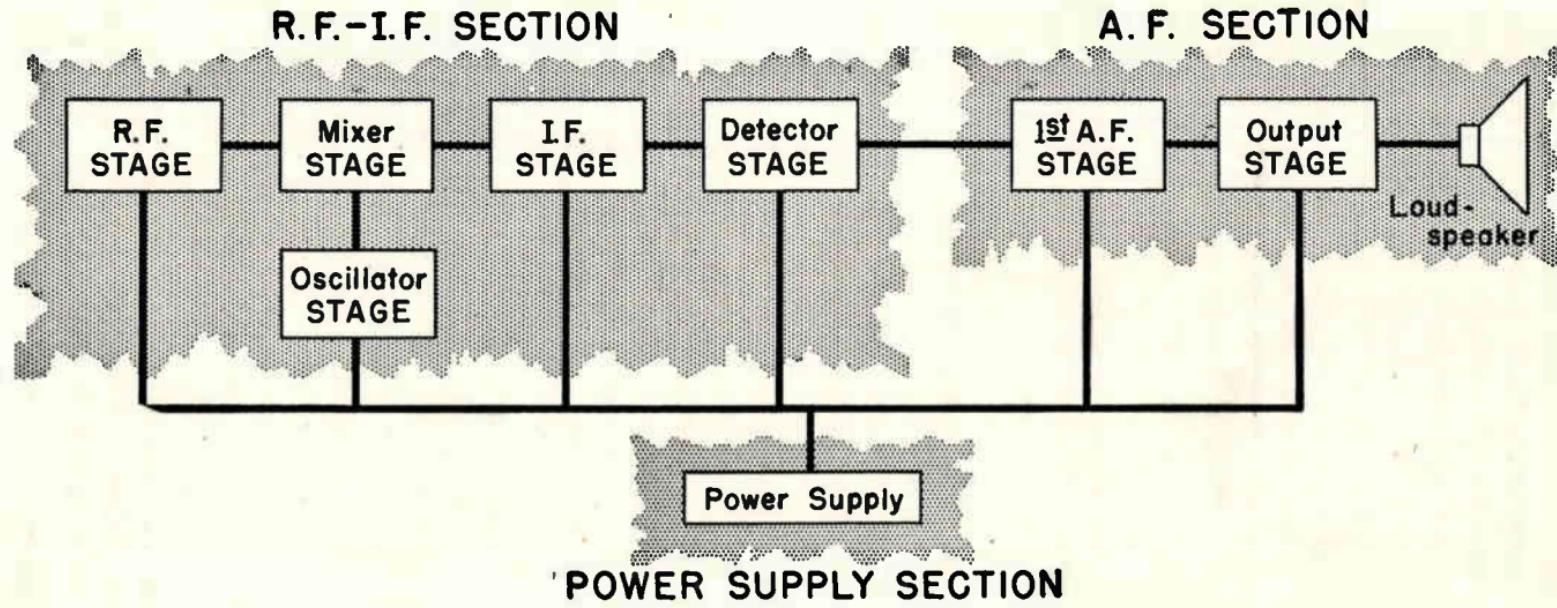


FIG. 6. This diagram gives the basis for the quick professional methods used in the isolation of troubles. Notice that the radio stages are grouped into sections. A single test (or a simple series of tests) will show in which section the trouble exists. Then, other tests will further localize the trouble to the defective stage. There are a number of systems of localization, and you will study them all. Some are better for one kind of trouble than for another; you would follow a different procedure when working on a "dead" receiver than you would when working on one with distortion, for example. All the systems require that you know how the radio should function—in fact, the more you know (and the better you know it) the faster you can service receivers.

how they fail, and their weaknesses; it also requires knowledge of the testing methods that will permit you to determine when a part is defective.

► The second method requires the same knowledge as the first and, in addition, makes use of some knowledge of the functions of radio parts.

► The professional method requires the same knowledge as the other methods, plus a thorough knowledge of how radio stages and sections function. If you ever watch an expert work, you will find that he touches or pulls out a tube over here, or makes a simple test over there and, from two or three such tests, locates the source of the trouble. Remember, the tests themselves are very simple—the knowledge required is used in properly *interpreting* the results of these tests.

## A GUIDE TO THE FUTURE

As you may know, part-time servicing has allowed many an NRI student to earn more than the cost of his Course before graduation. One of the chief purposes of these RSM Booklets is to get you started in spare-time servicing very quickly. They are designed to give you both the training and the experience you need to be a successful serviceman.

### TRAINING IN THEORY

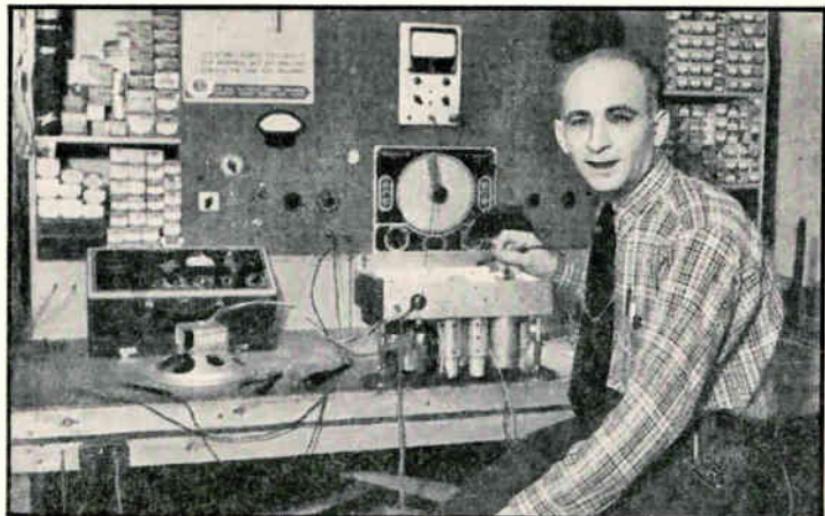


### + PRACTICAL EXPERIENCE



### = PROFESSIONAL ABILITY





Another graduate, and his simply constructed bench. There is no need for an elaborate bench while you are getting yourself established. Later, you can construct as elaborate and as decorative a bench as you desire. You will soon receive an RSM Booklet giving detailed plans for simple workbenches that you can build.

Students sometimes believe that the only way to get experience is just to start servicing, accepting any jobs they can get. Well, you can get experience this way—but it will certainly be a long time before you get the well rounded experience on all sorts of defects that you need to be a professional serviceman. Furthermore, right at the start, you will undoubtedly suffer the embarrassing experience of accepting jobs that prove to be too tough for you to handle.

How, then, are you to get the experience you need in a reasonable time? You will find the answer later on; a whole series of your RSM Booklets will contain sections devoted to giving you practical training in locating and repairing specific defects in an actual receiver. This NRI Practical Training Plan will give you as much all-around servicing experience as you might get from fixing hundreds of sets—and give it to you in a matter of weeks, instead of the months or even years the other way would take.

Yes, your NRI training is going to be both *thorough* and *fast*. Your RSM Booklets will concentrate first on giving you the knowledge you need to be a radio mechanic. Once you have learned this, your Booklets will

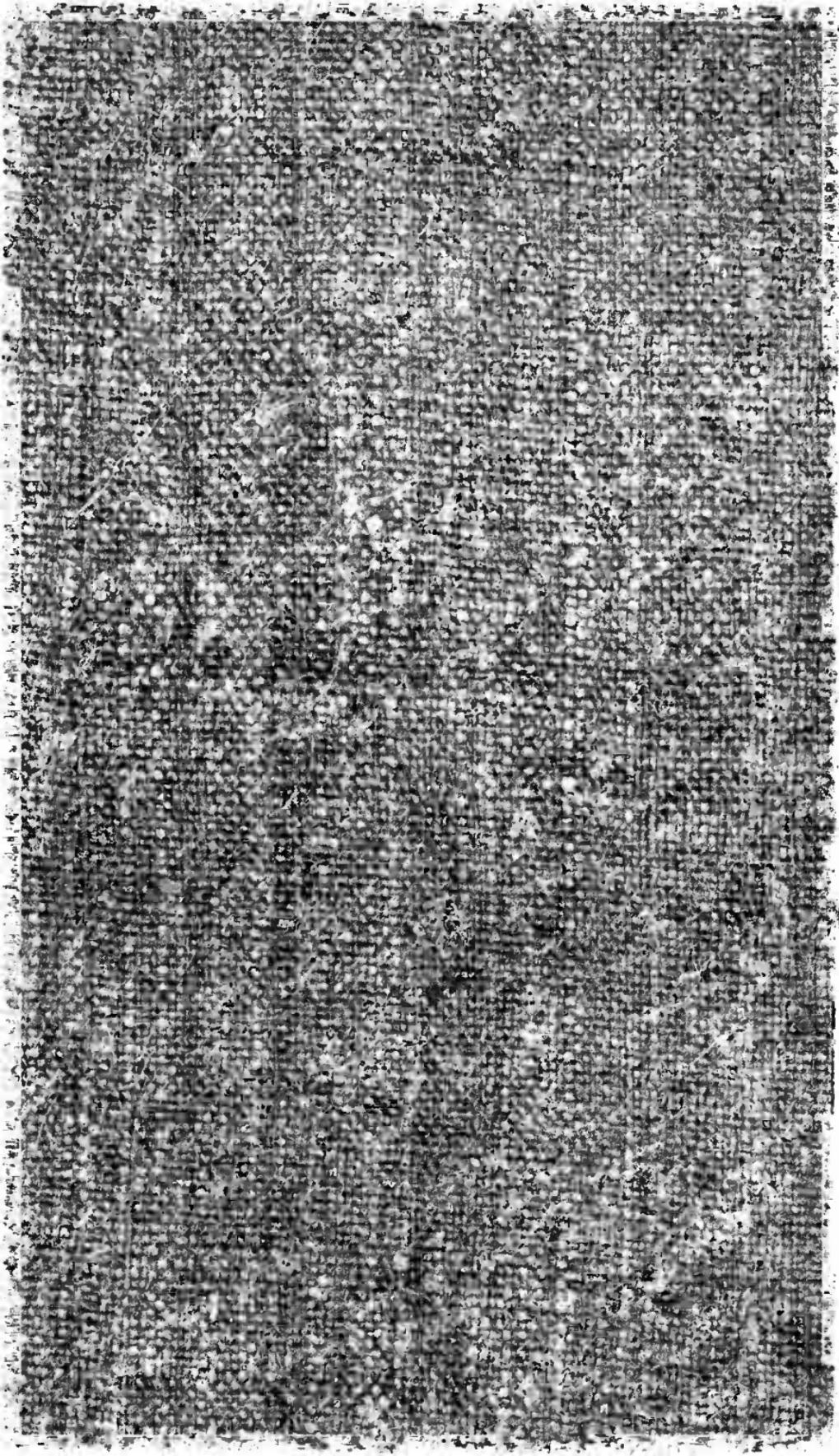
lead you by easy stages to semi-professional and professional servicing methods. In addition to strictly service instruction, the Booklets will give you other information of a related nature—such as how to build a work-bench, how to set up a shop, how to get business, and so forth. Throughout, the emphasis will be on practical, how-to-do-it information. At the same time, your Lessons in Radio Fundamentals will be teaching you the theory of radio circuits and stages. The Course and Booklets are so planned that you will always have the theoretical knowledge you need to understand the servicing methods you learn. Our experience in teaching thousands of Radiotricians has been that this system of instruction, tying theory and practice closely together, is by far the most satisfactory way to give you professional training.

Your step-by-step training begins in the next RSM Booklet, in which we describe the few simple tools you will need to start servicing. You may be surprised to learn that common tools, such as you probably already have around the house, will do for most of your service work.

Remember, you follow this plan: you study a Lesson, then you study the Radio Servicing Methods Booklet having the same number. Thus, after Lesson No. 2, study Booklet No. 2, etc.

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THE N. R. I. COURSE PREPARES YOU TO BECOME A  
**RADIOTRICIAN & TELETRICIAN**  
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# How to Make Extra Money **FIXING RADIOS**

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 2 How To Use Radio Tools

RADIO SERVICING METHODS



# NRI TRAINING

# Payoff...

Dear Mr. Smith:

I cannot praise NRI and its staff too highly. I started to earn a little about the twelfth lesson; by the time the Course was completed, I had earned enough to pay for the Course and buy a tube tester and other servicing equipment. At present I am doing part-time service work - making on an average of \$75 per month, and getting a larger amount of business every day. I value my training more every day.

C.E.H., Penna.



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



# How To Use Radio Tools

ONE of the many good features of radio servicing as a profession is that you need not invest much money in tools to get started. The familiar, every-day tools shown in Fig. 1, along with the soldering iron that we will send you, will be all you'll need for the experiments of your Practical Demonstration Course and for your first servicing jobs. Although you will need a few more as you advance, tools will never be a major expense.

This does not mean that tools are unimportant in servicing. Quite the contrary—you will use them constantly, and, to make fast, neat, professional repairs, you must know how to use them properly. This Booklet will teach you what tools to use and how to care for them. Details on their use will be in other RSM Booklets.

We will describe three groups of tools. First are those you will need for all radio jobs, both in the customer's home and at your bench. Next are tools that you will need occasionally at your bench. Last are those that you will want when you develop so large a business that it is profitable for you to use time-saving equipment in spite of its initial expense.

## GENERAL FACTS ABOUT TOOLS

Before discussing individual tools, let's get some practical pointers on tools in general.

First—**NEVER BUY A TOOL YOU DON'T REALLY NEED.** To tie up your capital in tools and equipment that you use very seldom is poor business—and

you must be a good business man as well as a good repair man to succeed in radio servicing.

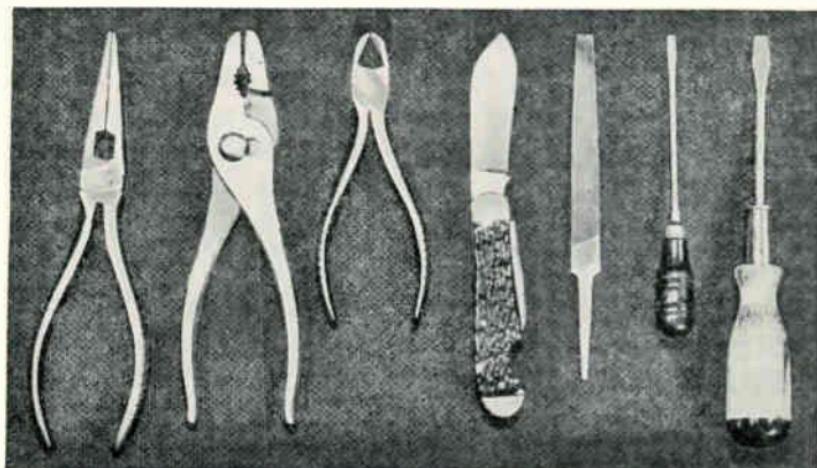
Since the tools in Fig. 1 are so common, you may already have them all. If you must buy one or two, buy the best you can afford. You can always do better, faster work with high-quality tools. If you must get your first ones at the "five and ten" or the bargain counter of a hardware store, buy better ones as soon as your servicing profits give you the money to do so.

**Care of Tools.** Start from the beginning to use a tool only as it is intended to be used. Never, for instance, use a good screwdriver as a chisel or a screwdriver handle as a hammer. Have a place close at hand for your tools so that you can pick them up and lay them down without tossing them across the workbench. Good tools will last a long time if not abused.

Above all, *be neat*—it will save you time. Have a place at your bench for each tool, and teach yourself to put back the tool in its proper place when you're through with it—or, if you intend to use it again soon, lay it in a nearby work tray. Nothing is more annoying or kills more time than having to hunt for a tool lost on a cluttered bench.

► For the same reason, as you take screws, nuts, dial knobs, and other small parts out of a set, put them in a small box, a tin can, or a jar. Then, if you have to put

**FIG. 1.** The soldering iron we send you, plus these few tools that you supply yourself, are all the tools that you need to start servicing.





A disorderly, cluttered work-bench can cost you money—you may waste many hours of valuable time looking for misplaced tools and parts.

Keep your tools in a rack—keep small parts and tools you're using in a work tray—and you'll find you can work much faster.

the receiver aside for a while, these parts won't be lost.

Keeping things in order will help you develop a logical, orderly work-procedure which will save the maximum amount of time.

Keep your tools and your tool box thoroughly clean. Use clean dustcloths to wipe off dust and moisture. To protect the tools, oil them regularly. Dip them into a flat pan containing light oil, then wipe them thoroughly dry. Just enough oil will remain on the surface to prevent rust. Don't leave excess oil on the tools—it will make your hands dirty, leave spots everywhere you lay the tools, and collect dust and dirt.

► A customer will be impressed either favorably or unfavorably by the *condition* of your tools, not by their number. Rusty, broken tools are certain to make him wonder if you should work on his radio.

We'll now discuss the various tools you'll need—indicating in each case whether you should have the tool soon or can wait for some time before you get it.

## PLIERS

Fig. 2 shows typical styles of the most useful types of pliers. One of each type will eventually find its way into your kit of tools.

**Long-Nose Pliers.** There are several styles of long-

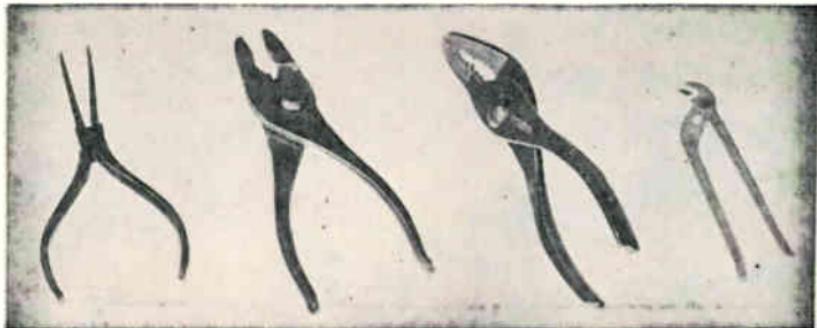


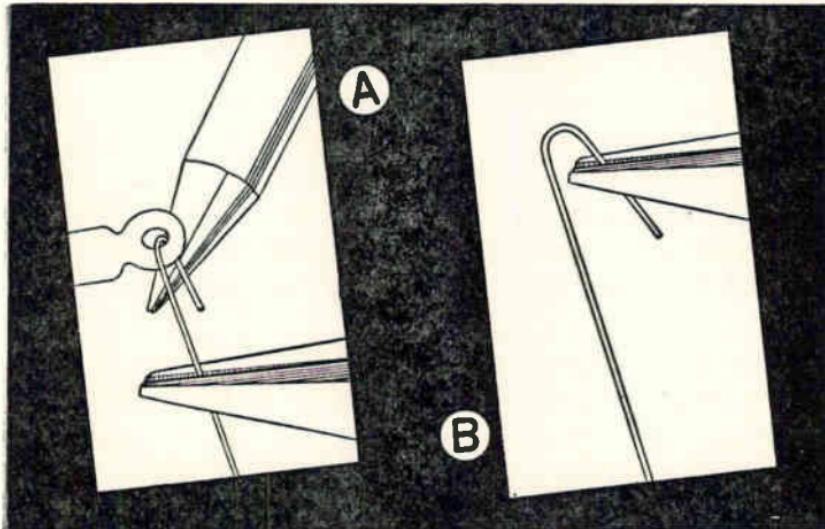
FIG. 2. These are the pliers you'll use most—long-nose, straight-nose auto, bent-nose auto, and ignition pliers.

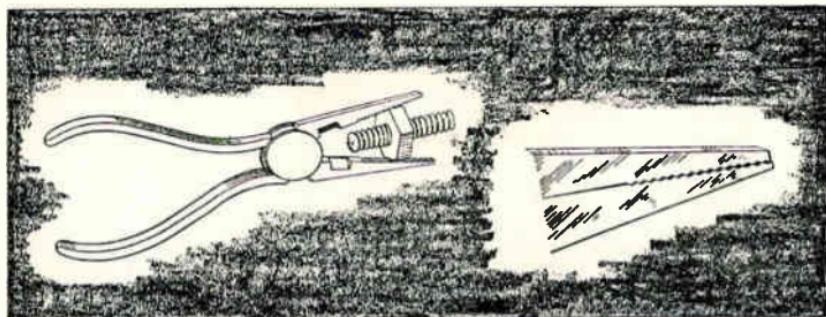
nose (sometimes called thin-nose or needle-nose) pliers. The types in Figs. 1 and 2 are most commonly used, but suit your own preferences. In any case, be sure to get a pair with jaws that meet squarely and have no side play.

Fig. 3 shows two major uses of long-nose pliers. Don't try to loosen a nut with them in the manner shown in Fig. 4. You will spring the jaws so that they no longer meet squarely. These pliers are intended only for light-duty *holding* or *pulling*, not for heavy *twisting*.

**Automobile Pliers.** Both straight- and bent-nose slip-joint or automobile pliers are useful for removing large nuts. The bent-nose type is preferable because it helps you to remove nuts close to the chassis or the chas-

FIG. 3. Common uses of long-nose pliers: A, holding a wire for soldering; B, bending a loop in a wire.





**FIG. 4.** Loosening a nut with long-nose pliers in the manner shown will often spring the jaws.

sis wall. Buy a pair made from thin stock, as it will be easier to use them in crowded places.

**Ignition Pliers.** The ignition pliers shown in Fig. 2 are lighter and less bulky than automobile pliers, but are surprisingly powerful. They are useful on small nuts, on nuts in hard-to-reach places, and in adjusting certain loudspeakers.

## CUTTING TOOLS

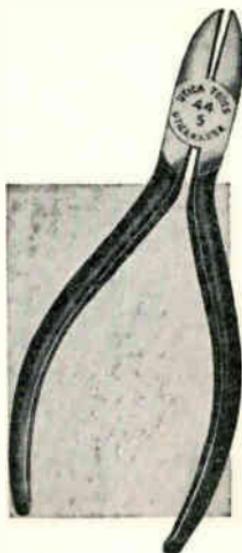
**Side-cutting Pliers.** Side-cutting pliers are used to snip the wires off defective parts, to cut pieces of hook-up wire from a roll of wire, to cut connecting leads to the proper lengths, and to cut off soldering lugs. The side-cutter shown in Fig. 5 is used because it is easier to get under wires and other parts than are other cutters. You will need side-cutters right away; get a pair about 5 or 6 inches long.

Cheap side-cutters are a waste of money. Before buying a pair, close the jaws and squeeze the handle lightly. Now hold the pliers against the light. The cutting edges should fit together perfectly (see Fig. 6). If you can see light between the cutting edges, the pliers will not cut insulation cleanly; don't buy them.

Never use side-cutters for cutting nails, bolts, or heavy wire; you will ruin them.

Courtesy Utica Drop Forge and Tool Corp.

**FIG. 5.** This is the type of side-cutting pliers you will find most useful.



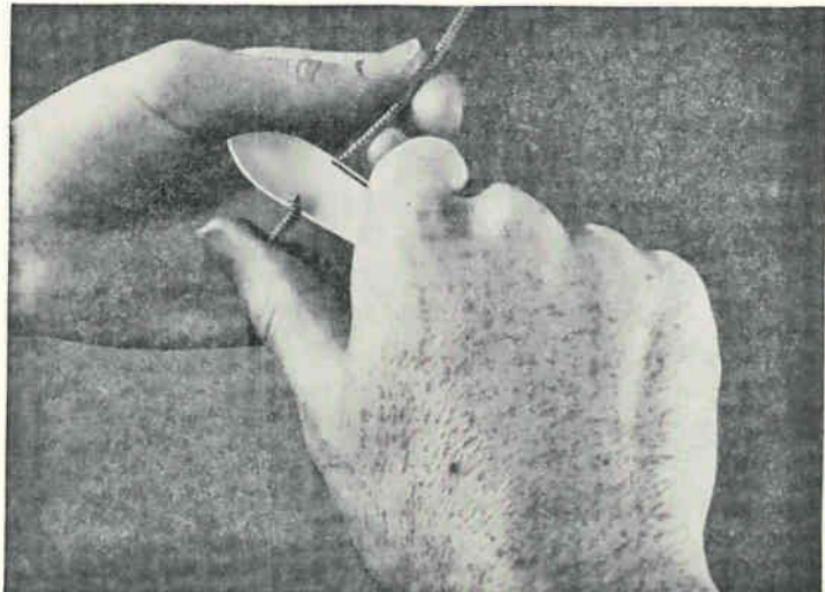


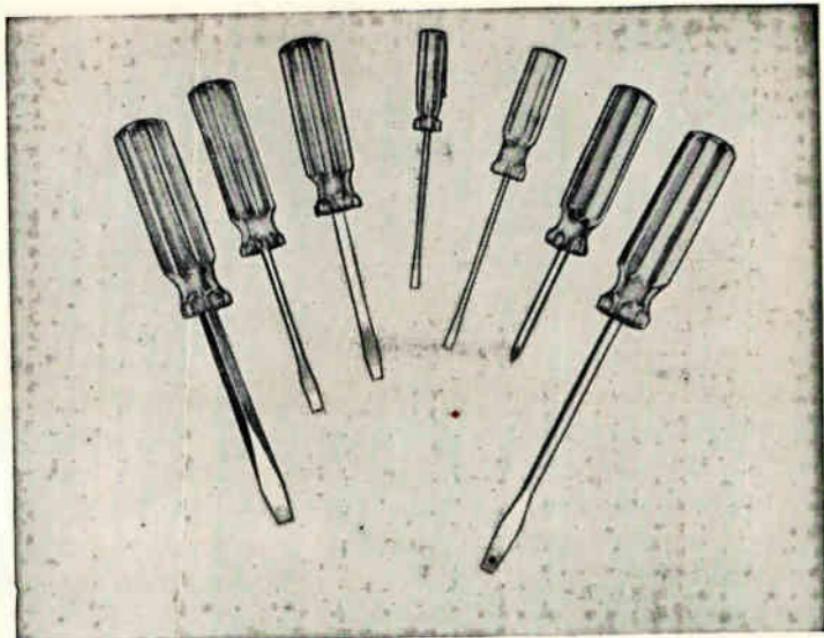
**FIG. 6.** Test side cutters by holding them up to the light. No light should be seen between the cutting edges.

**Jackknife.** Right from the start you will need a jackknife with a rugged blade. A typical knife is shown in use in Fig. 7, trimming insulation from a wire. Always be careful not to cut into the wire you are cleaning, as a deep nick will weaken it. Since scraping wires will dull even the best knife blade, some servicemen use an old knife or just one blade (or only part of one blade) for this purpose.

Never use a jackknife as a screwdriver. Don't cut wires with it either; you are certain to nick the blade.

**FIG. 7.** How to cut off insulation with a jackknife.





Courtesy Vaco Products Company

**FIG. 8.** These are the screwdriver sizes you will find most useful in servicing.

## SCREWDRIVERS

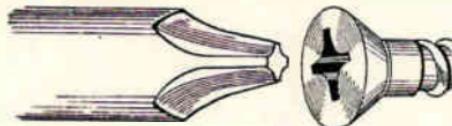
Screws of all sizes are used in radios—from big wood or machine screws used to mount large radios in their cabinets, down to tiny set screws used to hold control knobs on their shafts. Some screws are easy to reach, others are difficult. You will need both short- and long-bladed screwdrivers.

It is very important that the screwdriver tip fit the screw slot snugly so that the screw will be relatively easy to turn. Tips that are too wide, narrow, thin, or thick for the slot tend to twist off the head, chew up the slot, or make the screw hard to turn. You will need several screwdrivers to fit the various screws found in radios.

Fig. 8 shows a good beginning assortment of screwdrivers. There are six conventional types: two with small tips (these can both be the same length—you need two mostly because they are easily mislaid); three with medium tips, in the shaft lengths and weights shown; and one heavy-duty type with a medium-length shaft. You can add other medium-tip sizes later if you find you need them.

The sixth screwdriver shown in Fig. 8 is intended

**FIG. 9**



for use with the Phillips screw, now used in many radios. As Fig. 9 shows, this screw has a recess instead of a slot in the head and requires a special screwdriver. Because of the taper of the recess in the screw head, one Phillips screwdriver will take screw sizes up to No. 4, and another will take sizes 5 to 9. These two Phillips screwdrivers will be the only ones you will need in radio work. You will need both almost as soon as you start servicing.

► Screwdrivers with the hold-tight feature shown in Fig. 10 are handy for starting screws in hard-to-reach places. Get a medium and a small one of this type after a while.

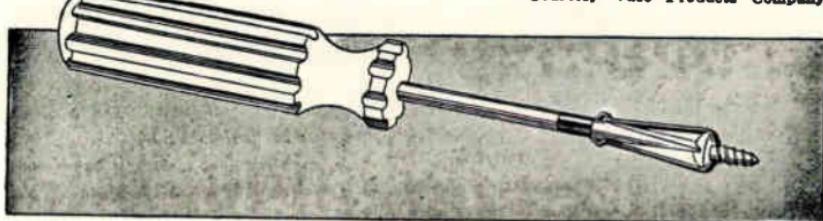
► When you buy a screwdriver, be sure that the blade will not loosen under strain and turn at the handle. While some wooden-handle screwdrivers are satisfactory, the best for radio work are those with shanks molded into handles of transparent, insulating plastic. One point—keep these handles away from heat and flame; they will burn.

### SOLDERING IRON

The most used of all your tools will be the soldering iron. Whenever you replace a part or disconnect a lead, you will unsolder and resolder one or more connections.

**FIG. 10.** The clamp on the end of the screwdriver is handy for holding the screw until it is well started in the work.

Courtesy Vaco Products Company



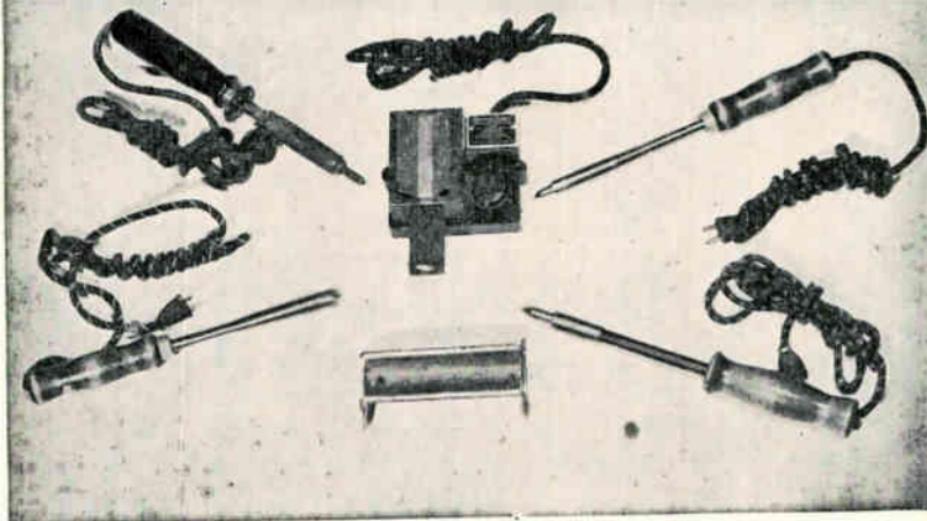


FIG. 11. The American Beauty temperature-regulating stand shown in the center top of the picture is excellent for keeping an iron at the right temperature for ready use.

Fig. 11 shows several soldering irons and soldering-iron stands.

**DON'T BUY A SOLDERING IRON AT THIS TIME.** We send you one with your first experimental kit (RK kit) and include both a stand and a supply of solder. This iron is intended for use with the experiments, but it is a practical, light-weight iron which you can use when you start repairing radios. Later you may find it worth while to get a heavy-duty, slow-heating iron for use at your workbench, and save this lighter iron for use on service calls in the customer's home.

When the time arrives for you to get this second iron, get a heavy-duty one rated at 100 watts. (If you do not have electricity, get a half-pound tinner's iron.) In the most efficient electric irons, the tip either will screw down over the element, or will be a rod that fits into a socket in the iron. Both types give good transfer of heat. A  $\frac{3}{8}$ -inch tip is the best size for most radio work, for it is small enough to use in tight places, and yet large enough to build up a good heat reserve.

**Soldering Techniques.** It is very important to solder properly. A poorly soldered joint can cause an open circuit, or an intermittent contact may develop that will cause noise and other troubles. If an excess of solder is used, it may run down from the joint and cause a short circuit. In your first experimental kit, you'll get

**TABLE 1****HOW TO MAKE A GOOD SOLDERED JOINT**

1. KEEP YOUR SOLDERING IRON CLEAN AND WELL TINNED.
2. REMOVE INSULATION FROM WIRES, AND SCRAPE OFF EXCESSIVE DIRT  
AVOID NICKING THE WIRE WITH THE SCRAPPING TOOL.
3. USE ONLY ROSIN-CORE SOLDER FOR RADIO WORK.
4. TIN EACH PART SEPARATELY IF ORIGINALLY UNTINNED.
5. MAKE GOOD MECHANICAL CONTACT BETWEEN THE PARTS BEING SOLDERED.
6. APPLY THE SOLDER TO THE LUG OR WIRE, NOT TO THE SOLDERING IRON.
7. DO NOT MOVE THE JOINT UNTIL THE SOLDER HARDENS.

detailed instructions on how to solder, and lots of practice.

However, you can't get too much practice—soldering is an art. An astounding number of receivers are serviced only because of poor soldering. Learn the rules in Table 1, and practice them constantly in your work. If you do make a poor joint, don't fail to do it over. Remember—*good soldering is essential*.

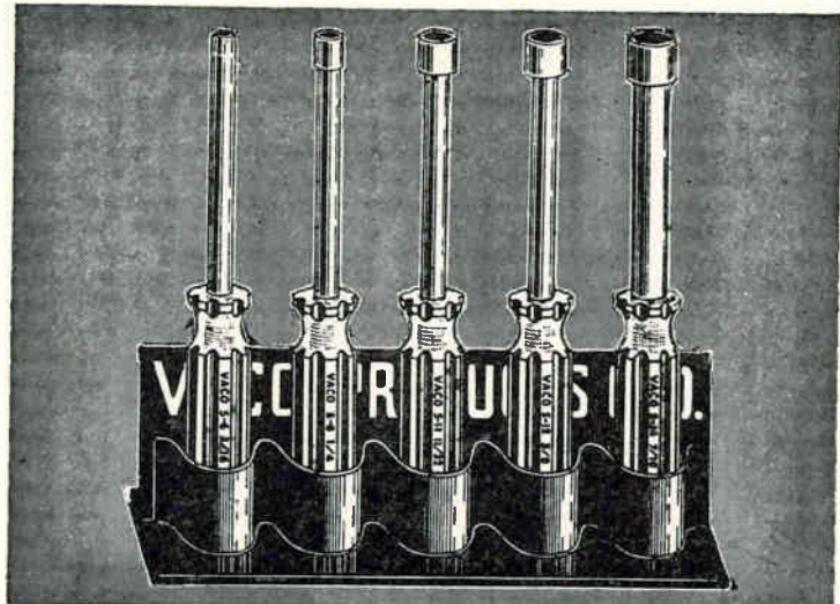
**Hints on Unsoldering.** Unsoldering, the reverse of soldering, is considerably easier. To unsolder, simply apply the iron tip to the joint until the solder melts. (If a coating of oxide or grease keeps it from melting, apply a very little flux to the solder with the end of a toothpick and bring the iron to the joint.) You can then pull the wire gently with a pair of pliers and break the joint. Never jerk or pull too hard; you may break leads, soldering lugs, or the parts themselves.

You can readily pick up excess solder from a joint by holding the hot tip under it. The solder that runs down onto the iron can be shaken off onto the shop floor. Repeat this until only a little solder is left on the joint, then, as it cools, wiggle the leads back and forth so the remaining solder cannot set properly. In many cases, this makes it easy to untwist and remove the leads.

If it proves too difficult to remove leads this way, just cut one wire with a pair of cutters. You can then remove the small end of the wire if it is in the way of a new connection.

## **SOCKET WRENCHES**

Socket wrenches are better than pliers for removing



Courtesy Vaco Products Company

**FIG. 12.** A useful set of socket wrenches in a convenient holder.

nuts from bolts. A socket wrench fits over the nut and does not slip off. You do not have to move it to get another grip; just "spin" the nut right off.

Socket wrenches come in sets like that shown in Fig. 12, or may be bought individually. They come in sizes to fit nuts of:  $3/16"$  —  $7/32"$  —  $1/4"$  —  $9/32"$  —  $5/16"$  —  $11/32"$  —  $3/8"$  —  $7/16"$  —  $1/2"$ . A set, one of which you



Cut-away view of one of the wrenches shown above. Notice that the shaft is hollow—this permits the wrench to be fitted over long bolts.

should get soon after you start servicing, contains the most used sizes. Eventually, you will want a complete collection of these handy tools. Special types ( $1/2"$  and  $9/16"$ ) with extra-deep hollow shafts are available for removing volume control nuts.

Good socket wrenches are expensive, so wait until your service earnings will pay for them—cheap types are a waste of money. A good one has a socket that is

free from burrs and is of sufficient depth to fit over two nuts. Also, a good wrench has a shaft that is hollowed out for a considerable distance, so that the wrench can fit down over long bolts to engage the nut; some cheaper wrenches do not have this feature. Furthermore, the better types have thin, strong sockets which can get into small spaces.

The better sets have stands, so you can keep them together and in order. Recently, plastic-handled types have been made with different colored handles; the size can be recognized by the color—this is a real time-saver.

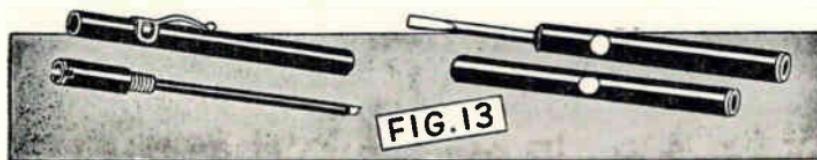
## MISCELLANEOUS ITEMS

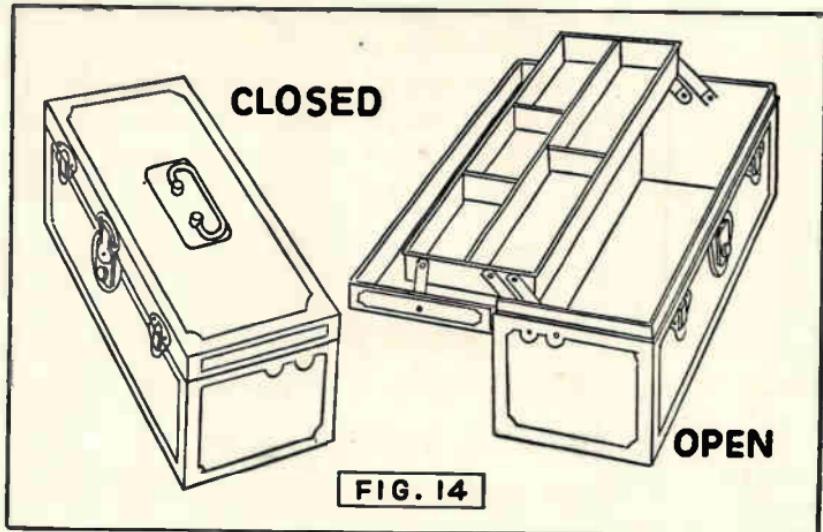
**Alignment Tools.** With age, receivers get out of adjustment, losing their pep or their ability to separate signals from different stations. To restore the set to its original characteristics, it is "aligned" by resetting a number of variable adjusters.

It is possible to align many radio receivers with ordinary screwdrivers and socket wrenches. However, for greatest ease and most accurate work, alignment tools should be used. Typical examples of these tools are given in Fig. 13.

These tools are small screwdrivers and wrenches made from plastic materials instead of metal. This eliminates the upsetting effect of bringing metal near certain adjusting screws and nuts, thus making it easier to align accurately. These tools can be obtained from almost any radio supply house—individually or in complete kits. Naturally, you won't need them until you learn how to align a receiver.

**Tool Box.** You will need a tool box right from the start to carry your tools with you on service calls. A sectional or tackle box like that shown in Fig. 14 is best: you can see all the tools when you open the box, and you can keep your tools separated according to types so that you can find them easily.





Have a place in your box for each tool, and put it there as soon as you are through using it. Otherwise, you'll often leave tools in your customers' homes. Don't toss the tools into the box either; the clatter is annoying, and you might miss and scar some furniture. Remember—you will be working right in the living room, perhaps surrounded by interested onlookers. The condition of your tools, and the way you treat them, will have much to do with the impression you make on the customer.

Empty your tool box regularly in your shop and clean both it and the tools carefully. Many servicemen place small bits of wire, excess solder, and other odds and ends in the tool box when in the home of the customer. It is perfectly all right to clean up this way—in fact, it makes a good impression on the customer—but be sure to remove this junk when you get back to your shop. Don't carry useless tools, either.

**Hardware.** A certain amount of hardware will be necessary as soon as you start your service business. You'll need a roll of hook-up wire, a roll of friction or tire tape, and an assortment of screws and nuts.

The most used screws for mounting radio parts are 6-32 and 8-32 machine screws. (By the way, say "six thirty-two" and "eight thirty-two," not "six thirty-second" or "eight thirty-second.") The six in 6-32 refers to the diameter of the wire from which the screw is made, and the thirty-two tells the number of threads

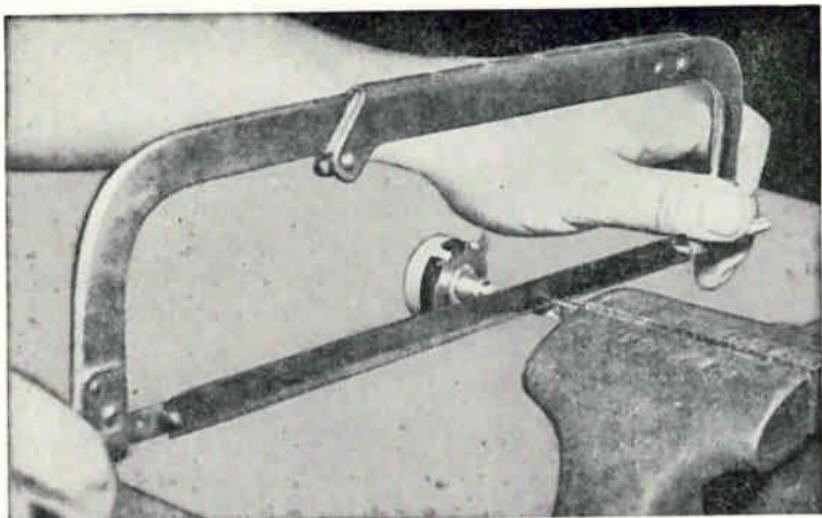


FIG. 15. Cutting off a volume control shaft with a hacksaw. This is a common radio servicing job.

to the inch. The lengths you will need in radio service work are  $\frac{1}{4}$ -inch and  $\frac{1}{2}$ -inch. One gross each of  $\frac{1}{4}$ -inch and  $\frac{1}{2}$ -inch 6-32 and 8-32 (round or binder head) machine screws, with nuts to fit, makes a good stock. Get screws that are cadmium- or nickel-plated (to prevent rust), and keep them separated according to sizes in small glass jars.

Eventually, you will probably get a box of assorted wood screws, and perhaps another box of assorted self-tapping screws. The latter do not require nuts; they cut a thread in metal and thus hold themselves.

## WORKBENCH TOOLS

The tools we've mentioned so far are those you will use both at the workbench and on service calls. There are others that you will eventually find desirable for use at your workbench.

**Hacksaw.** You'll need a hacksaw fairly soon for sawing the shafts off volume or tone controls, to make them the correct length. (General-purpose replacement controls come with extra long shafts so that they may be fitted to different receivers.) A typical hacksaw is shown in use in Fig. 15. Here are some pointers on using a hacksaw:

1. Place the blade on the frame holding-pins, with

the blade teeth pointing away from the handle.

2. Adjust the blade between the frame holding-pins so that there will be no twist, and keep it stressed tightly.

3. Bear down sufficiently hard on the forward stroke to make the blade cut into the work. If the teeth merely slide over the work, their cutting edges will be dulled.

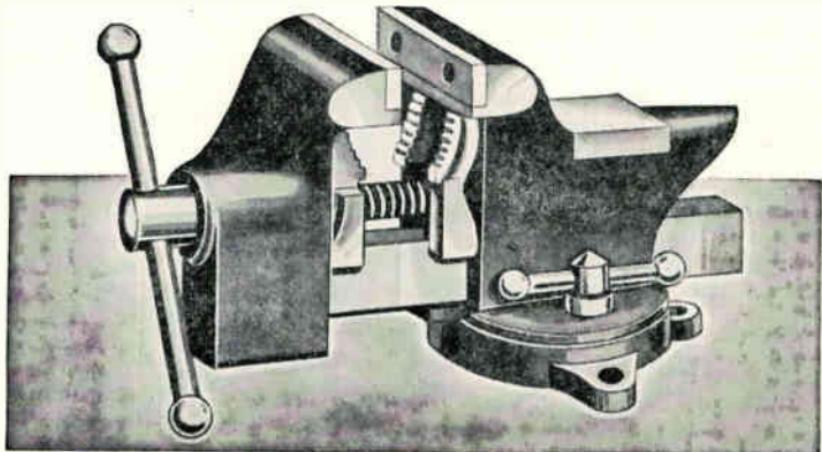
4. Lift the saw slightly on the return stroke to disengage the teeth—otherwise they will be dulled.

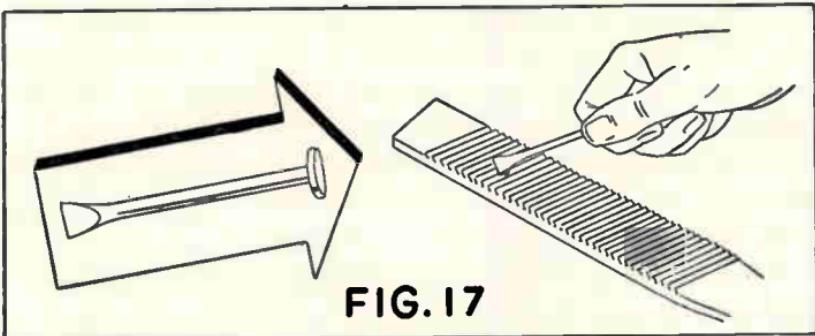
5. Don't saw too fast; you'll overheat the blade and cause it to lose its hardness. About forty strokes per minute is satisfactory for general work.

Hacksaw blades come in 8-, 10-, and 12-inch lengths. Be sure to get blades the right length for your holder (unless it is adjustable for various lengths). Blades are made with 14, 18, 24, or 32 teeth to the inch, depending on the cutting job they must do: those with fewer teeth are for soft metals like aluminum alloys, zinc, and copper, while those with closely set teeth are for iron, steel, and other hard metals. Blades with 24 teeth to the inch are most useful for radio work, but eventually you'll want others also. For instance, a fine-toothed blade is necessary for cutting thin metal (such as a chassis).

**Vise.** Eventually, you will need a husky vise like that shown in Fig. 16 for such jobs as holding a volume-control shaft firm while you cut it and for holding the soldering iron steady while you clean the tip with a file.

FIG. 16. A vise like this is the best kind for service work. The jaws should be at least 3 or 4 inches wide.





**FIG. 17**

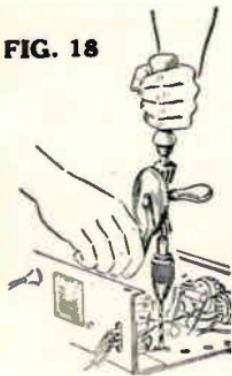
Get a strong vise that has 3- or 4-inch jaws and can be locked in any desired position. Bolt it firmly to your bench.

**Files.** One flat file and one round or rat-tail file will prove useful to you almost at once. The rougher the work or the softer the metal to be smoothed, the coarser the file should be. Get a medium-sized double-cut bastard flat file at first. A double-cut file has teeth in two sets of rows, the sets crossing each other at an angle. The term bastard refers to the rather coarse size of the teeth or degree of cut. Other cuts are known as second-cut, smooth, and dead-smooth, each of which is finer-toothed than the one mentioned before it. If too fine a file is used, the teeth quickly clog with "pins" (particles of metal).

When filing, hold the lower end of the file between the thumb and first finger of your left hand and the handle in your right hand. Move the file back and forth across the work in a direction parallel with the length of the file. Use pressure only on the forward or downward stroke, and release the pressure on the backward stroke so that you will not break the file teeth.

► When file teeth clog they must be cleaned. A special wire brush is available for this purpose, but you can easily make a satisfactory cleaning tool. Hammer the point of a large nail until it becomes spade-shaped. File this flat end square until the nail looks like the one in Fig. 17. Now hold the nail at an angle and work it back and forth across the file, in the same direction as the rows of teeth. This will

**FIG. 18**



cut teeth in the end of the nail that will fit down into the ridges on the file and scrape out all the metal particles.

Don't abuse your files. They are very hard and brittle. If you throw one on top of another in the tool box, the teeth or the whole file may break. Don't use a file as a prying tool—it will be sure to break.

**Hand Drill.** A hand drill is very useful for removing rivets holding parts to a chassis or for making new mounting holes in a chassis. You'll need one soon after you start servicing. An ordinary hand drill, with a three-jawed chuck capable of taking round-shank drills up to  $\frac{1}{4}$ -inch size, is all that is necessary for radio work. Fig. 18 shows a typical drill in use.

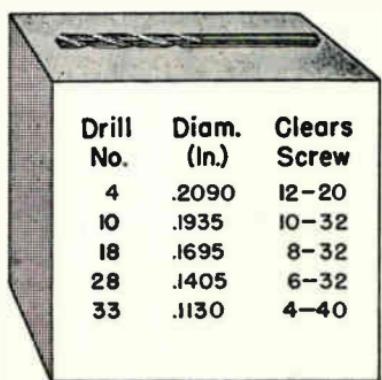
► You will, of course, need some drill points or drills. There are two kinds—carbon and high-speed. The carbon type is cheap and entirely satisfactory for use in a hand drill. Only high-speed drills should be used in electric drills, because they run so fast that they will overheat and destroy a carbon drill-point.

Fig. 19 shows a typical drill point and a table giving the numbers for the drill sizes that you will be most likely to use.

Even the best drills become dull with use. Carbon drills cost so little you may as well discard them, but it pays to have high-speed drills sharpened by a machinist. Don't try to sharpen them yourself unless you are experienced in doing so.

Always turn a drill slowly enough and use enough pressure so that the drill point will not slide.

After drilling a hole, particularly through thin metal, you may find a rough burr on the side where the drill point came through. You can easily remove this burr with a counter-sink or with a drill about twice the size of the one you used to make the hole. Wrap the shank end of the drill in a piece of cloth, grasp it firmly with



Drill No.	Diam. (In.)	Clears Screw
4	.2090	12-20
10	.1935	10-32
18	.1695	8-32
28	.1405	6-32
33	.1130	4-40

FIG. 19. These five drills will take care of most service work. Order them by number.

your fingers, hold the cutting point to the burr side of the hole, and turn the drill clockwise. This will trim off the burr and leave a smooth edge.

When you have to make a hole much larger than the drills you have, either drill a series of small holes and smooth the hole out with a file, or drill as large a hole as possible and use a reamer.

**Hammer, Punch, and Cold Chisel.** You'll probably need a hammer and a punch fairly soon. Any ordinary household hammer will do for radio work. A small center punch is helpful when you have to drill holes in a chassis. (Unless there is a starting indentation, a drill point will tend to skid about rather than enter the desired point.) To make a mark with a punch, center the point of the punch at the spot where you wish to drill and strike the top of the punch sharply with a hammer.

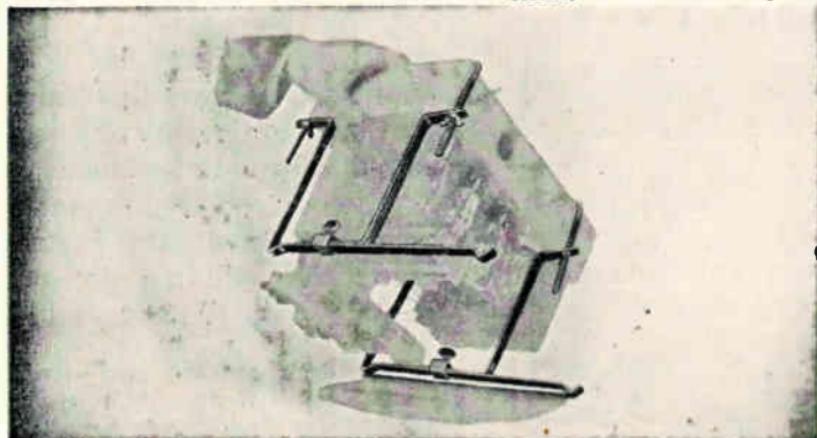
Before using a punch, take all the tubes out of the chassis so they won't be jarred by the blow, and, if possible, support the chassis at the point you plan to punch. A block of hardwood is just right for this. If it is impossible to put a support under it, don't strike hard enough to bend the chassis.

You will occasionally find a cold chisel useful for making a large, square hole in a chassis or for knocking off rivet heads.

**Marking Tools.** You will find occasional use for a wood or metal ruler. A pair of dividers will be helpful at

**FIG. 20.** A chassis cradle like this makes it much easier to work on a chassis without danger of injuring any parts.

Courtesy General Cement Mfg. Co.



times in determining the spacing between holes, although usually the ruler will be sufficient.

You can mark on most receivers with a pencil, although some are finished so that a sharp-pointed scriber must be used. In a pinch, an ordinary straight pin can be used to scratch a mark on a chassis.

## TIME-SAVING TOOLS

We'll mention now a few tools you *won't* need until you get a large shop. Before then, the time you can save with these tools won't be worth their cost.

**Chassis Cradle.** Often, a receiver must be turned upside-down so that you can work underneath it. In some cases there will be large parts, such as transformers and electrolytic condensers, so placed on top of the chassis that they will make steady supports while the chassis is turned over; but frequently you'll find a delicate part, such as the tuning mechanism, so placed that it will be damaged if the weight of the chassis rests on it.

Most servicemen use boxes, wooden blocks, or old radio parts to support the chassis. However, a chassis cradle like that shown in Fig. 20 is better. With the chassis fastened in such a cradle, it may be placed in any desired working position without danger of damaging any parts in the receiver.

**Wire Strippers.** Much of the wire used by servicemen has push-back insulation. You simply push back the insulation with your thumb and forefinger to uncover an end for soldering. However, some wires are covered by braided, plastic, or rubber insulation, which must be cut off the wire. Although you can cut this with a sharp knife if you are careful to avoid nicking the wire, it is a rather awkward procedure in tight places. In such cases, the wire-stripping tool shown in Fig. 21 is quite a time-saver. This tool strips off insulation neatly and cleanly, without nicking the wire.

**Ratchet Screwdrivers.** The ratchet screwdriver shown in Fig. 21 is convenient for removing and replacing long screws. Only the best grade ratchets last very long and have the necessary mechanical strength to tighten large screws firmly.

**Auto Radio Tools.** If you specialize in installing automobile receivers, you will find that both an adjustable end-wrench and an electric drill are necessary tools. Fig. 21 illustrates both.

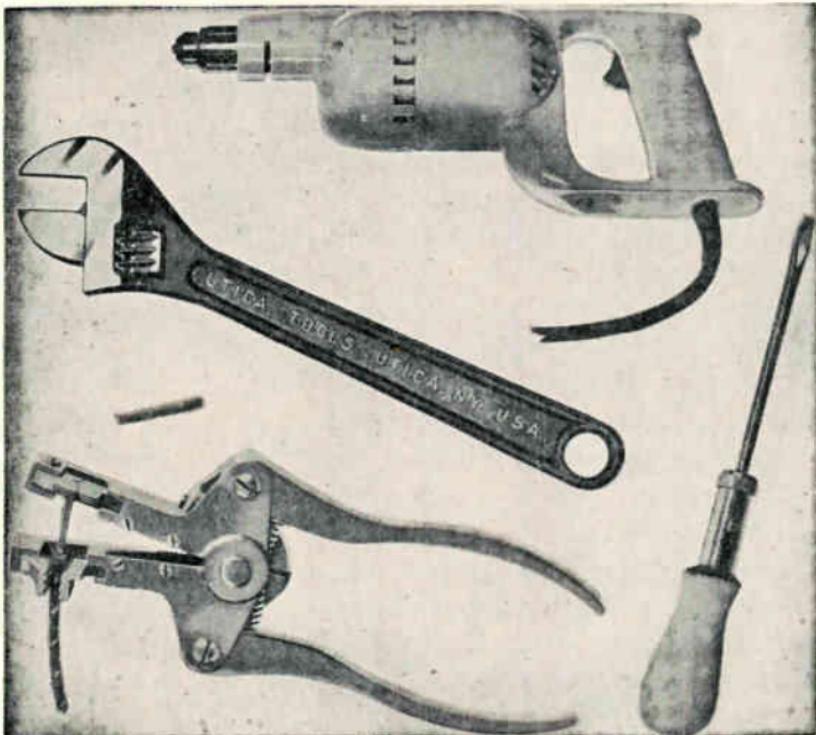
## CONSTRUCTIONAL TOOLS

The following tools are rarely necessary in a radio service shop, but will prove useful if you ever specialize in building or remodeling radio equipment. Naturally, you won't even consider entering these fields until you have had plenty of servicing experience, so you won't need these tools for some time:

- a. *Reamer and brace.* These are used to enlarge holes drilled in metal.
- b. *Tap wrench and tap.* These are used to cut screw threads in drilled holes.
- c. *Socket punch.* This is used to cut a hole in a chassis

**FIG. 21.** The electric drill (top) and the adjustable end wrench (center) are needed for auto-radio work. The wire stripper (bottom left) and the ratchet screwdriver (bottom right) are speed-up tools that come in handy in the well-established shop.

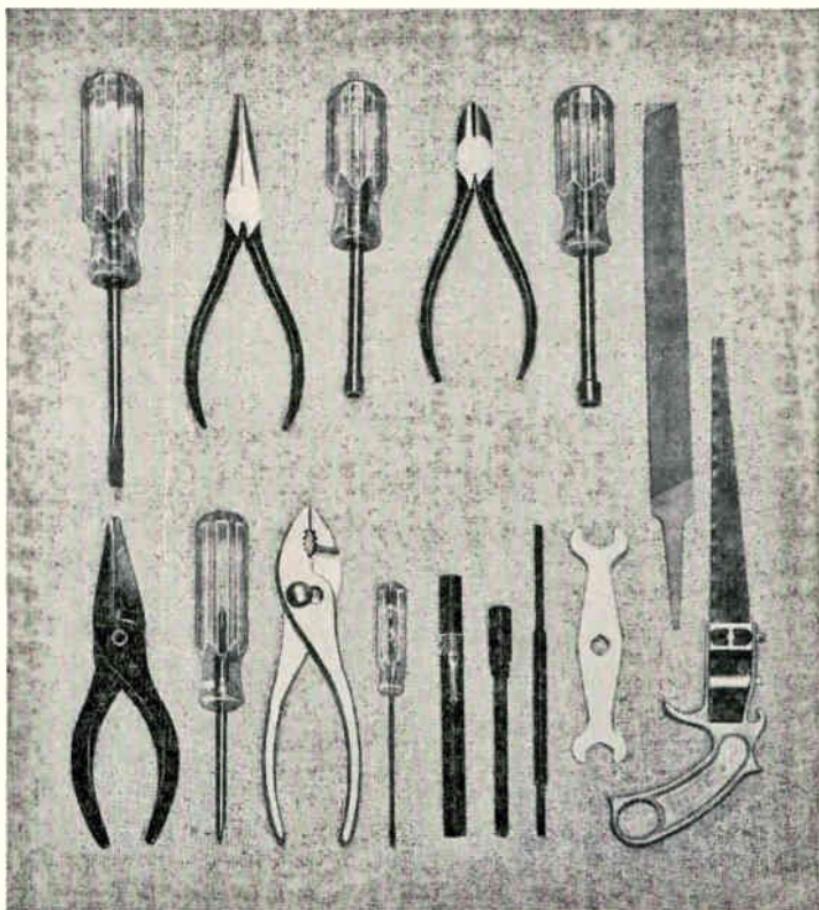
End Wrench, Courtesy Utica Drop Forge and Tool Corp.  
Wire Stripper, Courtesy General Cement Mfg. Co.



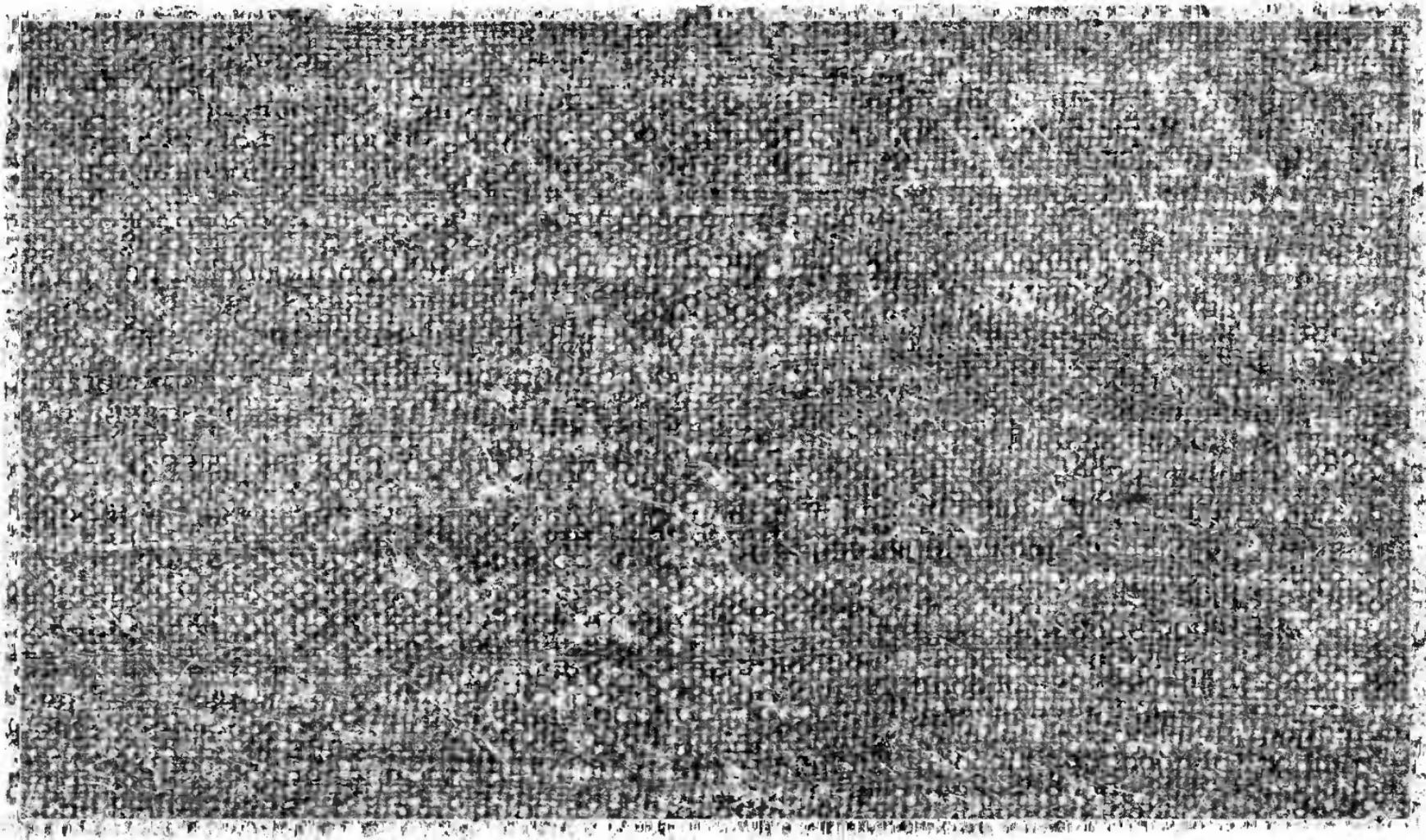
for a tube socket or the socket of an electrolytic condenser.

*d. Power tools.* A drill press and other power tools will be very useful if you do much constructional work.

**A Look Ahead.** Your next RSM Booklet, "Equipment Used by Servicemen," will tell you the basic features of testing equipment that servicemen use. Before you tackle RSM-3, however, study Lesson No. 3 of the regular Course, so you will be able to understand thoroughly everything in this practical Booklet.



A kit of tools like the above is available from the NRI Supply Division. This kit contains most of the commonly used radio service tools. They are of better quality than is usually found at the price. Write to NRI for a descriptive circular.



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

# NATIONAL RADIO INSTITUTE WASHINGTON, D.C.



# **No. 3 Equipment Used by Servicemen**

# **RADIO SERVICING METHODS**

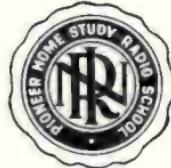
# NRI TRAINING

## Pay off...

Dear Mr. Smith:

My NRI training gave me confidence to apply for a job as a radio repairman with a large concern here. Later I became Radio Service Manager of the firm. Now I am Chief Engineer of a broadcast station, in charge of four assistant engineers. I owe all I know about radio to NRI.

C.J.B., South Carolina



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



## Equipment Used by Servicemen

EQUIPMENT for testing suspected parts is something every radio serviceman, beginner or expert, must have. You do not need to buy any test equipment immediately, however, for your second RK Kit will contain parts and instructions for building a multimeter you can use to get started in servicing. Later, profits from your early servicing jobs can be used to buy professional equipment. The purpose of this Booklet is to describe the various test instruments you will *eventually* need and to show you how to use them. We shall give most space to the all-important multimeter, in preparation for the Booklets on testing radio parts, but there will also be sections on other instruments.

### THE MULTIMETER

The multimeter is four instruments in one, consisting of a voltmeter to measure d.c. voltage, a voltmeter to measure a.c. voltage, an ohmmeter to measure resistance, and a milliammeter to measure current. Some multimeters have, in addition, an ammeter to measure large values of d.c. current.

Widely different voltage, current, and resistance values exist in radio receivers. D.C. voltages may range from a fraction of 1 volt to as much as 400 volts; a.c. voltages from 2 to 700 volts; resistances from a fraction of an ohm to as much as 20,000,000 ohms (20 meg-ohms). It is impossible to read such widely different values on a single range, so most multimeters have a

system of overlapping ranges to provide full coverage of the values to be read.

One of the major differences between multimeters is the means used to convert them from one use and range to another. Some use a series of jacks into which the test leads are plugged, others use selector switches, push buttons, or combinations of these methods.

Several typical multimeters, all of which are adequate service instruments, are shown in Fig. 1. Whatever type you choose, you must know three things before you can use the instrument to test a circuit or part: 1, where to connect it; 2, how to read the meter scales; and 3, how to interpret the readings you get.

Interpreting the readings is sometimes simple, sometimes difficult, depending on what you are testing. You will learn all about this important subject in future lessons and in other RSM Booklets. Let us concentrate here on how to handle the equipment, how to connect it to obtain proper readings, and how to read the meter.

## HOW TO READ MULTIMETER SCALES

Before you connect a multimeter to anything, you must be sure you can read the meter. The pointer moves over a card on which are printed the various scales provided for the meter. Reading such a meter is really less difficult than telling time by a clock, once you have had a little experience.

Here is the right way to read a meter. Figs. 2A, 2B, and 2C show three typical meter scales. They could be for either voltage or current values.

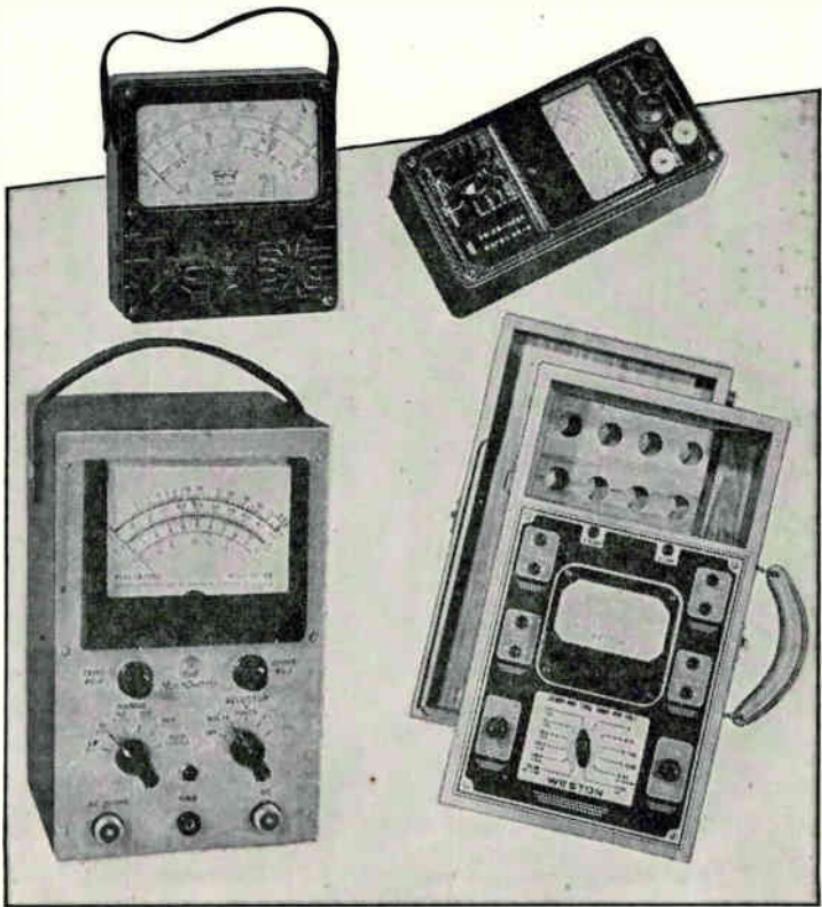
Naturally, you have no trouble reading the values that are marked, but there is not room enough to place the proper numerical value opposite each division on the scale. Thus, you must find out what each division represents before you can read values that fall between the numbers. To do so, count the number of division lines between any two marked divisions, starting with the line *after* one marked division and continuing *through* the next marked division. Then, divide this number into the numerical difference between the two divisions. This will give you the value of each division. In Fig. 2A, for example, there are ten divisions from

the one marked 20 up to and including the one marked 30. The numerical difference between 20 and 30 is also 10. Hence, each of the line divisions represents 1 (10 divided by 10 equals 1). If you want to find, say, 23 on this scale, you need only count three divisions past 20. Similarly, 12 is two divisions past 10.

In counting the marks, you will find that every fifth one is a heavier (thicker) line. This makes it easy to find points like 5, 15, 25, etc. Practice on this scale by finding various values.

► In Fig. 2B, we have a somewhat different scale. Let's see what each division represents, following the rules we just developed. Between 50 and 100 there are ten marks (including the mark for 100), and the numerical

**FIG. 1. Typical multimeters made by (top left and right) Triplet; (bottom left) RCA; and (bottom right) Weston.**

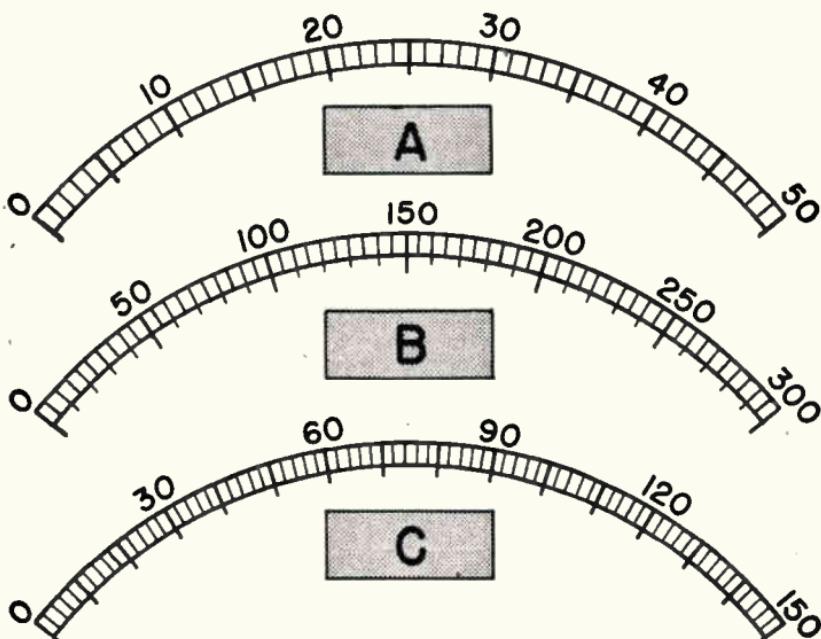


difference between 50 and 100 is 50. Dividing this difference by the number of scale divisions, we find that each division represents 5 (50 divided by 10 equals 5). Thus, 65 is three divisions past 50, 205 is one division past 200, etc. Notice that every other division is made longer so that it is easy to find numbers like 60, 70, 80, and 90.

Now see if you can figure out the value of the main divisions and the value of each scale division in Fig. 2C before reading on.

Using the same method as before, we find the difference between two numbered values, such as 60 and 90. The difference between these is 30. There are fifteen divisions from 60 up to and including 90. Dividing 30 by 15 gives 2, so each division represents 2. Thus, reading each division from 60, we have 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, and 90. The two heavy division lines are at 70 and 80.

**Reading In-Between Values.** Once you know what each division on a scale represents, it is easy to estimate readings with the pointer in between two divisions.



**FIG. 2. D.C. voltage and current scales of multimeters frequently use markings like these.**

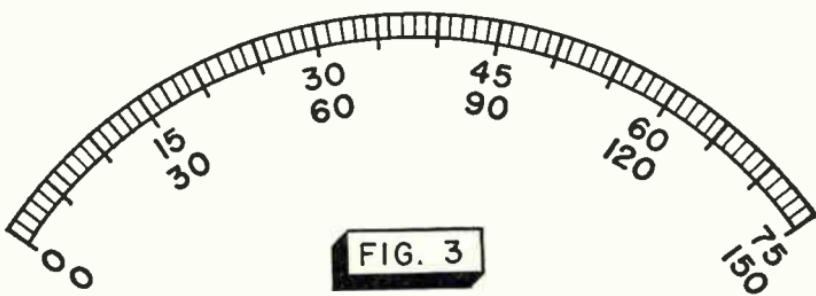
Suppose, for instance, the meter pointer moved to a position halfway between 90 and 92 (the first division to the right of 90 in Fig. 2C). Although there is no division line there, you know the reading must be 91 (since 91 is halfway between 90 and 92).

As we will show, you don't need to read a meter too closely for service work. In fact, it is all right to estimate meter readings roughly when the pointer does not fall directly on a division line. Close meter readings are unnecessary because the value of voltage, current, or resistance, in most cases, may be off as much as 20% from the rated value without affecting the operation of the circuit very much.

**Multiple Ranges.** In Fig. 3 we have the same scale as in Fig. 2C with a new 0-75 range added. (It is very common to find two or three ranges used with each scale in a multimeter.) To find the value of each scale division with the new range, proceed exactly as before, forgetting all ranges except the one in which you are interested.

There are fifteen divisions between 30 and 45 (on the 75-volt range), and the numerical difference between 30 and 45 is also 15, so each division represents 1. Thus, to find 34 on this range, you would count four divisions past 30. Each heavy division line represents 5.

**Scale Multiples.** Here is another point you should understand clearly. In Fig. 2A we have a scale marked 0-to-50, but the multimeter using it may have a 0-500 range in addition. Will there be another scale of 0-500? No, because this would unnecessarily clutter up the meter dial. You can use the 0-50 scale for the 500 range simply by mentally adding a zero to each reading. This



is the same as multiplying each reading by 10. Thus 10 becomes 100, 20 is 200, 30 is 300, 40 is 400, and 50 is 500. The "in-between" values are similarly stepped up; each division now represents 10 instead of 1.

In much the same way the 0-150 scale in Fig. 2C may be used for 0-15. Here you should "knock off" a zero from your reading or, as we say, "move the decimal point one place to the left." Thus each division, formerly equal to 2, is now equal to .2 (2/10), and the 30, 60, 90, etc. readings now become 3, 6, 9, etc. Starting at 0 and going to 3, the values now are .2, .4, .6, .8, 1, 1.2, 1.4, 1.6, 1.8, 2, 2.2, 2.4, 2.6, 2.8, and 3.

The scales in Figs. 2 and 3 are called linear scales because the divisions are spaced equal distances apart. That is, the distance between 100 and 150 in Fig. 2B is the same as that between 200 and 250 or between 0 and 50 on this same scale.

► This is not always true, particularly in the case of ohmmeter scales on which the readings will be crowded or bunched at one end of the scale. This is clearly shown in Fig. 4A; here the readings are spread out on the right half of the scale and are bunched together at the left-hand end. Such a scale is read just like any other, but you must determine the values of the divisions *in the region where the reading is being taken*, since all the divisions do not have the same value. For example, from 1 to 2, there is one in-between mark, which must be  $1\frac{1}{2}$ . From 10 to 20, there are ten divisions, so each must equal 1. From 20 to 50 there are six divisions, so each equals 5. Thus, you have to determine the division values for the section of the scale you are reading.

The scale in Fig. 4A is for a "series-type" ohmmeter. Its scale has zero (0) at the extreme right, the reverse of the usual voltage or current scale. This scale is marked 0-300, but on a typical multimeter using this scale the ranges actually are 300,000 ohms, 3,000,000 ohms, and 30,000,000 ohms, so when reading the meter, you must add to your reading the correct number of zeros for the range being used. For the 300,000-ohm range you add three zeros (000), the 3,000,000-ohm range calls for the addition of four zeros (0,000) to

your reading, and five zeros (00,000) are required when you use the 30,000,000-ohm range. (The 30,000,000-ohm value is 30 megohms, so you can read the 0-300 scale in megohms by dropping a zero. Thus, 300 at the extreme left is 30 megohms; 10 is 1 megohm; 5 is .5 megohm, etc.)

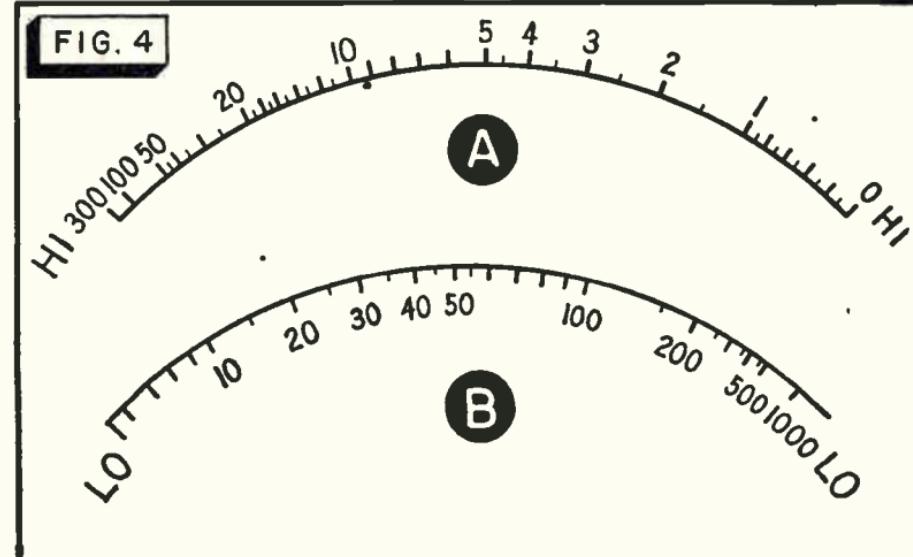
On some ohmmeters the "low-ohm" range is provided by a shunt-type ohmmeter. A scale of this kind is shown in Fig. 4B. Notice that zero on this scale is at the left-hand end. However, the modern trend is to use a series-type ohmmeter even for the low-ohm range; in this type of ohmmeter, all ranges have zero at the right-hand end of the scale.

**A Typical Multimeter Scale.** Fig. 5 shows a typical multimeter scale. The scale at the bottom is a dual scale for d.c. voltage and current. The next dual scale is for a.c. voltage (this scale is usually colored red on the standard dial to help make it stand out from the others). The top scales are for the resistance ranges.

Although there appear to be a number of markings on a dial of this kind, you don't have to worry about any of the markings except the ones on the scale that you happen to be reading at the moment. With practice, you will soon learn to disregard all other scales.

In Fig. 5, notice that the voltage scales are 0-12 and 0-30. On an actual meter of this kind, the voltage ranges may be 0-3, read on the 0-30 scale by moving the decimal point one place to the left; 0-12 volts, read directly

FIG. 4



on the meter; 0-30 volts, read directly on the meter; 0-300 volts, read by adding a zero to the 0-30 scale; and 0-1200 volts, read on the 0-12 scale by adding two zeros to each reading.

► Once you build the tester for the experiments (or obtain a test instrument) and practice a little, you will find it surprisingly easy to read meter scales. **ALWAYS READ THE SCALE FOR THE PURPOSE AND THE RANGE YOU ARE USING.**

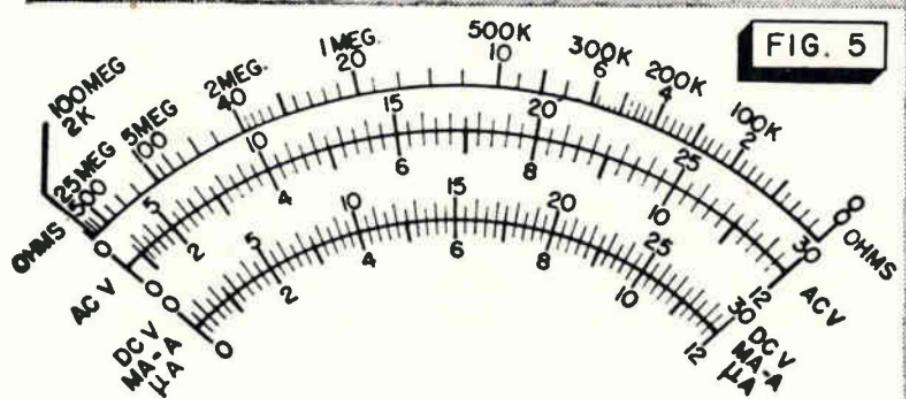
## MULTIMETER CONNECTIONS

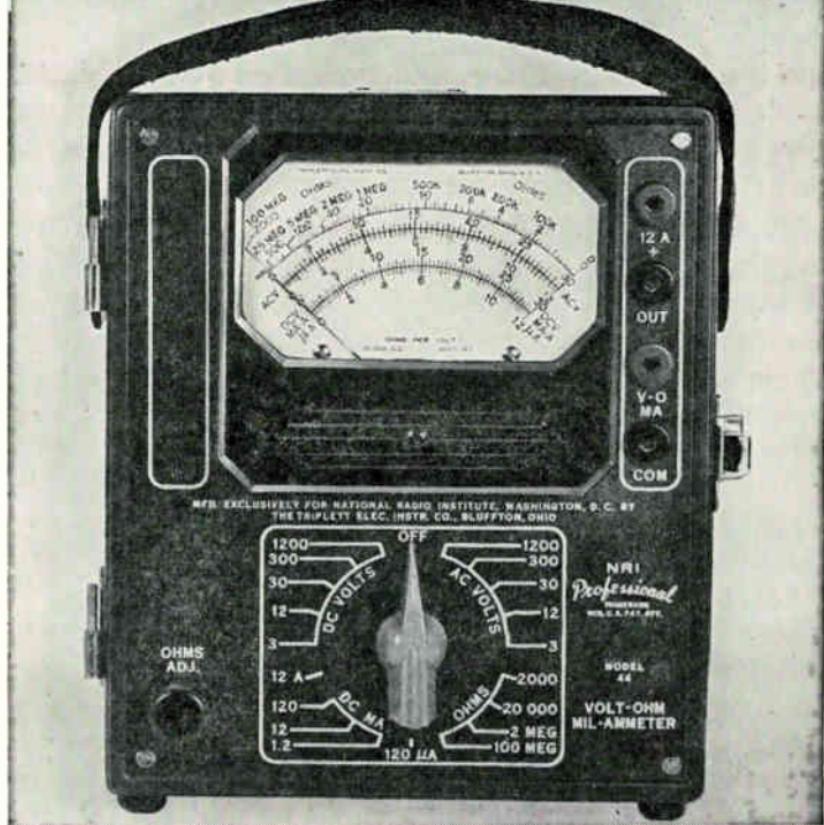
Now that you have learned something about reading meter scales, let us see how to connect a multimeter in order to get readings. Fig. 6 shows a typical modern multimeter.

A pair of test leads, one red and one black, are used to make connections between the tester and the circuit or part under test. One end of each lead is fitted with a pin connector which is plugged into the jacks mounted on the multimeter. The other end of each lead has a large insulated probe, which is used to make connections in the circuit.

At the right of the meter, there are four connecting jacks, colored (in order from top to bottom) red, black, red, and black. The bottom (black) jack, labeled "COM" is the "common" jack that is used for one connection in all uses of the multimeter. The black-colored test lead is always plugged into this jack. Then, the red test lead is plugged into one of the other three jacks, depending on what is to be checked.

FIG. 5





**FIG. 6.** The NRI Professional Model 44 Multimeter. This high-sensitivity instrument features ease of operation, and ranges that are carefully chosen to meet the needs of any serviceman—beginner or expert.

For most purposes, the red lead is plugged into the red jack next to the bottom—the one labeled “V-O-MA.” This is the jack for making voltage, resistance, and current measurements. The other two jacks are for special purposes that will be explained elsewhere in your Course.

Suppose you want to use this multimeter as an ohmmeter. First, plug the black test lead into the “COM” jack and plug the red test lead into the “V-O-MA” jack. Next, turn the selector knob to the desired ohmmeter range. There are four ohms ranges—2000 ohms, 20,000 ohms, 2 megohms, and 100 megohms. The names of these ranges come from the highest values that can be read on each. Thus, you should always choose a range that is higher than the resistance you want to read.

To calibrate the ohmmeter properly, touch the tips of

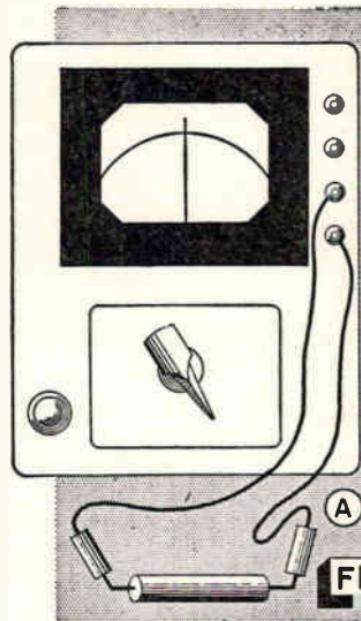
the test probes together, and turn the lower left-hand knob (labeled "OHMS ADJ.") until the meter reads zero at the right-hand end of the ohms scale. The instrument is now ready to be used as an ohmmeter.

**Continuity Testing With an Ohmmeter.** When we say that a circuit or a part has continuity, we mean that there is a continuous metallic or conductive path for the flow of direct current through the circuit or part. A circuit does not have continuity when an "open" (a break) occurs, for then the metallic path is not complete.

Elsewhere in your Course, you learned that the *series* ohmmeter consists of a voltage source (either a battery or a power pack), and a meter in series. If the ohmmeter test probes are held together, the voltage sends current through the test probes and through the meter, causing the meter pointer to move to a full-scale position, indicating that there is no resistance between the test probes. Thus, on the series-type ohmmeter, zero resistance between the test probes causes a "full-scale" reading. When the probes are separated or "open," there is no deflection—the pointer remains at the left of the scale.

Now, when the test probes are held on the terminals of a part having continuity, the battery causes current to flow through both this part and the meter. Because of the resistance of the part being tested, the current flow is less than when the test probes are held together, so the meter pointer deflects to some position other than that for zero resistance. The higher the resistance of the part, the less the current that will flow and the less the meter pointer will deflect from its "open circuit" position. If the part has no continuity (is open) the pointer does not move from the "open" position because no current can flow through the break.

Notice that the ohmmeter has two uses: 1, it indicates



whether the part (or the circuit) has continuity; and 2, if the scale is calibrated properly, it shows the resistance of the part.

► When you are testing for continuity, you should use one of the higher ohmmeter ranges; you will then get a deflection regardless of the part resistance if the part has continuity. For example, when a resistor is being tested as in Fig. 7A, the ohmmeter test probes are touched to the resistor terminals. The ohmmeter battery sends current through the resistor, and the meter needle deflects to some position on the scale, the exact position depending on the resistance value.

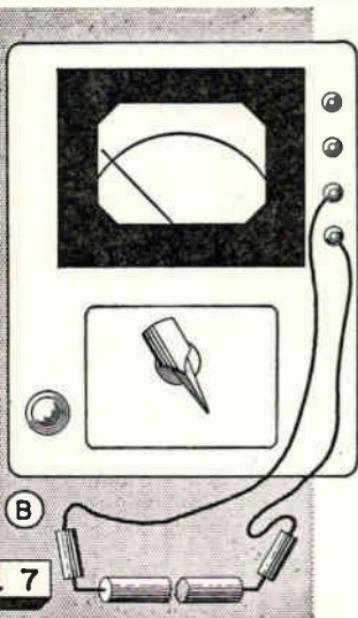
When the ohmmeter probes are placed on the terminals of a defective resistor as in Fig. 7B, no current can flow because the circuit is open (the resistor is broken), and there is no deflection of the meter needle.

In Fig. 7B, the break in the resistor is visible. In practice, however, it is rare to find a part that is visibly defective. Furthermore, in a radio receiver, parts are frequently concealed by shield cans or other parts. In such cases, you could not possibly see a break, so

you could check only by means of test instruments. *This is one of the most important reasons for using an ohmmeter.*

► Much of your continuity checking inside a radio set will be between what radio men call "reference points"—tube sockets, the chassis, and the high voltage terminal of the power supply, for example. A number of parts may be checked at one time by making ohmmeter readings between these points. If continuity is found, all the parts being checked are at least temporarily cleared of suspicion. You will learn much more about the use of reference points later in your Course.

**Resistance Measurements.** Continuity tests are



made merely to find out if a complete circuit exists. You don't try to read the meter—you just look to see if the pointer moves. Often, however, you will want to determine the exact resistance of a part or of a whole circuit. For example, you may find continuity through a short-circuited part, but the resistance of the circuit in which the part is used will be lower than normal.

You can measure resistance, as well as check continuity, with the ohmmeter section of your multimeter. However, there are certain precautions you must take. In later Booklets, we will show you how to test individual parts and circuits; you will learn the "do's and don'ts" of resistance measurements. If, right now, you have a fair idea of what continuity testing means, you are making real progress.

✓ **D.C. Voltage Measurements.** A serviceman uses a d.c. voltmeter almost as much as he does his ohmmeter. Multimeters have a number of voltage ranges so that they can be used to measure voltages of widely different values. The meter shown in Fig. 6, for example, has five d.c. voltage ranges. To use the instrument as a d.c. voltmeter, you should put the test probes in the same jacks as for the ohmmeter, with the black lead in the "COM" jack; then turn the center selector switch to the desired range.

Since some defect of the circuit you are checking may create an unexpectedly high voltage, always start with the highest voltage range first, then shift to lower ranges when the readings indicate it is safe to do so. Memorize this rule to safeguard your meter. Make a habit of turning the range selector switch to the highest d.c. voltage position (or the "OFF" position) immediately after completing the measurements; this will prevent your accidentally making another test later with the selector set to a low range.

You have learned from your Lessons in Fundamental Radio Principles that voltage exists between *two* points. In other words, you can't connect just one voltmeter probe to a single terminal and obtain a reading; both probes must be used, and they must be connected to points of different potential.



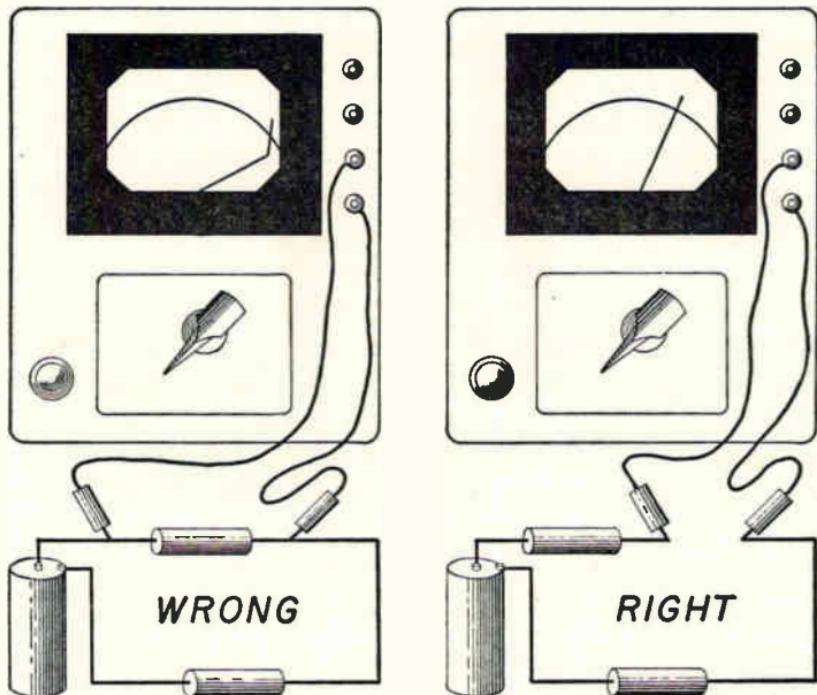
This is an example of an extremely neat, modern, and well-equipped test bench. The NRI graduate who owns it has an excellent business that justifies his having such elaborate test equipment.

For example, each radio tube has a plate and a cathode, and there is a voltage between these elements that radio men call the plate voltage. To measure this plate voltage, you connect the *negative* (black) voltmeter probe to the *cathode* socket terminal, and the *positive* (red) probe to the *plate* socket terminal. (Take care that the black and red probes are in the *proper* test jacks, or the meter pointer will swing the wrong way.) With the proper test probe connections and the proper range, you will read the plate-to-cathode voltage on the meter.

Later you will receive an RSM Booklet on voltage measurements and will learn just how to make measurements, what to expect, and how to use the results of your tests.

**A.C. Measurements.** To measure a.c. voltage with a meter like that in Fig. 6, set the center selector switch on the multimeter to the proper a.c. range, and touch the test probes to the points between which the voltage is supposed to exist.

Servicemen frequently measure the a.c. output signal voltage. However, in a receiver operated from the power line, the only other a.c. voltages are those used to heat the filaments of the tubes, and the high a.c. volt-



**FIG. 8. The wrong and right ways to measure current.** You can damage the pointer of a milliammeter, or even burn out its coil, if you connect the meter across some part in the circuit. Even if the meter is not harmed, you will not get a true reading of the circuit current. Always connect a current meter in series with the circuit, and be sure to start with the instrument set for its highest range.

age in the power pack (which is changed to the high d.c. voltage required to operate the other tubes).

Filament voltages are rarely measured, except in a.c.-d.c. universal receivers, for little can go wrong with the usual filament circuit. The high a.c. voltage applied to the rectifier is seldom measured because it must be all right if any tube has the correct d.c. voltage. Sometimes, however, you'll want to measure the line voltage. This is done by inserting the test probes into the wall socket holes.

As in making other voltage measurements, *always use the highest range of your meter first, switching to a lower range if necessary.*

**Current Measurements.** It takes time and some unsoldering to make current measurements, for, as you learned from your regular Course, the meter with which the current measurement is to be made *must always be*

*inserted in series* with the circuit so that the circuit current will flow through the meter. Failure to observe this precaution may result in a burned out meter, or at least in a bent meter pointer. Fig. 8 shows the right and wrong ways to measure current.

You should always use the highest current range first, switching to a lower range if necessary. Even so, it is a good idea to find out if the current is abnormally high before making any current measurement. Tests with an ohmmeter and with a voltmeter will disclose such a condition and will show you if current measurements can be safely made. However, these same ohmmeter and voltmeter tests usually eliminate all need for current measurements in practical service work, as you will learn in other RSM Booklets.

***Don't Burn Out Your Meter.*** The meters used in test instruments are fairly rugged, but in most multimeters too much voltage or current will burn out the meter coil or bend the pointer by making it hit the stop too hard. You can avoid such an experience by *always* remembering the following:

**1. Using the ohmmeter.**

a. The ohmmeter cannot be damaged unless the circuit under test is alive. Disconnect the set from its power source by pulling the plug out of the wall outlet before making measurements. (If it is a battery set, disconnect the batteries—don't just turn off the set.) A charged condenser can furnish enough current to damage an ohmmeter, so wait a few moments after disconnecting the set from its power source to let the charge leak off the condensers.

**2. Using d.c. and a.c. voltmeters.**

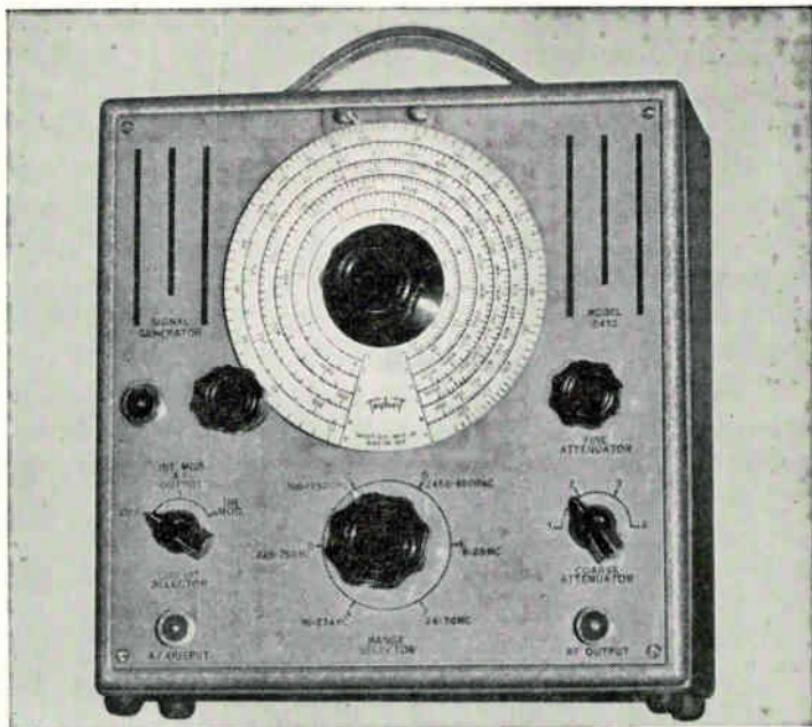
a. Always use the highest range of your meter first; switch to a lower range if it is safe to do so.  
b. Know what you want to measure and where to place your probes.  
c. If the meter pointer comes up with a rush and looks as if it will go off-scale, take one or both test probes off the circuit quickly—use a higher range since the one in use is too low.

- d. Don't try to measure a.c. voltage with the selector set at a d.c. position. The meter will not read, but, if the a.c. voltage is higher than the meter range employed, the meter coil will burn out.
- e. When you are through using some range of a multimeter, always reset it to the highest d.c. voltage value, or to the OFF position if there is one. If you don't form this habit, you may leave the multimeter set to an ohmmeter range and try to measure voltage. This will ruin the meter.
- f. If the meter starts to read down-scale, reverse the test probes.

- 3. *Using the milliammeter for current measurements.*
  - a. Don't make current measurements when voltage and ohmmeter measurements will do.
  - b. Before connecting the milliammeter, satisfy yourself that the circuit has no defects that will cause excess current to flow.
  - c. Break the circuit so the meter can be placed in series with it. *Never connect a current meter across a radio part or across a voltage source.* (Don't try to measure the "current" of a battery or of a power line.)
  - d. Always start with the highest range of the meter, being ready at an instant's notice to remove one or both of the probes if the meter needle shows signs of going off-scale. If the first range is too high for you to read easily, move the meter switch to a lower range.
  - e. If the meter starts to read down-scale, turn off the circuit, reverse the test probes, and turn on the circuit again. As you know, all circuits in which current measurements are made have a source of voltage. The meter must be placed in the circuit so that electrons will enter its negative terminal, hence the *positive* meter probe goes to the *positive* side of the voltage source.

## THE SIGNAL GENERATOR

As its name suggests, the signal generator supplies or generates a radio signal. It is a miniature broadcasting station but does not produce (radio men say "is not



Courtesy Triplet Electrical Instruments Co.

This is a typical signal generator—another of the three basic servicing instruments. You will learn how to use this device in later RSM Booklets.

modulated by") words or music. Instead, it has a steady, low-pitched tone that will be heard when its signal is tuned in on a receiver.

A signal generator has a dial similar to that of a receiver and can be tuned like a receiver. You are probably familiar with all-wave receivers that pick up short-wave as well as broadcast-band stations. Such receivers have a band switch to change from one wave band to another—signal generators are similarly equipped.

Signal generators are used to adjust (or align) receivers so that stations will come in at the proper points on the receiver dials, and to adjust receivers so that weak, far-away stations can be heard with good volume. Sometimes signals from broadcast stations can be used for this purpose, but in many cases they will not do, so plan to get a signal generator eventually.

► Signal generators have another important use. If you have a dead receiver, you already know that the trouble

is caused by a defective part that kills the action in some stage. The rest of the stages may be all right, and if you can find the bad stage, the job is almost half done. The signal generator helps in this. Just inject its signal into the various stages one at a time, working back a stage at a time from the output stage towards the antenna. As long as the signal tone is heard in the loudspeaker, all stages from the point of signal injection to the loudspeaker are in working order. When you pass through the dead stage, the speaker will be silent.

From your Lessons and the RSM Booklets, you will learn how to identify stages, how to tune your signal generator, and how to connect a signal generator to the different stages in a receiver.

## TUBE TESTERS

There is probably more difference between tube testers than between other pieces of service equipment. Some are rather simple in the tests they perform, while others will make a more complete test of the tubes. In general, the more elaborate the tests that can be made, the more expensive the tester. However, elaborateness of tests is not always desirable—manufacturers are constantly bringing out new tubes. Sooner or later, tubes are developed that the tester cannot test without redesign. When enough tubes like this have been brought out, the serviceman is forced to junk his tester and buy a new one.

For this reason, the alert serviceman chooses a simple, inexpensive tube tester that will check tubes for shorts or undesired resistance (leakage, servicemen say) and for emission (the ability of a tube cathode to give off, or emit, electrons). Modern testers of this type are made with controls and circuits that are adaptable to a wide variety of conditions. The better ones have individual selector switches for the various tube elements so that practically any arrangement of elements can be handled. With testers of this kind, only tubes with radically different sockets or with remarkably different characteristics require new instructions or changes in design.



This NRI Model 66 Professional Radio Tube Tester is a portable tester that is easy to operate, and cannot go out of date easily.

Even so, it is advisable to put off the purchase of a tube tester just as long as possible, then to purchase the very latest style. (It is never advisable to waste money purchasing some out-of-date, second-hand tester.) Remember, the multimeter and the signal generator are the most necessary of the basic instruments. At the beginning, you can get radio dealers or parts distributors to test tubes for you, or you can substitute good tubes for defective ones. Then, once you are in the service business, get your tube tester, and pay for it from your service earnings.

### SIGNAL TRACERS

The multimeter, the signal generator, and the tube tester are the basic instruments required for professional servicing. However, there are one or two additional pieces of equipment that you will want to own eventually, if you plan to build up your service business to a high volume.

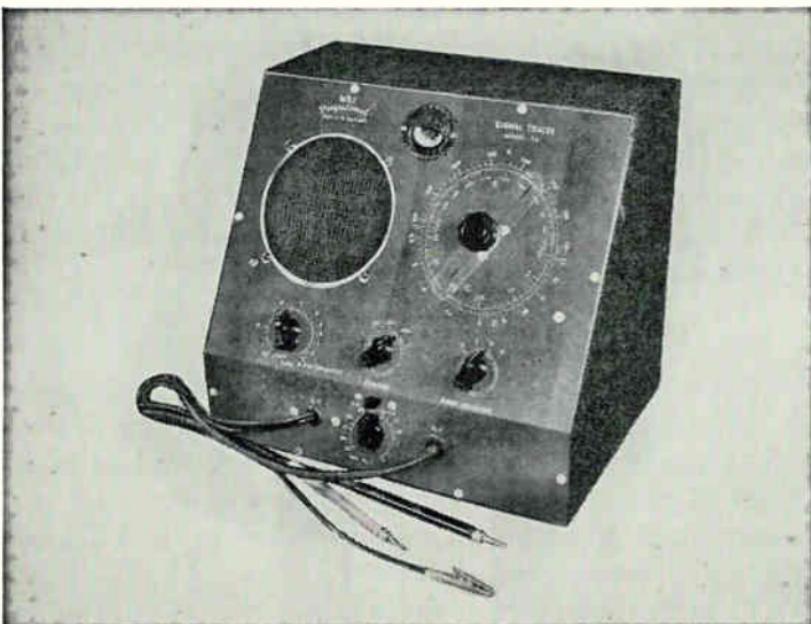
The most important of these instruments is the signal

tracer. The signal tracer is important because it speeds up service work. At the beginning, speed may not be absolutely necessary, but later on you will be faced with the fact that the more radios you can service in a given time, the greater your income will be. Anything you can do to speed up this service will be definitely worth while. At that time, you will find that a signal tracer, which helps you to localize the trouble in a quick, logical, and definite manner, will be very desirable. We won't go into the theory of operation of signal tracers here—this will be covered thoroughly in future Lessons and Booklets. Just keep this instrument in mind as something you will probably purchase after you have established your service business.

## R-C TESTERS

Another supplementary instrument, found in some service shops, is the R-C Tester. This device is most commonly used to test condensers to determine their capacity and leakage values. Although this tester is not an absolute necessity, it can speed up your service work

**The NRI Model 33 Professional Signal Tracer. This time-saving instrument is highly valuable to the full-time serviceman.**





**The NRI Model 111 Professional R-C Tester. Another supplementary instrument that will prove useful to you when you have a large volume of servicing.**

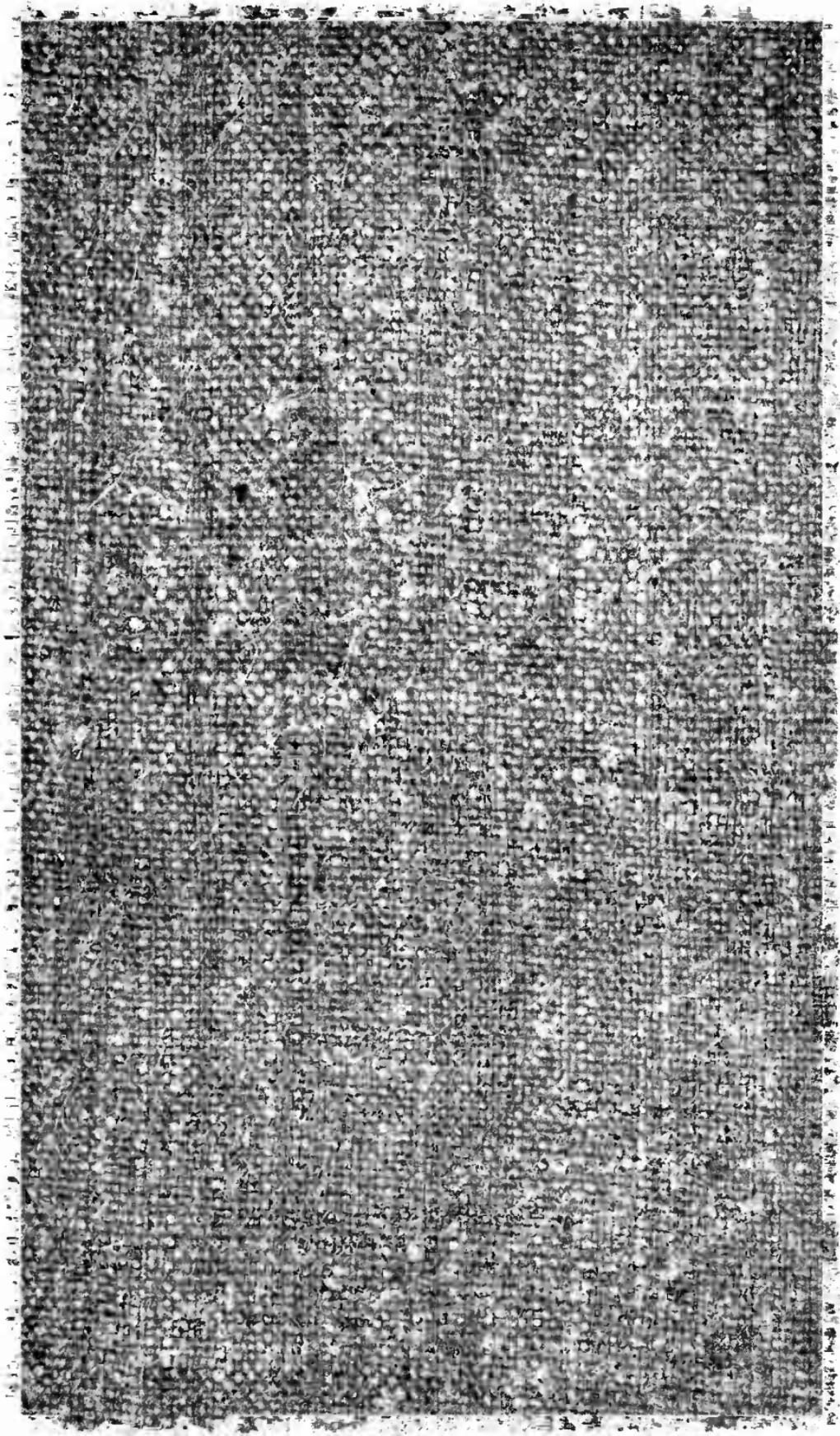
by making a direct test, when otherwise you might have to make an indirect and more time-consuming test to find the same answer.

In addition, an R-C Tester measures resistance. The ohmmeter of your multimeter is satisfactory for most purposes, but the R-C Tester can be made much more accurate in its measurements. For certain purposes, this greater accuracy may prove desirable.

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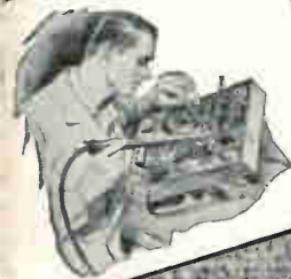


# How to Make Extra Money **FIXING RADIOS**

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 4      How To Remove and  
Overhaul the Chassis

RADIO SERVICING METHODS



# NRI TRAINING

# Payoff . . .

Dear Mr. Smith:

I made money before completing your Course by doing spare time Radio work. In May I opened a Radio repair store, and in about two months time there were about 150 radios ahead of me. In August I hired a Radio technician to help me. During the past year my profits were approximately \$3600. All I had was the will to get ahead — NRI furnished the rest. This Course includes everything to make a man tops in Radio.

R.B.F., Michigan



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



# HOW TO Remove AND Overhaul THE Chassis

**A**LMOST every time you repair a radio, you will have to remove the chassis from the cabinet to locate and replace the defective part. In some receivers (particularly small portables), you must even do so to remove the tubes for testing. Now removing a chassis may seem to be a simple job—yet, even when you know how, “pulling” the chassis can easily take longer than the actual repair!

In this Booklet, we shall give you practical hints on how to remove the chassis rapidly. In addition, you will learn how to overhaul a chassis so that it will be in first-class condition when you have made the repair and put back the chassis in the cabinet. Study this information carefully—it will help you to service *faster and better*.

First, let's learn how to remove a chassis.

## GENERAL PROCEDURES FOR REMOVING THE CHASSIS

There are three types of cabinets: the midget, which includes the portable; the table model, a receiver of medium size that is set on a table or bench; and the console, a big cabinet that stands on the floor and may also include a phonograph. We will take up each type in turn. But, before we do, let's learn some general procedures that apply to all three.

► Before you attempt to remove or reinstall a chassis, *always unplug the receiver power cord from the power outlet to prevent the possibility of shock*. Then take a few minutes to look over the receiver and study its ar-

rangement. Usually the fastenings will be simple.

As your first step, remove the control knobs. (These knobs fit on the ends of the control shafts which come from the chassis through the front panel of the cabinet.) The exact method of removal depends on the fastening. Some knobs have set screws; others are held on by friction springs. Just pull off the latter type. Further examination will show whether you must remove push buttons, dial pointers, etc.; instructions for removing these are given later.

Next, turn the cabinet around and look for speaker cables, power wires, antennas, etc., that have to be disconnected. Sometimes you will find it more convenient to disconnect these after the chassis has been wholly or partly removed from the cabinet. Some receivers have back covers or loop antennas that must be removed.

Next, locate the chassis fastenings. There should be screws or bolts holding the chassis in the cabinet, and sometimes shipping bolts or clamps used to protect the receiver in transport from the factory may still be in place. (On the other hand, another serviceman may have left off the securing bolts, so be sure never to tilt a cabinet until you are certain that the chassis is securely fastened in it.) Most sets have a straightforward arrangement of two to four screws or bolts, but some have "hidden" screws. Sets with inclined tuning dials, or those in period style console cabinets, sometimes have extra screws holding the tuning mechanism in place.

Once you have located the fastenings, remove them and lift the chassis out of the cabinet. If it sticks, *do not force it*. Pull and lift cautiously to learn where it is being held. Many sets stand on rubber "feet" or blocks, which are used to reduce vibration. These blocks may stick, particularly when placed in counter-sunk holes, and will have to be pulled or pried loose.

► Let's sum up the steps in removing a chassis:

1. Unplug power cord.
2. Remove control knobs.
3. Remove push-button knobs *if necessary*.
4. Remove dial pointer, dial scale, or dial cord connection to pointer *if necessary*.

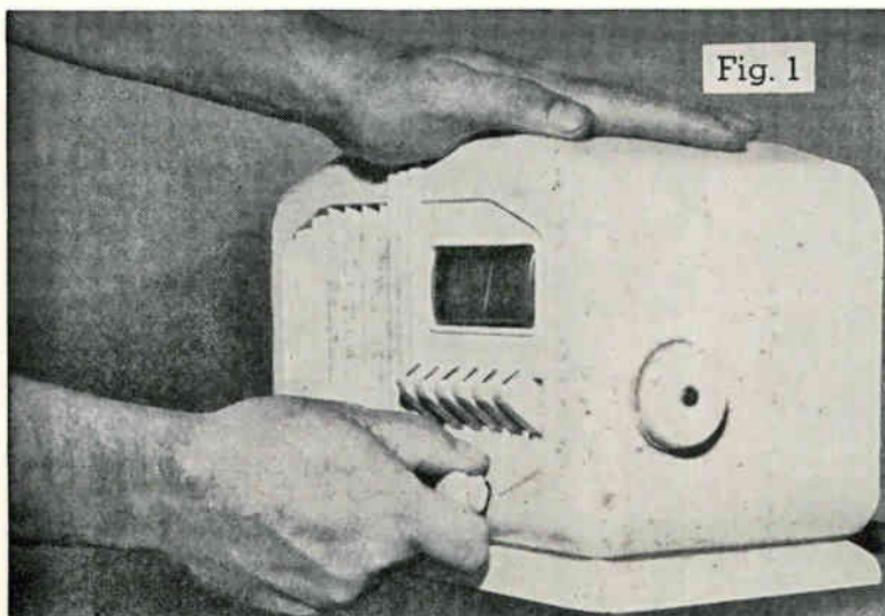
5. Remove back cover or loop antenna if in the way.
  6. Disconnect speaker cable, antenna and ground leads, phonograph cables, etc., when necessary.
  7. Remove chassis bolts and take out chassis.
- Now, we'll see how these steps apply to specific models. Remember that the *methods* we discuss will apply to *any similar case*, whether the cabinet is a midget, table, or console type. Thus, we may describe the removal of a certain type of knob under "midget sets," but this would apply to similar knobs on any set. Also remember that we are describing only representative types—we could not possibly cover them all.

## REMOVING A MIDGET CHASSIS

Fig. 1 shows a midget receiver in a plastic cabinet. This universal a.c.-d.c. set has a manual tuning knob or wheel on the right-hand side. The knob on the front is the volume control and ON-OFF switch. Push buttons for automatic tuning are above this knob.

► The first step in removing the chassis is to take off the knobs. This will allow the shafts to slip out of their cabinet holes when the chassis is removed.

There are three methods of fastening control knobs to shafts. There may be a set screw in the side of the knob which, when tightened, bites into the shaft; the knob may be held on simply by friction; or, as is the



case with the tuning knob in Fig. 1, a screw may pass through the knob and into the end of the shaft.

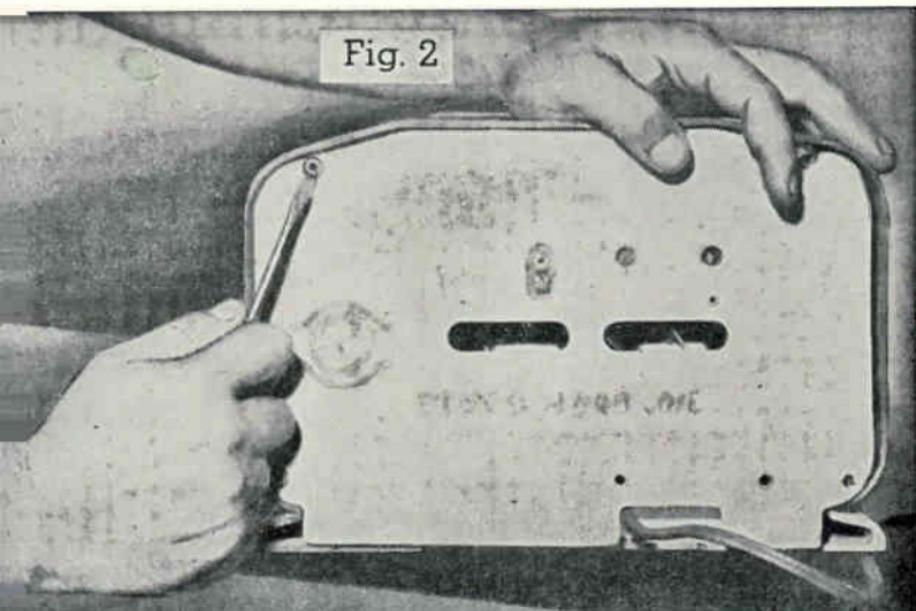
To remove a knob held by a screw, simply loosen or remove the screw and pull off the knob. If no screw is used, then the knob is held on by friction. TO REMOVE ANY FRICTION TYPE KNOB, JUST GRASP IT FIRMLY AND PULL IT OFF. Hold the cabinet with the other hand, as illustrated in Fig. 1.

Now remove the main tuning knob which projects from the side of the cabinet in the set shown in Fig. 1. A screwdriver is the only tool required. On many sets of this kind, releasing this knob also releases the locking mechanism for the push buttons. The push buttons will then probably get out of adjustment and will have to be reset. Details on resetting push buttons will be given in a later RSM Booklet.

As you take each part off the cabinet, put it in a small box so that it will not be lost, and you won't have to waste time looking for it when you reassemble the receiver.

► Next, remove the back cover, if one is used. In most cases four screws will hold the back in place on the cabinet. If a wooden cabinet and wooden back are used, a number of wood screws may pass through the back into the edges of the cabinet. However, in our example, snap fasteners are used instead of screws. They pass through

Fig. 2



holes in the back and snap into holes provided in the cabinet. Fig. 2 shows how you can pry out these snap fasteners with a screwdriver blade.

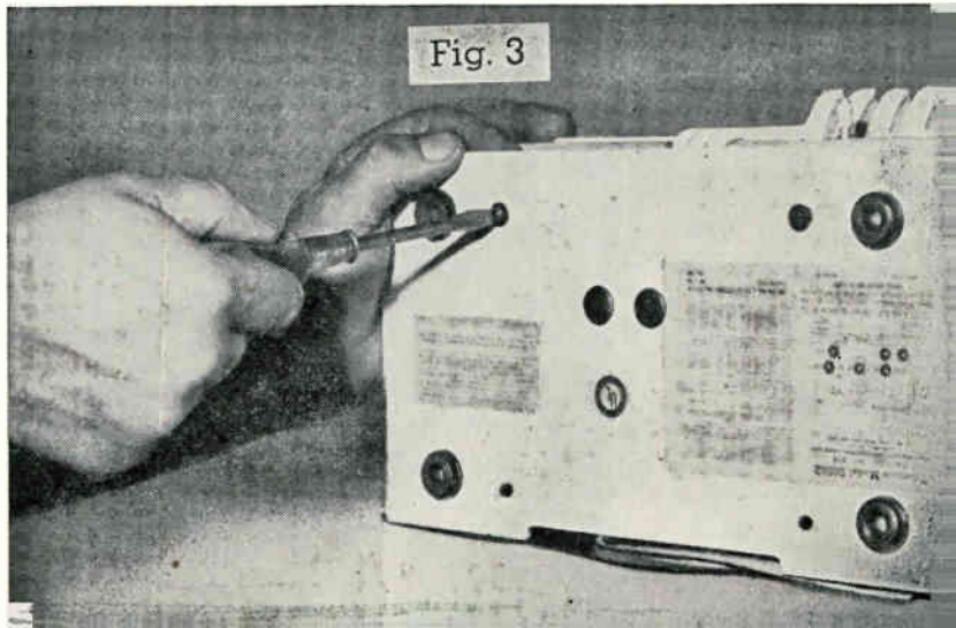
After the back cover is loose, tilt it back to see if a loop is mounted on it. If one is, it will be wired to the chassis, and you must be careful not to break the connecting leads. Sometimes you can leave the loop attached to the chassis, sometimes you'll have to disconnect it—but you should never rip it loose.

► Examine the back of the chassis to see how it is held in the cabinet. In our example the mounting bolts pass through the bottom of the cabinet into the chassis (see Fig. 3). Here, the cabinet has been turned on its back so the mounting bolts can be removed with a screwdriver. (Sometimes hex-head bolts are used; remove this type with a socket wrench.) Take out the lower bolts first, allowing the chassis to hang from the upper ones. If you take out the upper bolts first, the chassis will tend to twist in the cabinet and may jam.

► Notice, on the bottom of the cabinet, the chart giving the positions of the tubes and the make and model number of the receiver. In some cases, you will find a complete wiring diagram on the bottom of the cabinet.

As you take out the last mounting bolt, put your hand under the back of the cabinet. Hold the chassis up to prevent it from dropping out of the cabinet. Next, place

Fig. 3



the cabinet right side up with the back toward you. Hold the cabinet with one hand while you pull the chassis out with the other. Pull on a coil can or some other rigidly mounted part that won't be crushed or damaged.

Fig. 4 shows the chassis out of the cabinet and ready to be serviced. The numbers stamped on the front chassis wall are inspection numbers which do not identify the chassis. The model number of this receiver is on the label on the bottom of the cabinet.

The set shown in Fig. 4 has the speaker mounted right on the chassis, so it does not remain in the cabinet. This is generally true in midgets; however, in larger receivers, the chassis and the speaker are mechanically separate and are connected electrically with a cable.

In Fig. 4 the hardware (knobs, snap fasteners, and screws) have been grouped together on the workbench so that you can see them. On an actual job, you'd put each part in a container as you took it off.

► The push buttons on the set pictured did not have to be removed, but in some receivers, like the one shown in Fig. 5A, it is necessary to remove the push buttons before the chassis can be taken from the cabinet. The push buttons shown in Fig. 4 could be pulled off if necessary, but those in Fig. 5A have to be unscrewed in order to remove them, as shown in Fig. 5B. In each case a preliminary examination will show you what must be done and how to do it.

The midget shown in Fig. 5B is somewhat different

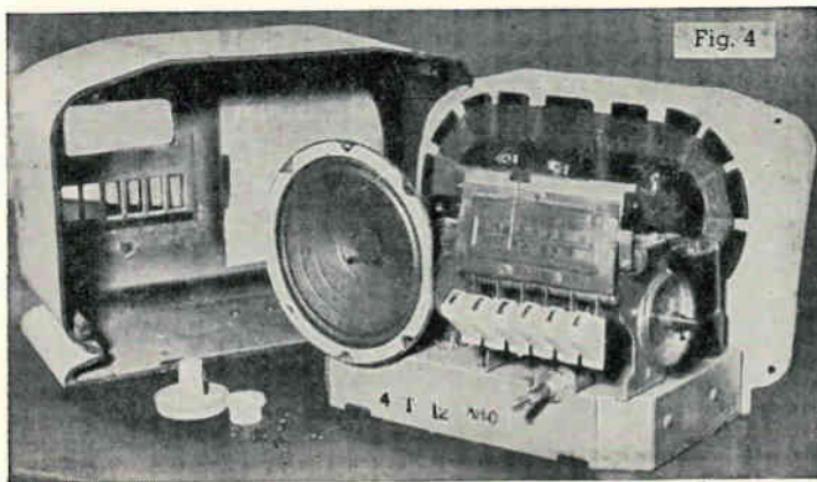
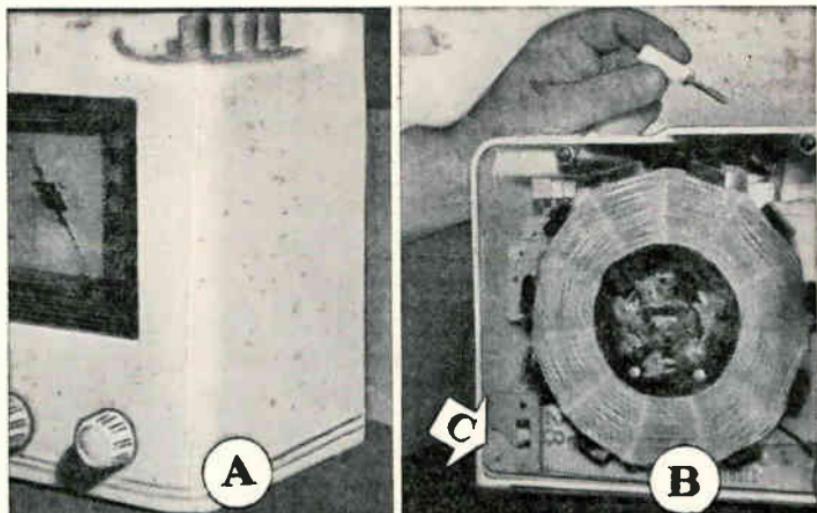


Fig. 4



**FIG. 5.** In most sets the chassis can be removed without removing the push buttons, but in some sets like the one shown here, push buttons must be removed first. Find out which kind you have before removing the chassis.

from the one in Figs. 1 to 4. Instead of screws through the bottom of the cabinet, the chassis is held in place by the bolt marked C in Fig. 5B and by another one on the opposite end of the chassis. Also, it does not have a back cover but it does have a loop. This loop can be removed to make it possible to remove tubes for testing without pulling out the chassis. The loop is held on by two screws. If the chassis is to be taken out for servicing, the loop can remain in place.

► In still another type of midget, the tuning dial pointer slips over a shaft that protrudes through the front of the cabinet. The pointer is held in place by friction and must be pulled off before you take the chassis out of the cabinet. You will find many variations like this—watch for them.

### REMOVING A TABLE-MODEL CHASSIS

Table-model receivers are larger than midgets, but are in cabinets designed to be placed on tables or shelves. Remove the control knobs first. If you find a set screw holding a knob, rotate the knob to make sure there aren't two screws—some early receivers used them.

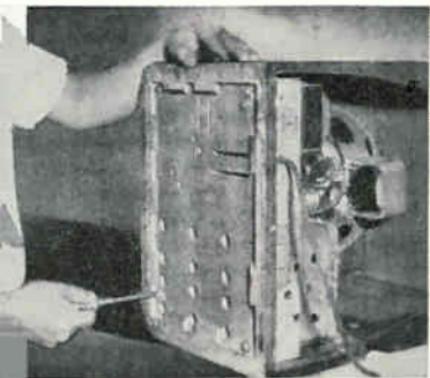


FIG. 6.



FIG. 7.

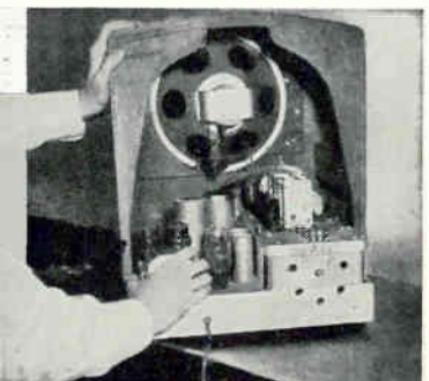


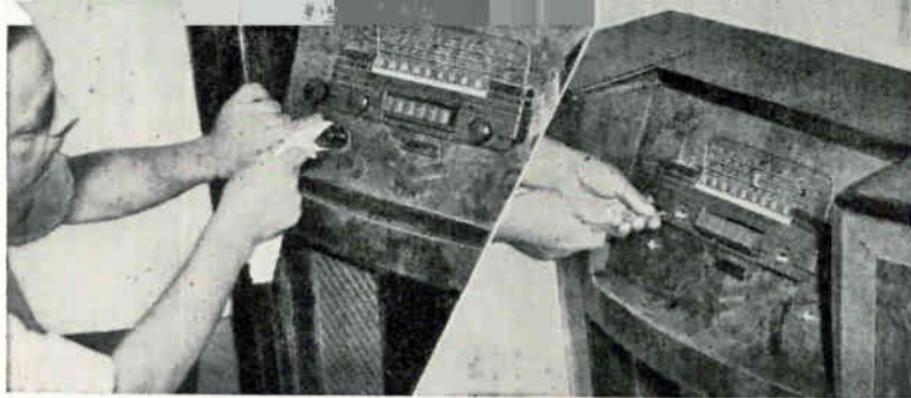
FIG. 8.

Next, turn the cabinet on its side and *loosen* the four mounting bolts as shown in Fig. 6. Don't take them out completely—if you do, the heavy chassis may fall over inside the cabinet, and some parts may be damaged.

After the mounting bolts are loosened, set the cabinet upright on the workbench with one edge of the cabinet sticking out over the edge of the bench, as shown in Fig. 7. Remove the mounting bolt thus exposed, then repeat the process to remove the other mounting bolts.

Next, grasp the power transformer (or some other large, firmly mounted part), and pull the chassis out of the cabinet (Fig. 8). If you look closely at this figure, you can see the cable that connects the loudspeaker and the chassis. If the cable is long enough, you may not have to remove the speaker from the cabinet. If you wish, you can unplug the speaker cable, *but be sure you NEVER turn on the set with its speaker disconnected.* (As you will learn later, this may damage the set.) On this set, the connecting plug is mounted on the speaker; sometimes you will find it on the back, the side, or the top of the chassis. Some sets have no plug in the speaker cable.

► When the cable is not long enough to let you take the chassis out of the cabinet and work on it readily, the loudspeaker must be removed. To remove the loudspeaker, loosen the nuts around the back of the speaker



**FIG. 9 (left).** Here is an easy way to remove a stuck knob.

**FIG. 10 (right).** One step in removing the dial scale. This step is not necessary in some sets.

rim with a socket wrench. Hold the speaker in place with your hand while taking off the last nut. Then, grasping the magnet frame, pull it straight back, and place it face down on the workbench on a clean piece of paper. Be careful not to puncture the speaker cone by putting it on some sharp object.

When you reinstall the speaker, be very careful to line up the holes in the speaker rim with the proper mounting bolts. Carelessness in reinstalling the speaker will allow the mounting bolts to punch holes in the speaker cone. If the cable is short, turn the speaker so that the cable will be long enough to reach from set to speaker when both are reinstalled. If the output transformer is mounted on the speaker, be sure it is placed so that it will clear all chassis parts when the chassis is slipped in place.

### REMOVING A CONSOLE CHASSIS

Fig. 9 shows part of the front of a console receiver. All knobs must be removed. These knobs are usually of the friction type. In this particular case, the knob is stuck and will not come off easily, so the serviceman has folded a handkerchief and slipped it under the knob. By pulling on the ends of the handkerchief, he can remove the knob without trouble. This is a trick to remember —you'll find it handy time and time again.

On this model, the dial pointer must be removed. Its operating mechanism protrudes through a slot cut in the cabinet. Fig. 10 shows how the dial scale is removed so that the dial pointer may be disconnected from the

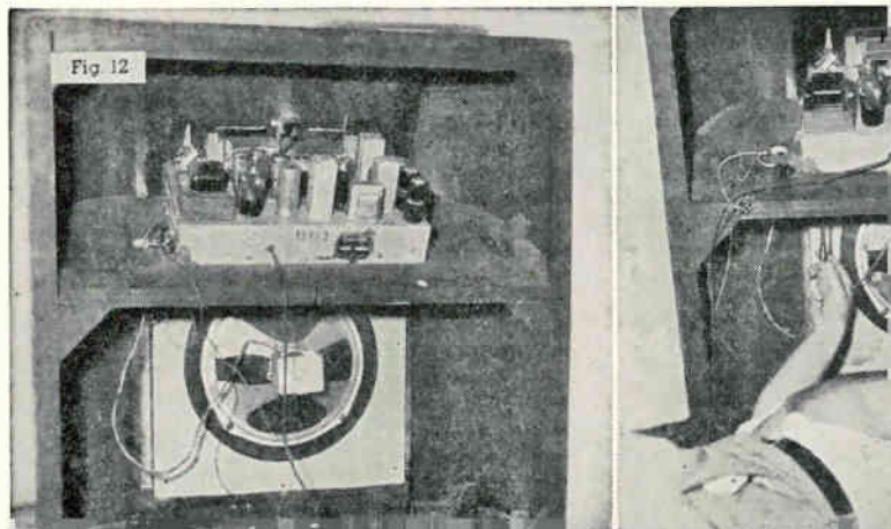
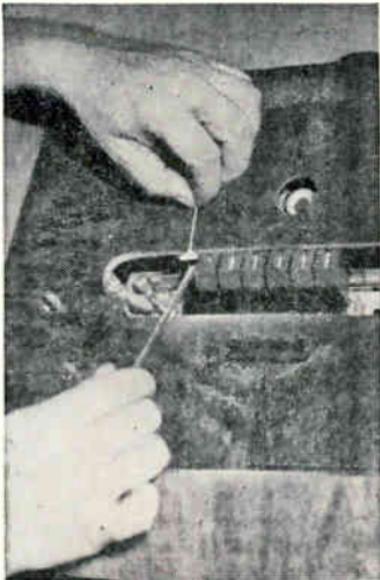
**FIG. 11.** Removing the dial scale pointer. This is not necessary in all sets, but must be done in this one so that the pointer will not be bent when the chassis is removed.

chassis tuning mechanism. The scale is held in place by four wood screws. (Watch for Phillips screws here; these require the use of a small Phillips screw-driver.) When these screws have been removed, slip off the dial scale. Then, as shown in Fig. 11, remove the dial pointer by loosening the screw that holds it at its bottom. The dial pointer will be bent or broken if you pull out

the chassis without removing the pointer first.

Fig. 12 shows a back view of the chassis. The speaker is in a compartment below the chassis. So is the loop antenna, which is inside the cardboard form that surrounds the speaker. Cable leads pass from the speaker and the loop through holes in the chassis mounting-board and plug into jacks on the left-hand side of the chassis. *Never cut a cable that passes through a hole in the cabinet.* You will always find a plug at one end of the cable. Disconnect such plugs, making careful note of where each goes.

Now take out the bolts holding the chassis to the wooden shelf. You'll probably have to lie on the floor so



that you can see the bolts and get a large screwdriver into them, as shown in Fig. 13. Before the last bolt is completely removed, put your hand on the back of the chassis so that it can't slide down the inclined shelf and fall on you or the floor. Fig. 14 shows the chassis being slid out of the cabinet.

In a few receivers, you will find that the dial is mounted on the chassis and also is screwed to the front of the cabinet to give it greater rigidity. If, when you start to pull the chassis out of the cabinet, you find that it is being held, don't just pull harder. Stop and see what's holding it. If the dial is screwed to the cabinet, remove the screws.

✓ ► Notice the tools and parts left on top of the cabinet in Fig. 14. This is something that should never be done, for the top of the cabinet may be scratched, and no housewife is going to like the idea even if the cabinet isn't damaged. It is best to replace all tools in the toolbox as soon as you are finished with them, and to place knobs and screws in a container (a small jar, can, or box carried in your tool kit).

Installing a chassis of this kind is much easier than taking it out, because generally you don't have to lie down on the floor. You can tell from the old dust marks or press marks just how the chassis was placed originally in the cabinet, and when you have it exactly in place, you can easily start the chassis mounting bolts with your hand and finish up with a screwdriver. By feeling with your fingers, you can slip the screwdriver blade

Fig. 13



Fig. 14



into the screw head slot without much trouble.

► In some receivers, the control knobs stick up through the top of the cabinet. In this instance, the chassis may be mounted on a baseboard, as shown in Fig. 15. This baseboard will be screwed to the front of the cabinet. Loosen the screws *A-B-C-D-E-F* one at a time, taking out first those that are hardest to reach. These are usually the ones in the top. Hold the chassis with one hand or put books or blocks under it to hold it in place while you take out the last screws. Lift the chassis out of the cabinet. You can then lay the chassis on its back or on its side and take out the bolts that fasten the mounting board to the bottom of the chassis.

Fig. 16 shows a side view of a chassis designed for

**Fig. 15**

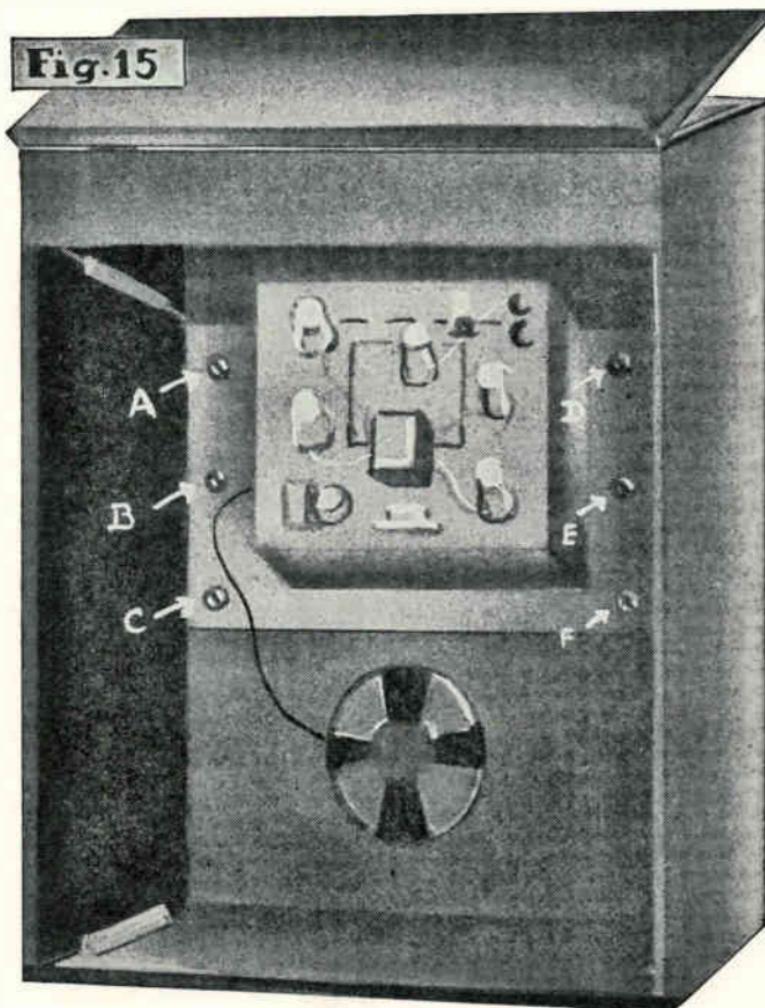
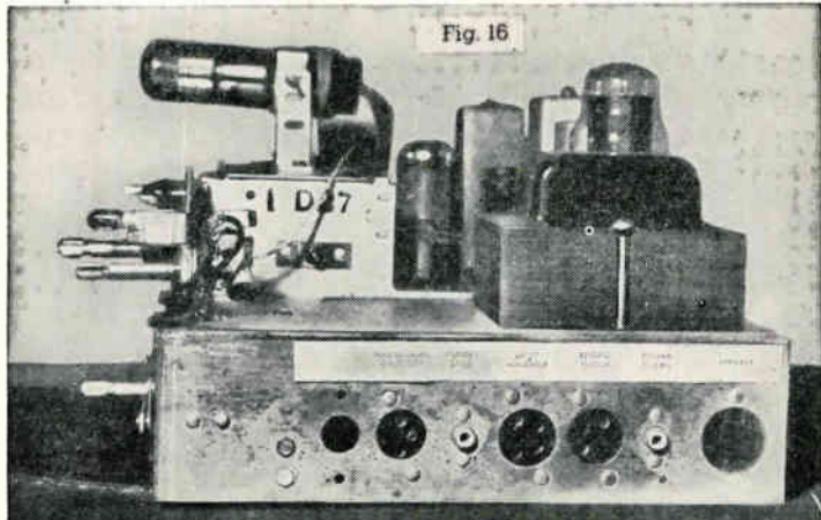


Fig. 16



many uses. It can be used as a small public address system by plugging a microphone into the jack provided for this purpose, or it can be used to amplify the output of an electrically-operated phonograph. Note the number of jacks and sockets for the various attachments. You will not always find a label pasted on the chassis indicating the use of each jack. It's a good idea to look first, and, if there is no label, to mark with a pencil on the side of the chassis the position occupied by each plug you remove. Then you will have no trouble in getting the right plug back in the right jack.

Of course, if you can look at the side of the chassis when you are ready to put back the plugs, you won't have much trouble, since the plug pins generally are arranged in such a way that they will fit only into the proper jacks. If you can't see the jacks, however, you may do considerable fumbling around before you get the right plugs into the right jacks, so a sketch of some sort will save you time.

In a few receivers, you will find that the leads from the phonograph motor are soldered inside the receiver chassis instead of being plugged into a socket (look for a plug at the motor). When there is no plug, these leads must be cut before you can take the chassis out of the cabinet. Be sure that the receiver is disconnected from the power line before you try to cut these leads with your side cutters. It's best to stagger the cuts on the

two wires, as shown in Fig. 17A, instead of cutting them both at the same place. When you reassemble the receiver, strip the insulation off these four wires, reconnect them with twist connections (Fig. 17B), solder the joints, and cover them with tape (Figs. 17C and 17D).

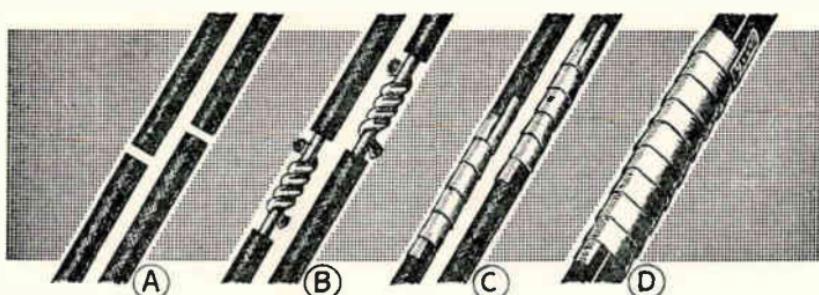


FIG. 17. Four steps in making a splice.

## Overhauling Radio Receivers

Regardless of the complaint for which the receiver is being serviced, certain general overhauling steps should be taken while the receiver is out of the cabinet. These steps are simple ones—removing dust and dirt, resoldering poor connections, replacing pilot lamps, etc.—but they all have a bearing on the appearance and operation of the receiver. Let us see just what you should do. We will assume that the chassis and the speaker have already been removed from the cabinet (in the manner given earlier in this Booklet).

**Cleaning the Chassis.** A thorough cleaning is part of every service job. There is always an accumulation of dust on a radio, for its heat of operation sets up air currents that carry dust to it. Furthermore, the average housewife is afraid to clean the inside of a radio for fear of possible damage to the radio (and, perhaps, shocks). A set owner may be embarrassed by the dirty appearance of his radio, and he is certain to notice and appreciate its return in a clean and shining condition.

There are technical reasons for cleaning, too. Moisture is the greatest enemy of a radio receiver, and dust tends to collect and hold moisture. When dust gets between the plates of a tuning condenser, it causes noise.

Dust is somewhat conductive, so dust can provide leakage paths between circuits.

For these reasons, and to be able to work under the cleanest conditions possible, remove all dust as one of your first service steps when the receiver is in your shop. (In the home of the customer, don't raise a dust storm in the living room. It is preferable to carry the dusty receiver out with you; avoid cleaning inside the home if possible.)

To keep your shop and yourself clean, wear a shop apron, and do your cleaning outdoors if possible. Don't inhale dust. Provide plenty of ventilation if you must clean up indoors.

Dust may be removed by wiping, by blowing, or by vacuuming. Outdoors, you could use a small bellows, bicycle pump or vacuum cleaner hose attachment to blow away most of the dust. Indoors, it is best to wipe the chassis with a clean cloth or with a small clean paint brush.

► Next, remove the tubes, *one at a time*, wiping off all dust with the cloth. If the tube base prongs appear corroded, clean them with fine sandpaper. Wipe the top of the tube socket and the chassis in its vicinity, then replace the tube. Repeat the process on each other tube in turn. *Never take out more than one tube at a time*, or you may get them mixed and replace them incorrectly.

Quite often a tube will be surrounded with a metal can known as a tube shield. One type of tube shield is removed by pulling upward (if there is a connection to a top cap on the tube, remove this first). Another type, made in two parts and known as a form-fitting shield, is held together by a spring-steel ring. Pull out the tube and shield together, then push this ring out of its groove with a screwdriver; the shield will then fall apart and can be removed easily for cleaning.

► It is most important that all dirt be removed from the variable condensers. Rotate the gang tuning condenser to its open or minimum-capacity position and run a pipe cleaner (the type obtained from tobacco stores) between each pair of plates to loosen the dirt,

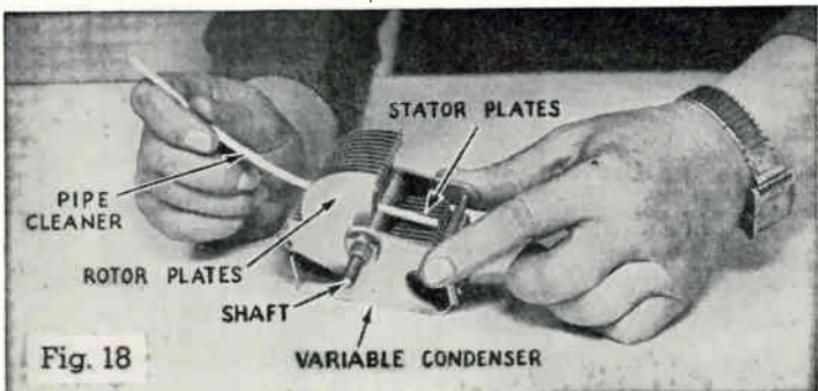


Fig. 18

then blow out any dust that remains. Fig. 18 shows the method. (The condenser was removed from the chassis for clarity in this illustration, but, of course, you should not remove the condenser to clean it.)

Any grease or dirt remaining on the chassis after the dusting procedure should be removed with a cloth dipped in a cleaning fluid such as carbon tetrachloride (Carbona). NEVER USE WATER ON A RADIO CHASSIS! Clean the tuning dial with a soft dry cloth.

**Tightening Screws.** It is rare indeed to find any "loose" screws on a radio receiver *except trimmer adjusters*. Many beginners find these, tighten them, and then find that the receiver no longer functions. An expert must be called in to realign the receiver—in practically all cases a signal generator must be used. Therefore this **WARNING:** *Do not blindly tighten every screw head and nut you see on a chassis; a great many of these screws and hex-head bolts or nuts are for tune-up or alignment purposes; they control the settings of trimmer condensers or adjustable coils.* You can recognize these screws by the simple fact that they are mounted *ON* a part and *do not* serve to fasten that part to the chassis. A few typical alignment screws are shown in Fig. 19. Some parts, even, are not supposed to be secured *tightly* to the chassis; tuning condensers, for example, are frequently mounted on rubber "feet." Therefore, there is rarely any necessity for tightening mountings unless you have loosened them for some testing purpose.

**Soldering.** Be sure to notice the condition of the

soldered joints. Manufacturers use good soldering techniques, but you can never tell what some other serviceman has done. Resolder any joints that appear to be defective—joints that have a green and corroded appearance, joints covered with excessive rosin, and joints over which the solder did not flow smoothly. You can test joints for looseness by pulling on the wires with a pair of long-nosed pliers.

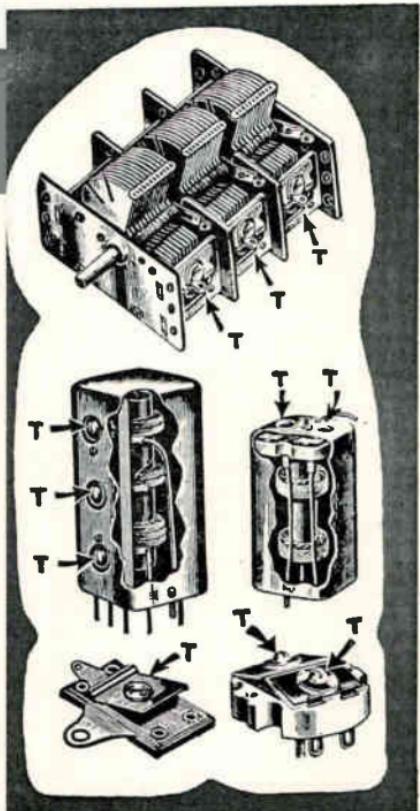
**Insulation.** Be on the lookout for frayed or cut insulation, particularly on wires that go through the chassis. If you find a lead with defective insulation, replace it with a new lead; or wrap insulating tape over it; or unsolder one end and slip a piece of varnished cloth tubing (called "spaghetti" by radio men) over the wire so it will cover the break in the insulation, then resolder the lead.

Inspect the power cord for defective insulation, particularly at the point where it enters the chassis and at the wall plug. The rubber insulation on power cords will

dry out and crumble with age. Replace any cord in poor condition, because such a cord is a fire hazard.

Examine the leads on top of the chassis going to the tube top caps. Polish the grid lead clips with sandpaper or scrape them with a knife, squeeze, and adjust them so they make firm contact with the top caps of the tubes. Be sure that each tube shield makes good contact with the chassis, and that the grid leads do not touch the shield.

FIG. 19. Typical locations of alignment screws on: tuning condensers; i. f. transformers; and trimmer condensers. Never tighten or loosen these screws; they are used to adjust tuned circuits, not to hold the parts to the chassis.



## REPLACING PILOT LAMPS

Nearly all radio receivers use pilot lamps to illuminate the tuning dial and to indicate that the receiver is "on." Like any lamps, these burn out with either age or overloading.

The two types of pilot lamps most widely used are shown in Fig. 20. The miniature screw-base lamp shown at A is like a flashlight bulb. The miniature bayonet-base lamp at B has a smooth metal base with two side studs, like an automobile dash lamp. Typical sockets for these pilot lamps are shown with them.

**Removing a Pilot Lamp.** Pilot lamps can usually be removed by reaching in from the rear of the radio cabinet. In some cases, however, (particularly in midget receivers), it is necessary to remove the chassis from the cabinet to get at the pilot lamp. (In the receiver shown in Fig. 11 you can see that the dial scale may be removed to replace the pilot lamps.)

Always make sure that a pilot lamp fits tightly in its socket before declaring it burned out, for the lamps often become loose. If the socket seems oversized, squeeze it a little with your fingers or pliers to get a tighter fit. You can remove screw-base lamps by twisting them in a counter-clockwise direction; bayonet-base lamps by pushing them down slightly and twisting them a small amount counter-clockwise, just as automobile lamps are removed. Some sockets are held on brackets by spring clips. When you find a socket of this type, just pull the entire socket off its mount if that will make removal of the lamp easier.



**Pilot Lamp Ratings.** Pilot lamps are rated for certain supply voltages, and also for the amount of current needed for proper illumination.

Typical operating voltage ratings are 2, 2.5, 3.2, and 6.3 volts, and a few new lamps with these ratings are usually carried by servicemen in their tool boxes. The voltage rating is usually marked somewhere on the lamp; a burned-out lamp must, naturally, be replaced with a new lamp having the same voltage rating. (The 6.3-volt lamps are marked 6-8 volts, which indicates that the lamps will work on any voltage between 6 and 8 volts.)

Different current ratings are also available; typical values are .06, .15, .2, and .25 ampere. To distinguish lamps according to current ratings, the small glass beads (see Fig. 20) supporting the filaments are colored. There are three common values of 6.3-volt bulbs; a brown bead is used to indicate .15 ampere, a white bead for .2 ampere, and a blue bead for .25 ampere.

*Battery sets rarely use pilot lamps. However, a few of the 2-volt types do use the 2-volt, pink bead, .06-ampere bulb. An extra switch is used to turn on these bulbs when they are needed for tuning; otherwise they are turned off to save the batteries. Don't presume these bulbs are burned out if they are not lit, at least until you have operated the lighting switch.*

► On a.c. sets with power transformers, the most important rating for the pilot lamp is its voltage. (You will learn how to identify power transformers later.)

If the markings on a defective lamp are not clear or are missing entirely, you could measure the voltage at the lamp socket terminal with the a.c. voltmeter in your multimeter. Choose a lamp having approximately the same voltage. However, a higher-voltage lamp is quite satisfactory if it gives sufficient light, and will have considerably longer life than a lamp rated lower than the measured voltage. Thus, the 3.2-volt lamp was developed to operate on 2.5 volts, giving adequate illumination and longer life.

In a.c. receivers using power transformers, the filament voltage ratings of the amplifying tubes are a di-

rect guide to the pilot-lamp voltage rating, because in most cases the pilot lamp is operated from a filament winding. This means that the pilot lamp will have the same voltage rating as these tube filaments. However, since there are only two standard a.c. voltages in receivers using power transformers (2.5 volts and 6.3 volts), you could use an elimination procedure. First try a 6.3-volt lamp. If it lights very dimly, then try a 3.2- or 2.5-volt type. In practically all cases, any current rating (any color of glass bead) will do.

► *Universal receivers*, which can operate from either a.c. or d.c. lines, require special consideration. Don't try to measure the voltage across a pilot lamp socket in one of these receivers, because the voltage will be far higher than normal until the pilot lamp is installed. You will learn why this is so in your Lessons in Fundamental Radio Principles. The pilot bulbs used are rated at 6.3 volts, but the current rating is quite important because of the special circuit used.

If you can be sure no one has previously installed the wrong lamp, you can put in a replacement having a glass bead of the same color. If there is any doubt, however, the proper size must be determined from the service information on the receiver.

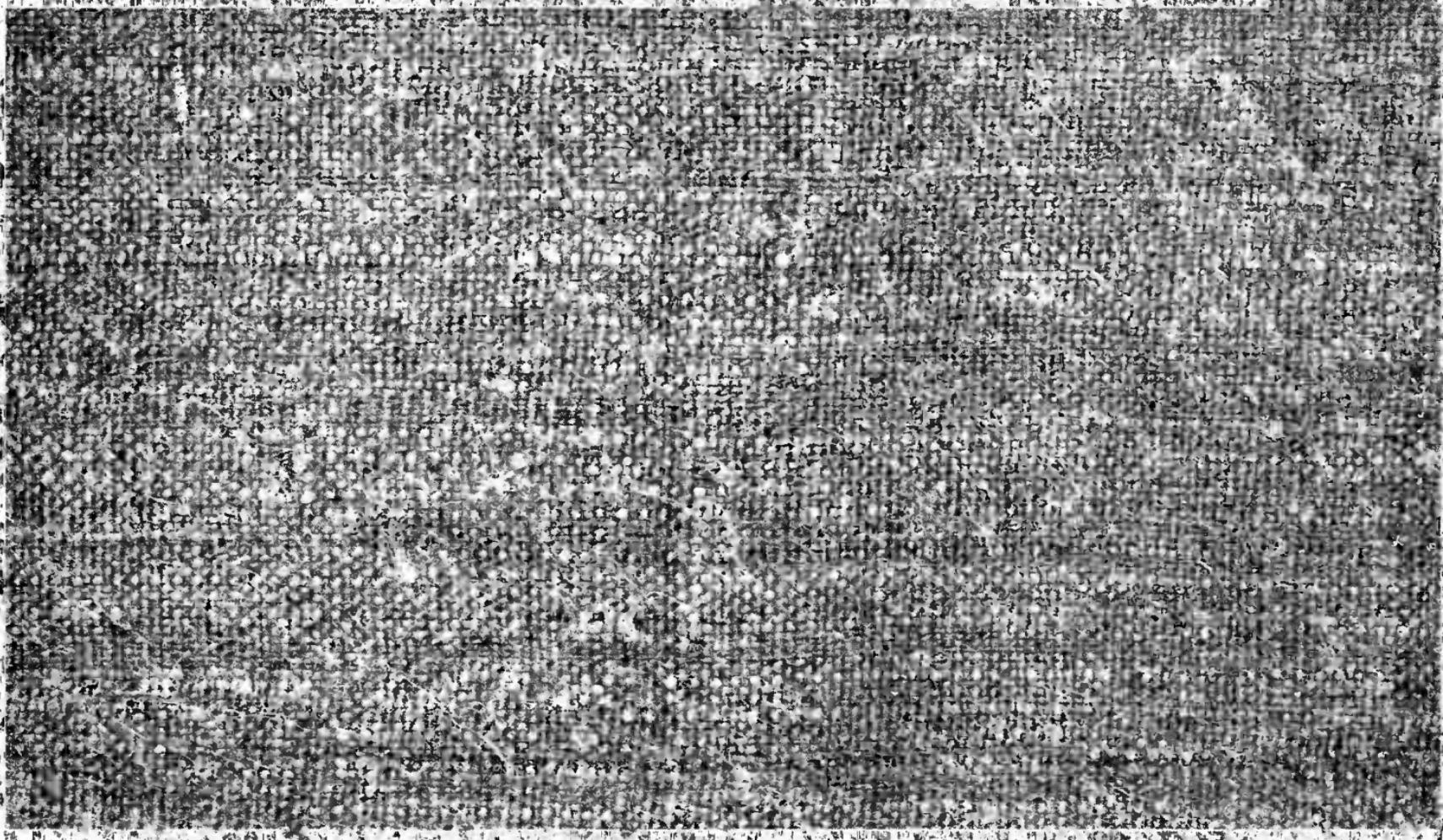
**Finishing the Job.** The foregoing overhauling procedure may be carried out before or after the repair of the defect, as circumstances may require. (Future RSM Booklets will discuss repairs in great detail.) However, check the receiver operation to be sure everything is normal after these procedures. Then, replace the speaker and the chassis in the cabinet by reversing the steps of removal. After doing so, polish the outside of the cabinet carefully with a good grade of furniture polish.

The receiver can now be returned to its owner with both its appearance and its operation improved. Connect it to its antenna and ground, plug in the power cord and make a final check of its operation. If it performs properly, then you have completed a service job —one of which you can well be proud!

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

NATIONAL RADIO INSTITUTE, WASHINGTON D.C.

No. 5 How To Restrung Dial Cords  
and Set Push Buttons  
**RADIO SERVICING METHODS**



# NRI TRAINING PAYS...

Dear Mr. Smith:

When I first started your Course, I couldn't imagine how it would be possible to start servicing radios as soon as you said. But it was true—I started servicing a few months after enrolling. Right now I am operating a spare-time radio business at this University, averaging about 4 or 5 sets a week. I netted a profit of about \$800 in the past 12 months, which isn't bad for a spare-time business.

A.H., Jr., Ohio



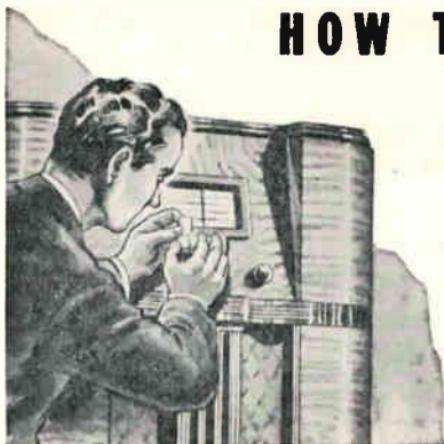
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1949 Edition

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# HOW TO RESTRING Dial Cords AND SET Push Buttons

MOST radio repairs call for considerable technical knowledge, but, if you have a little knack for mechanics, you'll be ready to take on two of the most common repair jobs as soon as you've finished this Booklet. We're going to show you how to repair dial drives, and how to set push buttons, which are two servicing jobs you'll be meeting all the time.

## DIAL-DRIVE MECHANISMS

When you turn a knob to tune a radio, your action changes the settings of condensers or coils within the set, and also operates a mechanism that indicates the frequency to which the radio is tuned (usually by moving a pointer over a dial or a dial past a pointer). When we speak of the dial-drive mechanism, we mean the mechanical system that causes these actions when you turn the tuning knob.

Belt and cord drives are the two types in most common use today. Other kinds of drives have been used—particularly direct drives, in which the tuning knob is attached to the tuning condenser shaft, and friction drives, in which a rubber roller, secured to the tuning knob, bears against a dial secured to the tuning condenser shaft—but these systems are so simple that you can repair them without instructions.

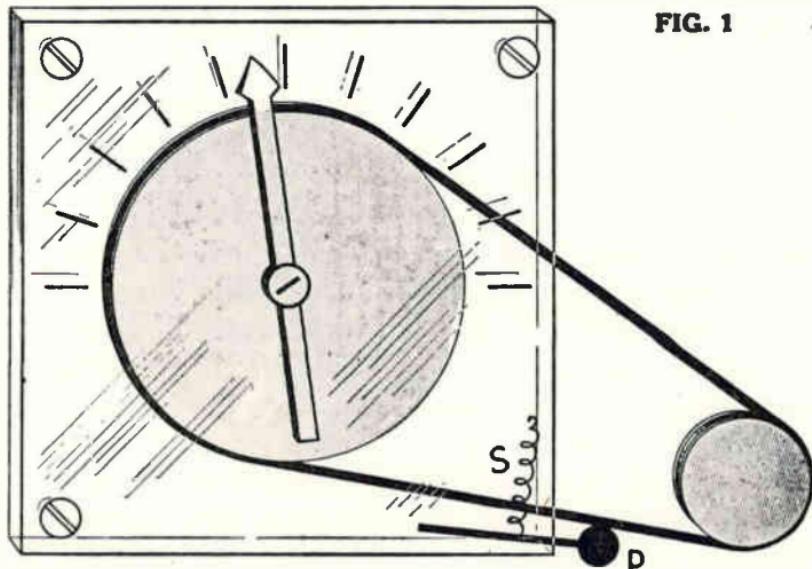
**Belt Drives.** A typical belt drive is shown in Fig. 1. As you can see, there are two pulleys, one mounted on

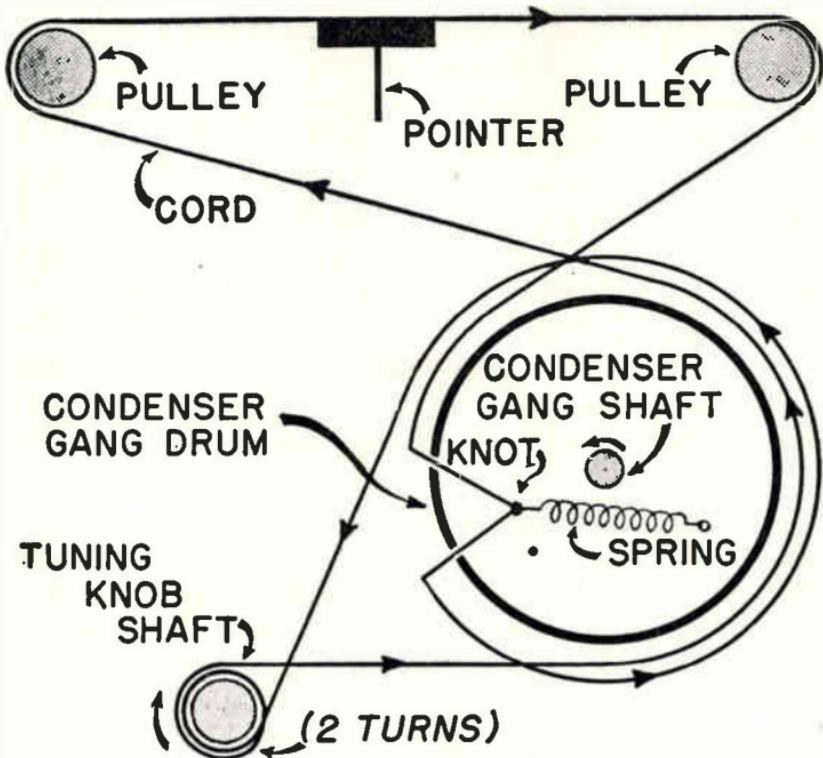
the tuning shaft, the other on the condenser shaft, over which an endless belt passes. Usually there is some way of controlling the belt tension; in the illustration, this is done by the idler pulley *P*, which is held against the belt by the spring *S* with enough force to create the desired belt tension.

Although the dial has been shown as transparent here so you could see how the system works, it is actually made of metal. The condenser shaft projects through a hole in the middle of the dial, and the pointer is fastened to the end of the shaft by a machine screw. The condenser pulley is mounted behind the dial.

**Cord Drives.** Cord drives are usually considerably more complicated than belt drives. Fig. 2 shows one of the simpler forms. Notice that the basic difference between this and the belt-drive system is that the dial cord (usually strong fishline or similar material) is securely fastened to the condenser pulley, or drum, instead of merely running around it as a belt does. In fact, the dial cord is brought down inside the condenser drum (through a slit in the drum rim) and is hooked to a spring that keeps it taut.

Besides connecting the tuning shaft and the condenser drum, the cord also passes over two small pul-





**FIG. 2.** A typical dial-drive system using a cord drive. The condenser gang shaft and the cord move in the direction shown by the arrows when the tuning knob is turned clockwise.

leys. A pointer is clamped to the cord in the length between these pulleys, and, as the arrows show, this pointer slides along a supporting edge from left to right when the tuning shaft is rotated clockwise. Thus, this system gives us a horizontal movement of the pointer instead of the rotating movement produced by a belt drive, and so permits use of the rectangular "slide-rule" type of dial that has become so popular.

Now let's see how to repair belt and cord drives when they become defective.

### REPAIRING BELT DRIVES

The usual defect of a belt drive is that the belt slips, either because it has stretched or frayed, or because the idler pulley does not hold it under tension. There is usually some way to increase the tension on the belt. In the system shown in Fig. 1, for example, the belt can be made tighter by shortening the spring that holds the

idler pulley against the belt. Sometimes the tuning shaft is in a slot, in which case the belt can be tightened by sliding the shaft in the slot. If the belt is stretched or frayed, however, it must be replaced.

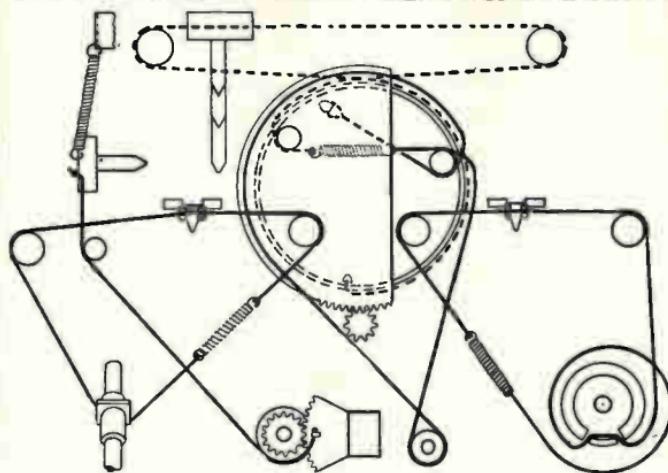
The important thing to watch in replacing a belt is that you have a belt of the right size. There are more than a hundred different sizes in use, and generally the wrong size will not work; either it will be too tight, in which case it will break very soon and make the set hard to tune in the meantime, or it will be too loose, and the tuning system will not work at all. The best way to get the right size is to order an exact duplicate belt for that particular receiver from either your supply house or the set distributor or manufacturer. The make and model number of the set are all you need to know to get the right belt from one of these sources.

► If an exact duplicate belt is not available, you will have to know the precise size of belt you want. One way to find this out is to cut the old belt and measure it carefully. Sometimes, though, the old belt will be missing, or will have stretched so much that a measurement won't give you accurate information. In this case, the best thing you can do is to run a silk cord (which will not stretch) over the pulleys to find the right length.

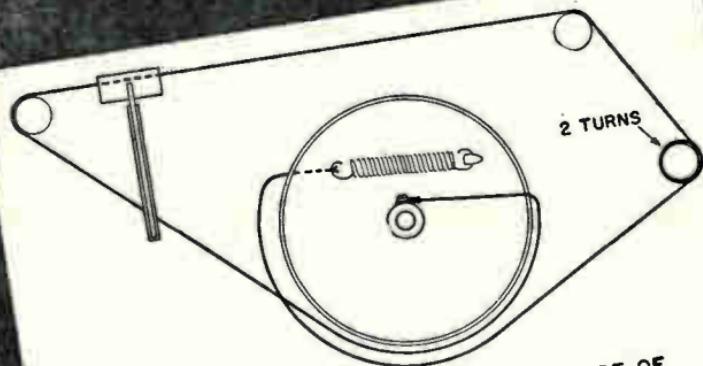
Installation of endless belts is easy. Usually you will have to remove the dial to put one on, and sometimes you must unscrew the bracket holding the tuning shaft so that its pulley can be moved closer to the condenser pulley; then the belt can readily be slipped over the pulleys.

## REPAIRING CORD-DRIVE SYSTEMS

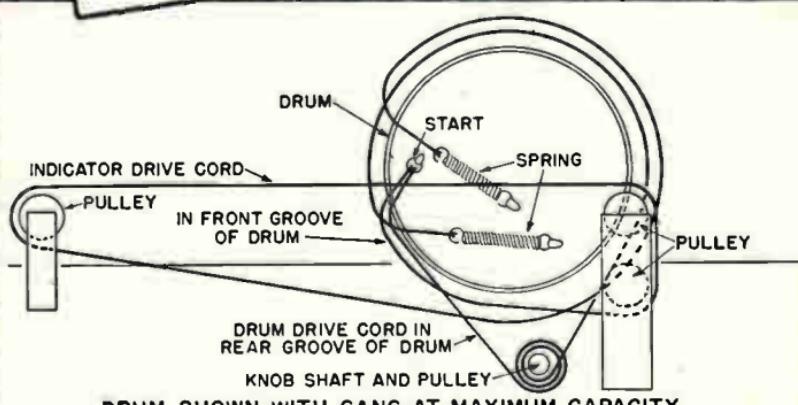
There are so many variations of cord-drive systems that a much larger book than this could not cover them all. However, each manufacturer usually issues diagrams showing how to repair and restrung his sets; these diagrams, and your own mechanical ability, will let you repair almost any system. We've included a number of samples of manufacturers' diagrams in this Booklet to show you what they're like. It would be a good idea for you to build up a file of such information;



DRIVE OF GE 73 RECEIVER. NOTICE USE OF MULTIPLE CORDS AND POINTERS TO INDICATE WAVE BAND, VOLUME, ETC.

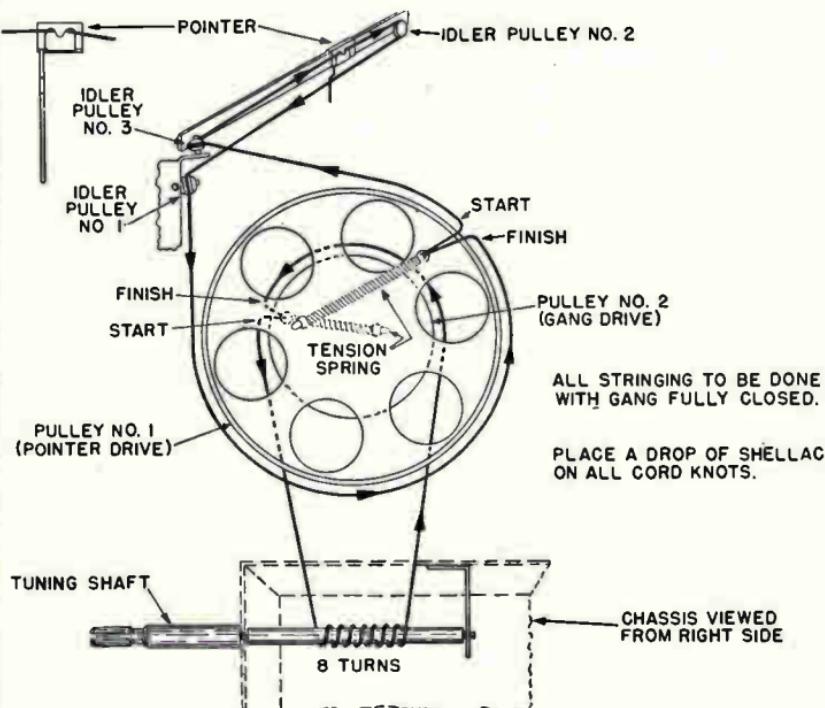


DRIVE OF GE J-64 RECEIVER. NOTICE USE OF SEPARATE ANCHORS FOR CORD ENDS.



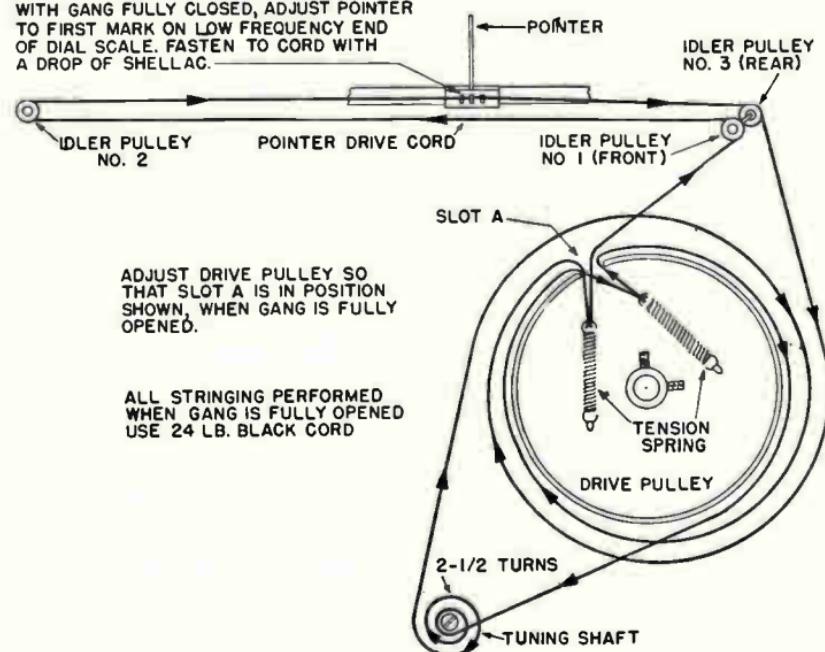
DRUM SHOWN WITH GANG AT MAXIMUM CAPACITY

DRIVE OF RCA U-125 RECEIVER. NOTICE USE OF TWO DIAL CORDS.



DRIVE OF MOTOROLA 10IR21 RECEIVER. NOTICE USE OF TWO DRUMS SECURED TOGETHER.

**POINTER ADJUSTMENT**  
WITH GANG FULLY CLOSED, ADJUST POINTER TO FIRST MARK ON LOW FREQUENCY END OF DIAL SCALE. FASTEN TO CORD WITH A DROP OF SHELLAC.



DRIVE OF MOTOROLA 6IT23 RECEIVER. NOTICE THAT THE TWO DRIVE CORDS ARE COMPLETELY SEPARATE

you can always get the instruction leaflets from the manufacturer, and usually from his distributor.

We're not going to attempt to cover specific drive systems here. Instead, we are going to give you a series of service hints that apply to any system.

► The first is—*be sure you know what the drive is supposed to do*. If you have the manufacturer's diagram, or the old cord is still on the set, trace what happens when you turn the tuning knob. Before you remove the cord, if you don't have the manufacturer's diagram, make a sketch to show where the cord is supposed to go, with arrows to show the direction the cord and the pointer move when the tuning knob is turned. (Generally, but not always, the pointer moves across the dial from left to right, and the condenser gang opens, when the knob is turned clockwise.)

If the cord is not on the set, or has broken and been pulled off the pulleys, you may have to study the set carefully to figure out just what the system is supposed to do. Once you have decided how to make the repair, draw a diagram to show just what you intend doing. This will serve a double purpose: it will keep you reminded of how you are going to make the repair, and, if you find you are wrong, it will show you what *not* to do the next time.

The cord is usually wound around the tuning shaft at least twice, often more, and you must be careful to wind the correct number of turns on the shaft when you install a new cord. If you put on too few turns, the cord will probably slip; too many turns, on the other hand, will tend to bunch up and may jam the system. If the cord is gone, so you can't tell how many turns there should be, try using two or three.

**What Cord to Use.** Ordinary string or thin cotton fishline is *not* satisfactory, because it will stretch. If a thin cord is needed, silk or nylon fish cord is best. A cord with a Fibreglass core and a synthetic braid cover will also work well. Cords of medium thickness (diameter approximately .04 inch) are made of nylon, linen, or cotton; cotton cords of this diameter are satisfactory because they will not stretch at the tensions normally

used. Any fishline you use should have a breaking strength of at least 18 pounds.

Phosphor-bronze wire cords are also available. These are particularly useful in sets where the cord must move a heavy mechanical system. Heavy linen cords are also used in such installations.

Cords usually come in 10- and 25-foot lengths, wound on spools. You can get them from any radio supply house.

**Common Defects.** Several things may happen to cord-drive systems. The cord may lose tension, either because it stretches or because the tension spring does; the cord may slip; the pointer may stick; or the cord may jump off its pulleys, or fray, or break. Let's see what to do in each case.

**Loss of Tension.** If the cord is too loose, it will simply slip around the tuning shaft instead of turning with it. Usually this defect can be remedied by shortening the cord. One way is to knot it again at the point where it is attached to the tension spring inside the condenser shaft pulley. Always use a square knot (shown in Fig. 3), which will not slip. You can put a drop of speaker cement, fingernail polish, or shellac on the knot as an added precaution against slipping.

Sometimes the cord is loose because the tension spring has stretched too much. If the spring allows the knot in the cord to come almost out of the slit in the condenser shaft drum, tighten the spring rather than shorten the cord. Inspect the end of the spring that is not hooked onto the cord. This end is anchored inside the drum, usually either to a bent-up metal ear or in a hole. There may be other ears or holes, farther from the slit, in which the spring can be anchored; if so, try one of them and see if the cord tension is sufficiently increased.

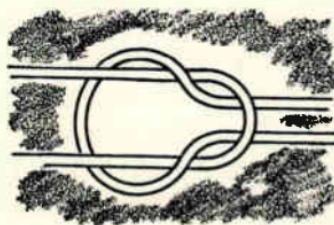


FIG. 3. This shows how to tie a square knot, which is the best knot to use to fasten the ends of a dial cord together. If you are not familiar with this knot, practice tying it a few times with this picture before you use it as a model.

If not, or if no other anchor points are provided, you can either shorten the spring or install a new one. To shorten the spring, cut off a few turns from the anchor end with a pair of cutting pliers, and bend the cut end to form a new hook.

If a shortened spring is still too weak, install a new one. The exact size is not important, but be sure it is strong enough so that it will not be stretched out of shape when it is installed—otherwise it will quickly lose its tension.

When you install a new spring, or shorten an old one, be careful not to let the cord slip off the pulley system—if it does, you may have to restring the whole drive. You can hold the cord in place by pressing your thumb firmly over the slit where the two parts of the cord emerge from the condenser shaft drum. If you need both hands for the spring, put a piece of scotch tape over the slit instead.

Be sure you seat the end of the spring firmly in its anchor hole or around its anchor post. Usually it's easiest to do this by grasping the end of the spring with a pair of needle-nose pliers, stretching it slightly past the anchor point, then allowing it to relax and guiding it into or around its anchor as it does so.

**Slipping Cord.** If the cord seems tight, but slips on the tuning shaft, probably grease or oil has gotten on it. You can remedy this condition by working powdered rosin into the cord. A commercial non-slip compound, having a rosin base, is available in stick and liquid form. This compound has the advantage that it shrinks the cord slightly in drying, thus giving increased tension as well as eliminating the effects of oil or grease.

**Sticking Pointer.** As we said earlier, cord drives are always used with slide-rule dials, in which a pointer moves horizontally over a long, rectangular dial that resembles a slide rule. If the pointer sticks or binds, the cord will get taut on one side of the pointer and loose on the other, and may jump off its pulleys; if the cord does not jump off, the tuning knob will at least be difficult to turn.

The pointer of such a dial usually slides along a metal

track on the edge of the dial, or on the dial plate edge itself. If the pointer sticks, inspect the track for burrs that may cause increased friction. Remove them with fine sandpaper, and spread a *light* film of vaseline over the track. (Don't get oil or grease on the cord.) Make sure the dial lights do not interfere with the pointer movement; if they do, bend their brackets slightly.

**Cord Jumps Off Pulleys.** Provided the cord is tight enough so that it should normally stay on its pulleys, the usual reason it jumps off is that it is caught somewhere in the system. Turning the tuning knob then tightens part of the cord and loosens part of it until the loose part finally slips off its pulleys altogether. The usual cause is a sticking pointer, as we just said. Whatever the cause, remedy it, then put the cord on again. Make sure that it is tight enough to stay.

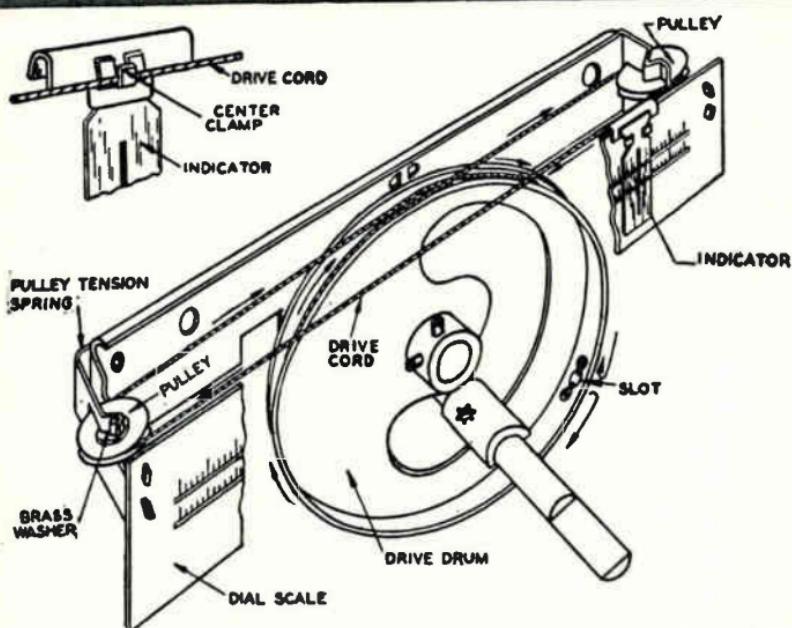
**Frayed or Broken Cord.** Either of these must be replaced. The broken cord is usually harder to replace, because the drive system will probably be completely unstrung, and you will have to figure out how the system works. Replacement is not difficult if you have the manufacturer's sketch of the stringing arrangement. If you do not, be sure to make a diagram of the system. If the cord is frayed but still in place, make the diagram before you remove it.

Turn the condenser gang either fully closed or fully open (maximum or minimum capacity) before you start restringing, then string the drive in a direction such that any tension you put on the cord will tend to keep the condenser in position. This will let you pull the cord taut during the operation without fear of its slipping. Manufacturer's instructions usually specify whether the gang is in or out for the direction of stringing shown. (Be sure you cut enough cord off the spool to do the job. It's better to waste a few inches than to have to waste the whole piece because it is short by half an inch.)

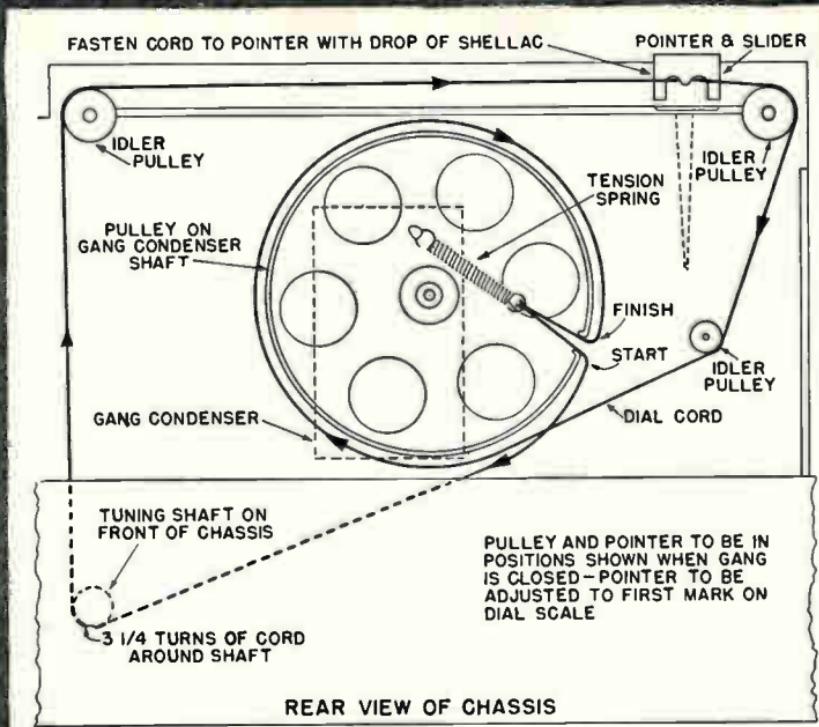
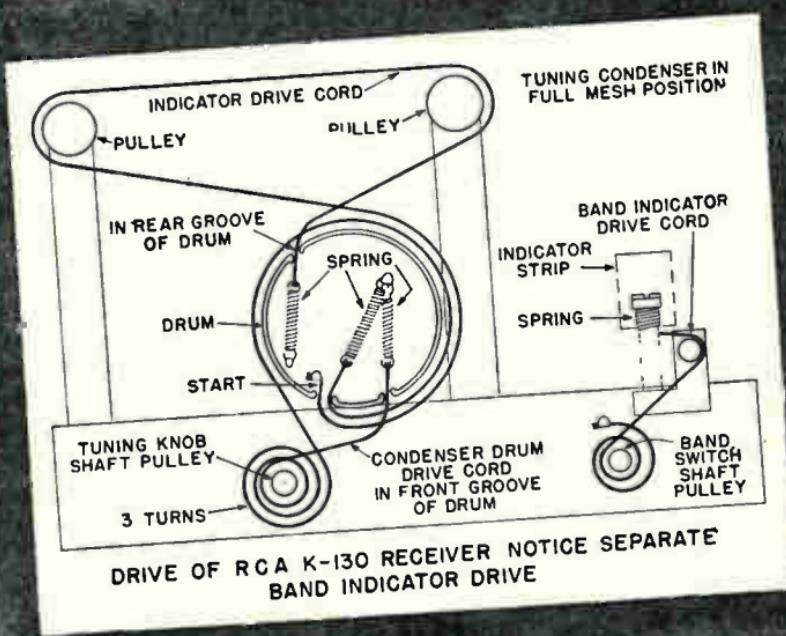
Finally, connect the pointer to the cord in a temporary manner. (Most pointers clip on the cord, but in some systems the cord is wrapped around a stud on the pointer slider.) See that it is at the high-frequency end

of the dial when the condenser gang is full out, and goes toward the low-frequency end when the gang is turned in. You may have the system strung backwards, in which case all you can do is try to smile and do the job over.

Turn on the set and check the accuracy of the pointer setting. If necessary, adjust the pointer position until both the frequency of the station being received and the frequency indicated by the pointer are exactly the same. Then, place a drop of speaker cement or collodion on the pointer clip to bind it to the cord. It's worth while to take a little trouble with this, because your customer may find it irritating to have the pointer indication even a little off what it should be. In fact, you can demonstrate to him how accurately the pointer is set when you're finished.



DRIVE OF GE-U51 RECEIVER. NOTICE USE OF FLAT SPRINGS TO HOLD PULLEYS.



DRIVE OF MOTOROLA 51F12 RECEIVER NOTICE USE OF EXTRA IDLER PULLEY

## **Setting Up Push Buttons In Radio Receivers**

Automatic tuning, in which a set is tuned to a desired station simply by pressing a push button, has become an almost universal feature. Adjusting the push buttons is an easy job, but one a set owner seldom attempts. If the button doesn't bring the station in "on the nose," or if he wants a different station, he will usually call in a serviceman.

► There are three main types of automatic tuning systems—*electrical*, *mechanical*, and *electro-mechanical*. In an electrical system, pushing in the button switches a preadjusted set of trimmer condensers or adjustable inductances (coils) into the tuning circuits of the radio, and, at the same time, releases any button previously pushed.

In a mechanical system, the motion produced by pushing in the button actuates a lever system that turns the regular gang tuning condenser of the set to the desired station.

► In an electro-mechanical system, pushing in the button (or, in some systems, turning a telephone-type dial) starts a small electric motor that turns the gang tuning condenser to the desired station. This is the only system that is particularly complicated. We're going to cover this system and its variations further along in your regular Course. It would be best for you not to attempt to adjust an electro-mechanical system until you've studied the lesson on automatic tuning systems—unless you have the manufacturer's adjustment instructions for the set in question. These instructions are usually complete enough for you to make the adjustment without difficulty, if you follow them closely.

However, electro-mechanical tuning is used in but few modern sets. In this Booklet, we're going to explain how to adjust electrical and mechanical systems—the kind servicemen are called upon to adjust almost every day. We will give you the general procedure for all sets instead of instructions for just a few specific radios. You can easily take care of any small variations you find in a particular set. Our instructions will be for setting up all the buttons in a set; if you're interested in

adjusting just one button, follow the procedure only until that button is set up.

## ADJUSTING ELECTRICAL SYSTEMS

If you have the manufacturer's instructions for the set you're working on, read them carefully. They may contain some short-cut methods that apply only to that set (which, of course, we will not give here). If you don't have them, the method described in the following paragraphs will work perfectly well.

First, turn on the set and let it warm up for at least twenty minutes. This will prevent drifting of the adjustments after the set reaches operating temperature.

While you're waiting for the set to warm up, count the number of buttons available for station selecting. Ignore any that are used for other purposes (for turning the set on and off, for manual tuning, for phonograph operation, etc.). Have the customer select a corresponding number of stations. These should be local or medium distant stations that can be received well. (Naturally, if you are merely readjusting buttons that have drifted off their settings, you will reset them to the originally selected stations unless the owner wants a change.) Look up the frequency of each station in a log book or the radio listings in the newspaper, then list each station in order of increasing frequency (lowest frequency first on the list).

► Next, locate the trimmer adjustments on or above the chassis (or directly behind the push buttons). There will be two of these for each button, and they will be marked to indicate the frequency range to which they can be tuned. (For an example, see Fig. 4.) Assign a station to each button on the basis of these frequency ranges, then make a rough sketch to show which station has been assigned to each button. If the customer has selected a station for which no tuning trimmers are available, (or two stations that need the same set of trimmers), have him pick some other station (or one of the two) and tell him he'll have to use manual tuning for the one you cannot set up.

You can usually reach these trimmer adjustments from the back of the cabinet, sometimes by removing a

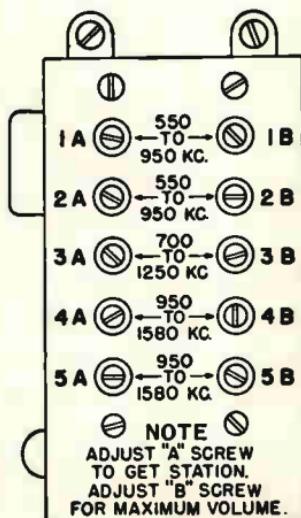
back cover. On a few sets, you can reach them from the front of the cabinet by removing either a cover plate or the escutcheon plate through which the push buttons protrude.

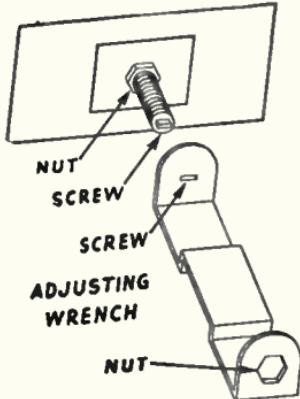
When the set has warmed up sufficiently, you're ready to adjust the first button. Tune the set manually to the station selected for the button, then press in the button. Now turn the *oscillator* trimmer (sometimes called the tuning or station-selecting trimmer) for that button until you get the same program. (You can identify the oscillator trimmer by the fact that you will hear several stations as you turn the adjusting screw.)

Next, turn the other trimmer (usually called the *antenna* trimmer) for that button until maximum volume is produced. This is not a critical adjustment. Readjust the oscillator trimmer carefully until the station is perfectly tuned. Return the set to manual tuning to make sure the station is heard at least as well on automatic tuning as it is on manual. (Usually the automatic tuning will be slightly better, since the trimmer condensers can be adjusted more accurately than the gang tuning condenser.)

This completes the set-up for one button; adjust each other button in exactly the same way. Since there's always a chance that you have tuned a button to another station carrying the same program as the one you want, check your work by pressing one button after another during the station announcement period. If the station you want is a local, you can readily check by comparing the background noise heard on automatic and manual tuning; if the background is much noisier on automatic tuning, you probably have tuned to some other station on the network.

FIG. 4. Typical trimmer adjustments. The oscillator trimmers (marked A) are at the left, the antenna trimmers (marked B) at the right. In some radios, one set of trimmers is above the other.





**FIG. 5.** Coaxial trimmers. The nut adjusts the antenna trimmer, the screw adjusts the oscillator trimmer.

**Precautions and Hints.** Never turn a trimmer condenser screw more than a few turns out (counter-clockwise) or it will fall out. Never apply force to a screw.

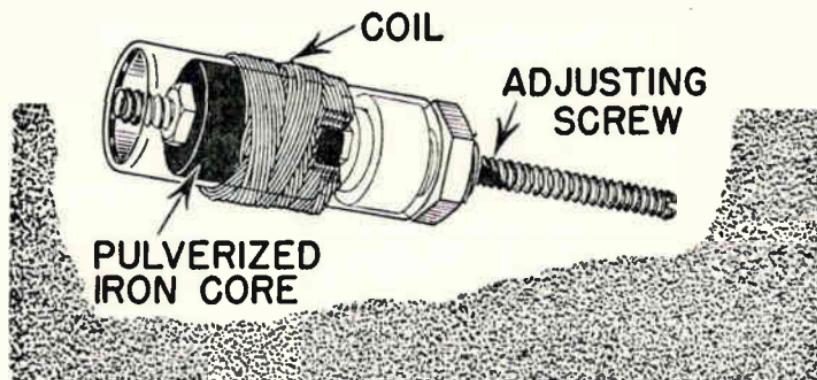
If you can't bring a station in with the oscillator trimmer, loosen the antenna trimmer a turn or two and try again.

► You may sometimes meet coaxial (one inside the other) adjustments like that shown in Fig. 5. Special wrenches are made for these, like the one shown.

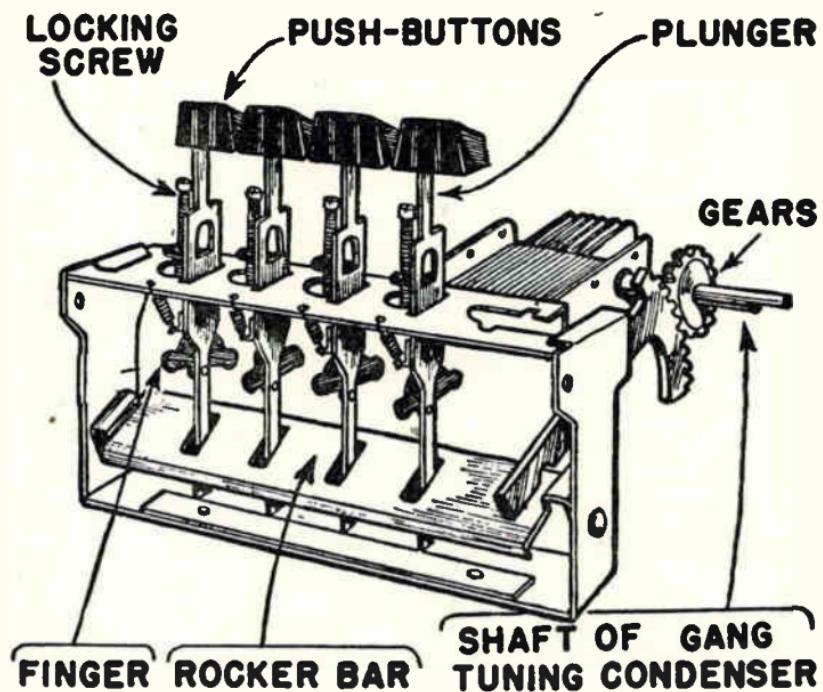
► Adjustable inductances called *permeability-tuned coils* are often used in place of trimmer condensers. A typical one is shown in Fig. 6. To produce the same change in frequency, the adjusting screw of a permeability-tuned coil must be turned many more times than that of a trimmer condenser.

## ADJUSTING MECHANICAL SYSTEMS

There are two types of mechanical automatic-tuning systems. In one, the rocker-bar type, each button has its own locking adjustment. In the other, the cam-and-



**FIG. 6.** Permeability-tuned coils like this are used in many sets in the oscillator circuit. Once tuned, such a coil will usually stay in adjustment for a long time.



**FIG. 7.** Rocker-bar tuning mechanism. Since this is a mechanical system in which movement of a push button turns the shaft of the tuning condenser, you must push buttons in all the way to get the desired stations. Pushing the button in only part way will not turn the tuning condenser enough. Be sure your customers understand this.

lever type, one locking adjustment takes care of all the buttons.

**Rocker-Bar Mechanisms.** A typical rocker-bar mechanism is shown in Fig. 7. The rocker bar is a flat pivoted metal piece that is connected to the gang tuning condenser through a gear system in such a way that the angle to which the rocker bar is rotated determines the condenser setting. Each button is on a plunger that goes through a slit in the rocker bar. On each plunger is a metal finger that can be set to any desired angle by adjusting a screw. When a button is pushed, the finger on its plunger bears on the rocker bar and turns the bar to the same angle as the finger; this changes the setting of the gang tuning condenser, and so tunes the radio.

To set up the buttons of a rocker-bar system, take the same initial steps as you do with an electrical sys-

tem: turn on the set and let it warm up, have the stations selected, then list them and assign them to buttons. You don't have to consider tuning ranges, because any button can tune any station. It is usually best, but not actually necessary, to assign stations to the buttons from left to right in the order of increasing or decreasing values of frequency.

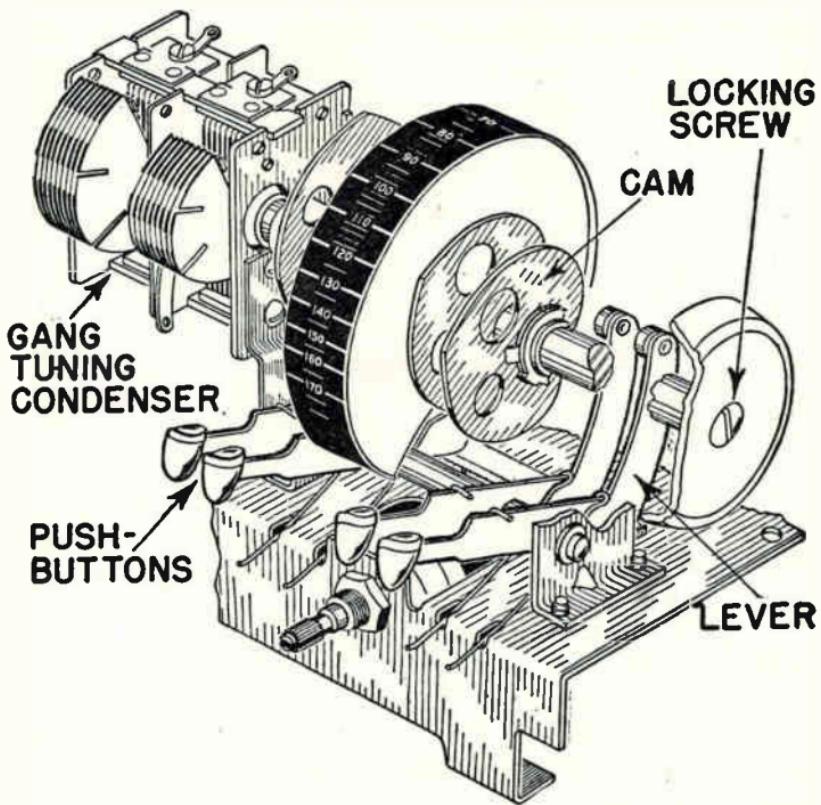
While you wait for the set to warm up, locate the adjusting screws. These are always accessible from the front of the receiver, but you may have to remove the push buttons, remove the station tabs from the buttons, remove the station tabs from the escutcheon (the ornamental plate around the buttons on the panel), or remove the escutcheon to get at them. In some sets, the push buttons themselves serve as the adjusting screws. If you have the manufacturer's instructions, they will tell you where the screws can be found.

Set up each button as follows: Back off its adjusting screw. Press the button in and hold it in. Carefully tune in the station desired for that button with the manual control. Run in the adjusting screw as far as it will go. Release the button.

That's all you need do to set up one button; set up each of the others the same way. Check your work when you're through by pressing each button in turn.

***Cam-and-Lever Mechanisms.*** A typical cam-and-lever mechanism is shown in Fig. 8. The cams—heart-shaped metal discs—are secured to an extension of the gang tuning condenser shaft by friction washers. A single locking adjustment, when tightened, locks all cams to the shaft simultaneously. The push buttons are mounted on the ends of pivoted levers. When a button is depressed, a roller on the other end of its lever is forced against one of the cams; this turns the cam, and the shaft to which it is locked, to the point where the roller reaches the bottom of the V of the cam.

To set up one of these systems, take the same initial steps you would for a rocker-bar mechanism: First, warm up the set and assign stations to buttons. Then locate the locking adjustment. This may be a screw in the center of the manual tuning knob, as it is in the



**FIG. 8. Cam-and-lever mechanism.** Mechanical systems like this one and the rocker-bar mechanism (FIG. 7) are used mostly in small and inexpensive sets. They seldom have more than four or five push buttons.

mechanism in Fig. 8, or a knurled screw on the side of the receiver, a wing nut on the side of the dial assembly, a screw accessible from the back of the receiver, a screw exposed by removing the push-button escutcheon or removing a snap-in button on the escutcheon, or a screw reached through a hole located below the tuning unit. Sometimes the tuning knob itself must be pushed in or pulled out, then turned, to unlock the cams. The manufacturer's instructions, if you have them, will show you where the adjustment is.

Once you have found the adjustment, loosen it. Firmly push down the first button to be set and carefully tune the set to the desired station with the manual control. Be sure to hold the button depressed until you are through tuning. Then release the button, *but do not*

*touch the locking adjustment.* Repeat the process until all the buttons have been set up; then, and only then, tighten the locking adjustment.

## FINISHING UP (ALL SYSTEMS)

No matter what kind of automatic tuning system you adjust, be sure to give it a final check by comparing push-button reception with manual-tuning reception for each station. If manual tuning produces better reception on any station, readjust the automatic tuning for that station.

A sheet of tabs on which are printed the call letters of all U. S. stations is usually supplied with automatic tuning sets. After setting up the buttons, secure the appropriate tab for each on the button or in the escutcheon surrounding them. When call-letter tabs are not furnished, get the sheets from the distributor of the set or from your radio parts supplier.

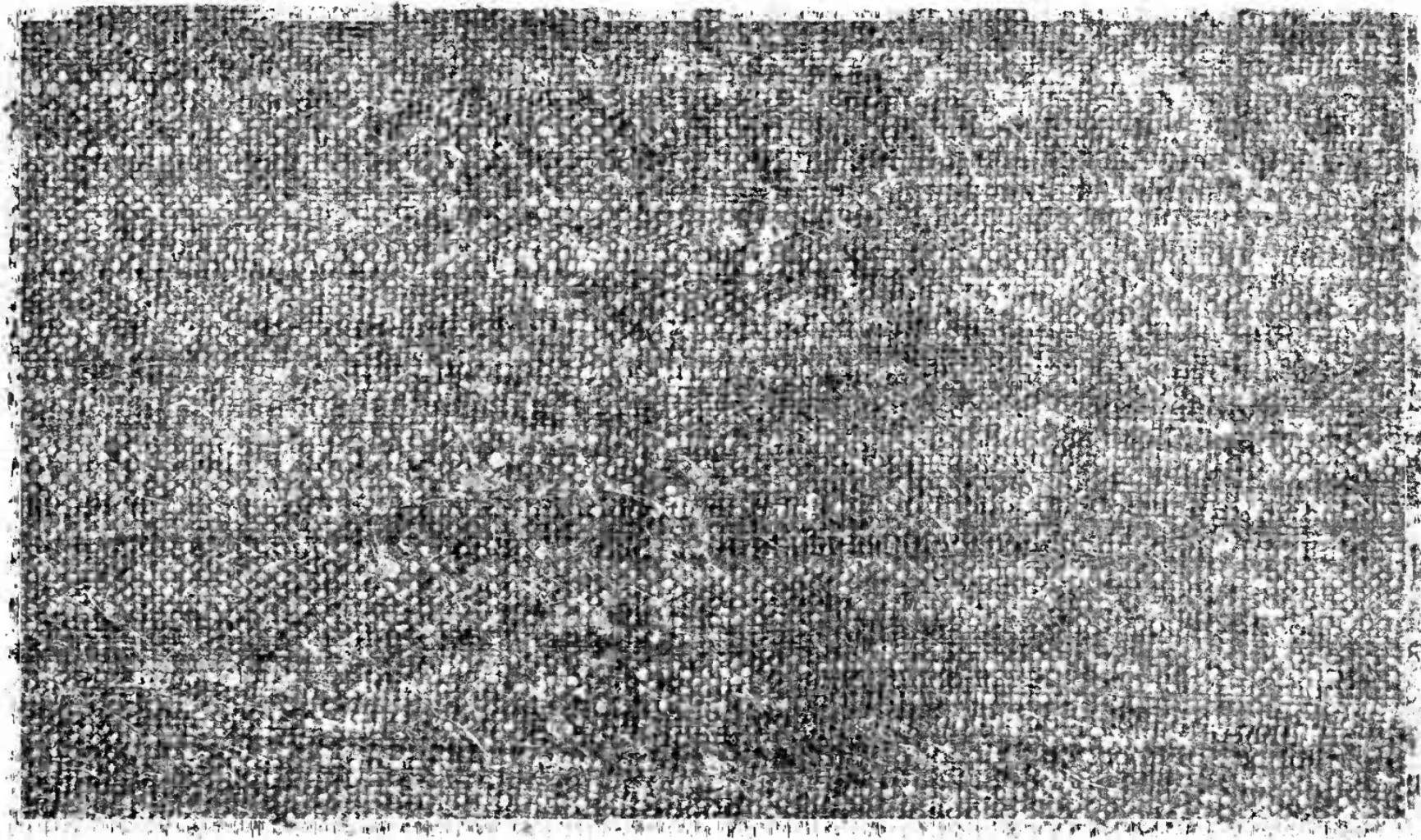
► Whenever possible, demonstrate the set to the customer in his own home. Press each button to show that it works as it should, and make sure he knows how to operate the automatic tuning system. You may think that anyone can operate automatic tuning—but a surprisingly large number of people don't realize that the buttons must be pressed in all the way in a mechanically-tuned set, and some even forget that an electrically-tuned receiver must be switched from manual to automatic and vice versa. You'll build good-will, and save unnecessary call-backs, by giving a short demonstration of every set you adjust.

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THE N. R. I. COURSE PREPARES YOU TO BECOME A  
**RADIOTRICIAN & TELETRICIAN**

(REGISTERED U.S. PATENT OFFICE)

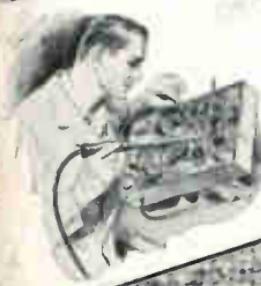
(REGISTERED U.S. PATENT OFFICE)



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

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 6 How To Test and Replace  
Resistors and Volume Controls  
**RADIO SERVICING METHODS**



# NRI TRAINING

# Pays . . .

Dear Mr. Smith:

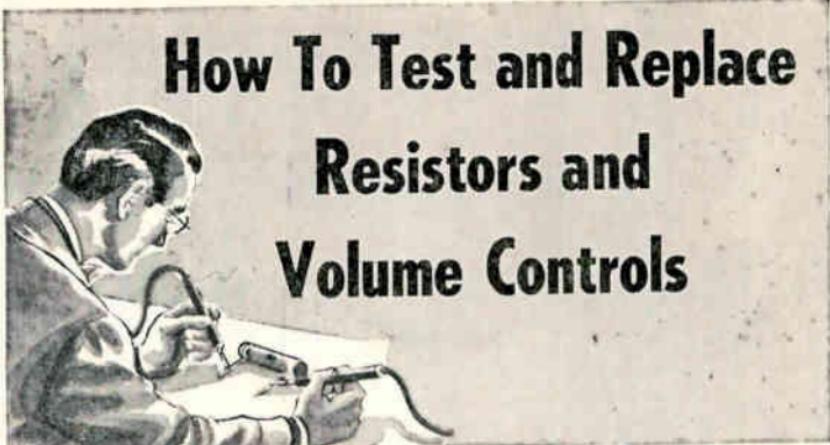
I want to tell you how pleased I have been with your Course. Frankly, I was rather dubious about getting an education through a correspondence Course when I started, but I was honestly more pleased with the Course than I can tell you. I only regret that I didn't take it while in high school instead of after graduating from college. I have cleared several times the cost of the Course already from spare time work.

P.R.F., Texas



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



# How To Test and Replace Resistors and Volume Controls

YOU are now ready to learn how to test and replace radio parts. From this RSM Booklet, you will learn how to deal with fixed and variable resistors; later Booklets will take up the testing and replacement of condensers, coils, and other radio parts. (Remember—these are the *mechanical* procedures of servicing, which are undertaken only after tests have isolated a part that may be defective. Your Lessons in Radio Fundamentals and later RSM Booklets will teach you the methods of isolating defective parts.)

At this moment, you may not be ready for all the information this Booklet gives you. We suggest you read it through now without worrying about any sections you may not understand completely. Retain mentally the facts that are useful to you now, and review the Booklet a few times when you've gotten farther along in your Course. You'll need all this information later on, when you're engaged in actual servicing.

## RESISTOR DEFECTS

First, let's learn something about the defects found in each type of resistor. In the following, notice how the manner in which each is made determines what may be the trouble. Hence, it pays to know how radio parts are constructed—this knowledge helps you see what may go wrong.

**Carbon Resistors.** These, the most common fixed resistors, are subject to several possible defects. An open

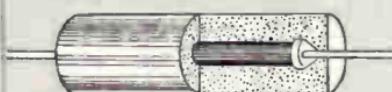
# TYPICAL RESISTORS

## CARBON



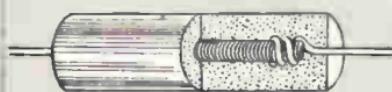
Carbon resistors are made of carbon granules mixed with a binder (bakelite or a ceramic), cut in a rod-like shape, and baked. After leads are attached, bakelite is molded over the assembly.

## METALLIZED



A metallized resistor is made by coating a glass rod with resistive material. Usually bakelite is molded over the metallized rod. Such a resistor is very stable in its value.

## WIREWOUND



A wire-wound resistor is made by winding a resistance wire, such as nichrome, on a porcelain or bakelite tube or rod. The entire device is then coated with a vitreous enamel, a cement, or a special varnish.

## FLAT WIREWOUND



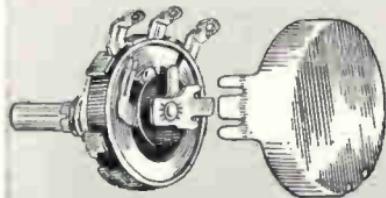
A flat wire-wound resistor is made by winding resistance wire on a bakelite or fiber form. The entire unit is then molded in bakelite, or wrapped in insulating paper, and cased in a metal container.

## WIREWOUND POWER



A wire-wound power resistor is a large wire-wound resistor fitted with taps at various points along its length. Some types are equipped with variable taps, others have only fixed taps.

## VARIABLE



A variable resistor consists of a resistance element with a slider contact. The rheostat has only two outside connections; one to one end of the resistance element, the other to the slider contact. Another type, known as a potentiometer, has a connection at each end of the resistance element and a third connection to the slider.

circuit is common, as carbon resistors are easily broken, and they will open if excessive current flows through them; this current burns away the carbon particles in a section of the resistor. Also, they decrease materially in resistance when a current somewhat above their rated current flows through them. This last peculiarity may upset the circuit conditions in the stage in which they are used. The resistor may return to its normal value when it becomes cool, but eventually this decrease in value may become permanent.

Carbon resistors rarely short-circuit internally. Many are so molded that the resistance element is completely surrounded by the binder material, which acts as an insulator. If you are careful to bend the leads so they do not touch other leads or other parts, there is little likelihood that a carbon resistor will cause a short circuit in a set.

**Metalized Resistors.** Like carbon resistors, these also can open internally, for excess current will burn away the resistive material and leave no path through which current can flow. However, because of the strength of the glass rod, these resistors are not easily broken. They seldom change in value.

**Wire-Wound Resistors.** Excess current flowing through a wire-wound resistor will cause the resistance wire to melt at some point and thus open the circuit. Wire-wound resistors seldom break or change materially in value. However, the method of fastening the connecting leads may permit a poor contact to develop at the clamp.

► Flat wire-wound resistors seldom break or change materially in value, but they do open (the resistance wire burns apart) when excess current flows through them, and poor contacts sometimes develop inside their cases between the leads and the resistance element. Occasionally, the resistance element will short through the insulating paper to the metal container. (One type of flat wire-wound resistor is known as a Candohm, from "canned ohm," because the resistance is placed in a metal container.)

► Wire-wound power resistors have the same troubles

as ordinary wire-wound resistors. However, individual sections usually are affected, rather than the entire unit.

**Summary of Troubles.** You can see that fixed resistors may open internally, change in resistance value, have loose terminals, or short-circuit to other parts or leads. Now, let's see how to check resistors for these faults.

## BURNED-OUT OR OPEN RESISTORS

When a resistor has been severely overloaded, it will sometimes be blackened and blistered, or even burned almost in half. Obviously, you need not check such a resistor—just reach for a replacement.

However, the external appearance of the resistor does not usually indicate anything. An open resistor can look just like a good one. You must use the ohmmeter section of your multimeter to detect the difference.

► If you are interested only in finding out whether or not a resistor is open, you need not bother to read the ohmmeter scale accurately. If the battery within the ohmmeter can force a current to flow through the resistor and thus cause a meter reading, the resistor is *not* open. If you get no reading (the meter pointer does not move), the resistor *is* open. To make such readings, use the highest ohmmeter range of your test instrument. If this range will indicate higher values than the largest-valued resistor in the set, then you can check *any* resistor and get a reading on the ohmmeter scale if the resistor has continuity (is not open). However, any resistor having a higher value than the highest ohmmeter range will not permit a noticeable pointer movement—don't assume such high-value resistors are open unless you have other reasons to suspect them.

► After setting the multimeter controls to the highest ohmmeter range, how does one check a resistor for an open? If the resistor is disconnected from everything, you need only touch its terminals with the ohmmeter test probes, as in Fig. 1, and watch the meter for a reading.

Sometimes the same simple procedure can be fol-

lowed when checking a resistor that is connected into a circuit. However, there are two important precautions to observe when you use an ohmmeter to make tests within a radio:

1. *ALWAYS be sure the receiver is turned OFF. If the receiver operates from batteries, COMPLETELY DISCONNECT them. Otherwise your ohmmeter may be ruined by excess current.*

2. *Disconnect one end of the resistor being checked, when shunt paths may give false readings.*

**Shunt Paths.** Shunt paths occur whenever parts in parallel allow more than one path over which current can flow. This will cause false readings. For example, suppose you wish to check voltage divider resistors  $R_1$  and  $R_2$  in Fig. 2. You would put one ohmmeter test probe on the end of  $R_1$  that goes to  $B_{++}$ , and the other on the end of  $R_2$  that goes to the chassis. (The chassis is indicated by the ground symbol.) You might expect the ohmmeter to read 40,000 ohms, the combined values of  $R_1$  and  $R_2$  (25,000 ohms plus 15,000 equals 40,000 ohms).

However, even a meter reading near the proper value is not definite proof that these resistors are in good

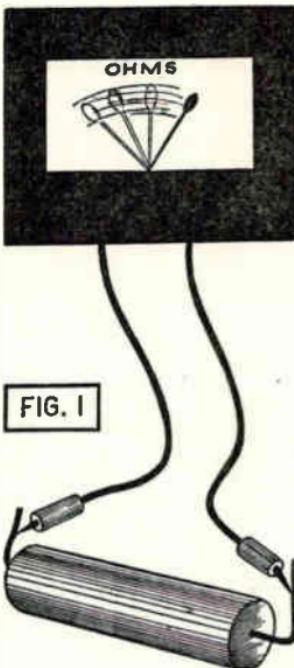
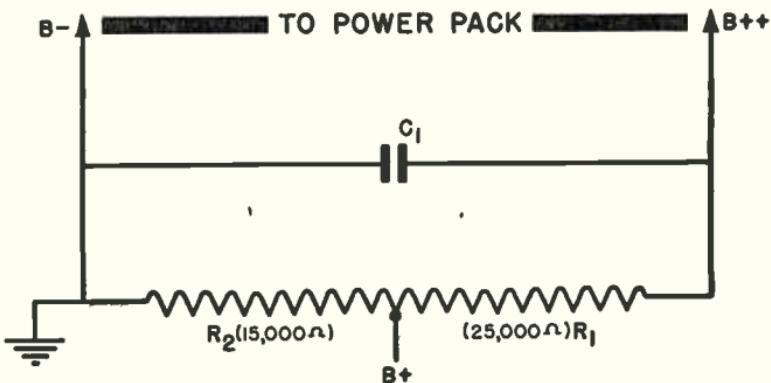


FIG. 1

FIG. 2



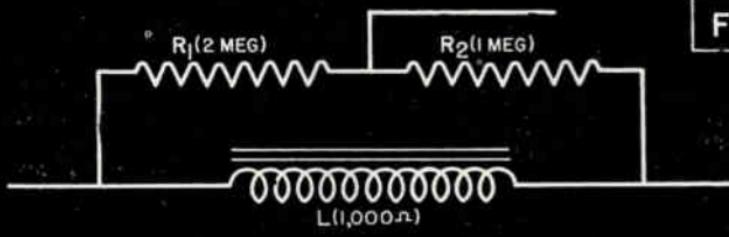


FIG. 3

condition. Perhaps one of them is actually open and condenser  $C_1$  is leaky.\* Notice that condenser  $C_1$  connects directly across  $R_1$  and  $R_2$ . If the condenser is leaky, there will be a direct current path through the condenser as well as through the resistors.

Fig. 3 shows a voltage divider connected across a coil (a fairly common circuit in power-supply filter sections). Here, the coil creates a shunt path for either resistor. If you put your ohmmeter test probes across the terminals of resistor  $R_2$ , you would actually have the circuit shown in Fig. 4; there would be a path through  $R_1$  and  $L$ , which are effectively in parallel with  $R_2$ . In the same way, if you connected your ohmmeter test probes across  $R_1$ , the ohmmeter current would flow through  $R_2$  and  $L$ .

Therefore, unless you know definitely that there is no possibility of shunt paths, unsolder one end of a resistor from the circuit before you check it. You can then apply the test probes between the two terminals of the resistor and be sure that you are checking only that part.

► Naturally, the fact that you are looking for continuity does not prevent you from reading the resistance value on the ohmmeter scale if you want to. At times this is very desirable, because it helps you to identify the resistor being checked.

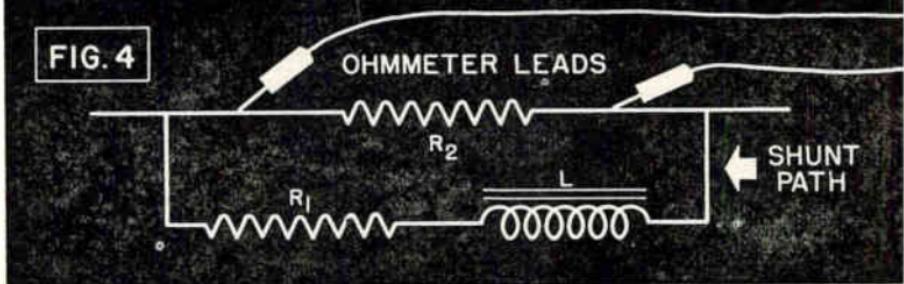
## CHANGES IN RESISTANCE VALUES

Let us now suppose that the operation of the radio

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\*Condenser failures will be taken up in another RSM Booklet. For now, just remember that condensers sometimes "leak"; that is, their insulation breaks down, and they act like resistors.

FIG. 4



has led you to suspect a change in resistance value. To check this, you will have to read the ohmmeter, rather than just notice whether or not its pointer deflects.

Of course, before you can say definitely that a change has taken place, you must know the original value of the resistor. You can find this from the service information or schematic diagram of the radio, or you may know enough about the circuit and the use of the resistor to be able to judge what its value should be. (Sometimes you will find that a resistor is marked with its original value, either by a stamping, or by the use of colors. We shall describe these methods of marking later.)

Once you know what the value ought to be, measure the actual resistance of the resistor with your ohmmeter. The ohmmeter scale is always more accurate near the center of the scale, so, if possible, choose a range that will give a reading nearest the center of the meter scale. However, except for accuracy, it makes little difference which range is used, as long as the deflection can be read.

Again, be careful about shunt paths. Disconnect the resistor if there is any doubt about there being a shunting path.

### LOOSE TERMINALS

In practically all cases, loose terminals on a resistor will cause the receiver to be noisy—a characteristic frying, crackling sound, along with the desired sounds, comes from the speaker. If you suspect a certain resistor of being the source of noise, you can check it by leaving the receiver turned ON and wiggling the connections on that resistor. It is best to use an insulated test probe or

wooden stick for this. (Sometimes a serviceman grasps terminals with a pair of pliers to wiggle them. There is always danger of getting a severe shock when one does this, so we don't recommend it.) If wiggling the lead causes the particular noise to come from the speaker (or makes it louder), then the resistor is probably faulty. However, remember that moving a lead may move other parts also. There may be a loose connection at the other end of that particular wire. Be careful to introduce the least possible disturbance, so that you can be more certain you have found the defect.

► You can also use an ohmmeter to check the resistor for loose terminals. With the set turned *OFF*, clip the ohmmeter test probes to the terminals of the suspected resistor, then jar or wiggle the terminals. (It is desirable to disconnect the resistor from the other parts when making this test, so that the reading will be accurate.) If there is a loose terminal, the ohmmeter reading will vary as the connecting leads are moved.

## SHORT CIRCUITS

In practically all cases involving resistors, short circuits occur because the resistor or its leads are allowed to touch the chassis or other parts. Watch for such conditions and you'll seldom have trouble.

Of course, as we said, the flat wire-wound resistor known as the Candohm will sometimes short between the resistance element and the metal container. To check for this condition, disconnect all terminals of the resistance element from the circuit, and use an ohmmeter to check between the resistor terminals and the container. Be careful when you make this check, because sometimes one of the terminals on a Candohm is supposed to connect to the metal container; this is how a connection to the set chassis is made in many receivers. Where this is true, naturally that particular terminal will show zero resistance to the container. Furthermore, there will be a resistance reading between other terminals and the container, the exact value depending upon the amount of resistance between the grounded terminal and the terminal to which the measurements

## BENCH HINTS

You may have tried to shorten a machine screw by cutting it to a desired length with a hacksaw, only to find that the thread on the cut end is so distorted that a nut won't fit over it. The remedy is simple - run a nut all the way onto the screw before making the cut. When the screw is the right length, run the nut off again. As it comes off, it will restore the damaged thread to good working condition.

Our long experience in radio servicing has taught us many practical ways of doing mechanical jobs that we would like to pass on to you. However, very often these practical hints do not fit into the subject matter of these RSM Booklets. We have therefore adopted the idea of presenting this information in the form of bench hints, like the one shown above. You will find hints of this sort in future Booklets wherever there is sufficient space for us to put them in. Watch for them—the practical information they give you will prove helpful in your servicing work.

are being made. However, if any value is lower than its rated amount, then there may be a short to the container. You will have to disconnect the resistor to make further tests.

## CHOOSING THE PROPER REPLACEMENT

Once you've found the defective part, you should replace it. Naturally, the more closely you can duplicate the original part value, the more nearly the receiver will perform as it did originally. Therefore, consult the manufacturer's service information to find the right resistance value. The physical size of the resistor is no guide at all to resistance value—a resistor one-half inch long may have a resistance of 100 ohms or of 10 megohms.

Any replacement resistor you buy or have in your shop will usually be labeled to show its resistance value. Carbon and metallized resistors usually are color-coded; sometimes the resistance value is also stamped right on the resistors. Wire-wound resistors usually have paper or metal tags attached to them that give the resistance values.

**Color Code.** There are several methods of painting the colors on the resistors, but the standard systems are

## RMA COLOR CODE FOR RESISTORS

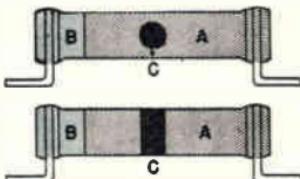
**FIG. 5**

BACKGROUND COLOR



**METHOD I**

COLOR BANDS A, B, AND C GIVE VALUE.  
GOLD OR SILVER BAND D, USUALLY  
OMITTED, INDICATES TOLERANCE.  
BLACK BACKGROUND—UNINSULATED.  
TAN BACKGROUND—INSULATED.



**METHOD II**

BODY COLOR (A), END COLOR (B), AND DOT  
OR BAND COLOR (C) GIVE VALUE.  
GOLD OR SILVER BAND D, USUALLY  
OMITTED, INDICATES TOLERANCE

COLOR	FIGURE
BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
GRAY	8
WHITE	9

COLOR A GIVES FIRST FIGURE OF RESISTOR VALUE.

COLOR B GIVES SECOND FIGURE OF RESISTOR VALUE.

COLOR C GIVES NUMBER OF CIPHERS FOLLOWING THE  
FIRST TWO FIGURES.

COLOR D: GOLD BAND INDICATES  $\pm 5\%$  TOLERANCE. SILVER  
BAND INDICATES  $\pm 10\%$  TOLERANCE. NO BAND  
INDICATES STANDARD  $\pm 20\%$  TOLERANCE.

### EXAMPLES

COLOR A	COLOR B	COLOR C	OHMS
Brown	Black	Black	10
Yellow	Violet	Black	47
Brown	Black	Brown	100
Orange	Green	Brown	350
Brown	Black	Red	1000
Red	Orange	Red	2300
Brown	Black	Orange	10,000
Blue	Gray	Orange	68,000
Brown	Black	Yellow	100,000
White	Brown	Yellow	910,000
Brown	Black	Green	1,000,000

shown in Fig. 5. This is known as the R.M.A. (Radio Manufacturers Association) Color Code.

As a serviceman, you will find the color code helpful in identifying resistors within the receiver, and in identifying the values of those in your stock. However, if you keep a color-code chart handy, you don't need to memorize it. In time, you will automatically learn the colors on the more common resistors. You can always check replacement resistors with your ohmmeter; most servicemen do this anyway, even after having identified the resistor by the code.

Don't expect *all* colored resistors to follow the standard code—those in many early receivers were marked by private manufacturer's codes.

**Common Resistor Values.** As you progress in your Course and study actual receiver diagrams, you will find that certain values of resistance are frequently used. In particular, 25,000-, 50,000-, 100,000-, 250,000-, 500,000-ohm, 1-megohm, and 2-megohm resistors are very common.

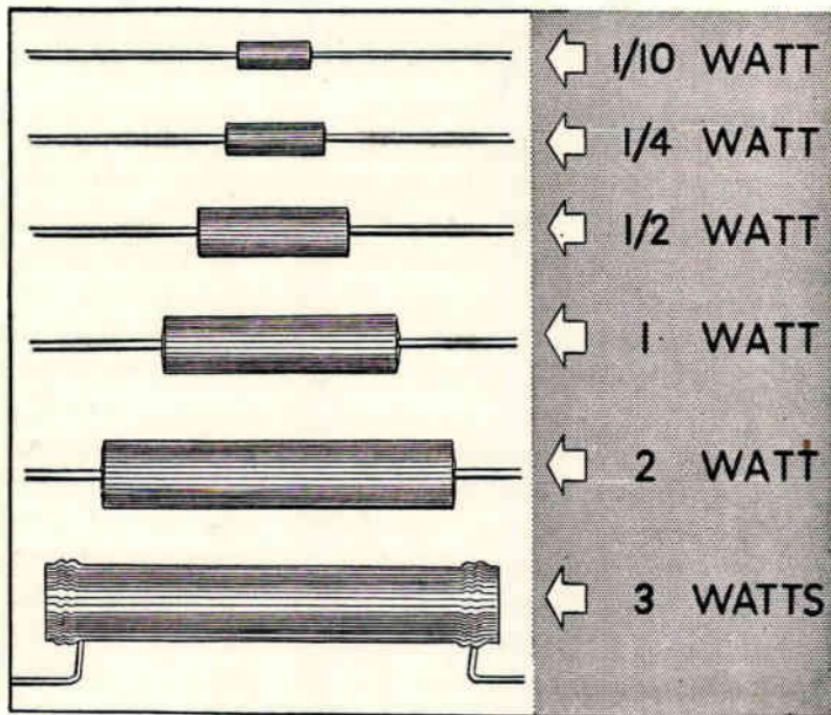
However, many manufacturers do not use these exact values. Instead, they use odd values such as 22,000, 47,000, 91,000, 270,000, and 470,000 ohms. These values are used simply because it is easier to see the color codes on them under factory lighting conditions. If you ever have to replace one of these odd-value resistors, you can generally use the nearest standard size with entire satisfaction. Usually a value 20% higher or 20% lower than the original value can be used unless otherwise specified on the wiring diagram. This means, for example, that any value between 80,000 ohms and 120,000 ohms may be replaced by a 100,000-ohm resistor.

On the other hand, if the diagram or the color coding of the resistors indicates that a resistor having a 5% or a 10% tolerance was used originally, it is usually advisable to stay within this tolerance.

It may seem strange that such large variations are permissible, but you will find wide tolerances of this type in most mass-production electronic devices because many radio circuits are self-adjusting. The manufacturer knows that, on the average, the differences will cancel and the over-all results will be satisfactory.

**Wattage Ratings.** When you have determined the proper resistance value to use, you next need to determine the wattage rating of the replacement. The replacement must have a rating at least as high as that of the original and preferably higher. If the resistor is too low in its wattage rating, it will overheat, which will cause it either to change its value or eventually open.

These ratings are not ordinarily given on wiring diagrams, but the size of the original resistance is a rather good guide to its wattage rating. Fig. 6 shows a num-



**FIG. 6. The wattage rating of a resistor depends upon its physical size. This illustration shows the actual size of typical resistors of various wattage ratings.**

ber of ordinary resistors in actual size with their wattage ratings marked beside them. As you will notice, the larger the resistor is physically, the greater its wattage rating. (The wattage rating depends on the *physical size*, not on the resistance.) You see, in general, the wattage rating depends on how well the resistor can dissipate heat; the larger its surface area, the greater the amount of heat a resistor can transfer to the surrounding air.

The wattage ratings of voltage-dividing resistors are rarely given. However, occasionally you will find a receiver using individual 4- or 5-watt carbon resistors as voltage dividers. These resistors will become defective eventually, and it is wise to replace them with 10-watt wire-wound resistors to prevent further trouble. Remember, you can always use a higher wattage rating —this just gives a greater safety factor.

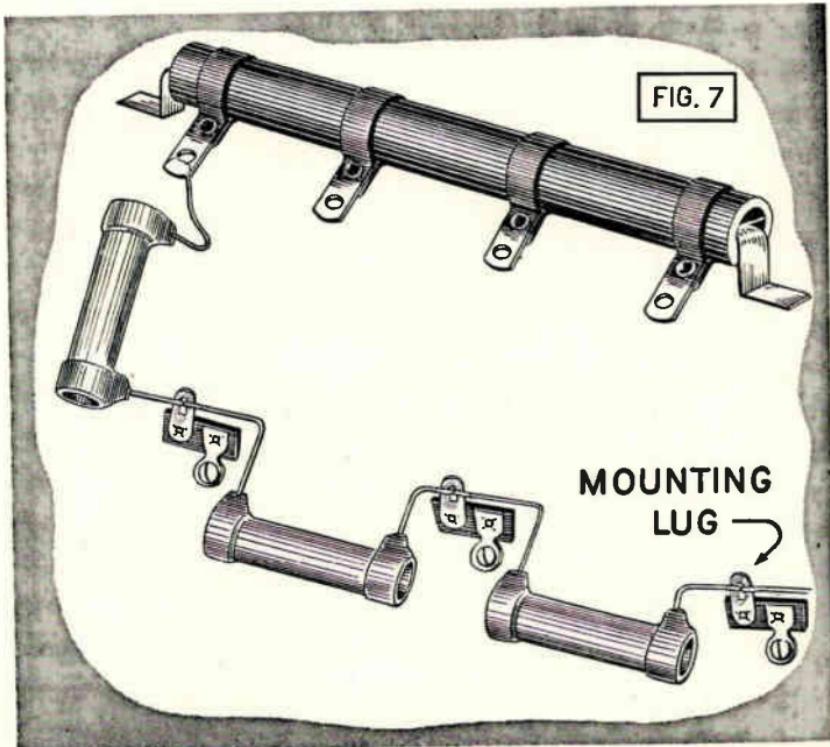
Therefore, *you can always use a resistor that is physically larger than the original resistor, as long as the re-*

sistance rating is either the same or within the tolerance limits.

► When only a single section of a multisection voltage divider opens up, many servicemen just connect a replacement resistor across the terminals of the defective section. Don't do this unless you destroy the defective section *permanently* by cutting it with a file or knife, so that it will never come back to life and upset the circuit voltages. Better yet, use a replacement voltage divider intended for that particular receiver; this will replace all the original voltage divider, and you won't have to worry about wattage values.

Occasionally, a replacement voltage divider is not available. If you know the values of each section, you may be able to use individual 10-watt resistors to replace the original, as shown in Fig. 7. However, these require mounting lugs (insulated supports to hold the resistors away from the chassis) for which there is not always room.

You may also use a general purpose voltage divider



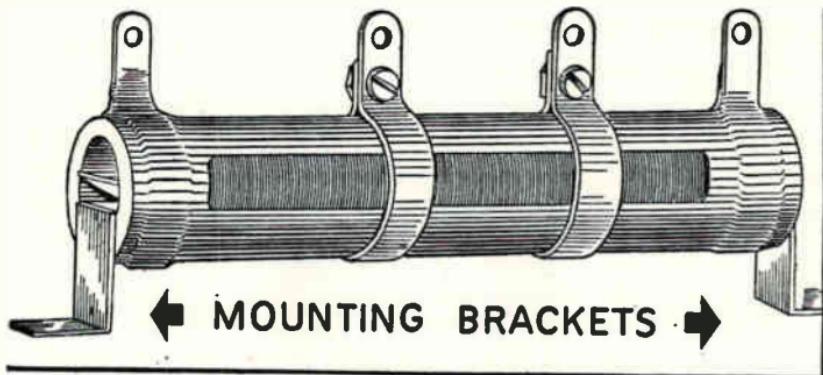


FIG. 8. Typical power resistor with variable taps. The mounting brackets shown are made of spring material so that the resistor can be removed or replaced with little difficulty.

having adjustable sliding contacts. Obtain one that has a total resistance value as near as possible to the total of the original divider. Install it as shown in Fig. 8, at some convenient point, or in place of the defective divider. Then, move each slider until voltmeter readings show that you have the proper voltages. To avoid shocks, remember to turn off the receiver when moving these sliders, then turn on the receiver again to measure the voltage.

**Facts To Remember.** When a resistor burns out, you may be sure that excess current has flowed through it or that its wattage rating was too low to carry the normal circuit current over a long period of time. The wattage rating of any replacement must always be equal to or *greater* than that of the original resistance, and the replacement resistor value must be within the normal tolerance limits for the particular circuit.

Before soldering in the replacement resistor, find out whether excess current can flow through the replacement. The trouble may have been caused by some other part defect, such as a breakdown in a condenser. In another RSM Booklet, we shall show in detail how to check for such troubles. As a general rule: BEFORE REPLACING ANY RESISTORS, CHECK THE CIRCUIT TO SEE IF THE FAILURE WAS CAUSED BY A CIRCUIT DEFECT.

## How To Test And Replace Volume And Tone Controls

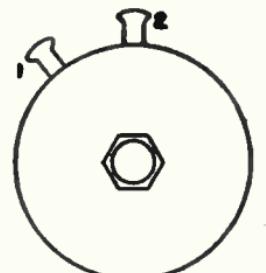
The replacement of volume and tone controls is a mechanical service job which you will do many, many times. It's simple, but there are certain points to keep in mind.

**How Controls Are Made.** Volume controls and many tone controls are physically alike—the only difference is in their use. (We are speaking now of tone controls that can be continuously varied—not the kind that can be changed only in steps. These latter use switches.) Hence, whatever we say about one applies equally to the other. Both may be either *rheostats* or *potentiometers*. A rheostat (Fig. 9A) is a variable resistor having two terminals. One terminal connects to one end of the resistance unit, the other connects to a slider that is moved along the unit as the shaft is rotated.

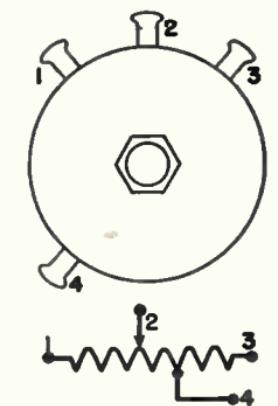
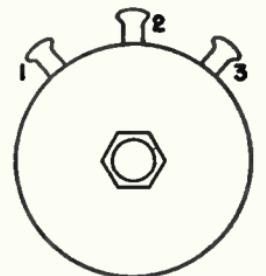
A potentiometer (Fig. 9B) has three terminals. Terminals are connected to each end of the resistance element instead of to just one end, as in the rheostat. (Of course, you can use a potentiometer as a rheostat just by ignoring one of the end terminals.)

Another less common control has a tap (Fig. 9C). This extra tap is fastened to the resistance unit and is connected to a condenser or an electrical network to provide automatic-bass compensation—a circuit action that will be discussed in another lesson.

Some volume controls are double units rotated from a single shaft. Also, some receivers use concentric shafts (a shaft within a shaft) to control in-



**A RHEOSTAT**



**C TAPPED POTENTIOMETER**

**FIG. 9**

dividual units mounted together. These and other special units require exact duplicate replacement parts.

Volume and tone controls frequently have an On-Off switch or a phono-radio switch mounted on the control. This switch is so mounted that turning the control shaft first operates the switch, then varies the resistance of the control.

**Volume and Tone Control Defects.** Since a volume or tone control contains a movable part that must slide over the resistance element, the element will be worn out eventually by friction. Poor contacts also develop between the rotating arm and the connecting terminal in some types. Then, too, circuit breakdowns sometimes occur that cause excess current to flow through the resistance element and destroy it.

► A good control must have three characteristics:

1. It must be noiseless in action.
2. It must control the volume or the tone.
3. It must be smooth in action (give a steady increase or decrease without sudden changes).

Tests seldom need to be made on a variable control to prove that it is bad. Usually a worn control will cause a very noticeable amount of noise. If the receiver is noisy when the control knob is pulled, pushed, or turned, or becomes more noisy as the control is rotated, then the control is defective and should be condemned at once.

If the volume control has no control whatever over the volume, probably there is a break or an open near one terminal. (On the other hand, if a tone control has no effect on the receiver tone, it is more common to find that some associated part is defective.) Sudden jumps and erratic control of the volume or tone indicate an internal defect or a worn element. Usually there will be some noise when this last condition is noted.

**Obtaining Replacement Controls.** To obtain a replacement volume or tone control, give your supplier the make and model number of the receiver. If the receiver is a standard make, an *exact duplicate* replacement or a *general purpose* replacement will be available for it and will be listed in the volume control guide books.

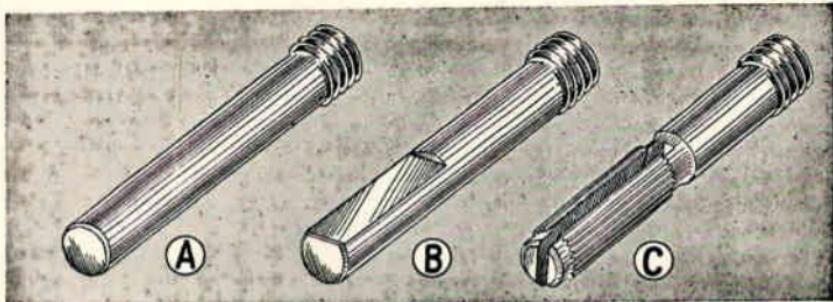


FIG. 10. Typical volume control shafts: A, round; B, half-round; C, slotted.

Sometimes, particularly if the receiver is of unknown make, you must give the resistance value and the circuit connections of the control. (The Lessons in Radio Fundamentals describe the many ways of connecting volume and tone controls, together with the details of resistance values needed.)

Naturally, if you're not using an *exact duplicate* control, the shaft on the replacement control should be similar to that of the original. Fig. 10 shows several shaft types. If the original has a switch, order a similar switch with the replacement.

Of course, if you carry volume controls in your stock of parts, you will undoubtedly use them wherever possible. A volume control guide book published by the manufacturer of the brand of control you carry will show you which control to use for the particular receiver.

Now let's run through the steps for installing a control. First, we'll consider *exact duplicate* controls, then *general replacement* types.

## INSTALLING EXACT DUPLICATE CONTROLS

Never disconnect any defective radio part until the replacement has been obtained. If you unsolder leads to check the part, put them back in place until you have the replacement.

► As the first step in replacing a defective control, draw a sketch showing all the connections to the old control. An *exact duplicate* control will be exactly like the old one and will need to have the same connections. If you

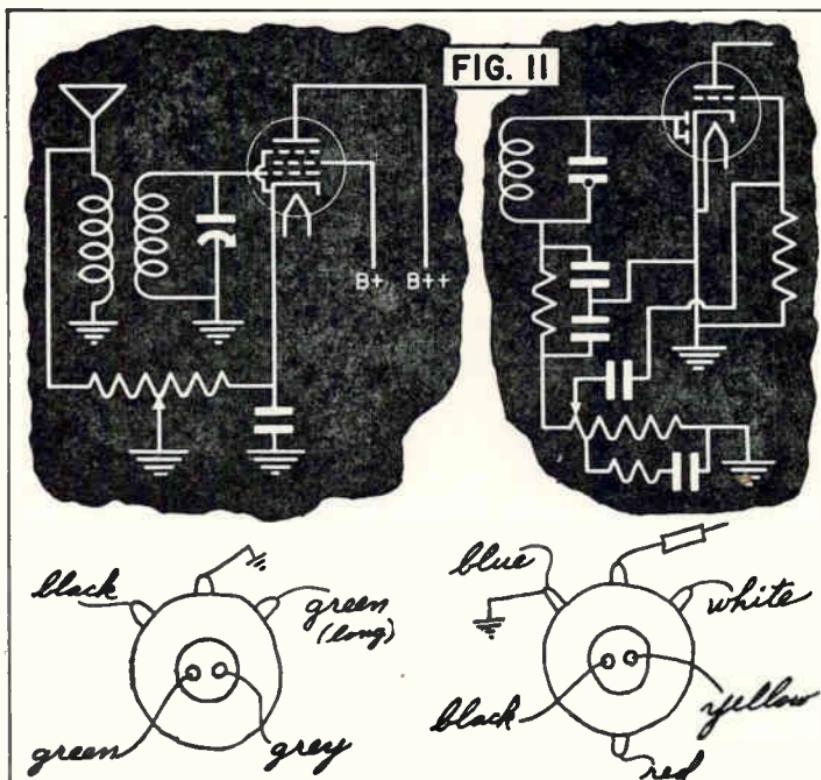
make this sketch before going further, you won't have any trouble in making the replacement.

Fig. 11 shows two typical volume control circuits in schematic form. Underneath them are sketches such as you might draw before disconnecting the leads to the old control. (The round object with two lugs at the center of the back of the control represents the On-Off switch.) To make the sketches, work from the back view of the control, as this is the normal position from which you will replace the leads.

After sketching the lead connection arrangement, unsolder the leads from the volume control terminal lugs, one at a time. Naturally, the receiver should NOT be plugged in the power line.

Occasionally you will find two or more leads, fastened to a single lug, that have been inserted through holes in the lug and twisted so that they are hard to get off. In such cases, cut the leads as close to the control as possible, or cut off the lug and pull it out where you have more

FIG. II



room to work. Twist together these leads (that go to the same lug) after they are unsoldered.

When the leads are all removed from the old control, take off the nut holding the control to the chassis and remove the control. You can generally use slip-joint auto pliers to loosen the nut, but the special socket wrench that fits volume-control nuts is better.

► Next, put the shaft of the new control through the chassis hole. If a lock washer is furnished, place it over the shaft and then thread on the nut holding the control to the chassis. Do not draw the nut up tightly, however; allow the control to be loose until the leads are soldered so you can turn it to the easiest position for soldering. After soldering all the leads, recheck against your sketch to be sure you have them properly placed. Then, tighten the volume control holding nut as much as possible. If the nut is not tightened fully, the customer may turn the whole control when he turns the knob and so break leads off the control. There may be (on the front or shaft side of the control) a projecting metal or bakelite tab that fits into a hole in the chassis wall when the control is properly located. If so, be sure it is in its hole before tightening the holding nut.

## INSTALLING A GENERAL REPLACEMENT CONTROL

A *general replacement* volume control or tone control is a unit that is electrically similar to the original control, but may be somewhat different in physical size and form. (If it is larger than the original, be sure you have room to mount it before trying to install it.) In addition, since the replacement control is designed to fit a number of different receivers, it will have an extra-long control shaft, often much longer than is necessary.

Most general purpose controls do not come with switches on them, but a switch can be added simply by removing a back-plate of the control and installing a new plate that has the switch mounted on it.

► After obtaining the recommended general replacement control and a switch, if needed, your next step is to draw a picture of the arrangement of the leads. Then,

remove all leads from the defective control and take it out.

Use your ohmmeter to check between the terminal lugs and the shaft of the old control. Many controls have an internal connection between the shaft and a terminal that should be grounded, thus making an automatic ground. *An exact duplicate control will have this feature, but a general replacement will not.* Therefore, if you find continuity between any terminal and the shaft of the old control, you will have to provide a ground connection between the proper terminal on the new control and the set chassis. Add this connection to your sketch.

► The next step is to cut the shaft of the replacement control to the right length. Measure the length of the old shaft with a ruler or caliper from the point where the body of the control touches the chassis wall. Mark off the shaft of the new control to the same length with a pencil or crayon. Then put the shaft (*not* the control itself—see Fig. 12) in a vise and cut it off at the marked length with a hacksaw. Smooth the cut edge of the shaft with a file.

► Next, add the On-Off switch to the control if one is

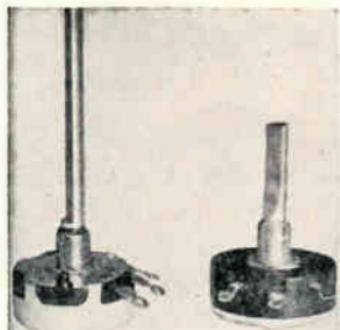


FIG. 12. The shaft of a general replacement control is extra long. To cut it to the right length, first measure the exact length of the original control shaft with a ruler. Transfer this measurement to the shaft of the replacement control, then cut off the replacement control shaft to the marked length with a hacksaw.



used. Remove the plain back-plate of the control by lifting a clamping lug (or two) that holds it down. You will then find that the new back-plate with the On-Off switch will slip into place easily. Rotate the shaft of the control to approximately the mid-position. Then put the switch on, hold it in place with your hand, and turn the volume control shaft all the way counter-clockwise. This should make the switch snap off. It should snap on again when you turn the control to the right (clockwise). This shows that the switch is in the proper position, so you can attach the back permanently. (Since controls differ in their clamp arrangements, the switch you use must be intended for the brand of control you are installing.)

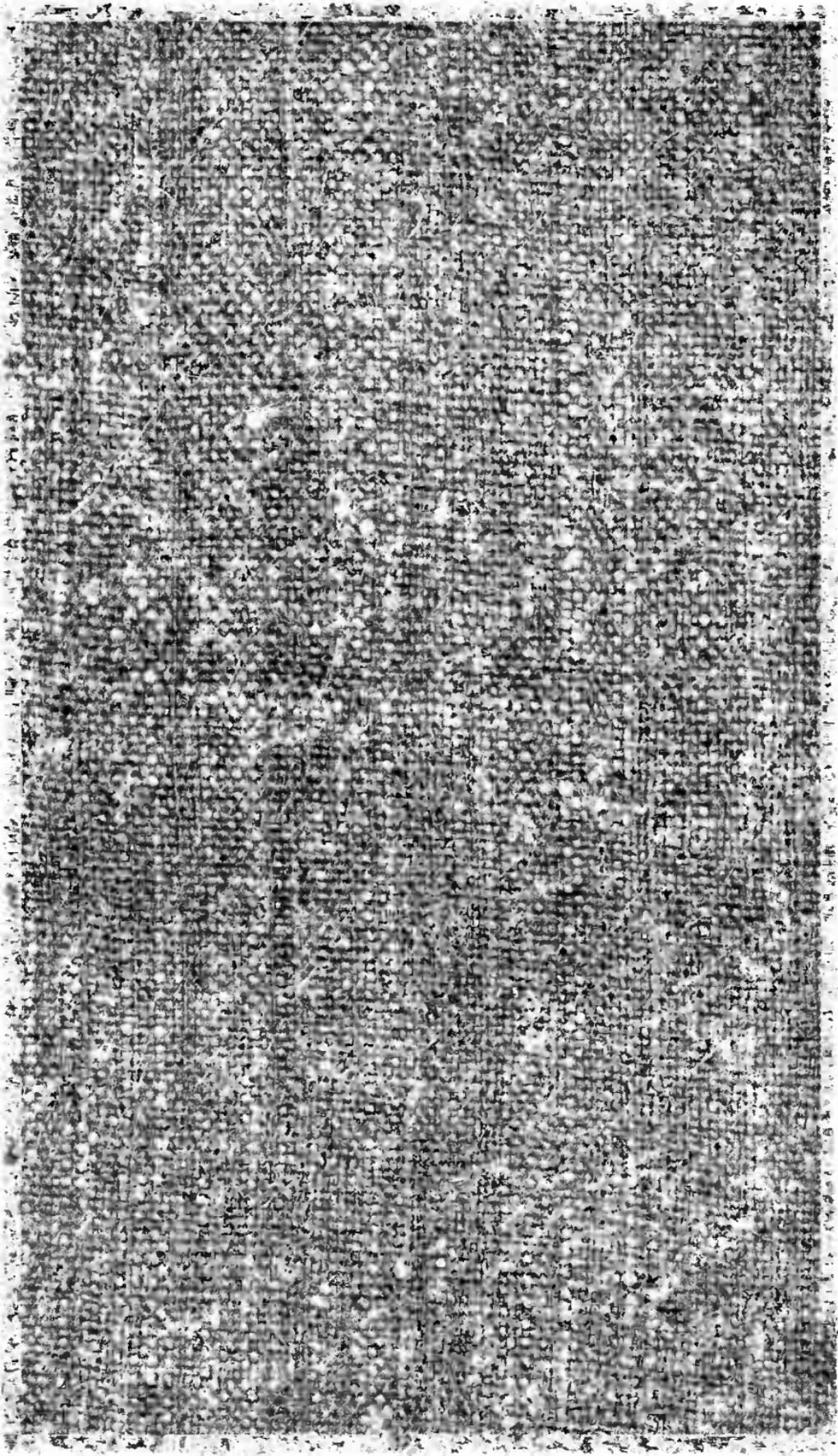
Finally, slip the shaft through the chassis hole and start the holding nut. Connect the leads according to your sketch, then tighten the holding nut.

**Summary.** The replacement of a defective volume or tone control may be broken down into the following simple steps:

1. Obtain the replacement.
2. Draw a picture sketch of the connections.
3. Remove the connecting leads and the defective control.
4. For a general replacement control, check for a grounded terminal on the original; cut the shaft to the right length; add a switch if one is used.
5. Install the new control with its nut loose.
6. Solder the connecting leads to the proper terminals on the replacement control.
7. Tighten the control holding nut.

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

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 7      How To Test and  
Replace Condensers  
RADIO SERVICING METHODS



# NRI TRAINING PAYS...

Dear Mr. Smith:

I had been going from job to job for fifteen years and was getting nowhere fast. I then decided to study radio. I knew nothing about it before taking your Course, and I was working as a farm hand. After completing the studies and experimental work I took a full time servicing job. Two years later I started my own shop. I now have a \$1000 stock of parts and \$1000 worth of equipment and fixtures. The NRI Course sure started me off right.

C.E.C., Calif.



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FM12M749

1949 Edition

Printed in U.S.A.



# How To Test and Replace **CONDENSERS**

WITH the possible exception of tubes, condensers cause the greatest amount of trouble in radio receivers. Electrolytic and paper condensers are the worst offenders, but defects also occur in mica, air, and trimmer condensers. This Booklet will show you how condensers of each type become defective, and how they should be tested and replaced.

Your Lessons in Radio Fundamentals have taught you how condensers are made, and what some of their defects may be. We'll review these subjects briefly before we discuss testing and replacement of condensers.

## PAPER CONDENSERS

You know that a paper condenser consists of plates made of sheets of metal foil, separated by a waxed paper dielectric, all rolled up to form a cylinder. Discs of solder or wire spirals to which the leads are attached are pressed into the two ends of the foils, then the condenser is sealed in a hard wax and (usually) encased in a paper container. Now, what can happen to this condenser?

The paper dielectric in one of these condensers may develop a burned spot if excessive voltage is applied or if there is a flaw in the paper. This spot is carbon, which is conductive, so a conducting path (or, as technicians say, a leakage path) is formed between the condenser plates. The effect is the same as if a resistor had been connected between the condenser plates; we say the condenser is leaky, for it will pass d.c. current when a d.c.

voltage is applied. If the burned spot is large enough, the two plates may touch each other. The condenser is then shorted, just as though a wire had been connected between the plates.

Also, if the wax casing cracks, moisture will enter the condenser and will eventually form a leakage path. In addition, leakage may develop on the surface of the condenser if moisture or dust collects on the container between the two leads. This will act like a resistor between the leads.

In some paper condensers, the connecting solder discs or wire spirals are soldered to the foil plate, but in most they are held against the foil only by the wax into which the ends of the condensers are dipped. Often the normal heat of the set will loosen these wax plugs so that the discs pull away from the foil. Effectively, this disconnects the condenser from the circuit, and we say the condenser is *open*.

► Since the condenser opens because one contact pulls away from the foil slightly, a mechanical jar, expansion and contraction caused by temperature changes, or a sudden electrical surge caused by snapping the receiver off and on, may allow the foil and the disc to make contact again and restore the condenser to full operation in the circuit. When this occurs the condenser is said to be *intermittently open*. (Condensers can also leak and short-circuit intermittently, but an open is the most usual intermittent defect.)

► Paper condensers almost never change in capacity. Moreover, they are not used in circuits where such a change in capacity would be important anyway.

**Summary.** Paper condensers may short-circuit, open, open intermittently, or leak; these are the only common defects such condensers have. Now let's learn something about the other condenser types.

## ELECTROLYTIC CONDENSERS

An electrolytic condenser is a chemical type in which an aluminum plate or foil is one plate, the electrolyte is the other plate, and an aluminum-oxide film is the dielectric. There are three kinds—the dry condenser, in which

# TYPICAL CONDENSERS

Paper condensers (those using paper as a dielectric) are the kind most commonly used in radio receivers. Usually they are cylindrical and have a wax-impregnated cardboard case. You will occasionally meet the kind shown at the right in the illustration; this is cased in metal.

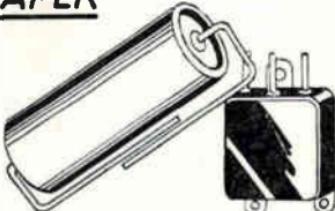
Electrolytic condensers are now universally used as power supply filter condensers. You may meet them in any of the shapes shown in the illustration. The two cylindrical condensers shown have metal cases; the others have cardboard outside cases, but may be enclosed in metal underneath.

Mica condensers are not widely used in modern broadcast receivers—generally only in the oscillator and second detector circuits. Capacities are usually indicated by a 3 or 6-dot color code. The condensers are encased in either dark brown or light tan bakelite; the latter is a low-loss covering.

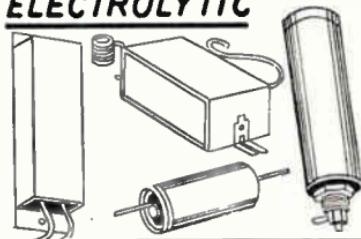
Variable condensers like that shown in the illustration are used to tune most modern receivers. There may be either two or three sections to a tuning condenser used in a superheterodyne; condensers with more than three sections are used in t.r.f. sets.

Several trimmer condensers are used in every set, but some are usually hidden within the shields of i.f. transformers so that only their adjusting screws are visible. The three small objects shown at the top of the variable condenser (above) are also trimmer condensers.

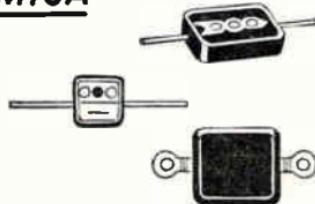
## PAPER



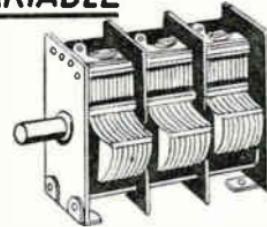
## ELECTROLYTIC



## MICA

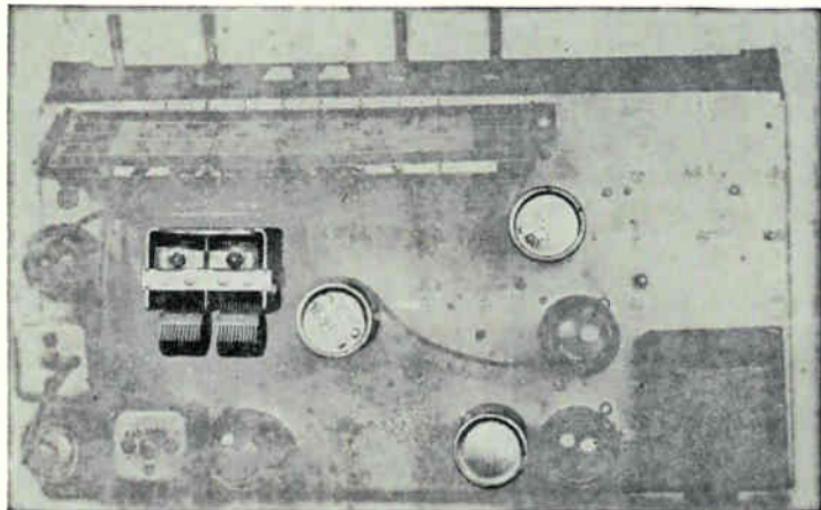


## VARIABLE



## TRIMMER





We have highlighted the condensers that are visible on the top of a typical radio chassis. Four trimmer condensers that are also on top of the chassis are not visible because they are contained within i.f. transformer shields.

the electrolyte is a paste impregnated in a cloth or similar separator; the semi-dry type, in which the electrolyte is a jelly-like substance; and the wet type, in which the electrolyte is an actual liquid.

Electrolytic condensers can short-circuit like a paper condenser if the applied voltage is too high, or if the applied voltage is fed to it with the wrong polarity. (The dielectric film breaks down and conducts current.) This may not damage a *wet* condenser permanently for removal of the overload may permit the dielectric to re-form, but dry or semi-dry condensers are ruined by a breakdown.

► Leakage is quite a problem with electrolytic condensers. They always leak a fairly considerable amount, and, with age (especially when not being used) and with chemical changes in the dielectric, the film gradually deteriorates so that this leakage becomes worse.

With age, also, an electrolytic condenser develops a high power factor, which makes the condenser act as though a high resistance had been placed in series with one of its leads. This is caused by drying out and by chemical changes in the electrolyte that increase the resistance of the electrolyte. This happens sooner in the

dry condensers than in the wet types, because the dry types already have a paste electrolyte, which, as it dries further, increases in resistance. This is the reason that the types sealed in metal cans last longer—they cannot dry out as easily.

► An electrolytic condenser also loses capacity. As the electrolyte evaporates in the wet types, or the paste dries in the dry types, less and less of the electrolyte is in contact with the dielectric, so, effectively, one of the plate areas is reduced.

► It is rather rare to find an electrolytic condenser that is open, for they are more soundly constructed than paper condensers. However, once in a while the electrolyte will corrode the connecting lead where it joins the plate; the condenser will then be open.

## MICA CONDENSERS

A mica condenser consists of alternate layers of metal plates and mica dielectric sheets. Since mica condensers are well made and are generally used in circuits that do not have high d.c. voltages, they seldom become defective. Their only fairly common defect is leakage between the condenser terminals caused by moisture and dust collecting in tiny cracks in the bakelite casing. Once in a while, a crack in the bakelite housing may allow the plates to expand or separate so that the capacity changes, and occasionally a mica condenser opens or shorts.

The capacity of a mica condenser will change somewhat with variations in temperature. This effect would be serious if the condensers were used in circuits where this change would upset tuning, but they seldom are.

## AIR CONDENSERS

When we speak of an air condenser, we mean a condenser having air as the dielectric. Although fixed air condensers have been made for laboratory purposes and for some transmitter uses, in radio receivers air condensers are always variable. A typical example is the variable condenser used to tune most receivers. In a few

of the higher priced receivers, some trimmer condensers are also variable air types.

Modern variable air condensers cause very little trouble. Older types, however, occasionally become defective. For example, the condenser plates may be bent out of shape by some accident, or by warpage of the material in the condenser. If they bend far enough, the stator and rotor plates may touch, which will short-circuit the condenser. Such a short circuit may occur over all the variable range or over only a small portion of it. Even if the plates do not touch, the shift in position will upset the circuit action because of capacity changes.

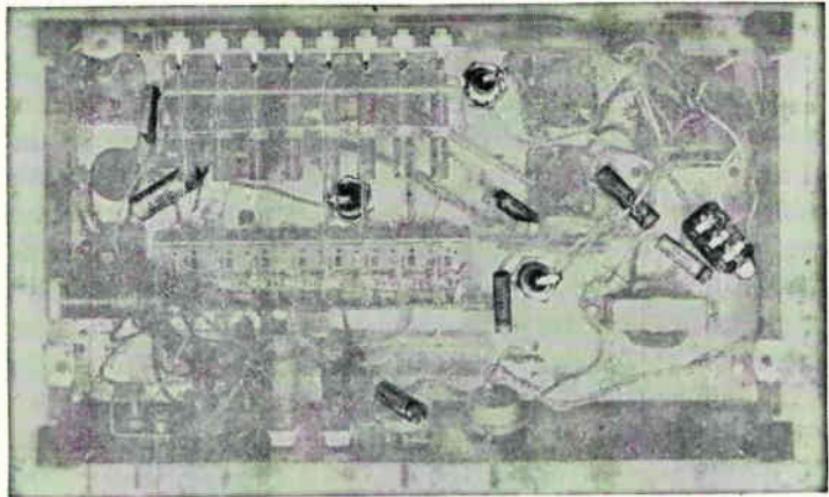
Dust and metal particles between the plates may provide a leakage path or cause a short circuit. In some earlier condensers, a plating was used over the plates of the condensers. This material peeled and flaked, allowing metal particles to short-circuit between the condenser plates.

- In some earlier types, connections were made to a lug that contacted the stator plates of the condenser through screws. Corrosion in the screw threads set up a resistance in series with the condenser. (Late types use a soldered connection that eliminates this.) The rotor section of the gang condenser connects to the frame through the front and rear bearings. Since these bearings do not provide a good electrical contact, often an additional spring contactor is used for each section. Dirt or grease in the bearings or between the spring contactors and the shaft will place resistance between the condenser rotor and the frame of the condenser.
- Thus, air condensers may short-circuit, develop leakage, or develop series resistance. They almost never open, however.

## TRIMMER CONDENSERS

Although a few trimmer condensers are actually air condensers, usually their dielectrics are a combination of air and mica.

Occasionally a trimmer condenser will short-circuit because of a break in the mica, because its plates are



This is a bottom view of the chassis pictured on page 4. Not all of the under-chassis condensers are visible here; others are obscured by other parts.

bent, or because excess solder has been allowed to run between the plates. Some leak because of dust and dirt paths between the plates or cracks in the mica.

The plates of a trimmer condenser are springy, and tend to separate. They are held at the desired spacing by a compression screw. With age, the plates may lose their springiness so that the condenser will not hold its adjustment. This may result in undesirable changes in capacity. A trimmer condenser rarely opens, although once in a great while a plate breaks away from its contacting lug.

► From this description of the various kinds of condensers and their defects, you can see that condenser defects are like those of resistors—short circuits, open circuits, changes in value. In addition, a condenser may develop leakage between its terminals and, particularly in electrolytic and air condensers, can develop a series resistance. Now let's see how you can check for each of these difficulties.

## HOW TO TEST CONDENSERS FOR SHORT CIRCUITS

When a condenser is short-circuited, there is a direct conductive path with little or no resistance between the terminals.

The obvious method of checking condensers for short circuits is to use an ohmmeter. Often you need not even disconnect the condenser to check for a short circuit, because its resistance will be so much lower than that of any shunting path, that you can detect the faulty part easily. However, if you suspect a tuning or trimmer condenser (used in a circuit where there is a coil connected in parallel), or if more than one condenser may be at fault, you must disconnect the suspected part to check it.

The ohmmeter can be used to check any kind of condenser for a short circuit. It indicates a short circuit by reading zero resistance between the condenser terminals.

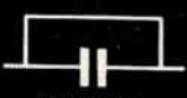
You may not need any instrument to check an air condenser, for you may be able to see the plates touch. If the receiver tuning condenser is defective (either shorting or out of line), you may find that reception is obtained over a portion of the tuning band but that further turning of the tuning knob results in noises, a scraping sound from between the plates, and (usually) no reception. These are all indications that the tuning condenser is short-circuited, or out of line.

► As extra information—a shorted condenser will frequently pass enough current to burn out a resistor or a coil in an associated circuit. Always check for charred resistors and for continuity through the circuit associated with the shorted condenser.

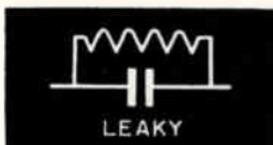
## HOW TO TEST CONDENSERS FOR LEAKAGE

An ohmmeter will also indicate leakage. However, there are certain things you must remember when you check for leakage.

► Leakage is far more important in some circuits than in others. For example, a by-pass condenser connected



A shorted condenser (left) acts as if a direct wire connection had been made across it. A leaky condenser (right) acts as if a resistor had been connected across it.



across a low ohmic value resistor can have a leakage resistance value of 50,000 ohms without greatly upsetting the circuit. On the other hand, a coupling condenser used to couple signals from one stage to another may cause distortion if the leakage resistance falls below 10 megohms. These are practical facts that you will study in your Lessons on Radio Fundamentals.

Condensers are never perfect—even the best will leak a certain amount—so you must know just how much leakage can be permitted. A paper or mica condenser freshly made by a reliable manufacturer will have a leakage *resistance* value\* so high that an ordinary ohmmeter cannot measure it. However, after a fixed condenser has been exposed to moisture and normal atmospheric conditions for a few weeks, its leakage resistance value will become lower. Mica and paper condensers smaller than .1 mfd. are considered satisfactory if their leakage resistances are *above* 20 megohms. Paper condensers larger than .1 mfd. are considered good if their leakage resistance is *above* 10 megohms.

Electrolytic condensers have far lower leakage values. An ordinary electrolytic condenser having a leakage resistance above 1 megohm is very good—it can usually be allowed to go down to about 100,000 ohms before needing replacement, and even this value depends upon the circuit conditions.

**Electrolytic Polarity.** You must know the polarities of the test probes of your ohmmeter before you can check electrolytics for leakage. As you know, your ohmmeter contains a built-in battery to which the probes are connected; one probe is always positive with respect to the other. The positive probe must always be connected to the positive terminal of the electrolytic condenser. Otherwise, the condenser will not function properly, and the leakage resistance your meter indicates will be far lower than the true value. (This is not true of other kinds of condensers; electrolytics are the only condensers that do not work equally well regardless of

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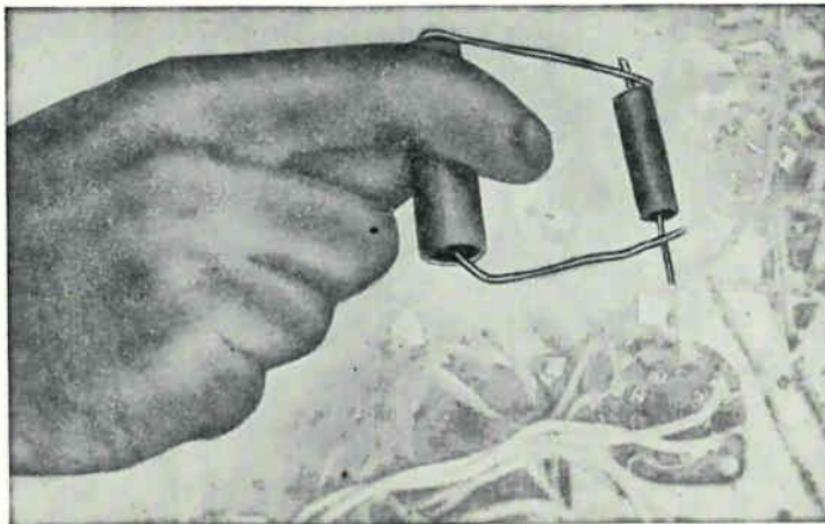
\*Don't become confused by *leakage* and *leakage resistance*. The higher the *leakage resistance*, the smaller the *leakage*, because higher resistance values permit less current flow through the undesired path.

the polarity of the voltage applied to the terminals.)

Ordinarily an ohmmeter is not marked to show which probe is positive, but it's easy enough to find out. Simply touch the probes to the terminals of an electrolytic condenser that you know to be good. The meter needle will swing toward zero resistance at first, then, as the condenser dielectric film "forms" and it charges, the needle will move toward a *higher resistance* value. Wait until the needle stops (or almost stops) and record the resistance indicated. Next, discharge the condenser by touching its leads together or by shorting its terminals with a screwdriver. Then interchange the ohmmeter probes and repeat the measurement. One of the readings you get will indicate considerably higher *resistance* than the other. The meter was properly connected when the higher *resistance* reading was made—at that time the positive probe was connected to the positive terminal of the condenser. Mark the meter to show which is the positive probe, and you are ready to test electrolytics for leakage. (In a multimeter that also measures voltage, the positive *ohmmeter* probe will often be the negative *voltmeter* probe. Therefore, pay no attention to the *voltage* polarity markings when determining the *ohmmeter* polarity.)

► Be sure you disconnect any condenser (paper, mica,

FIG. 1. How to test for an open condenser.



air, or electrolytic) from its circuit before you check it for leakage. You must measure resistance fairly accurately in a leakage check, and leaving the condenser connected to other parts may cause incorrect readings.

## HOW TO CHECK CONDENSERS FOR OPEN CIRCUITS

If you suspect that a paper, electrolytic, or mica condenser is open, there is one very simple test you can make. Just turn on the radio, allow it to warm up, and then hold a condenser you know to be good across the terminals of the condenser which you are testing (Fig. 1). If this test improves the performance of the radio, then the suspected condenser is open.

Sometimes the presence of long leads or of your hand holding the case of the test condenser may cause hum or prevent normal operation. If so, temporarily solder in the new condenser; then you can determine the operation of the receiver more accurately.

► The capacity of the test condenser should be approximately the same as the one across which you connect it, although it need not be exactly the same. If the original condenser is open, any capacity near the original value will improve reception.

Remember to hold paper and mica condensers by their cases, *not by their leads*, to avoid getting a shock. If the leads are insulated, as they are in many electrolytic condensers, you may hold them safely provided your hands remain always on the insulation and never touch the bare wires.

► Checking a condenser not connected in a radio is a somewhat different problem. You must either solder it in a circuit in place of a good condenser, or use your test equipment. If the condenser is fairly high in capacity (above .25 mfd.), your ohmmeter will give you a fair indication as to whether or not it is open. First, make sure the condenser is discharged, by shorting across its terminals with a screwdriver blade. Then touch the ohmmeter probes to the terminals. The ohmmeter battery will charge the condenser (provided the condenser is not open), which will make the needle kick toward



FIG. 2. The NRI Model 111 Professional R-C Tester. This instrument can check condensers for capacity, opens, shorts, leakage, and power factor. It also measures resistance. "Extra" instruments like this are time savers—worth having after a service business is established.

zero. Thus, if the condenser is not open, connecting the ohmmeter to it should produce first a "kick" of the meter needle toward zero resistance; then, as the condenser becomes charged, the needle should move back to a high resistance value almost at once. The amount of "kick" of the needle will depend upon the capacity of the condenser—the larger the condenser the greater the kick. This method works well on fairly high-capacity condensers, but cannot be used with low-capacity (below .05 mfd.) condensers because the kick is too small to be seen.

An instrument known as a capacity analyzer (see Fig. 2) will check condenser capacity accurately and will also check condensers for shorts and leakage.

**Intermittent Opens.** To check for an intermittent open, grasp the suspected condenser and twist or turn the outer case slightly while the set is operating, or move the suspected condenser with an insulated probe or wooden stick. If the condenser is intermittently open, this movement may either create considerable noise or cause the set operation to change radically as the condenser opens and closes.

If the intermittent condition cannot be made to show up by such mechanical jarring or bending, solder a good condenser temporarily across the suspected one. If the

receiver operation clears up when this is done, or the intermittent trouble does not reappear, then the original condenser is probably defective and should be removed from the circuit.

**Important Notice.** *Shunting a condenser across another one is a test that is good ONLY for open condensers, high series resistance (to be discussed next), and, sometimes, for changes in capacity. It does no good whatever to shunt a good condenser across one suspected of leakage or of being short-circuited. The good condenser cannot clear up the leakage or short circuit, so don't try anything except an ohmmeter test for these two troubles.*

## HIGH SERIES RESISTANCE

As you learned earlier, high series resistance usually develops only in electrolytic or air condensers. To detect this condition in air condensers you must be able to interpret the behavior of the receiver as you will learn to do in a later RSM Booklet. However, an electrolytic can readily be tested for high series resistance.

Any series resistance will waste power, thus reducing the effectiveness of the condenser. A logical way to test an electrolytic for high series resistance, then, is to shunt it with another one known to be in good condition. If the receiver operates better, the original condenser is defective.

As you can see, this test doesn't show whether the electrolytic condenser is open or simply has high series resistance, for the result of the test is the same in either case. However, you usually don't care what the defect is; the important thing is that the condenser is defective, and must be replaced.

You can also test for high series resistance with a capacity analyzer that is capable of measuring power factor (the condenser must be disconnected to do so).

**Air Condensers.** You can use a low-range ohmmeter to check for series resistance between the rotor and the condenser frame, and between the stator and its contact. However, poor contacts between the test probes

and the condenser can easily give erroneous readings, so it is better to rely on the operation of the radio to confirm this condition. The series resistance may develop at either the stator connections or the rotor connections, and both can be repaired. If the trouble is due to corrosion on the threads of the screws that make the connections to the stator, it is necessary only to loosen these screws and then to retighten them to break up the corrosion and to provide a good connection again.

If corrosion or dirt occurs at the spring contact that makes the connection to the rotor shaft, pull out the contact, clean it, then bend it to give greater tension and firmer contact. Clean the end bearings on the condenser shaft with carbon tetrachloride or a grease solvent, then regrease them with Grafoline, a conductive lubricant made of vaseline and graphite.

## HOW TO CHECK CONDENSERS FOR CHANGES IN CAPACITY

Changes in capacity occur most frequently in trimmer condensers and in electrolytics. Any change in capacity of an electrolytic condenser will always be a reduction. You can check for this by connecting another condenser across the suspected one, thereby increasing the capacity in the circuit. If doing so improves performance, the suspected condenser is defective. (Again, this test merely shows that the condenser is defective, without indicating the exact defect.) You can also check the capacity with a capacity analyzer.

► A trimmer condenser may either increase or decrease in capacity if it gets out of adjustment. Usually either condition is detected during alignment of the receiver, which is a subject you will study in later RSM Booklets. Generally the trimmer can be readjusted satisfactorily, but occasionally one must be replaced.

**WARNING.** Do not fall into the bad habit of checking every condenser in a receiver. This is the time-consuming procedure of a radio "mechanic," and is one of the principal reasons why such men are severely limited in the number of sets they can service in a day. Future Lessons and Booklets will teach you how to deduce from

the operation of a set, and by a system of localization, whether a condenser is probably defective and which condenser it is likely to be. *Never check a condenser unless you have a good reason to suspect that it is defective.*

## HOW TO REPLACE CONDENSERS

Defective condensers can usually be replaced from a stock of standard types. You will rarely have to order an exact duplicate replacement part except for air condensers, trimmer condensers, special electrolytic filters, and certain special mica condensers. Replacements for the condensers that most commonly break down—paper and electrolytic types—can readily be obtained. Here are a few good rules to remember.

**Paper Condensers.** A paper condenser has two ratings of importance—its capacity and its voltage rating. Physical size doesn't matter as long as a replacement fits into the space allotted.

Usually the original capacity is marked right on the condenser. Generally, this marking is a decimal—such as .1, .05, or .001—followed by the abbreviation "mfd." Sometimes the abbreviation is not given. Similarly, the working voltage is usually marked on the condenser case. Common working voltages are 200, 400, or 600 volts.

If the defective condenser is not marked to show the capacity and working voltage, you can find them from the manufacturer's information or from Table 1, which shows satisfactory capacity values for various paper and mica condenser uses. (You'll learn about these uses in your Lessons.)

TABLE I

USE	CAPACITY CAN BE ANY VALUE BETWEEN
R.F. AND I.F. BY-PASSING	.01 to .1 MFD.
A.F. BY-PASSING	.25 to 1 MFD.
GRID LEAK CONDENSER	.00025 to .0005 MFD.
A.F. COUPLING	.002 to .05 MFD.
BUFFER (FOR VIBRATORS)	.001 to .05 MFD.

► It is best to use 600-volt condensers even when you replace a 200- or a 400-volt unit. The extra cost for the higher working voltage is negligible, and you are sure that the condenser will stand any voltage normally present in a receiver. (There is one exception to this rule—a buffer condenser must be rated at 1200 to 2000 volts.)

**Electrolytic Condensers.** In addition to capacity and working voltage, electrolytic condensers have a third important rating—the surge voltage. The surge voltage rating is important because it is the maximum peak voltage that may be applied to the condenser, and, for electrolytics, it is only a little higher than the working voltage. When the set is turned on, the set voltage will first rise to near the surge value, then come down to the working value as the tubes warm up. You must be sure that the condenser surge voltage rating will not be exceeded during the first few moments of operation; otherwise, the condenser will break down.

Table 2 gives the ranges of values of electrolytic condensers that are used in various radio circuits. (You will study the circuits in your lessons.) Usually there is some clue to the size of the electrolytic that should be used to make a replacement. However, if there is none, simply use a condenser with a capacity near the bottom of the range for the particular circuit. If the result is not satisfactory, try condensers with higher capacities until normal operation is produced. An electrolytic can almost always be satisfactorily replaced by one of higher capacity.

The types of electrolytics (dry, semi-dry, and wet) are usually interchangeable if of the proper ratings.

TABLE 2

CIRCUIT	CAPACITY (MF <sub>D</sub> )	D.C. WORKING VOLTAGE (VOLTS)
OUTPUT FILTER A.C. SET	8 to 60	450
INPUT FILTER A.C. SET	8 to 40	450
OUTPUT FILTER A.C.-D.C. SET	16 to 60	150
INPUT FILTER A.C.-D.C. SET	8 to 30	150
A.F.-R.F. FILTER	8 to 30	350 to 450
A.F. CATHODE BY-PASS	5 to 50	25 to 50

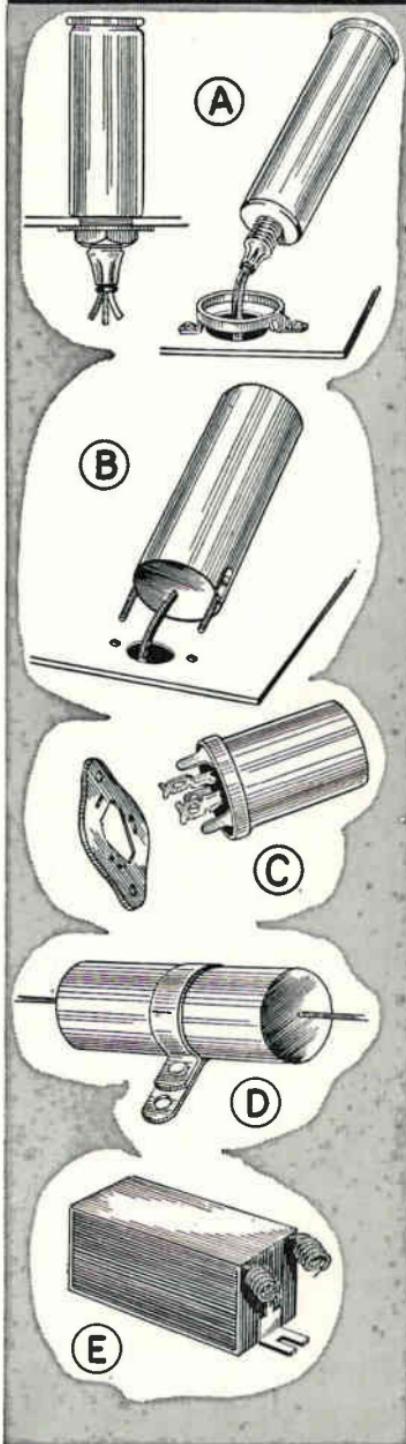
However, you should check the surge voltage carefully before using a dry in place of a wet condenser. Some circuits have high surge voltages that do no permanent harm to a wet, but which would ruin a dry type. In such cases, a replacement wet type is the best to use.

► Electrolytic condensers may be physically different, particularly in their methods of mounting (see Fig. 3). It is not necessary to use an exact duplicate type as long as the replacement can be mounted in the available space.

When you replace the "can" type shown at A in Fig. 3, remember that the can is often the negative terminal connection of the condenser. The can may ground to the chassis, or it may be insulated from the chassis by insulating paper. In replacing the latter types, be sure you replace the insulation (or use a condenser that does not ground to the chassis) so that the circuit will not be upset.

**FIG. 3.** You may find any of these methods used to mount an electrolytic. In the relatively new mounting method shown in C, the condenser is plugged into the socket, then the three outside lugs are twisted to lock the condenser in place.

## METHODS OF MOUNTING ELECTROLYTICS



Where two wire leads are brought out of a *single* section electrolytic, the can is merely a housing, and the leads go to the condenser. Although there is no universally used code, the positive lead is usually colored red and the negative lead is black.

► Electrolytic condensers are frequently combined into "blocks" or units of two or more condensers. Frequently only one of the condensers in a block will be defective. This one unit may be replaced by a single-section unit, but usually it is best to replace the entire block, as other units are likely to go bad soon.

Identifying leads and connections on a multi-section block may not be easy if the color code is not marked on the unit. You will learn farther along in your Course how to trace connections to find the proper connecting polarities.

Let's suppose you have to replace a 2-section block (the most common type). The manufacturer may have brought out all the leads as in Fig. 4A, or he may have connected leads together inside the block as in Figs. 4B

and 4C. In Fig. 4B, the positive leads are connected together — this unit is intended for use in a radio where both these leads go to the same point. This condenser is described as having a *common positive* lead. Fig. 4C shows a unit with a *common negative* lead. The blocks shown in Figs. 4B and 4C are not interchangeable, but the one shown in Fig. 4A can be used to replace either of these just by connecting the proper leads together.

Also, two single-unit condensers could be used as the replacement. Fig. 5 shows examples of this. The original unit is shown at A.

FIG. 4A

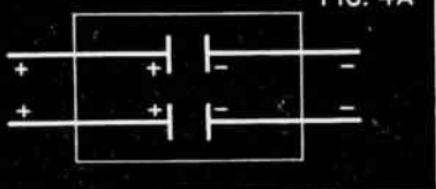


FIG. 4B

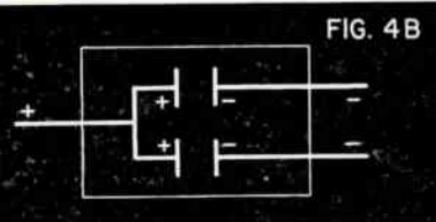
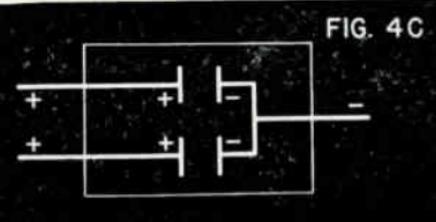


FIG. 4C

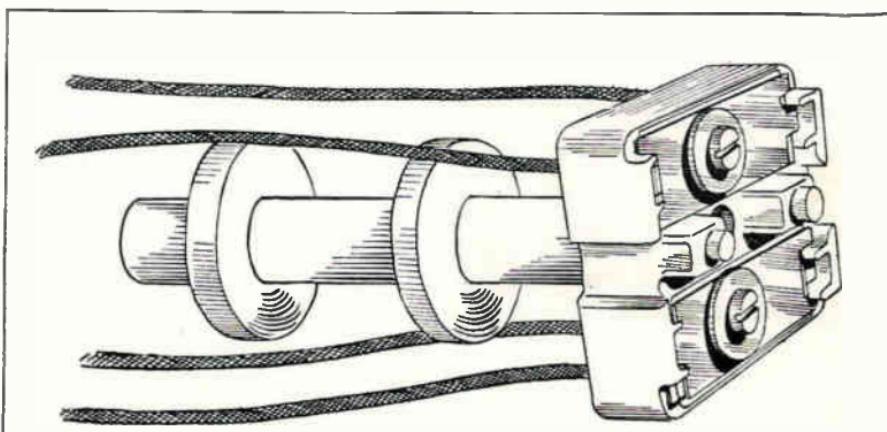
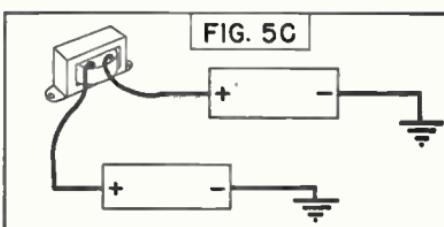
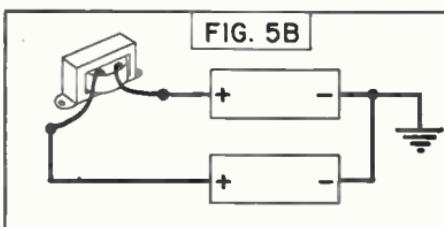
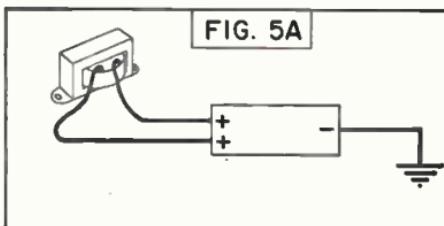


Sometimes it is convenient to cut the leads off the original condenser, close to its case, and use these leads as the connecting wires on the replacements (Fig. 5B). The replacements may also be mounted as in Fig. 5C if there is room and the connections are easy to make.

**Air Condensers.** These condensers rarely need replacement. If one does, obtain an exact duplicate—one intended to operate in that particular make and model receiver. This can be ordered from the manufacturer or distributor of the set or from some of the large supply houses. If an exact duplicate is not available, send the defective gang to a supply house to be matched as closely as possible.

**Trimmer Condensers.** When trimmer condensers become defective, it is usually necessary to replace them with exact duplicates. If the trimmer is part of a coil assembly, as in Fig. 6, it is easier to replace the entire assembly, as a replacement assembly is much easier to obtain than are replacement trimmers.

**FIG. 6.** Here's what a typical i.f. coil assembly looks like when the shield can is removed.



**Mica Condensers.** Mica condensers should be replaced by units having similar capacities. The capacity value may or may not be stamped on the condenser. There is a color code used with mica condensers, shown in Fig. 7, but this is not followed by all set manufacturers. For this reason it is usually best to determine the proper size from your knowledge of the circuit action, or by consulting the manufacturer's information.

As you will notice, there are several methods of marking these condensers. In the style using six colors, the tolerance of the condenser value and the working voltage are also given (the latter is usually 500 volts for mica condensers used in receivers).

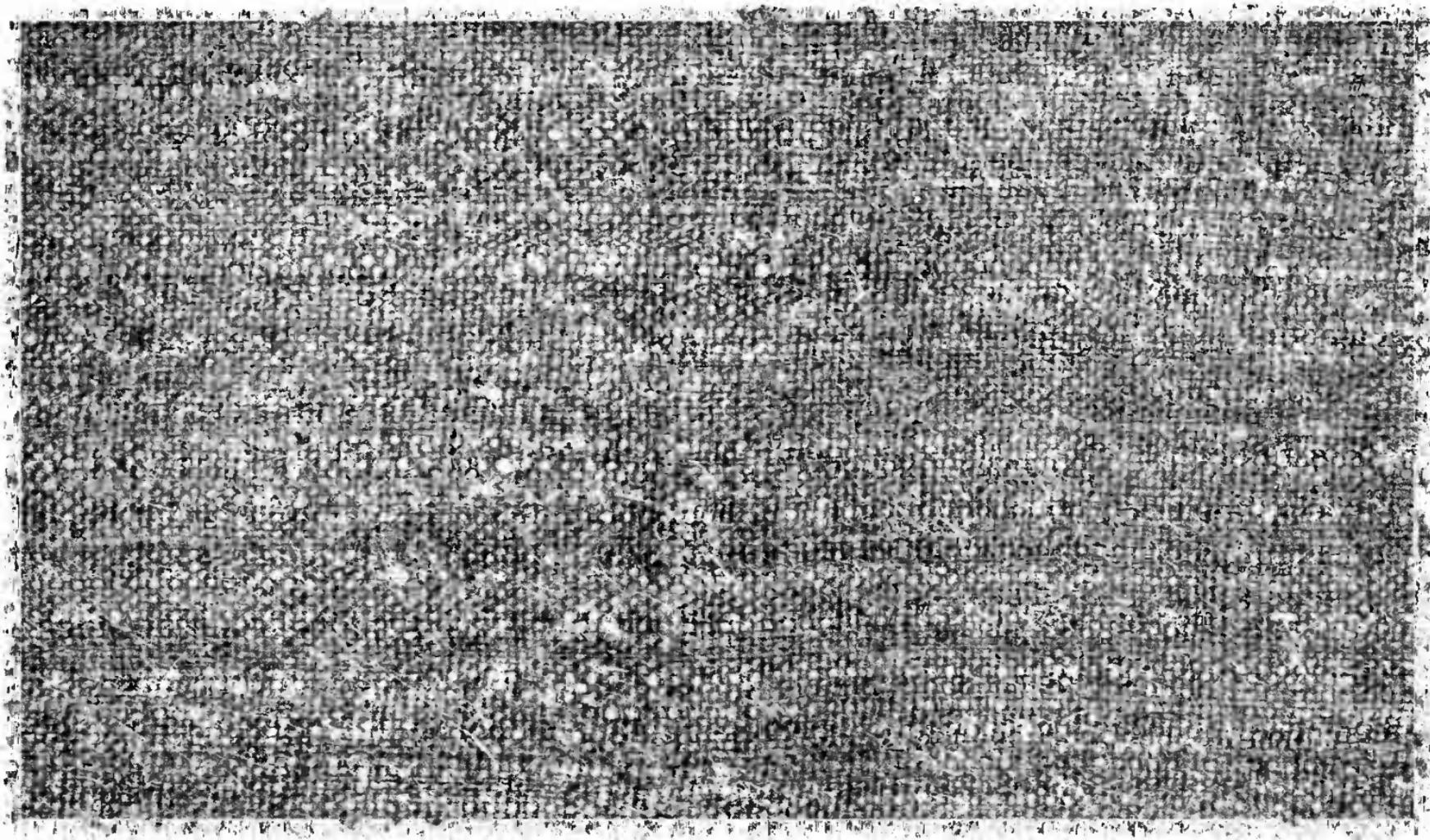
RMA COLOR CODE FOR MICA CONDENSERS					
 CONDENSER A B C MFG. CO.			 A B C F E D		
COLOR A is first figure of capacitance.			COLOR A is first figure of capacitance.		
COLOR B is second figure.			COLOR B is second figure.		
COLOR C is number of zeros after second figure.			COLOR C is third figure.		
			COLOR D is number of zeros after third figure.		
			COLOR E is tolerance.		
			COLOR F is working voltage.		
Capacitance in MMFD for condensers smaller than .01 mfd, capacitance in MFD for larger condensers. Arrow or lettering usually shows right direction for reading dots.					
COLOR	FIGURE	TOLERANCE	WORKING VOLTAGE		
BLACK	0	—	—		
BROWN	1	1%	100 V.		
RED	2	2%	200 V.		
ORANGE	3	3%	300 V.		
YELLOW	4	4%	400 V.		
GREEN	5	5%	500 V.		
BLUE	6	6%	600 V.		
VIOLET	7	7%	700 V.		
GRAY	8	8%	800 V.		
WHITE	9	9%	900 V.		
GOLD	—	5%	1000 V.		
SILVER	—	10%	2000 V.		
NONE	same as case color	20%	500 V		

FIG. 7

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

NATIONAL RADIO INSTITUTE WASHINGTON D.C.

No. 8      How To Test Tubes

RADIO SERVICING METHODS



# NRI TRAINING

# *Pays . . .*

Dear Mr. Smith:

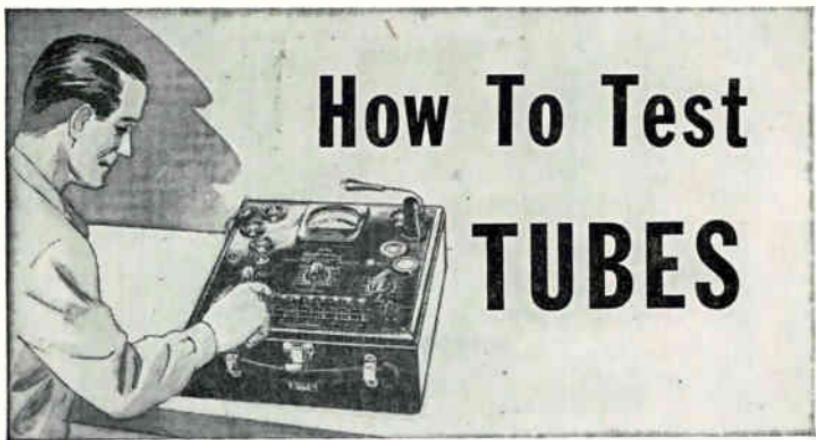
I have just completed the NRI Course and have a nice repair business established. I have been repairing radios since early in the Course, and did about \$1.00 worth of repair work while I studied. The Course easily paid for itself and purchased needed equipment. My only regret is that I did not study at NRI years sooner.

C.W.E., Ohio



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



# How To Test TUBES

DESPITE constant improvements in their manufacture, tubes are still the weakest link in the radio chain. They may become defective in a variety of ways, and, since they are used in so many different sections of a radio receiver, they can cause almost any radio complaint. Defective tubes may cause a receiver to be dead, or weak, or noisy, or may cause distortion or hum—in fact, whatever complaint a receiver exhibits, a tube could be the cause of it.

You have already learned, in your Course in Radio Fundamentals, some of the ways in which tubes can become defective. Let's review the most common defects briefly, then learn how tubes are tested.

## TUBE DEFECTS

The following paragraphs list the tube defects you will usually find in service work. We have listed these defects in their approximate order of occurrence. That is, those described first are found more frequently than those later, although this may not hold for certain specific tubes or receivers.

***Open Filaments.*** All receiving tubes, with very few exceptions, contain wire filaments that are heated by the passage of a current through them. The heat produced is what causes emission of electrons, either from the filament itself or from a metallic cylinder (called the cathode) that surrounds the filament. A filament may break for any one of a number of reasons—from

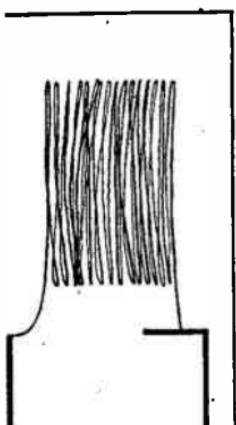
mechanical shock, from fatigue caused by stretching and contraction each time the current through it is turned on or off, or from accidental application of too high a voltage. Whatever the cause, a broken filament cannot heat up and produce electron emission; the tube can no longer function. Usually this means the receiver will not operate, although occasionally the circuit arrangement may be such that the signal can pass around the tube and produce weak or distorted reception.

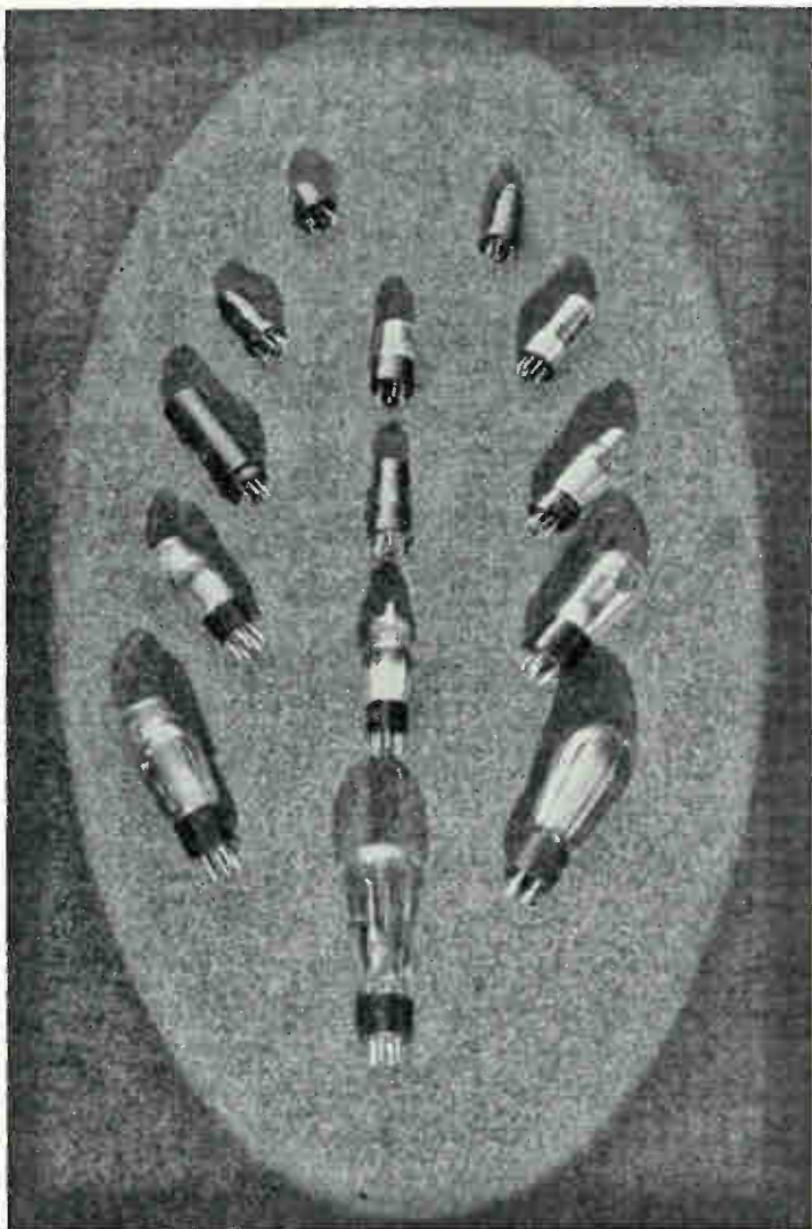
**Leakages and Short Circuits.** Often tube elements are spaced very close to one another, so it is possible for them to touch one another when the tube is subjected to vibration—caused by, say, the loudspeaker or by passing traffic.

Leakage frequently develops between the filament and the cathode in an indirectly heated tube. In these tubes, the filament and the cathode are separated by a ceramic insulator which, with age, may become semi-conductive because of deterioration and deposits on its surface. Consequently, leakage often develops between the cathode and the filament.

The filaments of some tubes operate from higher voltages than do others, but draw the same amount of current. In other words, high-voltage filaments have higher resistance than low-voltage filaments. Usually, this high resistance is produced by making the filaments extra long and doubling them back and forth as shown in Fig. 1. With this construction, it is possible for one filament turn to short to another, so that the total resistance is reduced. This causes an extra current flow through the unshorted portion of the filament. This may cause the filament to burn out or may affect the life of another tube somewhere in the radio, particularly when other filaments are connected in series

**Gas.** Even after careful evacuation, there may be some gas left in the tube. Electron flow through the tube may ionize this gas, producing positive ions that will be at-  
**FIG. 1. High-voltage filaments are folded like this. If the ceramic coating (insulation) on the wire breaks down, the folds may short.**





This photograph shows a collection of the radio tubes that have been, and are now, used in receiving sets. Notice that they vary considerably in size; in general, the most modern types are also the smallest. The large tube at the bottom of the center column is one of the early power rectifier tubes. More modern rectifier tubes are shown at the bottoms of the other columns. Bases with 4, 5, 6, 7, and 8 prongs are shown; most tubes now use the octal (8-prong) base. Metal tubes, and the small glass (GT) tubes, shown in the top half of the photograph, are very widely used in modern sets, where chassis space is usually at a premium.

tracted to the cathode or the filament and bombard it heavily. This will eventually destroy the emitting ability of the filament or cathode, and so ruin the tube. Gas within the tube can also cause a grid current flow, which, as we will see later in this Booklet, may cause distortion.

**Loss of Emission.** Even if nothing unusual happens to it, a tube will eventually "wear out"—that is, lose its ability to emit electrons. This does not happen abruptly; rather, the tube becomes weaker and weaker until finally the receiver goes dead. Tubes vary considerably in their length of life, depending chiefly upon their construction and the use to which they are put.

**Loose Elements.** Each element within a tube is welded to one or more supports, one of which acts as the connection to a prong in the tube base. A poor or erratic contact at the weld may result in an uneven flow of current through the tube, usually producing noise. Sometimes an element may break away from the support that acts as an electrical connection, producing what is called an "open" element. However, loose or open elements are rarely found today because of improvements in manufacturing.

**Miscellaneous Defects.** Tubes sometimes exhibit other defects, the reasons for which are more difficult to determine. For example, expansion of the elements caused by the heat of operation sometimes changes the tube characteristics. You can expect mysterious defects of this sort to appear occasionally.

► Now that we've reviewed tube defects, we shall go on to study how and when to test tubes. Some of these tests are made with a tube tester, others with an ohmmeter or voltmeter. To perform these latter tests, you must be able to tell which tube element is connected to each tube prong, so we shall take up the identification of tube prongs before going on to the tests.

## HOW TO IDENTIFY TUBE PRONGS

Tube prongs may be readily identified from tube charts like those pictured in Fig. 2. You can get such charts from tube manufacturers or from the distributor



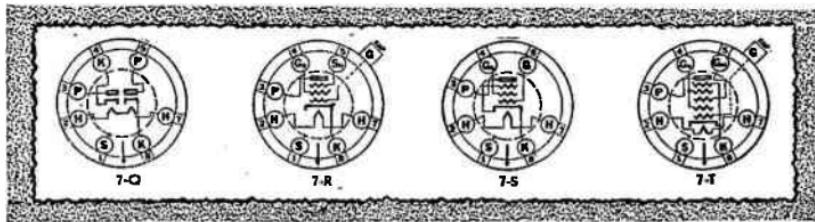
**FIG. 2.** Manufacturers list tube characteristics in manuals like these, which are free, or cost only a nominal sum.

or wholesaler from whom you buy the tubes; many are free; others cost ten to twenty-five cents. They are revised at least once each year, so get the latest copy when you need this information.

Fig. 3 shows how tubes are listed in a typical chart. As you can see, the tubes are listed by their type numbers, which are arranged numerically and alphabetically according to the RMA tube numbering code. That is, tubes are listed first by their initial numbers, which indicate the filament voltage classification: tube type 2B7 appears in the chart before type 6A3, because 2 is a lower number than 6. Tubes having the same initial number are listed by the letter or letters following the first number: the type 6A3 tube appears before type 6D7. Finally, tubes of the same initial number and same letters are listed by their last numbers, which indicate the number of elements within the tube that are brought out to base connecting prongs (or to a top cap): the 6A3 tube appears before a 6A4.

**FIG. 3.** A section from a typical tube hand-book.

Type	Construction			Emitter			Use
	Style	Class	Basing Diag.	Type	Volts	Amps	
6J8G	ST-12	Tri.-Heptode	8-H	Cathode	6.3	0.30	Mixer Oscillator
6K5G	ST-12	Triode	5-U	Cathode	6.3	0.30	Amplifier
6K5GT	GT						
6K6GT	GT	Pentode	7-S	Cathode	6.3	0.40	Power Amp.
6K7	Metal	Pentode	7-R	Cathode	6.3	0.30	Amplifier
6K7G	ST-12	Pentode	7-R	Cathode	6.3	0.30	Amplifier
6K7GT	GT	Pentode	7-R	Cathode	6.3	0.30	Amplifier
6K8	Metal	Tri.-Hexode	8-K	Cathode	6.3	0.30	Mixer Osc.



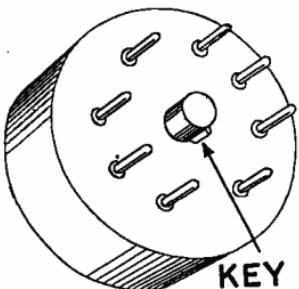
**FIG. 4.** One manufacturer represents the base layout of a tube like this. Others use different symbols.

This classification system makes it easier for you to find the tube you want in the tube chart. Once you have done so, follow its line across the page to the column marked "Basing Diag." or "Base Connections." Here you will find a key number, key letter, or group of numbers and letters; this designation identifies the base of the particular tube in a group of base layouts which you will find elsewhere in the tube chart.

Fig. 4 shows a typical base layout. Unless the chart states otherwise, the view shown is always the one you would see if you held the tube with the prongs facing you. This, of course, corresponds to an underside view of the tube socket. Since most of your testing will be made from the bottom of the socket, you will make use of a tube chart rather constantly in your service work.

► To take a concrete example, let us suppose we want to identify the prongs of the 6K7 tube. The chart in Fig. 3 indicates this tube has a type 7R base. Looking up the base in Fig. 4, we find it to be an octal type—that is, the base has provision for 8 prongs, which are numbered from 1 to 8; prong 1 is just at the left of the key on the tube base, and the others are numbered in order going clockwise around the circle of the prongs from prong 1. Fig. 5 is a closeup of an octal base, showing the location of the key.

Once prong 1 has been located, identification of the prongs is simple. The layout for the 6K7 tube shows prong 1 as a "blank," although the



**FIG. 5.** The locating key on an octal-base tube makes it impossible for you to put the tube in the socket wrong.

metal shell of a metal tube or a shield in a glass tube may go to this prong so that it may be grounded at the socket. (The shield connection may or may not be indicated on the base layout, depending on the tube chart you are using.) Prong 2 is connected to one end of the filament, prong 3 to the plate, prong 4 to the screen grid, prong 5 to the suppressor grid, prong 7 to the other end of the filament, and prong 8 to the cathode. Notice that there is no prong 6 on this tube. The control grid of the tube is brought out to the top cap, indicated by a small rectangle on the side of the base layout between prongs 5 and 7.

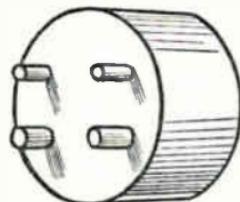
Most modern tubes use this octal base arrangement (or the loctal base, which is the same thing with a lock-in feature). However, other types of bases are also in fairly general use. Miniature tubes, used in very small portables and hearing aids, have 7-prong bases. And the older tubes, many of which are still in use, have 4-, 5-, 6-, and 7-prong bases. Fig. 6 shows typical examples of non-octal bases. However, regardless of the base arrangement, you can look up the tube in which you are interested and can then determine which prong connects to which element.

Now that you know how to identify tube prongs, let's see just when and how to test tubes.

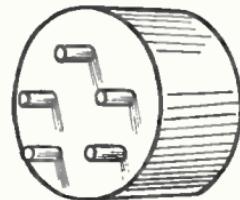
### WHEN TO TEST TUBES

One thing you'll learn very quickly when you go into professional radio servicing is that the customer always expects you to check his tubes. Even if the defect has nothing to do with tubes, not one customer in a hundred will believe you have done a thorough repair job unless you check

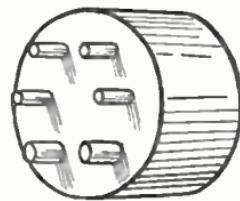
### TYPES OF NON-OCTAL BASES



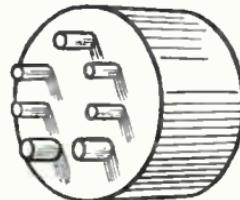
4 PRONG



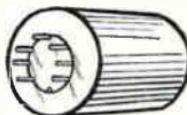
5 PRONG



6 PRONG



7 PRONG



MINIATURE

FIG. 6

every tube when you repair the set — so, even if you know that the tubes are good, to please the customer, you must almost always check the tubes in a tube tester whenever you repair a set in his presence. Once you have shown him that the tubes are all right, he will be willing to consider other repairs.

However, although you will be practically forced to check all the tubes in each set you repair, this does not mean you should do so at the beginning of your service procedure. Remember—*your goal is to find the trouble as quickly as possible*. You'll develop a definite service procedure, as you go through your Course and these RSM Booklets, that will enable you to find the source of the trouble very quickly. In fact, you will usually be able to have a pretty good idea of just what is the matter before you test any tube, and, if a tube is to blame, you will probably have to test only one to locate the defect. You will very seldom find it necessary to check all the tubes in a set before you can restore it to operation. However, as we have said, you will have to check all the tubes at some time in the service procedure to satisfy the customer.

## HOW TUBES ARE CHECKED

Most tube testing is done with a special piece of test equipment known as a tube tester. We shall describe the two main types of tube testers later in this RSM Booklet. However, tube testers are by no means infallible; in fact, it is often possible to make tests with an ohmmeter or voltmeter or by other means that will tell the condition of the tube more quickly than will a test with a tube tester. We shall describe these tests in detail before taking up tube testers. Some of the information we give you may be a little advanced for you right now, but you'll be able to put it to good use when you have gotten a little farther along in your study of servicing.

**How To Check for Opens in Parallel Filaments.** Tube filaments in most a.c.-operated receivers that use a power transformer, and in certain battery receivers, are connected in parallel in the manner shown in Fig. 7. If the filament opens in a tube so connected, that

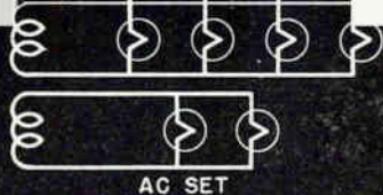
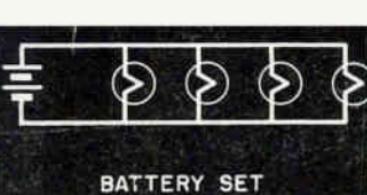


FIG. 7



BATTERY SET

tube will be dead, but the other tubes will not be affected. Some tubes have a visible glow when they are operating, and others, particularly metal tubes, become warm if they are operating properly. However, there are many glass tubes in which the filament cannot be seen, and many metal tubes do not become warm until they are run for some time. Thus, in many cases, you cannot rely on direct observation to lead you to the defective tube.

You can check any suspected tube readily for an open filament. Just remove the tube from its socket and check between the filament prongs with an ohmmeter; no reading indicates an open filament. If a replacement tube is handy, you can check the suspected one by plugging in the replacement and seeing if the radio operates properly.

When tubes are connected in parallel, it is very rare to find more than one tube with an open filament. If several tubes do not operate, the trouble is probably in the power supply circuit rather than in the tubes.

**Opens in Series Filaments.** In a.c.-d.c. sets, filaments are connected in series as shown in Fig. 8A. Some battery sets and three-way portables (a.c.-d.c.-battery-operated) also use series connections (Fig. 8B).

If one filament opens in a series filament arrangement, all the tubes stop operating. This is because the break in one filament opens the circuit and prevents current flow through any filament. The fact that a break exists in the filament circuit can be determined by checking between the prongs of the power cord (see Fig. 8A) with an ohmmeter. (The plug must NOT be in a wall socket, and the off-on switch must be turned on.) No reading indicates that a break exists

FIG. 8

(A) AC-DC SET



(B) 3-WAY PORTABLE



somewhere in the circuit. However, to find the actual defective tube, it is necessary to pull all of them and check their filaments individually with an ohmmeter, or to check the tubes in a tube tester.

**Tests for Gas.** Few tube testers have an adequate test for gas. Of course, a gassy tube will eventually destroy itself, and the tube tester will then indicate that it is defective. However, a gassy tube may cause disturbances in circuit operation long before it destroys itself. Positive ions in a gassy tube draw electrons to the grid, thus producing a grid current flow through the external grid circuit. In some circuits, this grid current flow may produce a voltage drop in the grid circuit that will affect the operation of the tube.

Figs. 9 and 10 show two grid circuits. A gassy tube would cause little trouble in the circuit shown in Fig. 9, because the transformer  $T$  has such low resistance that any grid current flow produces too little voltage drop across it to be measurable. A gassy tube here would probably escape notice until the tube was ruined. However, a gassy tube in the circuit in Fig. 10 would cause trouble. Here,  $R_2$  is a rather high resistance, so even a small grid current flow through it would produce a voltage large enough to upset the bias. (The upset in the bias causes the radio signal to be distorted—the radio sounds as if it has a cold.) It is easy to check for gas in a tube in this circuit; all we need to do is measure the voltage across  $R_2$  with a d.c. voltmeter with no signal tuned in. If we find a voltage across this resistance, then current is flowing through it.

Current flow through  $R_2$  indicates one of two things: either the tube is gassy, or the coupling condenser  $C_1$  is leaky. (If the condenser is leaky, electrons will flow from the B— terminal of the plate supply through  $R_2$ , then through the leaky condenser and through  $R_1$  back

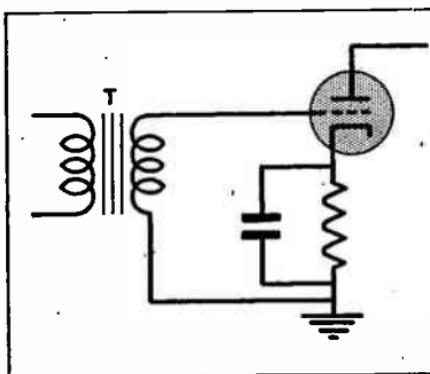


FIG. 9

to the B supply.) It is easy to distinguish between these possible causes if the set has its tube filaments in parallel, for then we need only pull out the tube and measure the voltage across  $R_2$ . If the voltage disappears, the tube is gassy; if it remains, then the coupling condenser is leaky.

If the tube filaments are in series, as in an a.c.-d.c. and in some battery receivers, we cannot pull out a tube to make tests, because this interrupts the filament current for all tubes and prevents current flow through  $C_1$  also. We must therefore make the test by disconnecting the condenser temporarily. If the voltage drop across  $R_2$  disappears when the coupling condenser  $C_1$  is unsoldered, then the coupling condenser is leaky; if it remains, the tube is gassy.

This measurement for voltage across the grid resistor is a standard test for gas. It is a typical example of why a professional serviceman is able to make a repair faster than a "radio mechanic." The mechanic type of serviceman would have to make tests on the coupling condenser for leakage and the tube for gas, both of which are somewhat difficult. The professional serviceman, on the other hand, makes one simple voltage measurement and thereby finds that either the condenser or the tube is at fault and, with another simple test, discovers which it is.

**Tests for Loose Elements.** We mentioned that loose elements will cause the receiver to operate erratically and noisily. An easy test for this is to thump or jar the tubes lightly one at a time with the receiver on. If the noise or erratic operation is increased when a particular tube is thumped, that tube probably has loose elements. Be careful not to jar the tube any harder than necessary, because the shock may go to some other part that is defective instead of the tube. When you believe

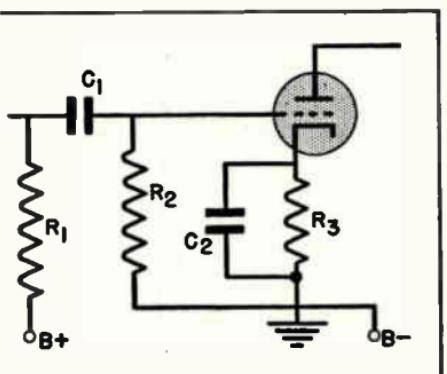


FIG. 10

you have located the faulty tube, you can check it quickly by substituting another tube to see if the noise or erratic operation ceases.

**Other Tests.** Tests for other tube defects cannot be made readily within a receiver. To check the emission of a tube, or to find out if leakages, shorts, or open elements exist, it is best to check the tubes in a tube tester. Let's see what a typical tester is like and how to use it.

## TYPES OF TUBE TESTERS

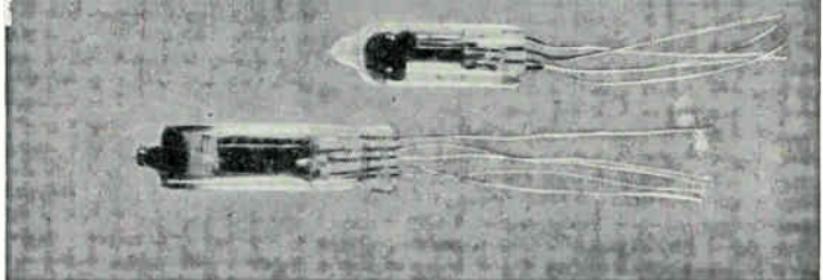
There are five requirements that a tube tester must meet to be useful to a serviceman:

1. It must give a satisfactory test.
2. It must be reasonably free from obsolescence—that is, it must not get out of date easily.
3. It must be easy to operate.
4. If the tester is a portable type, intended to be carried to the home of the customer, it must be light in weight and not bulky.
5. The tester must have "eye appeal"—it must impress the customer.

The last two of these are, of course, not technical requirements, but they are something to keep in mind when you buy a tester.

The other three requirements oppose each other to some extent. Obviously, the best way to test a tube is to apply normal operating voltages to it and measure its performance under the conditions to which it will be subjected in the radio. It is equally obvious that such a procedure is impractical in a tube tester that is designed to test all tubes. Tubes require widely different operating voltages, for example; this one factor alone would make it necessary for the tester to have a great many variable controls as well as an elaborate power pack. Such a tester would certainly not be easy to operate. Further, it would probably get out of date as soon as new tubes requiring different operating voltages or having different element arrangements were produced.

The easiest tester to operate would be one that had only one adjustment—say a dial that could be turned to a specific setting for each tube type being tested. It



These are two of the new sub-miniature tubes; they are shown actual size in this illustration. These tiny tubes are used in hearing aids and in "pocket" radio receivers. Some types have a basing arrangement instead of the wire leads, permitting the use of a tiny socket.

would be possible to make a tester of this sort that would give a satisfactory test. However, it would necessarily be so complex in its design that it would almost certainly go out of date as soon as new tubes were developed.

The result of these conflicting requirements has been a compromise. Modern tube testers give a reasonably satisfactory test, although by no means a complete one. They are relatively unlikely to get out of date, unless some radical new types of tubes are developed. And, finally, they are fairly easy to operate; it is necessary to adjust several controls or throw several switches to operate them, but it is a matter of only a few seconds to set them up to test a tube.

► There are two types of tube testers in general use today, the emission tester and the mutual conductance comparison tester. The emission tester is by far the more widely used. We shall describe both testers briefly, then describe the operation of a typical emission tester in some detail.

The mutual conductance of a tube is a measure of the control of the grid over the plate current. This tube characteristic is not measured directly by the mutual conductance comparison tester; instead, a measurement is made that shows roughly how the mutual conductance of the tube under test compares with the average mutual conductance of similar tubes. The meter of such a tester generally shows whether the tube is good, questionable, or bad.

When a tube is tested in an emission tester, all its grids are connected through the tester circuit to the

plate of the tube. A low voltage is then applied between the cathode and the combined elements (they act together as a plate, so the tube is effectively a diode), and the plate current produced is measured. The meter of the tester indicates whether the tube is good, questionable, or bad, and sometimes also gives a numerical indication of the amount of plate current.

Both testers give a fairly satisfactory test of the condition of the tube. At least, you can be sure that a tube is bad if the tester says so. That is, from the nature of the tests made, the tube will not always operate properly in a radio receiver if the tester says it is good, but it will always fail to operate properly if the tester says it is bad.

Both types of testers are relatively free from obsolescence. This is particularly true of those types of emission testers in which each tube element is brought out to a separate switch, thus allowing complete flexibility of connections. Generally speaking, either type needs only new calibration data to make it a suitable tester for new types of tubes. This will not hold, of course, if manufacturers bring out tubes that are greatly different from those the tester is designed to handle.

► In addition to their basic tests, both types of testers will show whether the tube has leakage or shorts between any of the elements. The test for leakages and shorts is always the first test made on the tube, since a tube exhibiting either of these defects can ruin the tester when a test for emission or mutual conductance is made.

Emission testers do not usually have any way of testing for gas in a tube, except that the presence of gas may cause an extraordinarily high emission that will move the meter pointer off-scale when the tube is tested. Some mutual conductance comparison testers do have gas tests, but this is by no means a universal feature of these testers.

Practically all tube testers are designed to operate from 115-volt, 60-cycle power lines. When operation on some frequency other than 60 cycles (25 cycles or 40 cycles, for example) is desired, most tube tester manu-

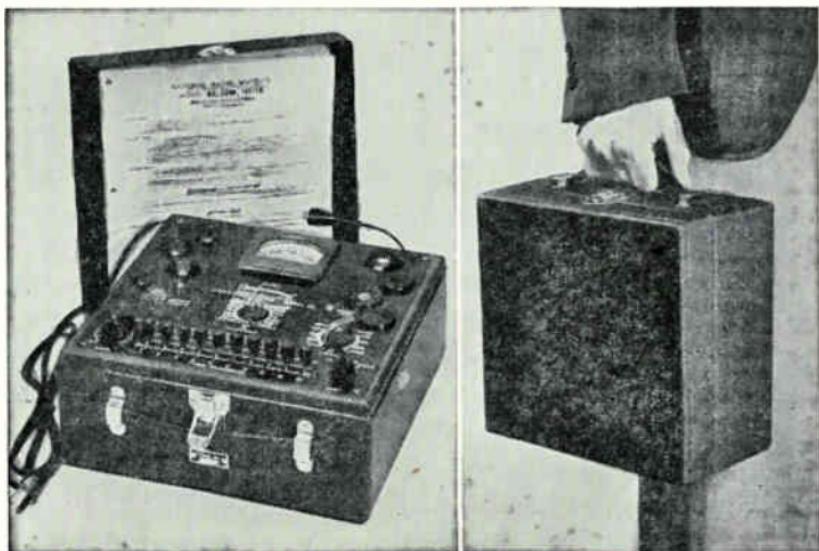
facturers, for a small increase in price, can supply a tester that will do this. In districts where only d.c. or storage batteries are available as power sources, a small inverter that will supply 115-volt, 60-cycle power from these sources may be used.

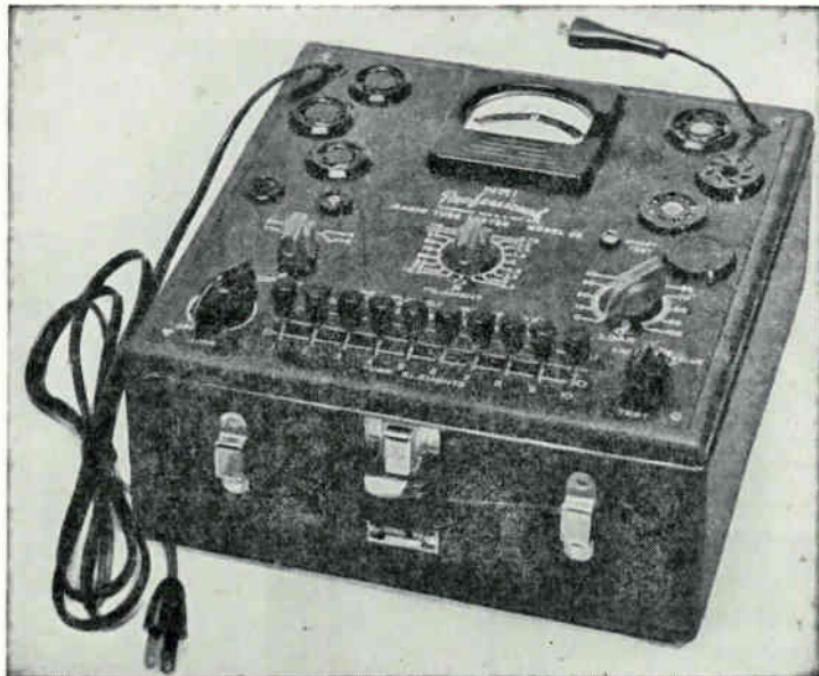
► Greater ease of operation, more freedom from obsolescence, and lower cost are the chief reasons why the emission tester is more popular than the mutual conductance comparison type. Now, let's see how you would use a typical emission tester.

### A TYPICAL EMISSION TUBE TESTER

Fig. 11 shows a typical instrument that is designed to be carried out on jobs as well as to be used in the shop. When used in a shop, the lid can be removed and the tester set on the counter or in an instrument panel. We're going to describe the procedure you should follow to test a tube in a late model of this tester. Although this exact procedure will apply only to the particular tester we used, any other emission tester (either another make or a different model of this one) can be used in much the same way. You should always follow the

**FIG. 11.** This is the NRI Professional Radio Tube Tester, an emission tester with several exceptional features. As you can see, it is easily carried.





Close-up view of the NRI Professional Radio Tube Tester. The row of lever switches at the bottom of the instrument is used to connect individual tube elements to the testing circuit. These levers have a center position, and may be moved up or down, according to the instructions.

instructions accompanying any tube tester you buy for the exact procedure for that model.

The tester in our example must be calibrated for the power-line voltage, then the tube is tested for shorted elements, and finally, the emission or "value" is checked. However, to make the power-line calibration adjustment, the tester transformer must be loaded by having the tube under test drawing filament power, so all the switches are set up first. This is desirable also for the shorted element test, as many shorts will show up only when the heat of normal operation has caused the elements to expand. The switch set-up procedure for the tester in our example is as follows:

First, the power cord is plugged into a 110-volt, 60-cycle power wall outlet. Then, the switches and controls are adjusted in order.

The three center selector knobs are lettered *A*, *B*, and *C*. A tube tester of this sort is always accompanied by

a set of instructions that gives the settings for these knobs as well as the settings for the various other controls and levers. A small section of the chart for this tester is shown in Fig. 12; the complete instruction pamphlet gives operating details and specific set-up data for all the several hundred tubes that you may encounter. Let us suppose, to take an example, that we are testing the 6K7 tube from these instructions in Fig. 12.

Looking up this tube in the chart, we find that the *A* knob is set at position 2 (this selects the test circuit within the tester), then the *B* or filament knob should be set to 6.3 volts, which is the filament voltage for this tube. The knob *C* is set to 32 on a scale ranging from 0 to 100. (This sets the "load" for the test circuit).

The next step is to set the row of ten levers. Each of these lever switches is marked to correspond to the number of the tube prong to which it is connected. Thus, levers 1 through 8 correspond to prongs 1 through 8 of an octal-base tube; lever 9 is provided for 9-prong tubes, and lever 0 is connected to the flexible lead that is used to make connections to the top caps of tubes having this feature. Initially, all ten levers should be in their center positions, and those to be used are then moved to one or the other of the two positions available. You should refer to the chart columns labeled "LEVER PO-

**FIG. 12.** This is a section of the instructions furnished with the NRI Professional Radio Tube Tester.

TUBE TYPE	KNOBS			LEVER POSITION	
	A Cir	B Fil	C Load	U Up	D Down
6K5 .....	1	6.3	20	30	78
6K6 .....	3	6.3	34	345	78
6K7 .....	2	6.3	32	340	578
6K8 .....	1	6.3	20	56	78
6K8 Test 2 .....	1	6.3	22	340	578
6L5 .....	2	6.3	26	35	78
6L6 .....	3	6.3	27	345	78
6L7 .....	2	6.3	56	4	78
6L7 Test 2 .....	2	6.3	26	350	78
6N5 .....	1	6.3	37	23	56

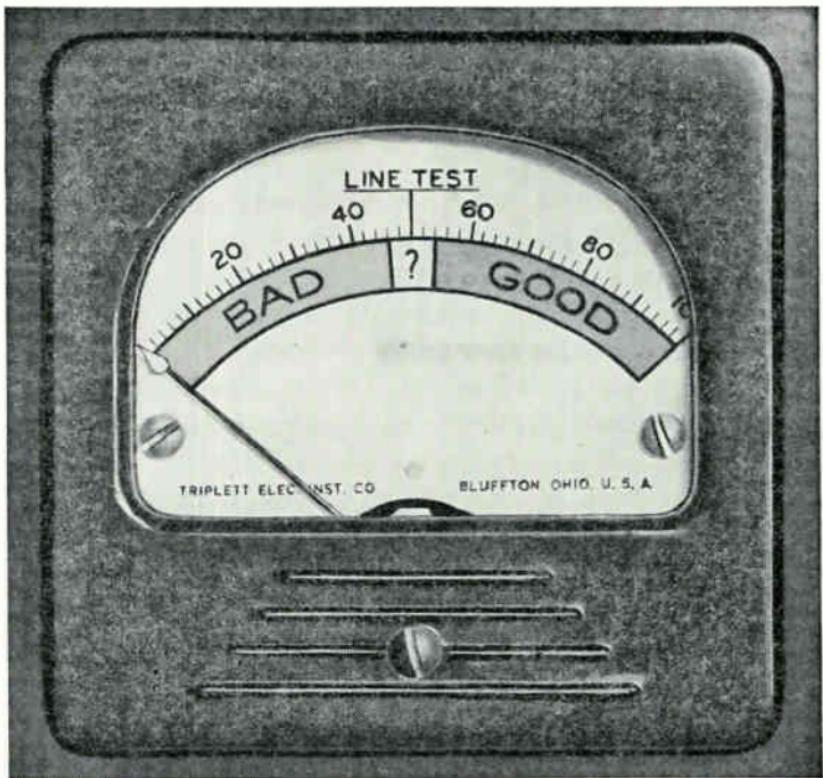
SITION" to see how to set the levers for each tube. One column is labeled *U*-Up, and the other is marked *D*-Down. *Only the levers marked for the tube under test should be moved*, and they should be moved to the position indicated. (All others are left in the center position.) Thus, for the 6K7 tube, the levers 3, 4, and 0 should be moved Up (to the line marked *U* on the tester), and levers 5, 7, and 8 should be moved to the Down position (marked *D* on the tester).

Now plug the tube into the socket it fits; the 6K7 goes into an octal socket. Connect the top cap clip to the top cap (when one is used). You are now ready to make the line calibration, the shorted element test, and the "value" test. The preliminary switch set-up procedures have prepared for all these except for the simple procedures below.

To make the line calibration, turn ON the lower left-hand knob labeled "*LINE*." The meter pointer will indicate, and the *LINE* knob should be rotated until the meter pointer is at the center of the scale at the position marked "*LINE TEST*." This calibrates for the line voltage, and you can now make the test for shorted elements.

To do this, move only the levers marked (for the tube you are testing) in *light face* type, *one at a time*, to their opposite positions, then return to their original positions. Thus, for the 6K7, move levers 3, 4, and 0 *one at a time* from the *U* position to the *D* position, then back to *U*. Then move levers 5 and 8, one at a time, from *D* to *U*, and back to *D*. *Don't move the levers in bold face type for this test*; so leave lever 7 in the *D* position. There may be a flicker of light from the neon bulb when a lever is moved. This can be ignored. However, if the bulb glows steadily when a lever is in the position opposite to its pre-set position, there is a short circuit or leakage between that element and the others, unless the instructions say otherwise. If you get this indication of a short-circuit, *make no further tests*; the tube is defective.

After testing for shorts, you can check the condition of the tube. To make the test, move the *TEST* knob at the lower right to the "*VALUE*" position and hold it there while you read the tube condition on the meter.



The meters of most tube testers give both a Bad-?-Good reading and a numerical reading.

The meter scale is divided into colored segments. The segment at the left is colored red and marked **BAD**. The small center section is colored yellow and is marked with a question mark (?). The remainder of the scale is colored green and is marked **GOOD**. If the meter pointer deflects to any point within the green region, the tube is good. If it deflects to the questionable region, the tube is in doubtful condition, and, if not bad already, will probably be bad soon; it should be replaced if the customer is willing. If the meter pointer deflects to the red region, the tube is definitely bad. The sections of the meter dial are colored this way for two reasons—to make it easier for you to check the tube, and to make it possible for the customer himself to see the condition of his tubes.

Numbers just above the colored sections of the meter scale are for making comparisons. In some receivers, it is necessary to use two tubes with matched emission in

the output stage of the set. You can find such tubes by choosing a pair that cause a meter deflection to the same number in the *GOOD* region of the scale.

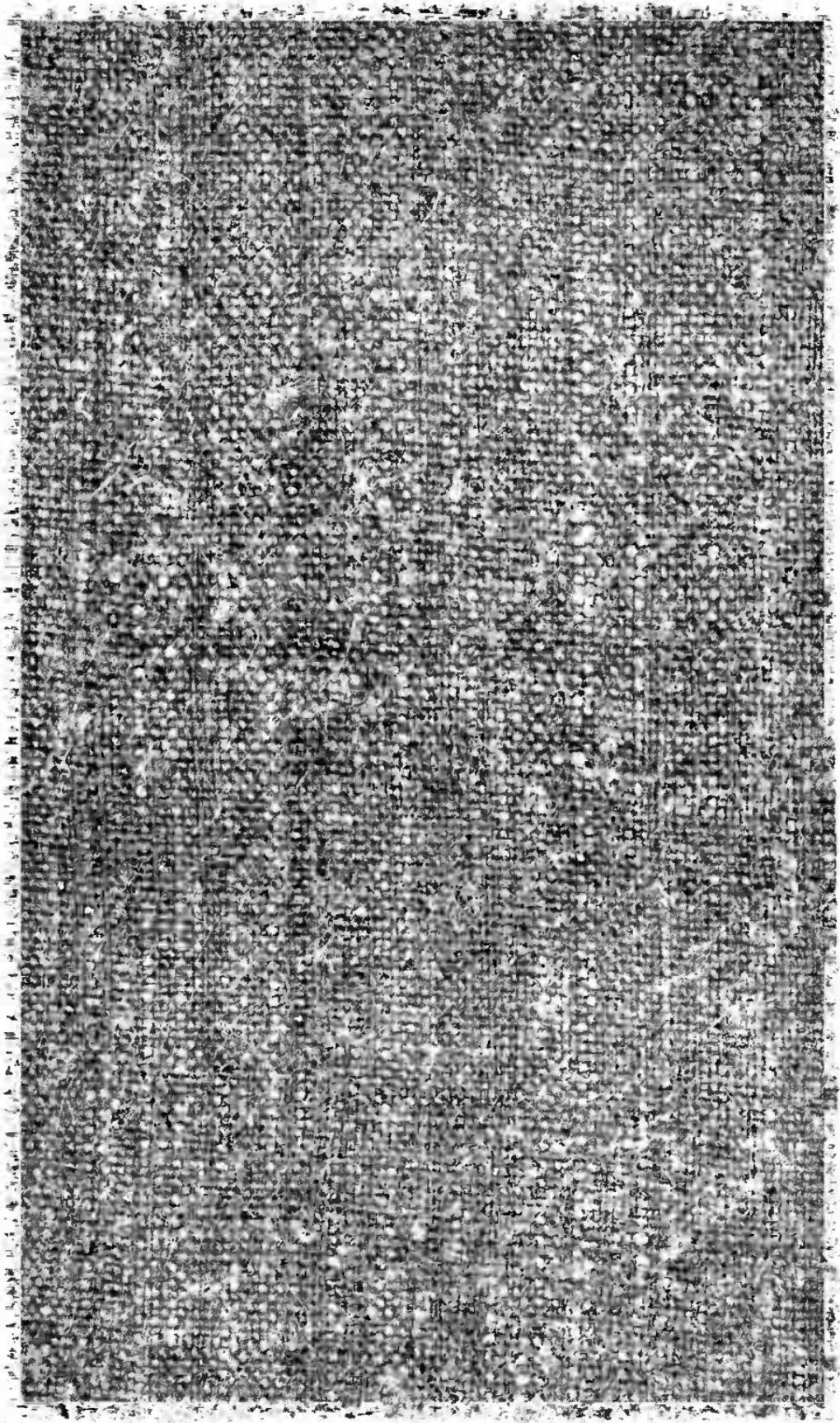
Also, some tests give readings that must be above certain of the numbers. For these, you ignore the colored segments and follow the tester instruction manual. ► The tests we have just described are all that are usually made for the 6K7 tube. Some tubes, however, like the 6K8, require two tests. These tests would be made in the same manner as those described. After completing your tests, let the *TEST* knob return to the left position and move all levers back to the center position. Turn the *LINE* knob to the *OFF* position. For safety, some servicemen always return the filament knob *B* to the "OFF" position in between tests of different tubes so that they will never accidentally apply a filament voltage higher than that for which the tube is designed. However, if you are testing a series of tubes that all require the same filament voltages, you may just as well leave the filament knob set to the correct voltage until you have finished that group of tubes.

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

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 9 How To Test and Replace  
Coils, Chokes, and Transformers  
**RADIO SERVICING METHODS**



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FM13M549

1949 Edition

Printed in U.S.A.



# How To Test and Replace Coils, Chokes, and Transformers

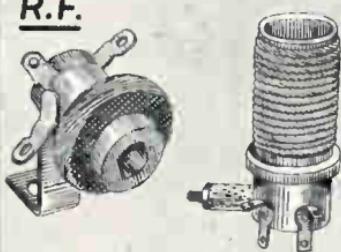
ALTHOUGH a number of coils (chokes and transformers) are used in radio receivers, they do not become defective nearly as often as condensers, tubes, and resistors. This is fortunate, because a replacement coil must often have exactly the same electrical characteristics as the original to operate properly; consequently, considerable care is necessary to order the right replacement. Since exact replacements are so frequently necessary, servicemen rarely carry in stock any great number of replacement coils. Instead, they order specific coils when replacements are needed.

Your Lessons in Radio Fundamentals have taught you much about how coils are made, and there will be more details in other Lessons. For now, we shall briefly review the types of coils, then shall go on to give you information about testing coils and replacing them.

**Coil Types.** All coils are made by winding copper wire on supporting forms. If there is no core material except the fiber, bakelite, wood, or cardboard form on which the coil is wound, we have an *air-core* coil; these are found in the r.f., oscillator, and i.f. stages of a superheterodyne receiver. If laminated strips of magnetic materials (iron, steel, or magnetic alloy metals) are used inside the form, the device is called an *iron-core* coil and will be found in the a.f. amplifier or power supply. (Some r.f. coils use powdered iron cores; however, air is still the major core material, so they are not called iron-core coils. You will find them referred to as "permeability-tuned" coils.)

## TYPICAL COILS

### R.F.



### I.F.



### A.F.

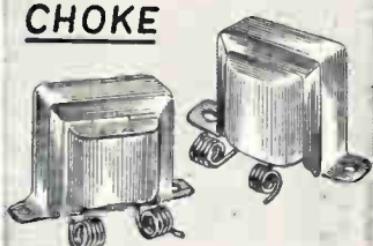


The r.f. coils shown in the illustration are "air-core" coils—wound on fiber forms that contain no magnetic materials. (They are sometimes also made with powdered iron cores.) R.F. coils are used in preselector and oscillator circuits.

Two i.f. coils, wound on the same form, are shown in the illustration. The coils are inductively coupled, but have no actual wire connection between them. Some special-purpose i. f. transformers have three coils wound on a common form.

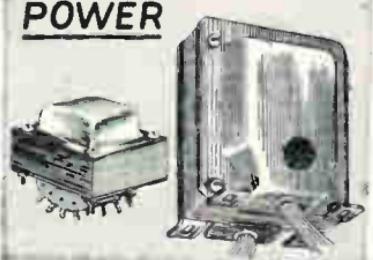
A.F. transformers were once commonly used for coupling between stages in the audio section. In modern home receivers, however, they are used almost solely as output transformers to couple the power output stage to the loudspeaker.

### CHOKE



The iron-core chokes shown resemble audio transformers in outward appearance. However, each has only one winding — notice that there are only two leads from each. Transformers always have at least 3 leads, and usually 4 or more.

### POWER



Power transformers like those shown normally have four windings—a primary winding, a high-voltage secondary winding (plate supply), a low-voltage secondary winding (filament supply), and a special low-voltage secondary winding for the filament of the power tube.

All these windings are classed as *coils*. If there is only a single winding on the form (or if there is no inductive coupling to another coil) the part is called a *choke*. When there are two or more windings *inductively coupled*, the part is a *transformer*.

## COIL DEFECTS

In general, coils can have the same defects as other parts—they open-circuit, short-circuit, and change in value. Except for open circuits, coil troubles are not as easy to find with an ohmmeter as are similar troubles in other parts. However, there are definite clues in the manner in which the set operates; you will learn about these elsewhere in your Course.

**Open Circuits.** An open circuit in any kind of coil can be found by checking for continuity with an ohmmeter. The normal coil resistance is far less than that of ordinary shunting parts, so it is usually possible to check coils without unsoldering them. If you fail to find continuity between the terminals that you know should go to a continuous winding, then the coil is open. (If you get a higher resistance reading than you expect for the coil alone, it may be that the coil is open, and that you are measuring the resistance of the shunt part. In this case, unsolder the coil and check it directly.)

► A break in the wire is likely to be caused by a chemical action that eats through the copper wire—an action known as electrolysis. Also, with air-core coils, the form on which the coil is wound may be expanded enough by temperature changes to break the wire. (Such a break is generally near one of the terminal lugs to which the wire leads are connected.) In addition, it is always possible for the coil winding to burn out if excess current flows through it, although this is rather rare. When this occurs there is considerable likelihood that other parts are also defective.

**Short Circuits.** Short circuits may occur either between turns or between layers. (Many coils are wound in layers of turns.) The wire is insulated either with a silk or cotton covering or with enamel. If the covering frays, or the enamel flakes off, adjacent turns or

layers may touch. In iron-core coils, the heat produced by power losses in the core may eventually destroy the insulation and permit a short to occur. When this happens, excessive current will flow through the shorted turns and may eventually burn out the coil. And, of course, excessive current caused by any other trouble will overheat a coil and cause eventual damage if not corrected in time.

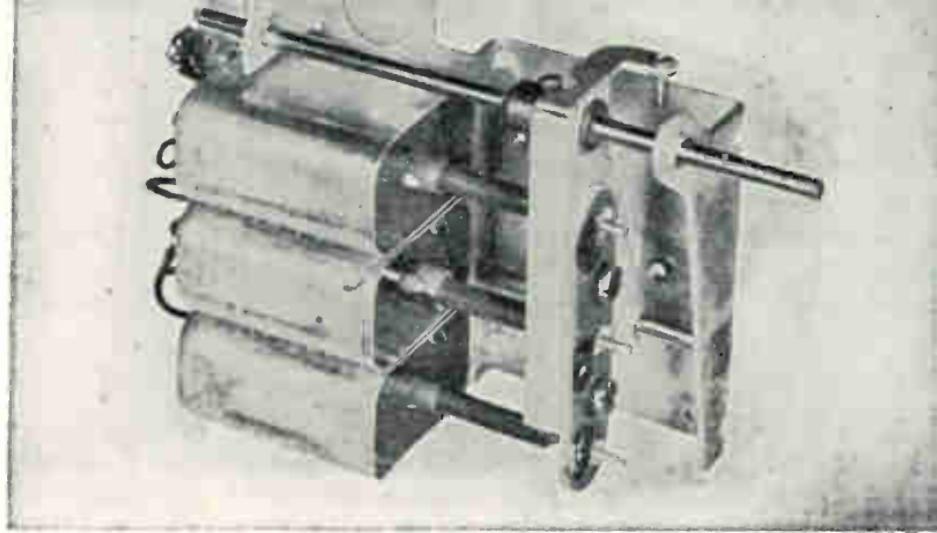
Short circuits between *adjacent turns* are hard to detect because the resistance of the coil is changed so slightly. For one thing, you will seldom know the exact resistance the coil should have; even if the value is given on the circuit diagram, it will be only an average value from which any specific coil may vary somewhat. Also, your ohmmeter will seldom be accurate enough to indicate whether the coil is a turn short, even if you do know what the exact resistance should be.

Power transformers or filter chokes become hotter than normal when a short circuit exists, but these coils run hot anyway. Unless you know exactly what the temperature should be, you can rarely judge whether there has been a slight increase.

► The operation of the receiver is almost the only indication that a short circuit between turns has occurred. Short circuits reduce the inductance and thereby affect the circuit action, either upsetting the tuning if the coil is in a resonant circuit, or, possibly, changing the fidelity of response if the coil is an audio transformer. (You will learn later how to recognize and check for these conditions.)

In a layer-wound coil having hundreds of turns, short circuits between *layers* are somewhat easier to detect, since there may be a fairly considerable change in the total resistance. However, the change is seldom so great that you can be sure a short circuit exists unless the operation of the receiver confirms your suspicion. It is rare indeed to find a coil that is completely short-circuited (near zero ohms), although this may occur if the terminal wires cross each other on their way to a terminal strip or to the connecting lugs.

In other words, two characteristics of a coil are



One of the permeability tuning units that are becoming increasingly popular in modern receivers. This unit is tuned by sliding the long bar on the top in or out.

changed when a short circuit occurs between turns—its resistance decreases and so does its inductance. Generally speaking, the decrease in resistance is too small to be readily detectable with an ordinary ohmmeter. However, the decreased inductance may have a considerable effect on the operation of the receiver, and, in most cases, you will have to rely on this to show you whether a short circuit has occurred.

**Changes in Value.** Short circuits are not the only reason why the inductance of a coil may change. A change in inductance may also be caused by a shift in the position of the coil turns or sections, particularly in r.f. and i.f. coils. You will rarely be able to tell whether the changed inductance is caused by shorted turns or by turns that have changed position. However, the cause of the inductance change doesn't matter—you'll have to replace the coil anyway if there is a change.

► Iron-core coils may at times develop leakage between the core and the coil. Leakage can be checked with an ohmmeter by disconnecting the coil in question from the circuit and measuring the resistance between one of its terminals and the core. A reading showing a resistance below 20 megohms indicates leakage, which usually means a new iron-core coil is required. You will learn later when to suspect leakage.

► The effectiveness of an air-core coil is reduced sharply if it develops a higher than normal a.c. resistance. As you know, a coil should have inductive reactance, but it should have a minimum of resistance in series with this reactance. A poor connection at a terminal, or a wire that is almost open (corroded through all but a slender section) will increase this series resistance and so reduce the Q of the coil. As you have learned in your Lessons on Radio Fundamentals, the lower the Q, the poorer the coil will be, particularly in a resonant circuit.

Coil Q may also be reduced by leakages along the coil form and by leakage through the insulation. Loss of Q may be a serious defect in a coil, but, unfortunately, it cannot be measured readily by service instruments. An ohmmeter will rarely show the losses that cause lowered Q nor will it indicate how these losses will affect the coil at the frequencies at which the coil is to be used. There are laboratory instruments with which Q can be measured, but these are not practical for service use.

You must, therefore, depend on the manner in which the receiver operates to show you whether the Q of a coil has become so low that the coil should be replaced. When coils lose their Q, the amplification of the receiver drops and so does the selectivity. There is increased interference from stations on adjacent frequencies, and the radio output is less than normal. As a bit of advanced information, the trimmer associated with a lowered Q coil will adjust much more broadly than normal.

**Summary.** Except for opens, your ohmmeter is not a reliable indicator of the condition of a coil. To detect troubles with coils, either you must eliminate all other possible suspects, or you must know how the circuits are supposed to operate and whether the observed defect in operation can be caused by a coil. You will gradually acquire this ability.

► Let's suppose that we have determined that a coil is defective, so that we can run through the steps of repair or of ordering the proper replacement. In the following discussion, we shall limit ourselves to r.f., oscillator, i.f., a.f., and power *transformers* and r.f., a.f., and power *chokes*. We shall not consider the speaker

**FIG. 1.** How to use sandpaper to remove insulation from a coil wire before soldering the wire to one of the coil terminals. For greater clarity, we have exaggerated the length of wire unwound from the coil in this illustration; normally, you should unwind as little as possible—an inch or so at the most.



field or the speaker voice coil, because these will be discussed in the RSM Booklet on Repairing Loudspeakers.

## REPAIRING COILS

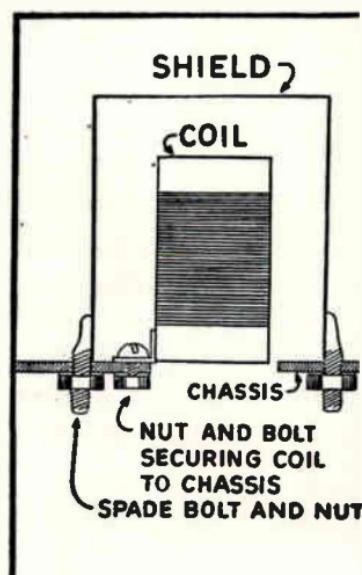
**Open Coils.** It is sometimes possible to repair an open coil. A break in an air-core coil is usually right at one of the terminal lugs, so examine the coil carefully. If you find a break, clean away the enamel insulation as shown in Fig. 1, then resolder the wire to the proper lug. If the wire is too short, solder a piece of fine wire to the lug and use the wire to splice the coil lead.

Often an r.f. or an i.f. coil will be in a shield can that has to be removed before the coil can be examined. Generally the shield will be fastened to the chassis by "spade" bolts that are permanently attached to the shield, as shown in Fig. 2. Use a socket wrench to remove the nuts from the bottom of the chassis, then lift the coil shield straight up and off.

In many i.f. stages, a connecting lead from the coil to the tube top-cap is run through the top of the shield. Sometimes the lead may be long enough to slip the shield up on it and thus expose the coil terminals. If not, the grid clip must be taken from the lead before the shield can be removed.

Look for green corroded spots on the windings. These are points where electrolysis is at work. If there is only one spot, you can scrape off the green corrosion and

**FIG. 2.** A typical shield and coil installation. Be careful not to bend the spade bolts when removing the shield.



make a good soldered connection. However, if there are a number of these green spots, a new coil should be installed because, even though you correct the present trouble, there will be more difficulty later.

After replacing or repairing a shielded coil, be sure to put back the shield properly. In the case of a shield with a grid lead through the top, you may have some difficulty in fishing the wire up through the hole. If so, run a length of thin wire through the hole in the top of the shield. Then, wrap or solder this wire to the grid lead and use the wire to pull the grid lead up through the hole as you push the shield down over the transformer. After you have fastened the shield in place, you can disconnect this extra wire and resolder the grid lead to the top cap clip.

► More difficulty is usually experienced in getting to the winding of iron-core coils, most of which are sealed in a shield container by a pitch compound. Because of the trouble involved in chipping this material away (or the messy process of melting it out), few servicemen try to make repairs on these coils, except in emergencies.

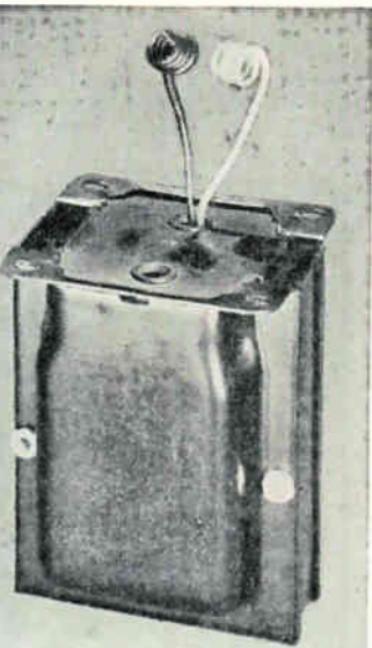
In any case, if the break is not visible or is not easy to repair, there is little point in wasting time on it as long as a replacement is readily available.

**Low-Q Coils.** If a coil has losses, go over the terminals with a hot soldering iron, leaving the iron in

place long enough so that the solder on each joint will melt and flow. This will eliminate any high-resistance joints. If this does not clear up the trouble, however, moisture probably has been absorbed by the coil form, and it is usually necessary to replace the coil. (The coil

*Courtesy Thordarson Electric Mfg. Co.*

**An iron-core choke.** Chokes of this sort are still used in power supply filter systems of sets using p.m. speakers. In sets having electro-dynamic speakers, however, modern practice is to use the field coil of the speaker in place of a separate choke.



can sometimes be dried out in an oven set at low heat (200°), but the coil then must be dipped in a special moisture-proofing compound known as "coil dope" or else in melted wax. Even with this protection, the cure is seldom permanent; the coil will usually absorb more moisture soon.)

## HOW TO ORDER REPLACEMENT COILS

Securing a proper replacement coil is no problem if the set manufacturer is still in business. Simply order an exact duplicate from the local distributor or directly from the factory; all you need to specify is the make and the model number of the receiver and the part number of the coil. You can find the part number in the service information supplied by the set manufacturer. If you do not have the part number, then the make and the model number of the set and the *function* of the part (that is, whether it is an r.f. transformer, i.f. transformer, filter choke, etc.) will enable the manufacturer to supply you with the proper replacement.

Of course, to tell the function of a part, you must know more about radio circuits than you have yet learned. However, we don't expect you to be replacing coils at this point in your servicing training, and, by the time you are, you'll have learned all the names of the parts found in receivers.

You can also get exact duplicate coils from coil manufacturers. These manufacturers issue catalogs in which you can look up the coil you want by the make and model number of the receiver and the part number of the coil and from these find the designation the coil manufacturer uses for this particular coil. Even if the set manufacturer has gone out of business, the coil manufacturers may have exact duplicate replacements for the "orphan" set. If not, they will wind you a new coil that is an exact duplicate of the defective one. Catalogs of these manufacturers indicate what information they need to wind you a new coil.

You should always use an exact duplicate when you replace an air-core coil if it is possible to get one. Air-core transformers are almost invariably used in some

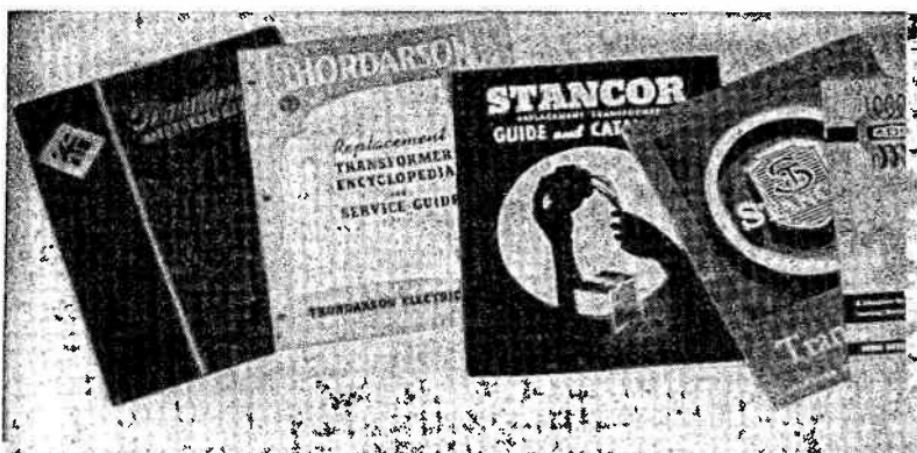
form of resonant circuit. For this reason, it is important that the replacement for the tuned coil have exactly the same inductance as the original. Also, for the set to have the same amplification and selectivity, the Q of the coil must be near that of the original. The only way you can be sure of getting a replacement coil that duplicates the original in these important respects is to use exact duplicate replacements.

► Exact duplication of electrical characteristics is not quite as important with i.f. coils as it is with r.f. coils. For best results, you should use an exact duplicate i.f. coil if you can find one, but, if you cannot, coil manufacturers can supply so-called "universal" i.f. coils that will be satisfactory. You will have to specify the i.f. frequency to be used, and whether the transformer is an input, interstage, or output type.

► R.F. choke coils are not widely used today. If you do find a defective one in a broadcast band receiver, a coil with similar inductance will be a satisfactory replacement. However, if the choke is tuned (in a resonant circuit), then an exact replacement should be obtained. Also, you will have to be a little more careful to get an inductance match if the coil is used in a short-wave receiver.

► You will rarely find an iron-core choke or iron-core transformer whose inductance value is critical. For this reason, it is practicable to use less exact replacements for these devices. Manufacturers of iron-core coils issue "service guides" in which you can find suitable replace-

Coil manufacturers list their products in catalogs like these, fro



ment parts if you know the make and model number of the receiver and the function of the part. It is also helpful to know the part number of the coil, but not usually necessary. It would be well for you to get these guides from the various manufacturers (they are usually either free or sold at a nominal price) or from a radio supply house.

These guides will show you the part number the coil manufacturer has assigned to the coil you want, and you can use this part number to order from him or from your usual parts supplier. The replacement coils you get by ordering this way are not usually exact duplicate replacements, but will be close enough in electrical characteristics to be usable. Sometimes you may find a considerable difference in physical size.

Universal replacements are also obtainable for iron-core coils. These are usually more satisfactory than similar replacements for air-core coils. We will say more about this later in this Booklet, when we discuss replacement of iron-core devices.

Of course, you need not look up part numbers of replacement coils in your manufacturer's catalog unless you wish to do so. You can always take the necessary information (make and model number of the set, function of the part, and, if possible, part number of the coil) to your supply house where they will do the looking up for you, and supply you with the closest available replacement or order a specially-wound coil for you if you prefer. Mail order supply houses will also give this service.

which you can find a replacement for almost any defective coil.



Now let's see what should be done to replace defective coils.

## HOW TO REPLACE AIR-CORE COILS

If you have obtained an exact duplicate replacement, all you need to do is to remove the old coil and mount the new one in its place. To be sure you make the proper electrical connections, don't disconnect the original coil until the replacement arrives. Then, make yourself a picture diagram or sketch like that shown in Fig. 3, showing the position of all the leads before you remove them.

An r.f. coil is likely to be located in a place that is hard to reach. For this reason, it is sometimes desirable to clip the lugs off the defective coil rather than to remove the leads themselves. Then, when the new coil is in place, you can solder the old lug (with the leads attached) onto the proper lug of the new coil, if you find it too difficult to remove the cut lugs from the leads.

Most i.f. transformers come with leads instead of lugs. In such cases, don't cut the leads of the defective unit too short. Instead, it is best to cut the leads so that an inch or two of each remains connected in its circuit. These short wires will allow you to determine the color of the leads fastened to different points and also will help to indicate the place of connection. You can remove these short leads as you solder each new wire in place.

I.F. transformers come with shields of various sizes. If you are not using an exact duplicate, try to get one the same size as, or smaller than, the original. If the replacement does not fit the mounting holes of the old

coil, it will be necessary to drill new mounting holes on the chassis. Mark on the chassis the positions of the shield bolts and, if necessary, the position of a hole through which the leads can

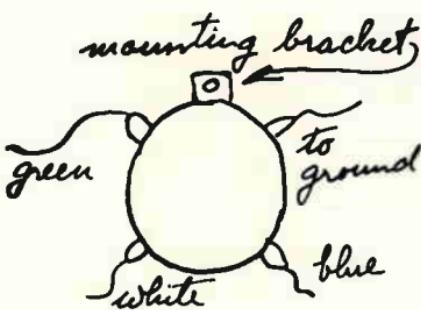


FIG. 3. Before removing a coil, make a rough sketch like this to show the proper connections.

pass. Then examine beneath the chassis to be sure that, when the drill goes through, you will not drill into some part. After moving any such part out of the way, and preferably removing tubes to safeguard them, you can proceed to drill the new hole or holes.

Any general-purpose replacement i.f. transformer will be adjusted at the factory to approximately the right i.f. frequency. However, when it is installed in a receiver, stray capacities between wires and between parts will not be compensated for, so the adjustment will not give the best results. For this reason, the receiver should be realigned, (in accordance with the instructions you will be given in a later RSM Booklet) whenever an i.f. or r.f. transformer is replaced.

## **REPLACING IRON-CORE CHOKES AND AUDIO TRANSFORMERS**

Iron-core choke coils are commonly used as filter chokes, and occasionally as a.f. chokes in inductively coupled circuits. It is, of course, best to use exact duplicate replacements or one of the replacements recommended by the coil manufacturer whenever possible. However, if you can't get one of these, one of the universal replacement types will generally be satisfactory.

To use a universal replacement, you must know the function of the choke, the inductance value, and the current rating. In the case of certain filter chokes, the resistance value may also be of importance. By "function of the choke," we mean the position the choke occupies in the circuit. As an example, a filter choke may be either an input or an output choke; one coupling choke may be used in the plate circuit of a stage, and another may be used in the grid circuit. (You may not exactly understand these terms now, but you will learn their meaning shortly. In the meantime, remember that the name "choke" may not be enough identification.)

If you have plenty of time, and want as exact a duplicate as possible, you can have your supply house send the choke to a coil manufacturer who can duplicate it. If you do not wish to wait this long, you can often find

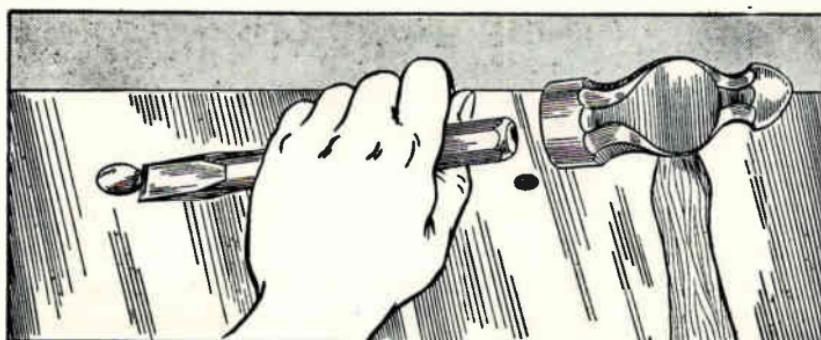
a satisfactory replacement just by specifying the type of set. For example, in receivers using a power transformer, the filter choke will usually have an inductance of 8 or 10 henrys and will be rated at 60 to 100 ma. Any choke meeting these specifications will probably work well enough. A.C.-D.C. receivers, which do not use a power transformer, are so much alike that you can ask for an "a.c.-d.c. filter choke" and will get a satisfactory replacement for most receivers of this kind.

► When you start to install the new choke, you may find that the original choke is riveted to the chassis. This means you must cut the rivet, as shown in Fig. 4. You do not need to use rivets to fasten the replacement, however; ordinary bolts and nuts will be satisfactory. If the replacement choke is of different physical size than the original, you may find it possible to use one of the original mounting holes and thus be required to drill only one hole. Again, be certain you will not damage any radio part underneath the chassis when you drill through.

**Audio Transformers.** There are a number of styles of audio transformers, as shown in Fig. 5. Each is named according to its use, which you will study in your Lessons on Radio Fundamentals.

Although interstage and input push-pull audio transformers are not used in many modern receivers, they were widely used in the older receivers that still come in for service. If you cannot identify the receiver sufficiently to get exact duplicate replacements, ordinarily you can use general-purpose replacements. Interstage

FIG. 4. Here's how to remove a rivet from a chassis.



transformers "amplify" the signal according to the ratio of the number of turns on the two windings. However, replacements rated at 2-to-1, 2½-to-1, or 3-to-1 will all prove satisfactory in most cases.

► Output transformers are found in all modern receivers, and they frequently become defective. If you cannot obtain an exact duplicate output transformer, then one of the universal types can be used. These have a secondary winding with a number of taps on it, so that the proper taps can be chosen to match the loudspeaker to the output tubes. Again you must know something about radio to make the proper replacement, because you have to know the characteristics of the output tubes and should know the voice coil impedance of the loudspeaker. However, if you do not have exact information, the instructions which accompany universal transformers will give directions for choosing the proper secondary terminals.

There are a number of other audio transformers; some have extra windings, and others are for special purposes. You will learn about these in your Course, and will then be in a better position to make a replacement when duplicate transformers are not available.

### HOW TO REPLACE POWER TRANSFORMERS

Power transformers develop the same troubles as do other transformers. However, it is usually easier to locate a defect in a power trans-

#### TYPES OF AUDIO TRANSFORMERS (SCHEMATICS)

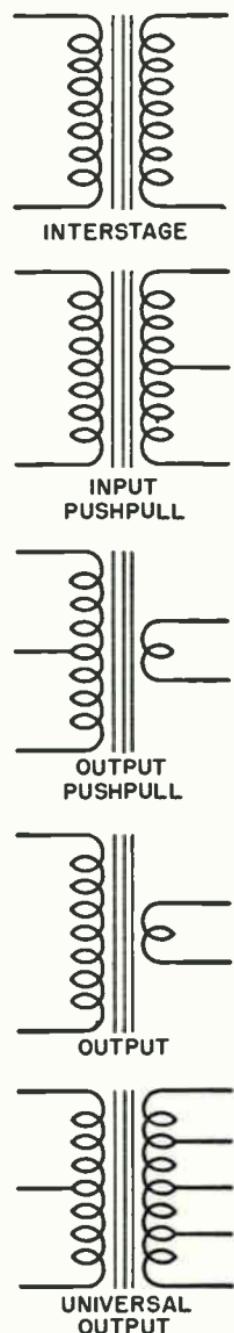


FIGURE 5

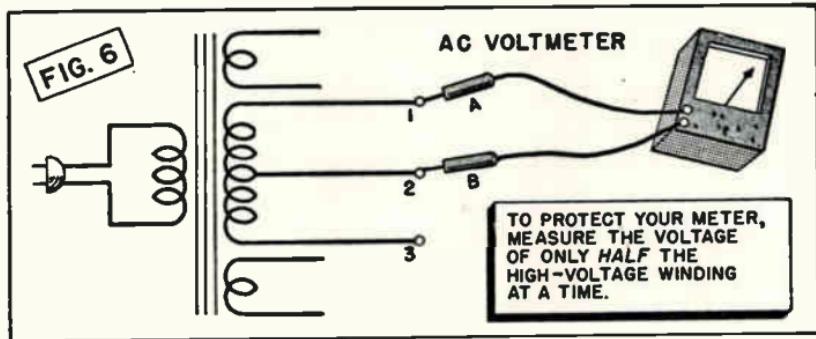
former, for frequently there are direct clues to what is wrong. For example, an open primary winding on the power transformer will cause the receiver to be completely dead and there will be no illumination of tube filaments or of pilot lamps. If one of the low voltage secondary windings opens, then the tube filaments connected to this winding will not be energized, and these tubes will be cold. If the high voltage winding opens there will be no B supply voltage, and, although the tubes will light, the receiver will be completely dead.

If the radio is completely dead, and there are no pilot lamps or tubes lighted, be sure to check the wall outlet before condemning the power transformer. The best way to do this is to plug in a floor lamp to be sure that electricity is available.

► You can check the power transformer with an ohmmeter, provided you follow the safety rule of unplugging the power cord from the power outlet.

You can also measure the voltage delivered by the various windings with an a.c. voltmeter. (The transformer must be connected to the power outlet and the receiver must be turned ON when making voltage measurements.) Be careful about measuring the voltage of the high voltage winding. Test only one-half the winding at a time as shown in Fig. 6. To check the other half of the winding move the voltmeter probe A from terminal 1 to terminal 3, leaving B on 2.

► No test instruments are necessary to identify a power transformer that is overloaded. Your nose, ears, and sense of touch will provide all the evidence required. Engineering design and the underwriters requirements limit the normal temperature rise of a power transformer to about 72° Fahrenheit. As room temperature is normally in the vicinity of 77° Fahrenheit, a transformer should not exceed the sum of these, or about 150°, which is considerably below the boiling point of water. This temperature will not cause a sensation of burning when the hand is placed upon the core of a transformer, but, if the transformer is overheated, it will be too hot to handle comfortably. When the transformer overheats, the insulation between windings and



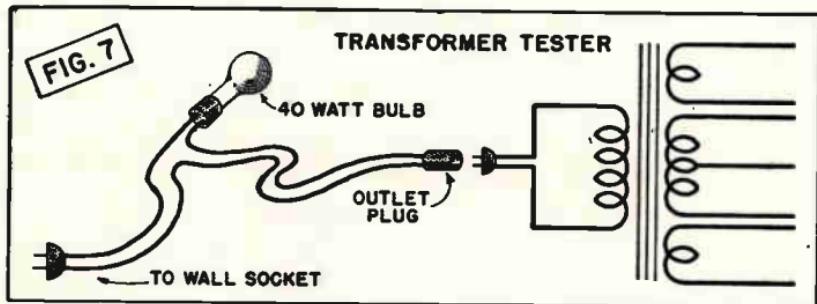
between layers will burn slowly (char), producing a smoke with an unpleasant, irritating smell. Sometimes the sealing compound boils, producing a sizzling sound. When this condition is found, don't leave the power transformer connected to the power line. If you create too much smoke, the resulting disagreeable odor remains a long time.

This overload condition is caused by an excessive power demand that may be the result of trouble in some circuit connected to the transformer or may be caused by a short circuit within the transformer itself. Regardless of the source of trouble, charred insulation is conductive, and short circuits will develop within the transformer (if not already there) if the overload is allowed to continue.

► Since the transformer may not yet be damaged, it is necessary to make a test to determine whether the overload is due to external causes. To do this, remove *ALL* tubes from the radio, then turn it back ON to see if the transformer still overheats.

If the transformer heats up and smokes when all tubes are removed from the receiver, then it is probably defective or has been damaged, although there still exists the possibility of a short circuit between some of the leads coming from it. On the other hand, if the transformer eventually cools with all the tubes out, there may be an overload condition in the radio and the transformer may not yet be damaged. If the defect is found and corrected, then it may not be necessary to replace the transformer.

A simple test rig is sometimes used as a time saver in testing for short circuits within a transformer. Fig. 7



shows the circuit. Connect a 40- to 60-watt light bulb in series with the primary in the manner shown, and remove all the tubes from the receiver. When the receiver is plugged in and turned on, the light should be very dim, or there should be no light at all. If there is a short circuit within the transformer or in the wiring to the transformer, the lamp will light brightly. No further tests are necessary except to examine the leads from the transformer to be sure that the secondary leads have good insulation, and that no bare wires are allowed to touch.

► Let's assume that the transformer is defective or has been damaged by an overload. (If there is an overload condition, it must be corrected *before* the replacement is installed.) Again it is desirable to obtain an exact duplicate replacement part. Not only will the replacement then have exactly the same characteristics as the original, but also it will be the same physically. This means all connecting leads and lugs will be in exactly the same places, which simplifies the replacement considerably. Even so, it is best to make a sketch showing the connections before disconnecting the defective transformer.

If a duplicate is not obtainable, you may be able to find an equivalent transformer listed for the make and model of the receiver, in catalogs of transformer manufacturers. If not, a universal replacement will be satisfactory if you are careful to order one with the proper ratings. You will seldom have to compute current or voltage ratings (though you will learn how to do so in a later lesson); usually a list of the tubes used in the receiver will be all you'll need to find a suitable replacement in manufacturers' catalogs. Of course, you will

have to be sure the replacement has the proper number of secondary windings.

Although it is perfectly all right to use a replacement transformer that is larger physically than the original, be sure the replacement won't be too large to fit the available space. Check the cabinet space in midget receivers to be sure the replacement will not prevent the receiver from going into its cabinet. If the original transformer was placed in a hole or "window" in the chassis, you will have to obtain a replacement to fit that space or else figure out another way of mounting the replacement on top of the chassis.

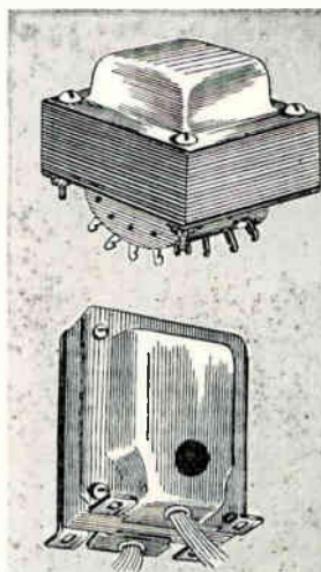
Replacement transformers come with universal mounting brackets, which make it possible to mount them in practically any position on the chassis.

Some transformers have lugs; others have leads. As long as the proper connections are made, these types can be considered interchangeable. Both are pictured in Fig. 8. Naturally, a replacement transformer may be different from the original in the color code of its leads or in the position of lugs. On standard replacements, the leads are identified by the instructions packed with the transformer so you won't have much trouble in identifying them. However, you have to be able to read the circuit diagram and to make the proper connections. This will be an easy task when you have progressed further in your Lessons on Radio Fundamentals.

► Most power transformers have two primary leads; three high voltage leads (including the center tap); two filament leads for the rectifier tube; and two filament leads for the other tubes. In addition, there may be an extra filament winding, or there may be a center tap on one of the filament windings.

In general, replacement transformers will have a center tap

FIG. 8. The transformer on top, called a half-shell type, mounts in a hole in the chassis. The other mounts on top of the chassis.



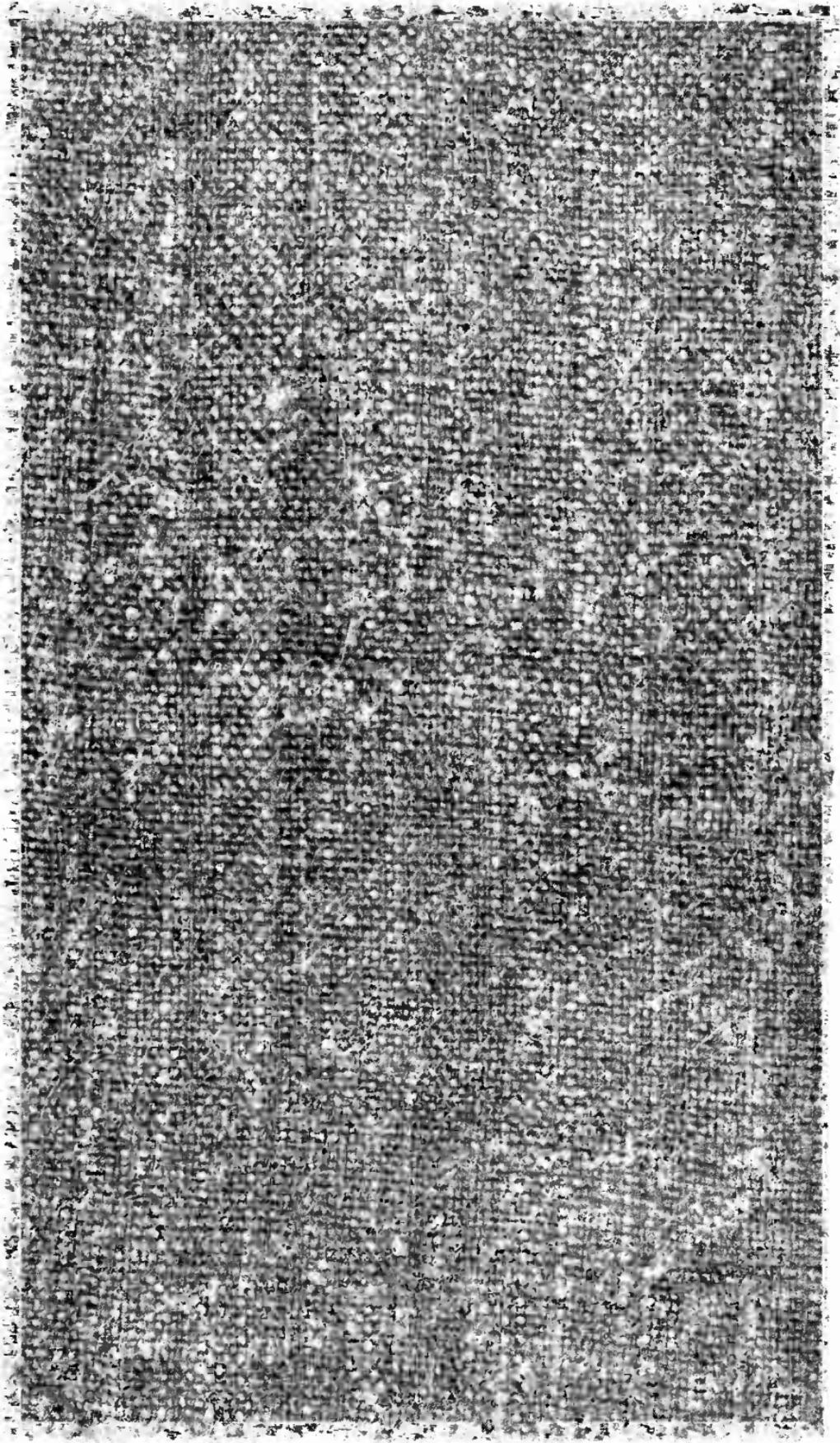
**lead for the tube filament windings.** If this lead is not used in the receiver connections, cut it to about two inches long and wrap the end with tape to prevent it from shorting to anything. If an extra secondary winding is on the replacement transformer, just tape up its leads individually so that they cannot short to each other, and ignore them.

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

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 10 How To Test and Repair  
Loudspeakers  
**RADIO SERVICING METHODS**



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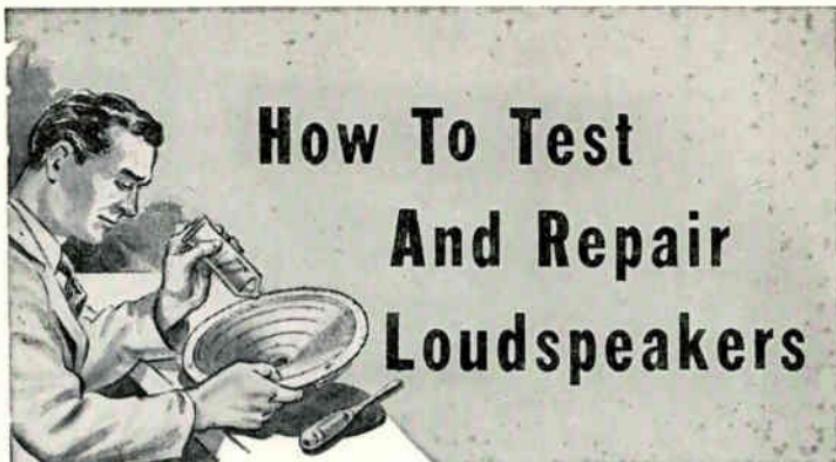
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# How To Test And Repair Loudspeakers

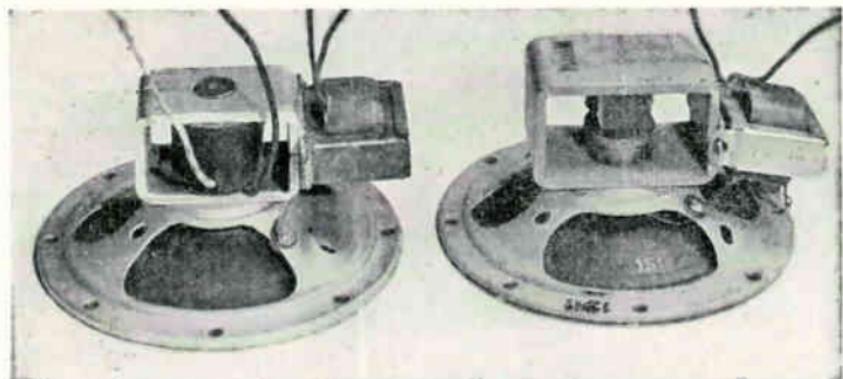
**T**O complete our study of the major parts in a radio receiver, we shall now discuss the loudspeaker—the device that translates electrical signals into air vibrations that we can hear.

Although you now have a general idea of how loudspeakers operate, you have not yet studied them in detail (this comes later in your Course). Therefore, we shall first give a *brief* description of the operation of a loudspeaker. Then, we shall take up loudspeaker troubles in order and explain how to check for and how to remedy each type of defect.

► A loudspeaker, whatever its type, has two basic parts—a *driving mechanism* and a *cone* or *diaphragm*. The driving mechanism converts audio signals into vibratory (back and forth) mechanical motions. The cone (or diaphragm) is secured to the driving mechanism and vibrates with it. The cone vibrations cause similar vibrations in the surrounding air; it is these latter that we hear as sound.

There are three types of loudspeakers in use today, but one, the magnetic speaker, is gradually disappearing. Therefore, we shall study first the two more common types, known respectively as electrodynamic and p.m. (permanent magnet) dynamic loudspeakers.

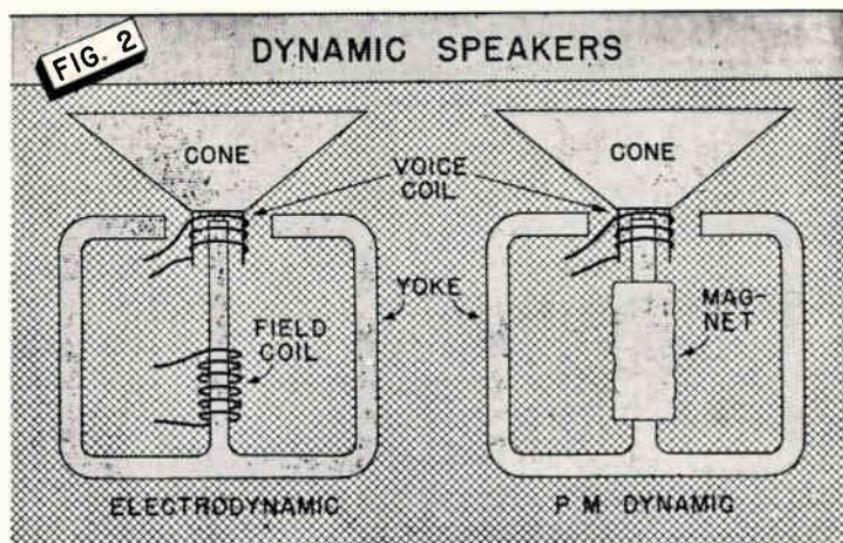
The driving mechanisms of these two speakers are similar. Each contains a source of magnetic flux that produces a fixed magnetic field. A small coil, mounted at the small end of the speaker cone, is positioned in this field. Since the audio signal from the receiver is fed to



**FIG. 1.** The two most common types of speakers: left, electrodynamic; right, p.m. dynamic.

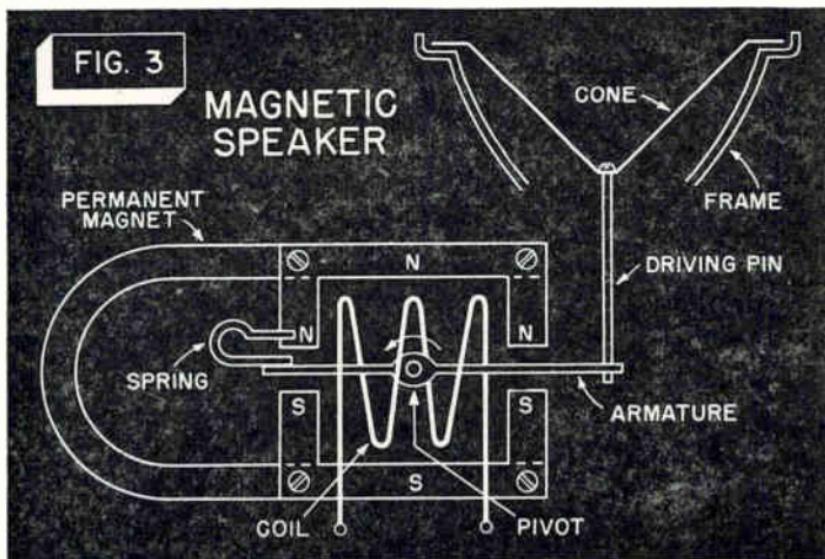
this coil, it is called the "voice" coil. When there is no current in the voice coil (that is, no audio signal from the receiver), it is motionless. However, when the receiver is tuned to a broadcast, current flows through the voice coil and produces a varying magnetic field in and around it. The interaction of the voice coil field and the fixed magnetic field causes motion of the voice coil, moving it in and out at a rate that corresponds to the frequency and shape of the audio signal. (This is a phenomenon you will study in detail in your Course.) This motion of the voice coil causes a similar motion of the cone and so produces sound.

Both an electrodynamic and a p.m. dynamic loud-



speaker are shown in Fig. 1. Their chief operating parts are shown in Fig. 2. Notice—the only essential difference between them lies in the source of magnetic flux used to produce a fixed field. A powerful permanent magnet is used to produce the fixed field in a p.m. speaker. In an electrodynamic speaker, the fixed field is produced by a coil (called a "field coil") through which a d.c. current is passed.

This fixed field exists across an air gap between the central pole piece and the ends of the yoke or "pot." The voice coil, which is wound on a light fiber form, slips over the central pole piece and is held in the air gap by the paper cone and by a flexible support called a "spider." When it is properly positioned, the voice coil touches neither the central pole piece nor the ends of the yoke. The cone is secured at its outer edge to the speaker frame.



Because of the way they operate, both types of speakers are known as "dynamic" or "moving-coil" speakers.

► The magnetic speaker is shown in Fig. 3. This speaker uses a horseshoe-shaped permanent magnet and a large coil wound around a pivoted armature. The changes in the flux produced by audio current variations in this coil cause the armature to swing back and forth around its pivot. This motion is transferred through a driving pin

to the cone apex, moving the cone in and out.

We will dismiss magnetic speakers now because they are becoming rather rare and, when defective, they are almost invariably replaced rather than repaired. Usually they are replaced by one of the small p.m. dynamic types. We will show you later how to order these replacements.

► On the other hand, electrodynamic and p.m. speakers are repaired rather than completely replaced in most cases. Usually only one part of a dynamic speaker becomes defective, and such a part can frequently be repaired or replaced without much difficulty.

Both these speakers have cone troubles, caused by natural aging of the cone, by rips and tears in the cone material, and by loosening of the cement that is used to hold the outside rim of the cone to the speaker frame. The spider, which is used to center the voice coil in the magnetic air gap sometimes warps or breaks.

In either speaker, the fixed magnetic field may be upset. In the electrodynamic, the field coil may open or short-circuit like other coils, and in the p.m. dynamic, the permanent magnet may weaken.

Now, let's see how to test for and repair these various speaker defects.

## TESTING AND REPAIRING FIELD COILS

The most usual field coil trouble is an open coil, although shorted turns sometimes occur. If you suspect that the field is open, you can check it easily by holding a screwdriver or other iron tool near the center pole piece (Fig. 4) while the receiver is turned on. If magnetism is present, as it should be if current is flowing through the field coil, the screwdriver will be strongly attracted, and you will have to exert appreciable force to pull it away. If the field coil is open, or if energizing current is not flowing because of some other defect, there will be either no pull or only a slight pull caused by residual magnetism.

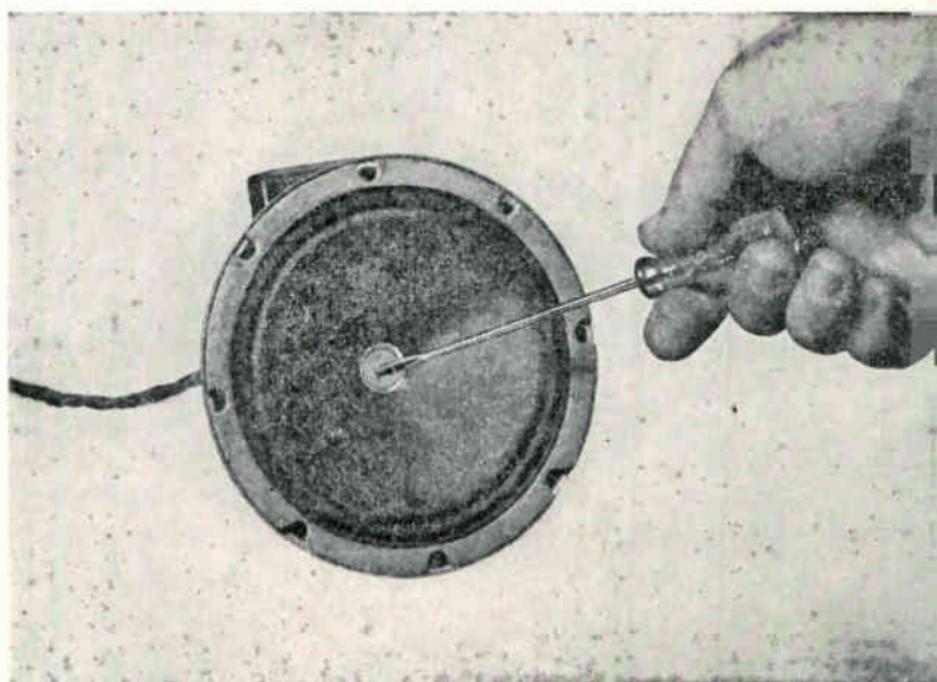
This test will magnetize your screwdriver, and you will find that for quite some time it will pick up bits of iron and steel. A magnetized screwdriver is often use-

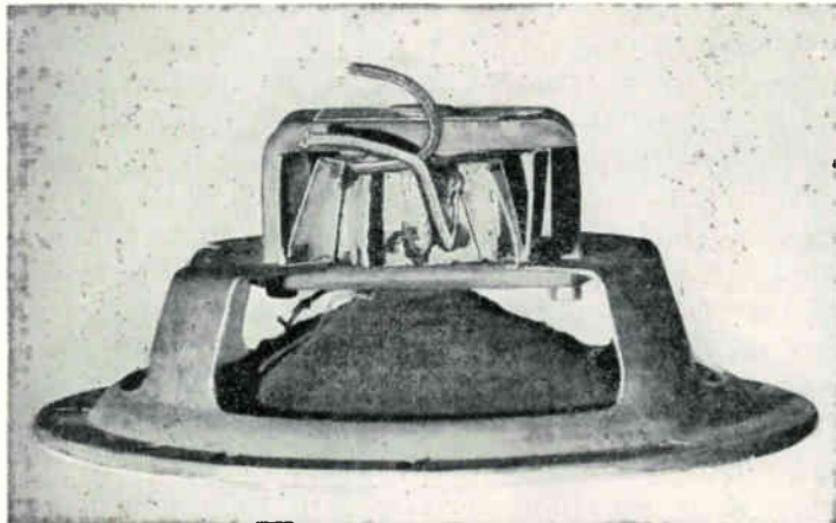
ful. However, it is also annoying sometimes—when you are trying to start a screw through an iron washer in an inaccessible hole, for example—so don't magnetize all your screwdrivers. The magnetism will disappear with time, or you can remove it by rapping the screwdriver across the edge of your workbench.

► You can also check the field winding with your ohmmeter. Place the ohmmeter test probes on the terminals of the field, after disconnecting the field from the set to avoid shunt paths. No reading indicates that the field coil is open.

**Shorted Turns.** When the turns on a field winding are shorted, the inductance is reduced, as with any other coil. An ohmmeter test is of value only if you know just what the field resistance should be. However, even when the field resistance value is given, it may be the "hot" resistance—the value reached after the set has warmed up. Since shorted turns cause excessive heating, the measured resistance may not be very different from normal. When you have had enough experience, you can judge from the heat of the field and from the receiver operation whether shorted turns are a possibility. Even so, you must make a check to see that the overheating is not caused by a short elsewhere in the set, and you should remember that speaker fields

**FIG. 4. How to test the magnetic pull of an electrodynamic speaker with a screwdriver.**





**FIG. 5.** Cut away the insulation like this when you are looking for a field-coil break. Be careful not to cut the coil wire.

become somewhat warm even under normal conditions.

**Repairing the Field Winding.** Short-circuited coils cannot be repaired; a new field is necessary. However, when a field coil *opens*, it is always worth while to see if repairs can be made. Carefully cut through the insulating paper wrapped around the field so that the field leads are exposed as shown in Fig. 5. Often you will find the break near the point where the field leads join the external leads. If you can see the break, use fine sandpaper or emery cloth to clean the insulating enamel off the broken wire and then resolder the connection. If necessary, splice on an extra length of wire to complete the circuit.

**What To Do When the Field Coil Is Defective.** When you cannot repair a speaker field coil, you can do one of the following things:

1. Install a new field yourself.
2. Have one installed through or by your local parts jobber.
3. Install a new loudspeaker.

To make the repairs yourself, you must be able to get the old field out of the yoke or "pot." If the yoke is held together by bolts, this will not be difficult. But if special tools are needed to remove the center pole piece, it will be best to have your local parts jobber do it.

If you can get the old field out, simply reverse the procedure to install a new one. Of course, you must use a suitable replacement. The new field must have the same physical dimensions as the old and, also, approximately the same resistance. The best way to insure a good fit is to give your supplier the make and the model number of the receiver and the speaker part number. Sometimes different speakers are used with the same model receiver when this model is used in several different cabinets. In such a case, if you cannot give the speaker number, usually the cone diameter will identify the speaker. This is the *outside* diameter of the cone, measured across the face of the speaker.

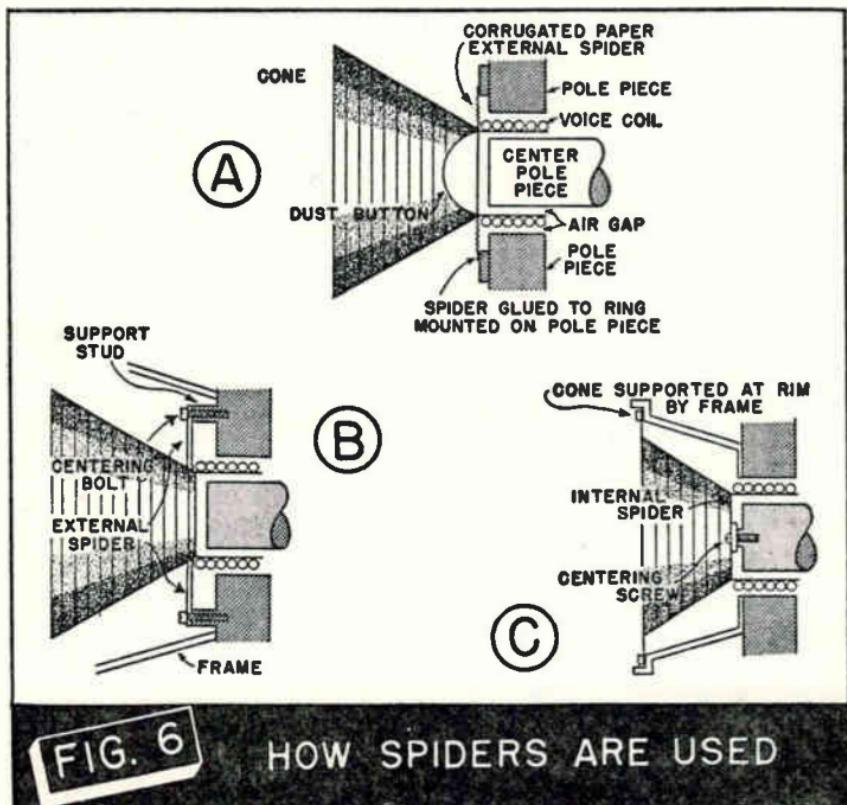
If you find it difficult to get the old field out and cannot obtain a new field locally, it is worth while to take or send the entire speaker to your parts jobber or supply house. In either case the speaker will come back to you completely repaired and "ready to go" in about the same length of time it would take you to secure a replacement field. The cost of such professional service is usually less than your labor cost, and the time saved will really save you money if you are charging properly for your service time.

Then, too, you may find that the magnetic circuit is welded together and cannot be disassembled in an ordinary service shop. In this case a new speaker is necessary. Many of the larger manufacturers such as Philco and General Electric, who make speakers of this type, have an exchange service. The old loudspeaker is returned to them through their nearest local distributor for a new one.

In some cases, your customer may not wish to wait for such an exchange to go through. If so, you can simply discard the old loudspeaker and buy another.

### P.M. SPEAKER FIELD TROUBLES

About the only trouble you will encounter in the magnetic circuit used in a p.m. speaker is a loss of magnetism through age or through the fact that someone has disassembled the yoke or magnetic circuit. (Never take apart the yoke or pot assembly of a p.m. speaker; the magnet may lose so much magnetism that it will be



**FIG. 6**

HOW SPIDERS ARE USED

worthless.) There is no easy test for this except for the peculiarly distorted operation of the receiver, about which you will learn. The screwdriver test is no good until the field is extremely weak, and you will usually be called in long before this.

There is no way for you to remagnetize a p.m. speaker in your shop. If the speaker is an expensive one, have the job done by either the manufacturer or some firm specializing in loudspeaker work. Your local parts distributor will be glad to send the speaker off for you and to notify you when it is returned. If the speaker is inexpensive, it may be better to buy a new one.

### CONE AND VOICE COIL DEFECTS

Speaker field defects are not the only source of trouble. In fact, there is more likelihood that something will be wrong with the cone, the voice coil, or the adjustment of the voice coil.

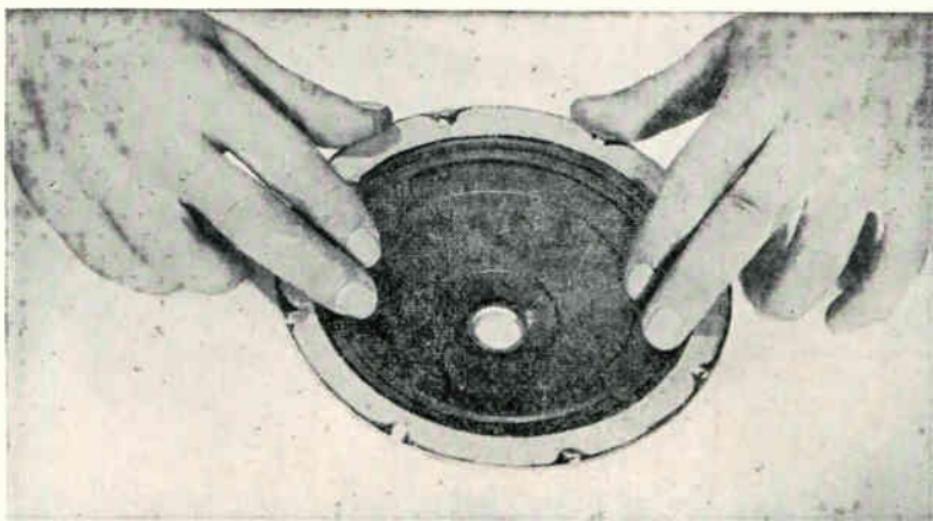
The voice coil must move freely to follow the signal variations. Hence, there are centering supports or

spiders designed to hold the voice coil in the center of the air gap between the pole pieces. These spiders must not hinder cone movement any more than is necessary, so they are made of flexible paper or fiber and are fashioned to permit the desired movement. (They are called "spiders" because the early types all had long "legs".) Three types of spiders are shown in Fig. 6. The corrugated paper external spider in Fig. 6A is the type most widely used at present. The cone suspension methods shown in Fig. 6B and Fig. 6C were employed in older loudspeakers, but you'll find plenty of them requiring service.

► Normally, corrugated paper spiders like those shown in Fig. 6A will not cause trouble once they are properly installed. Of course, even with this type, the cone may tilt if the cone warps or the frame becomes bent. This will throw the voice coil to one side and allow it to strike the pole pieces as it moves back and forth. This can be corrected by bending the frame that supports the cone to correct for the warpage, and re-centering the voice coil. You must experiment to learn just how to bend the frame. If bending it in one direction makes the trouble worse, bend it in the opposite direction.

One of the tests you can use to determine when a cone is properly centered is shown in Fig. 7. *With the set turned off*, press evenly on the outside edges of the cone with your fingers. Listen carefully to the speaker. You can hear the voice coil scraping against the pole piece if the room is quiet, and you can sometimes even feel

**FIG. 7. How to test a cone for proper centering. Be careful to push gently, so as not to damage the cone.**



the obstruction as the voice coil strikes a pole piece. ► In the spider system shown in Fig. 6B, one of the centering bolts holding the spider in place may loosen, allowing the voice coil to hit the pole pieces. In the system shown in Fig. 6C, there is but one bolt; if it loosens, the voice coil may readily shift in position. In either of these cases, loosen all bolts holding the spider. Then push centering shims down between the voice coil and the center pole piece as shown in Fig. 8. These shims (which you can buy for a few cents from any radio supply house) will properly center the voice coil and will hold it in the required position while you tighten the adjusting screws. In the system shown in Fig. 6B, the cone is in such a position that an end wrench is the best tool to use when working on the bolts, for there isn't room to get at them with a screwdriver.

When you do not have shims available, it is possible to center the voice coil by working on the cone in the manner shown in Fig. 7. That is, apply differing pressures until you find the position where the voice coil will move up and down without rubbing, then hold the cone while the bolts are tightened. Usually, however, this is rather difficult to do when working on the system shown in Fig. 6B. The cone is likely to shift when you move the speaker to tighten the bolts.

**How To Clean the Air Gap.** The same effect as an off-center voice coil will be produced if dirt or metallic particles get into the air gap. With the modern corrugated external spider and dust button shown in Fig. 6A there is little danger of this happening, for everything is sealed up. However, with the spider arrangements shown in Figs. 6B and 6C, it is quite a common occurrence for dirt and metallic particles to work their way into the air gap.

► Incidentally, if you ever work on a receiver that is part of a phonograph

Courtesy General Cement Mfg. Co.

**FIG. 8. How to center the voice coil with centering shims.**



combination and hear an odd buzzing noise from the speaker when it is producing bass notes, examine the speaker carefully for phonograph needles. These needles are attracted by the magnetism and will hang so that they vibrate against the cone.

Ordinary dirt may be removed by turning the speaker face down on the workbench and *lightly* tapping the back of the speaker while a program is coming in. (Don't hammer on a p.m. speaker and don't hammer *hard* on any kind.) Shaking or jarring the speaker this way will cause the dirt particles to work themselves out of the air gap and fall on the bench.

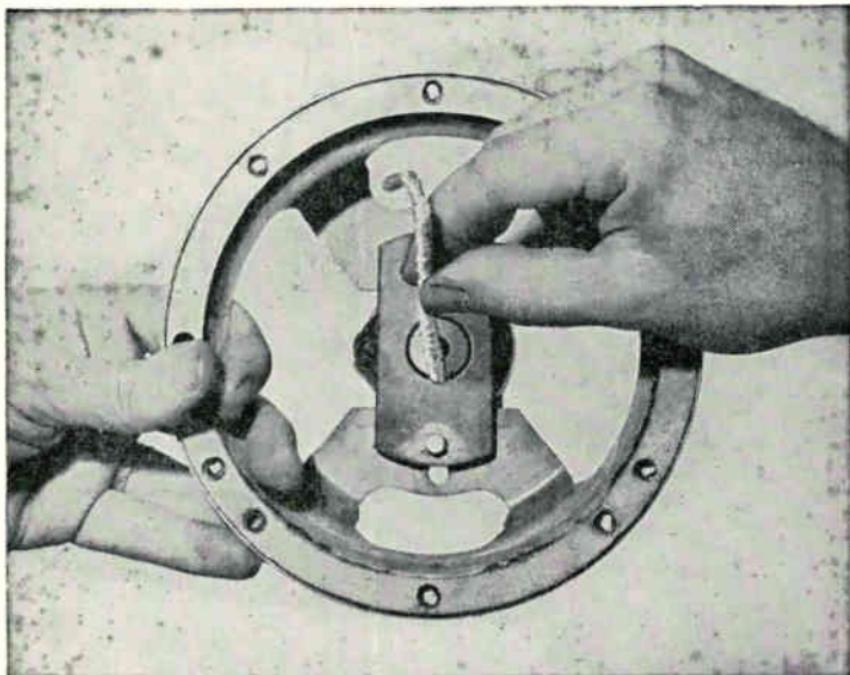
Iron filings and other magnetic particles are not so easy to remove, since the magnetism holds them in place. This is true even when the field is cut off, for there is a certain amount of residual magnetism present at all times.

The residual magnetism must be removed before these particles will fall out. The only simple way of doing this with an electrodynamic speaker is to apply an a.c. voltage to the field coil. First, disconnect the speaker field from its receiver connections (naturally, the receiver must be turned off), and then connect the field directly across the 110-volt a.c. power line and rap on the yoke. When the a.c. is applied to the field, the field is completely demagnetized twice each cycle. Your rapping on the yoke will make the metal particles slip slightly each time the magnetism is removed, and eventually they will fall out.

If the dirt or metal particles prove stubborn, it may be necessary to remove the cone and the voice coil altogether to clean out the air gap. (This is necessary anyway in a p.m. dynamic, since there is no way of removing magnetism.) However, whether this step is practical or not will depend on the ease of removing the cone, which we shall discuss later.

If you can get the cone and voice coil out, then you can use a pipe cleaner, obtainable from any tobacco store, to clean





**FIG. 9. How to clean the air gap with a pipe cleaner.**

the air gap. All you need do is run the pipe cleaner around in the air gap (as shown in Fig. 9), and it will remove the dirt and filings. After the gap is thoroughly cleaned, replace the cone and voice coil or install a new assembly.

► Loose turns on the voice coil will often produce the same effect as an off-center voice coil or dust in the air gap. Suspect this if you find that you cannot re-center a voice coil and apparently there is nothing foreign in the air gap. If it is easy to remove the cone, you may find it practical to take the cone out, cement the voice coil turns, and reinstall the cone. However, it is usually far better to replace the cone-voice coil assembly. We'll explain how shortly.

► Sometimes a crack in the spider will cause another kind of rattling noise. You can check for a cracked spider by moving the cone in and out with your fingers just as though you were checking for an off-center voice coil. You will find that a broken spider will come apart when you move it in this manner. This trouble is normally experienced only with the spiders made of fiber, in the styles shown in Figs. 6B and 6C.

## CONE TROUBLES

Loudspeaker cones are made in two ways. Some are pressed or molded of paper-like material. Others are rolled into shape and then glued along a seam running from the voice coil end to the outer edge of the cone. In either case, the outside flexible rim of the cone is glued to the frame, and the cone and voice coil are glued together. When a corrugated paper external spider is used, the outside rim of the spider is glued to a ring mounted on the pole piece.

Thus, loudspeakers depend on glue to a considerable extent. However, they work in closed compartments and often become quite hot. The heat may dry out the glue and permit some seam to open.

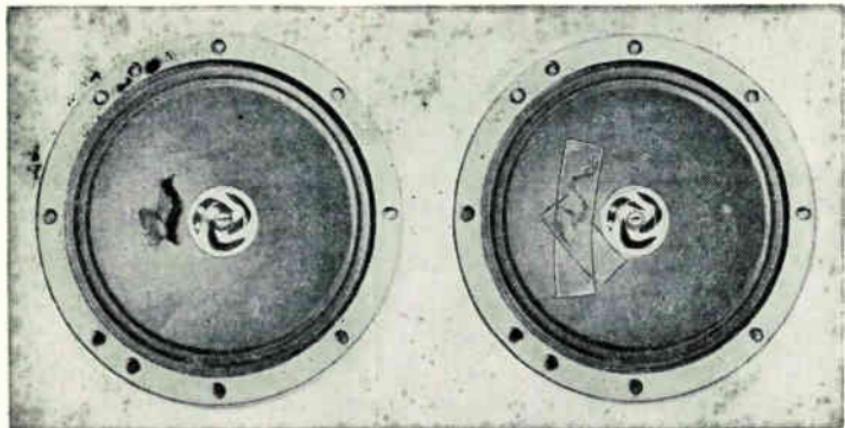
Much depends on just which seam opens as to the exact effect produced. In all cases except when the cone becomes unglued from the voice coil, the speaker will still work, but there will be distortion accompanied by a rattling noise. Once you have heard it, you can always recognize this trouble. The effect is like that produced by humming on a comb through a piece of paper.

To check a cone to see if it has become unglued, apply a gentle pressure to see if you can open the seam or joint that you suspect. Thus, if you push on the inside of the cone, moving it away from the frame, you can determine whether it has become unglued at the rim. Try on several sides, since the cone may have become unglued over just a small portion of the circumference, although often it becomes unglued all the way around.

An open seam or a loose edge can be quickly corrected by the use of speaker cement, applied under the cone rim or inside the seam. Wait long enough for the cement to dry and then try the speaker again. (All radio supply houses carry a suitable cement.)

Regluing the voice coil to the cone is somewhat more difficult. The same cement is used, but you must be sure not to get it down in the air gap. Sometimes it is necessary to take out the cone to reglue it. In these cases, if the cone is difficult to get out, it may be more practical to replace the cone.

Rips and tears in cones will also cause trouble. The



**FIG. 10. How to repair a torn cone with Scotch tape. Be sure the tape covers all parts of the tear. If the tear is large, it is a good idea to apply Scotch tape to the back as well.**

easiest way to repair a torn cone is to use Scotch tape, as shown in Fig. 10.

► Any repair of the cone will change the weight of the cone somewhat. Naturally, this is bound to affect the tone quality, although often the difference will not be very noticeable.

If the cone is quite old, then usually it will have changed in weight anyway. Dust or moisture absorption will add to the weight of the cone, while a cone that has dried out may be lighter than normal.

In any event, since cones age, it is frequently more desirable to replace the cone than to repair it. In some instances it is even possible to improve the response of the loudspeaker because newer cones are made of better materials than some of the older types.

**How To Replace a Speaker Cone.** The first step in this procedure is to make a careful examination to see if it is easy to replace the cone.

The kind with the corrugated paper spider, shown in Fig. 6A, is not always so simple to replace. The spider and the cone rim are both glued in and are positioned so that the voice coil is properly centered. The replacement must be similarly installed, and calls for some skill. Some of these cones come in units with the spider and the voice coil already assembled. This assembly is installed first, then the cone is glued to the voice coil and to the speaker frame.

If it appears that replacing the cone will be a difficult job, then it is better to send the cone to a firm specializing in this or to have your local jobber send it away for you. In either case, you will receive the loudspeaker with the best possible cone installed in it in a professional manner.

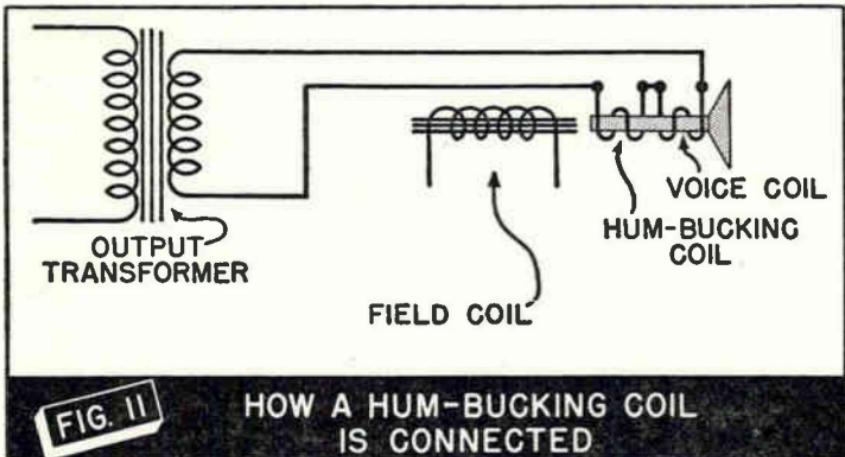
► However, if you decide to do the work yourself, you must give your supplier the make and the model number of the receiver. If the model is not listed, it is advisable to turn in the old cone to your supplier so that he can duplicate it.

Unless you intend to send the old cone in as a sample, you can simply cut it out with a knife, after cutting or unsoldering the voice coil leads from their mounting brackets. After lifting the cone out of the way, you can then remove the paper and glue from around the edge, using a special cement solvent designed for this purpose. Sometimes the cardboard spacing rings around the edge of the old cone must be used again on the replacement, so don't destroy these until you see whether they are needed.

When installing the new cone, be sure to place it so that the voice coil leads will reach the point to which they should be soldered. If there are holes around the rim of the speaker for mounting purposes, and the cone has similar holes, be sure to position the cone so that the holes match. If the cone has no holes, and some are needed for mounting the speaker, make them by punching through the paper after the cone has been fastened in place.

Examine the cone, while holding it in position, to see if you can reach the voice coil leads easily. If it is going to be difficult to reach them and hold them in position with the cone properly in place, then you had better solder them first. However, if it will be easy to solder later, mount the cone first, if you wish.

The next steps depend on the instructions you obtain with the replacement cone. If there is anything unusual about the installations, an instruction slip will usually be found packed with the cone. Sometimes the voice coil should be centered and the spider fastened before the



cone is glued in the rim; sometimes the cone should be glued in first. When in doubt, follow the first procedure. Otherwise, if you glue the cone at the outer edge first, you may throw the voice coil into a position where the spider cannot center it. Of course, while the cement is still wet, you can move the cone into position for greatest voice coil freedom. When the cement has dried, the speaker is ready to be tried out.

### HUM-BUCKING COILS

A certain amount of alternating current, in addition to the required d.c., flows through an electrodynamic speaker field in most receivers. This varying current will cause the magnetism produced by the field to vary in strength. As a result, a hum voltage may be induced in the voice coil which will cause it to move in and out as the field strength changes, producing hum.

This effect is reduced in some speakers by what is known as a hum-bucking coil. The hum-bucking coil is wound around the central pole piece (next to the field coil) and may consist of five to ten turns of insulated wire. It is electrically separate from the field, but it is connected in series with the voice coil as shown in Fig. 11. If the strength of the field varies, hum voltage will be induced in the hum-bucking coil as well as in the voice coil. These two induced voltages are equal and, if the proper connections are made to the hum-bucking coil, their polarities will be opposite. Therefore, they will

cancel each other, and no hum current will flow through the voice coil.

Whenever it is necessary to wire the voice coil circuit of a speaker using a hum-bucking coil (as may be the case when you are replacing the cone), excessive hum will be encountered if the proper connections are not made. If you do find hum, try reversing the voice coil connections to the hum-bucking coil. If the hum increases, the original connections were right; if it decreases, the original connections were wrong.

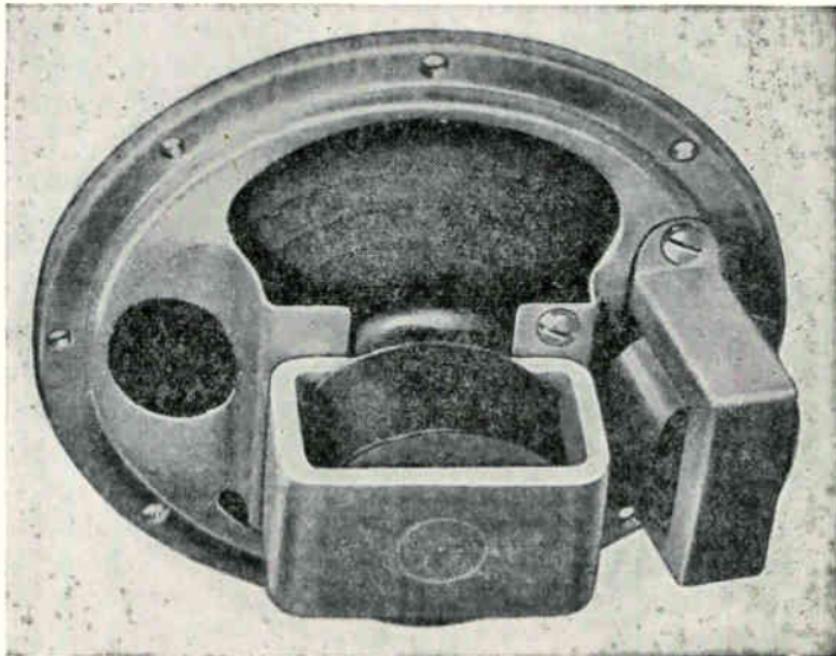
## OUTPUT TRANSFORMER TROUBLES

We have already discussed output transformers when we were discussing coils and transformers. However, the output transformer is actually a part of the loudspeaker system and is very frequently mounted on the loudspeaker frame, as shown in Fig. 12. Now that you know more about speakers, there are a few additional hints we may give here.

The most usual trouble with an output transformer is an open primary, which you can easily discover by

**FIG. 12.** In this speaker, the output transformer is mounted on the frame (at right of field coil).

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checking for continuity with your ohmmeter. An exact duplicate output transformer is available if the receiver is a well-known make. However, if you cannot find a duplicate, you may use a universal type.

When unsoldering the voice coil leads and resoldering the new leads, be careful not to allow excess solder to drip down inside the cone assembly.

If the original output transformer was mounted on the speaker frame, you may find that the replacement does not fit the same mounting holes. In some instances, a supporting bracket may have to be installed. It is not desirable to drill holes in the speaker frame for mounting the new transformer, because the drill shavings are metal and may get down in the voice coil gap where they will be very hard to remove. Be careful also in removing rivets, nuts, and bolts—be sure that you keep such objects out of the air gap.

## ORDERING NEW LOUDSPEAKERS

There will be times when it is desirable to order an entire new speaker rather than to have an old one repaired; you may have a speaker that is not worth repairing, or you may want to replace a magnetic speaker with one of the p.m. dynamic types. (A magnetic speaker is seldom replaced by an *electrodynamic* speaker, because, to do so, it would be necessary to rewire the receiver to provide voltage for the field coil. A p.m. speaker requires no such circuit revision.)

Many servicemen replace the entire speaker when the field coil is burned out, since the old cone probably should be replaced anyway, and very frequently it is necessary to destroy the cone to get the defective field out. In such instances, time will be saved if an exact duplicate speaker is available, even if no exchange policy is followed by the manufacturer of the set.

When you buy a replacement speaker and no exact duplicate is available, you must consider the physical size of the original speaker. In particular, the outside diameter of the cone must be the same size as the original. This is necessary so that the replacement will fit properly over the opening in the cabinet. If the speaker

is mounted on the receiver chassis, as it is in a midget receiver, then the depth of the speaker and the position of the mounting holes may also be important. In these cases it is best to take the original speaker to your supplier so that he can duplicate it.

If the original speaker is an electrodynamic type, you will have to obtain a replacement speaker with a field resistance like that of the original. You will have to determine the field resistance from the manufacturer's data on the set or by measuring the resistance of the old field if it is still good.

► To use the same output transformer, the replacement speaker should also have the same voice-coil impedance. Unfortunately, it is rare to find the old voice-coil value given, although that of the replacement will be known. (You will learn more about this problem of impedance matching in your Lessons in Radio Fundamentals.) Therefore, since the output transformer is usually on the speaker, it is good practice to replace it along with the defective speaker. If you can give your supplier the types and number of power output tubes used in the radio, he will be able to supply you with the proper output transformer for the speaker you are purchasing.

When you replace a magnetic speaker with a p.m. dynamic, be sure you get an output transformer designed to operate with the dynamic speaker.

## GETTING PRACTICAL EXPERIENCE

A number of the steps mentioned in this and in other RSM Booklets are rather easy to try out and will give you valuable practical experience. For example, the first time you service a receiver using an electrodynamic

### BENCH HINTS

If you don't have a "hold-tight" screwdriver, and you must drive a machine screw in some hard-to-reach hole, bend a U-shaped loop in the end of a piece of wire, insert the screw and its washer in the loop, and use the wire to guide the screw to the hole. After turning the screw with your screwdriver enough to catch the threads, remove the wire.

speaker, make the screwdriver test for magnetism. First, repair the set. Then, with the receiver turned on, hold a screwdriver blade near the center pole piece and note the strong pull. Next, turn the receiver off and feel how the strong pull has disappeared. This effect will be the same as that encountered when the field coil is open or when some other receiver defect prevents current from flowing through the field coil. You will thus learn how to detect low magnetism by the screwdriver pull.

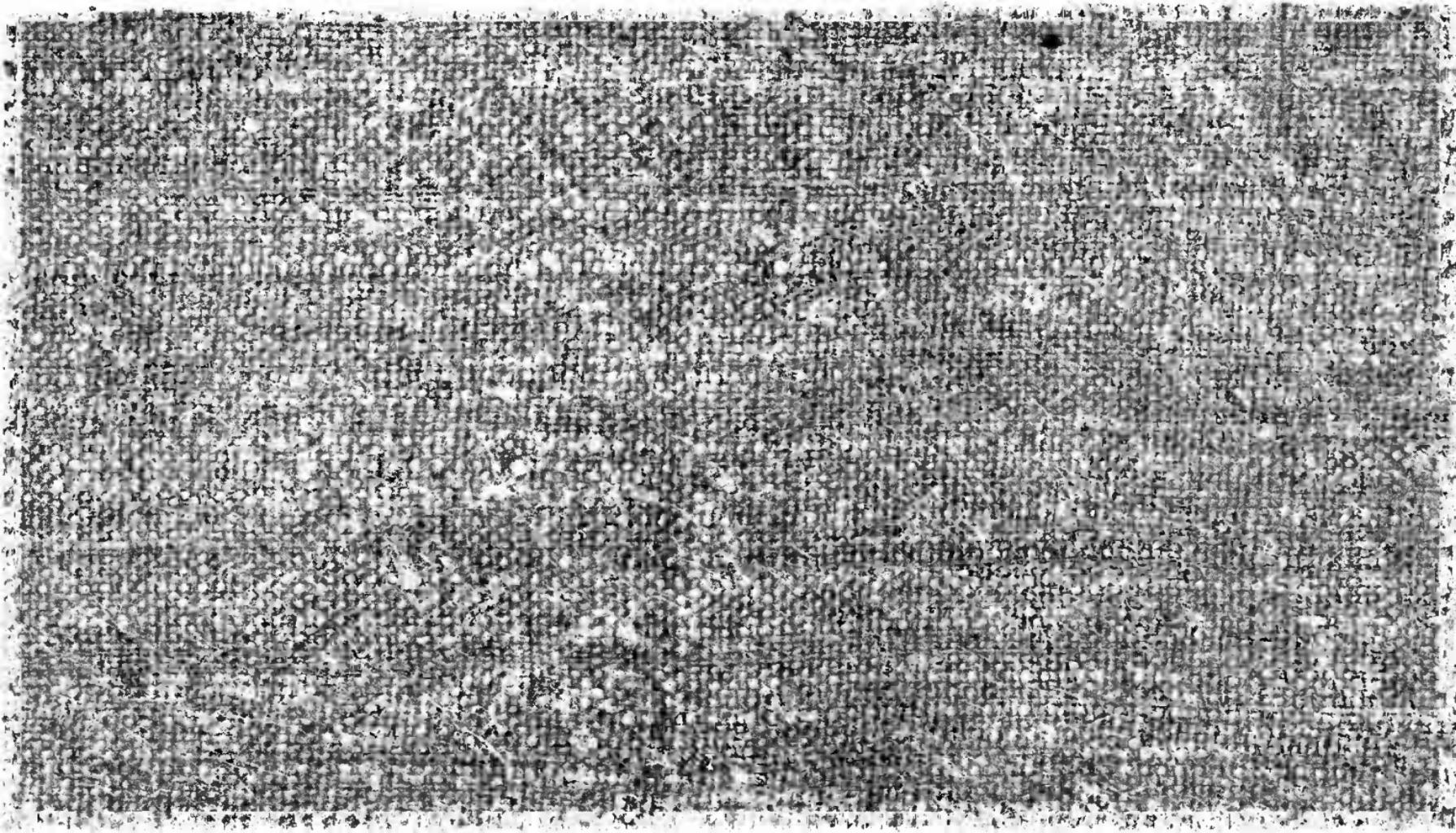
► For more experience, listen to the distortion that occurs when there is an off-center voice coil. The next time you see a speaker that has an internal-type spider like that shown in Fig. 6C, deliberately throw the cone off-center. Loosen the centering screw and push down on one side of the cone edge so that the voice coil will be moved to one side, then tighten the centering screw. Now move the outer edge of the cone up and down with your finger tips to feel the voice coil rubbing against the pole pieces and listen to the scraping sound. Then, turn on the receiver and listen to both music and voice reproduction. You will find that low-frequency notes are affected far more than high-frequency notes because there is greater movement of the cone at low frequencies. This will cause men's voices to be distorted more than women's voices. Some musical tones will be quite distorted, but high-frequency musical tones will come through fairly well. Once you have familiarized yourself with the sound of an off-center voice coil, then recenter the voice coil in the manner we have described. Often, you won't have to use shims at all, because the spider will cause the voice coil to spring right back in place as soon as the centering screw is loosened.

► It is also a good idea to get some practice in installing cones, if you intend to do this work yourself and not have it done for you. One way to do this is to obtain one or two junked speakers from some local radio man and obtain new cones for them. Of course, it is preferable to obtain speakers taken from well-known receivers, so that replacement cones will be available.

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# How to Make Extra Money FIXING RADIOS

NATIONAL RADIO INSTITUTE, WASHINGTON D. C.

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



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Dear Mr. Smith:

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

L.R.F., Penna.



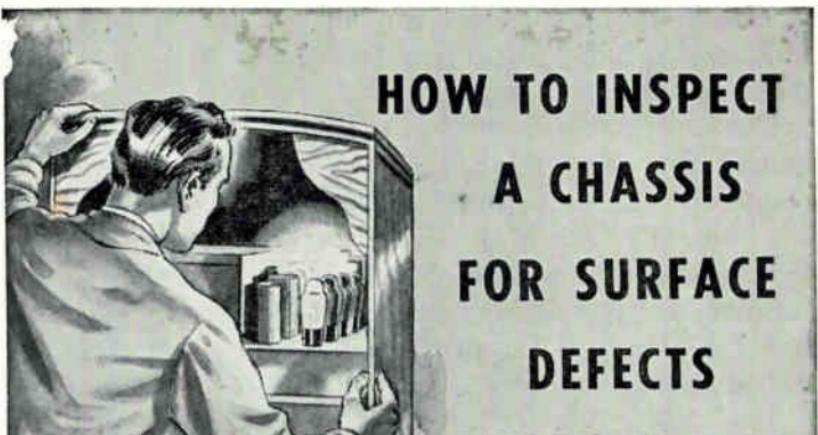
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FM13M1149

1950 Edition

Printed in U.S.A.



## HOW TO INSPECT A CHASSIS FOR SURFACE DEFECTS

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

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

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

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

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

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

## RADIO COMPLAINTS

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

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

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

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

► Sharp shrill whistles, squeals, or howling sounds are

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

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

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

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

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

### BENCH HINTS

When you must drive a screw into hard wood, coat the threads of the screw with soap. It will then drive easily, and will not split the wood. The screw will hold as well as if it had not been lubricated. The same trick will make it easier to drive a nail into hard wood.



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

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

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

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

times suggest, however, certain tests that lead on to the defective part.

## SURFACE DEFECTS ON TOP OF THE CHASSIS

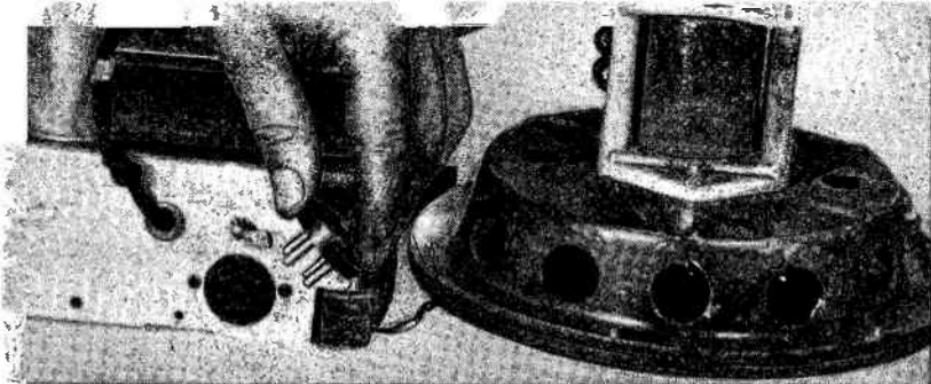
First, let's consider those surface indications that you can perceive without removing the chassis from the cabinet.

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

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

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

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



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

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

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

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

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

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



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

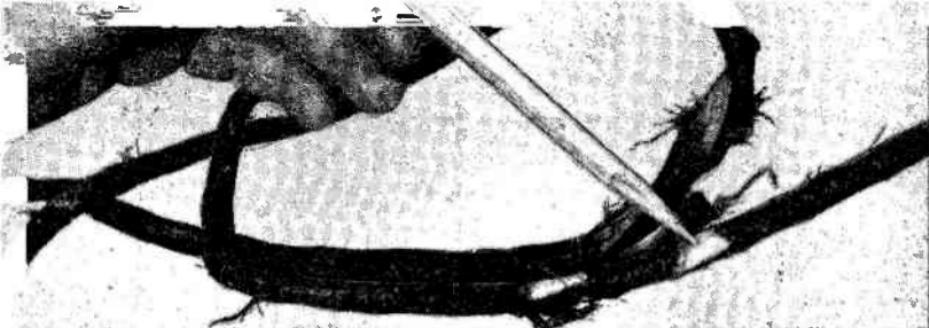
► *If no sounds come from the speaker, and none of the tubes appear to be lighted*, probably the trouble is in the power transformer (if one is used), the power cord, the on-off switch, or the wall outlet, or possibly there is no power at the wall outlet. If the set has no power transformer, or uses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

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

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

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

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

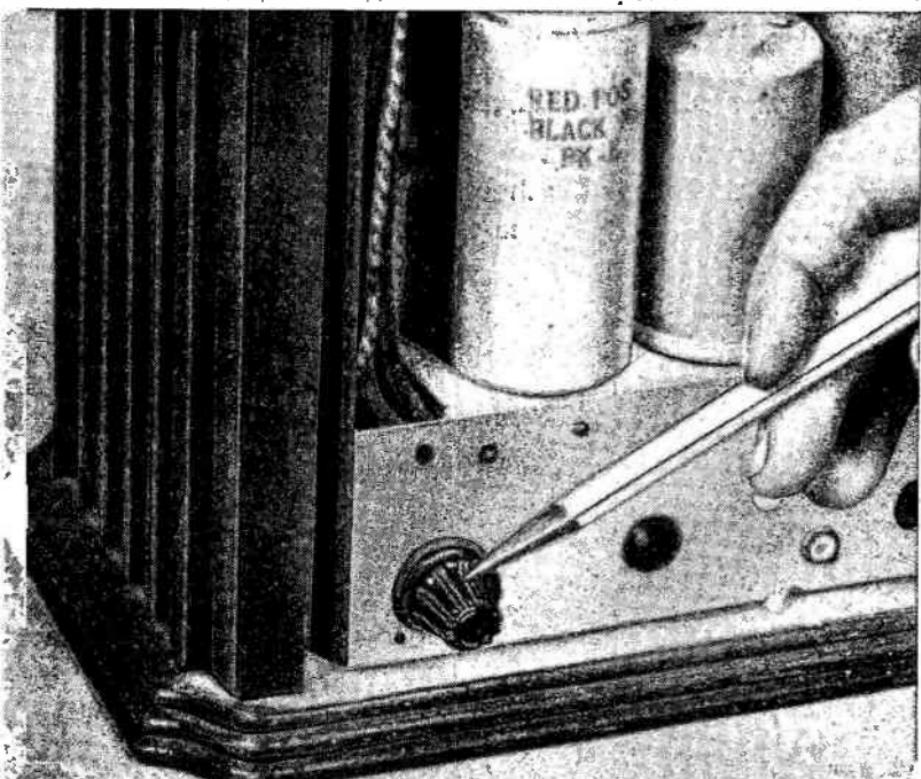


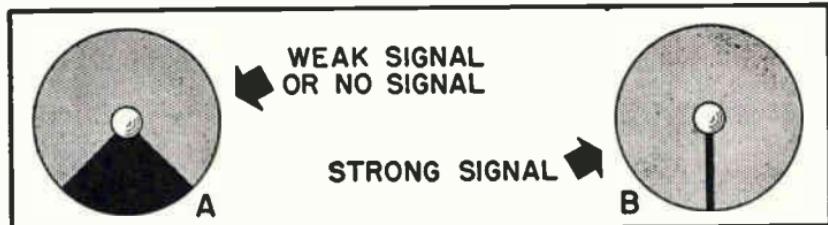
**FIG. 3.** A cord as badly frayed as this should be replaced, even if it is causing no trouble at the moment.

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

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

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





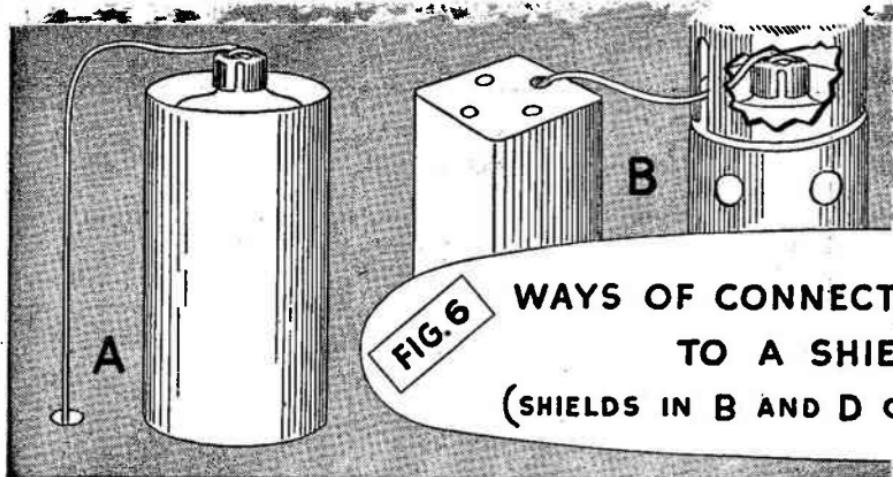
**FIG. 5.** These sketches show how the shadow of a "magic eye" tuning indicator changes as the signal varies.

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

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

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

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

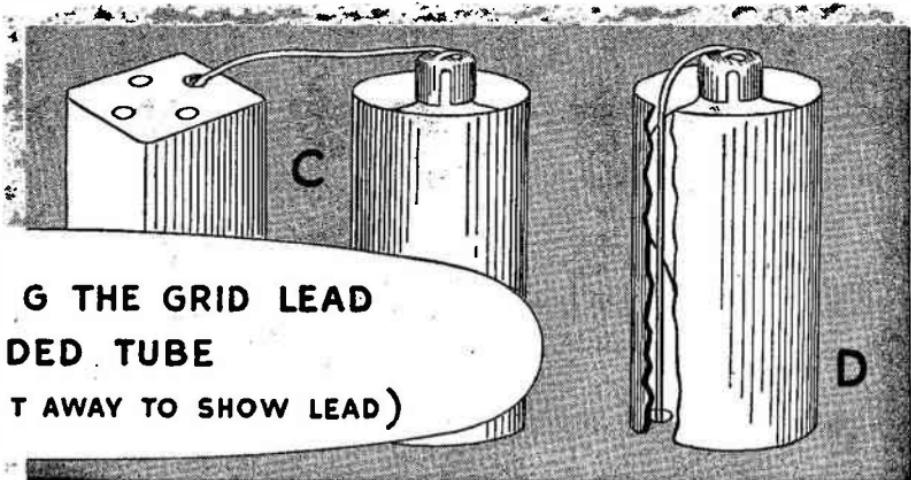


is bad; if the tube were gassy, the receiver would probably play, but a loud hum or roar would accompany the program.

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

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





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

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

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

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

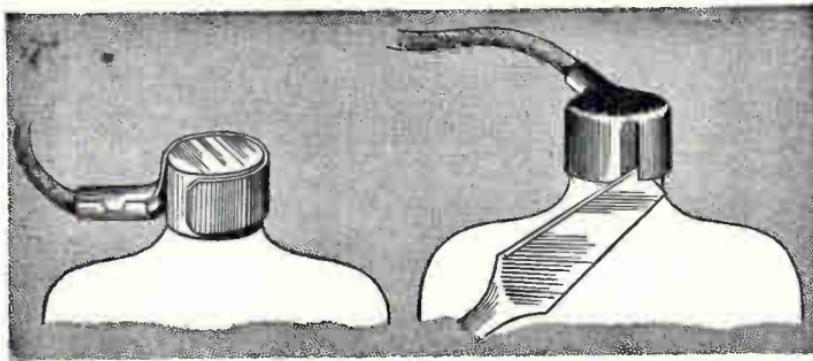


FIG. 8. Two common types of top cap clips. To remove the kind at left, press down on the cap with a screwdriver while you pull up the clip; remove the other kind as shown.

moved from broadcast stations.

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

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

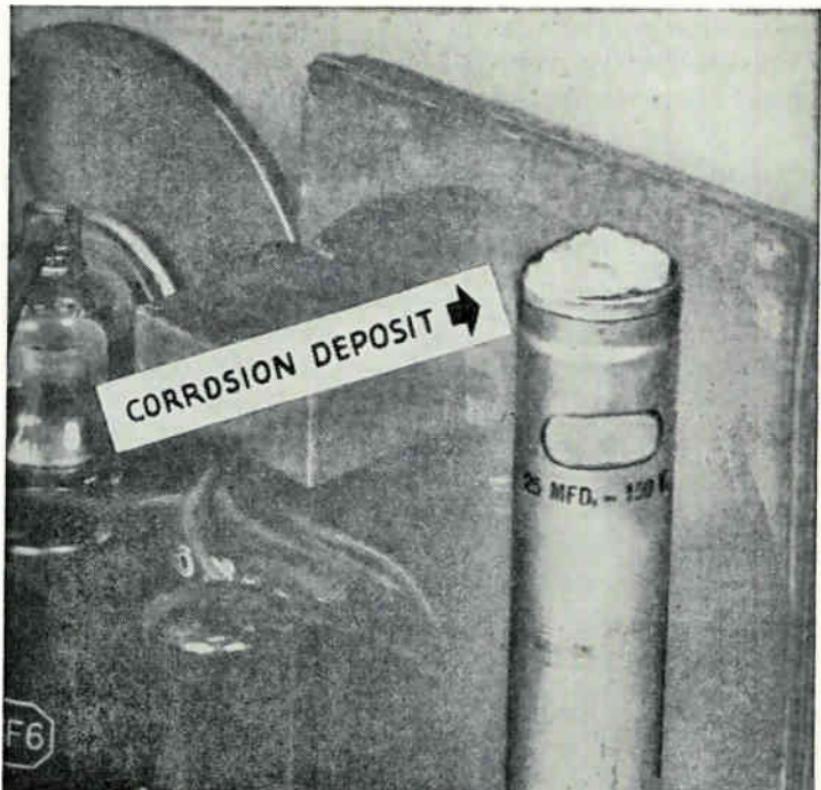
**Hum.** When the receiver plays but has a considerable amount of hum, there is usually either a defect in the power supply or a cathode-to-heater leakage in one of the tubes. Occasionally hum is caused by the set owner's having tucked part of the power cord into the cabinet near the chassis.

Turn the set around and look for electrolytic filter

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

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

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



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

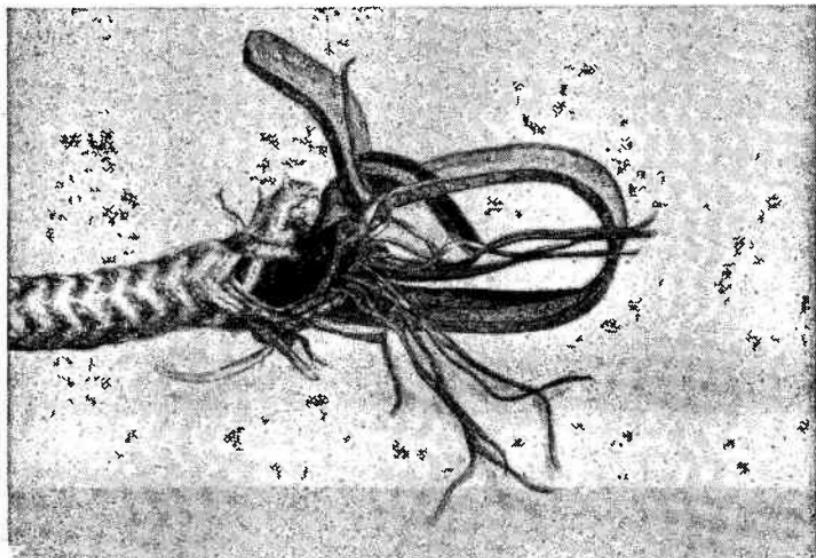
► There is no indication of when a tube has cathode-to-heater leakage insofar as its appearance is concerned. This can be discovered only by making a tube test. Therefore, if the filter condenser does not show signs of being defective (or it is not visible), the next step usually is to test the tubes.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

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

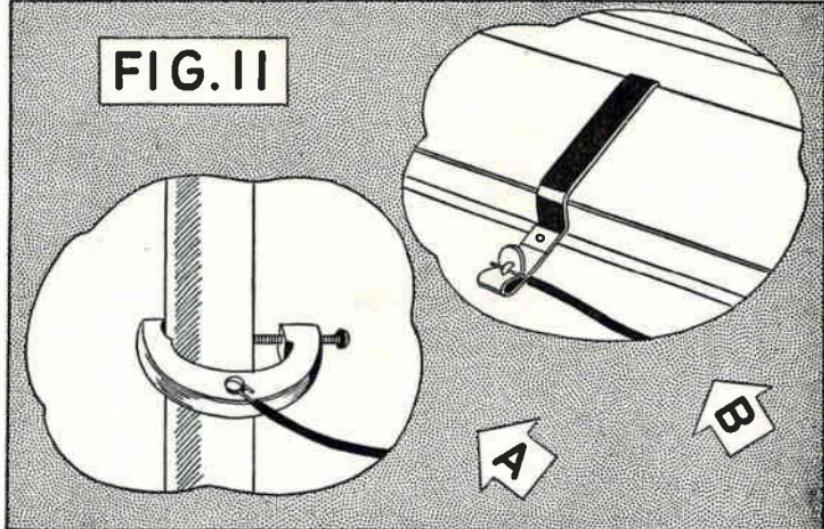
**Noise.** There are a number of indications to watch for when the receiver is noisy. First, rotate the various controls. If you find that the receiver is very noisy when the tuning knob is touched or rotated, but the noise quiets down when the knob is not being moved, there is a possibility of dirt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

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

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



**FIG. 11**



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

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

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

*Never use a gas pipe as a ground; it is a fire hazard.*

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

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

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

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

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

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



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

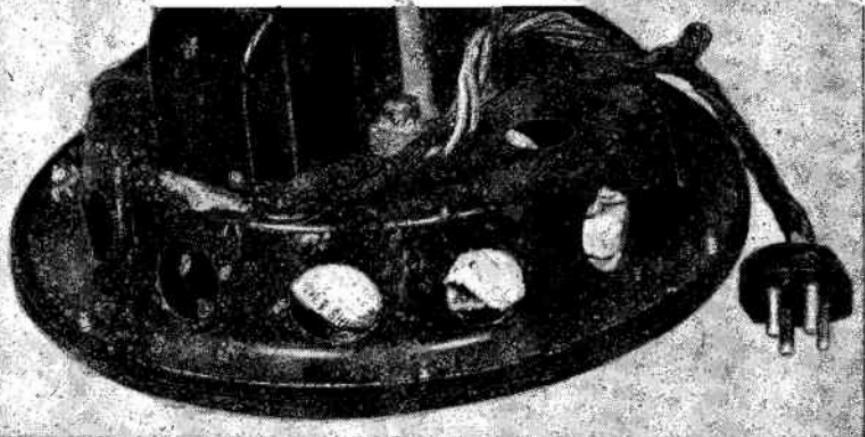
have a shield; if no shield is present, install one. Also, you may find that someone has substituted (in an r.f. or an i.f. stage) a glass tube for a metal one bearing the same type number. This is perfectly all right as long as oscillations do not develop, but the metal tube is shielded and a glass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

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

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

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

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

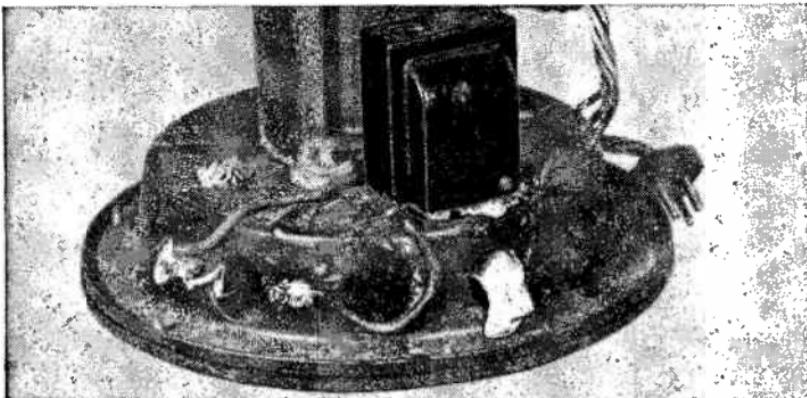


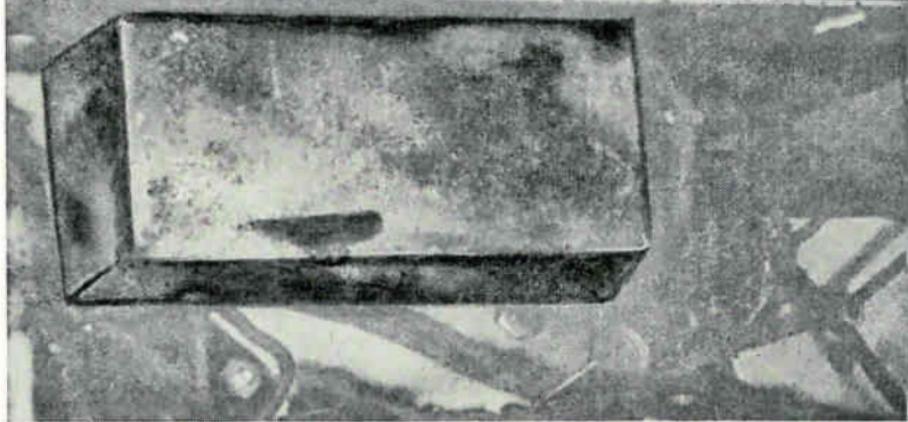
**FIG. 13.** Packing paper in this manner behind a warped cone is only a temporary repair.

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

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

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





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

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

### UNDER-CHASSIS DEFECTS

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

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

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

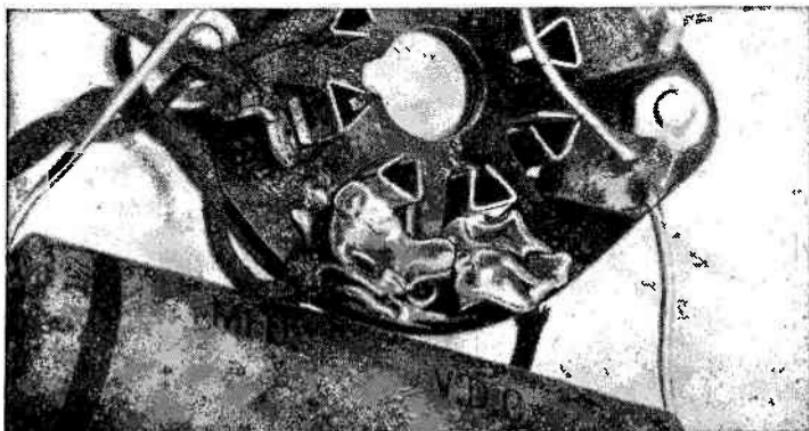


fective; you should check it for excessive leakage and for loss of capacity.

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

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

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



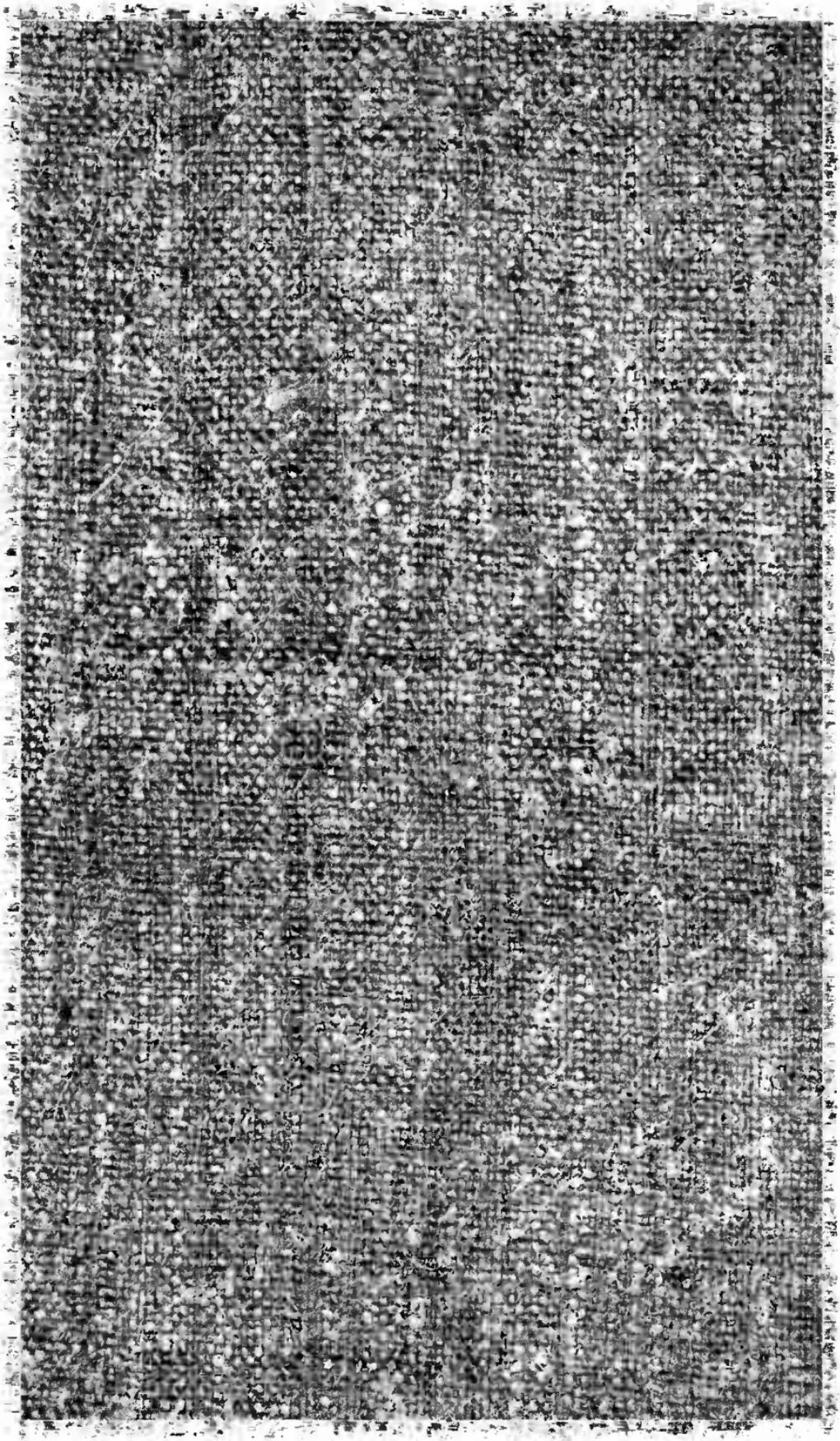
- If the set is noisy, turn off the lights and watch the bottom of the receiver carefully. Often you can see a tiny spark where a piece of insulation has charred or where two wires are touching.

## LOOKING AHEAD

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

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

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

NATIONAL RADIO INSTITUTE, WASHINGTON D.C.

No. 12 How To Put Up Antennas

RADIO SERVICING METHODS



# NRI TRAINING

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Dear Mr. Smith:

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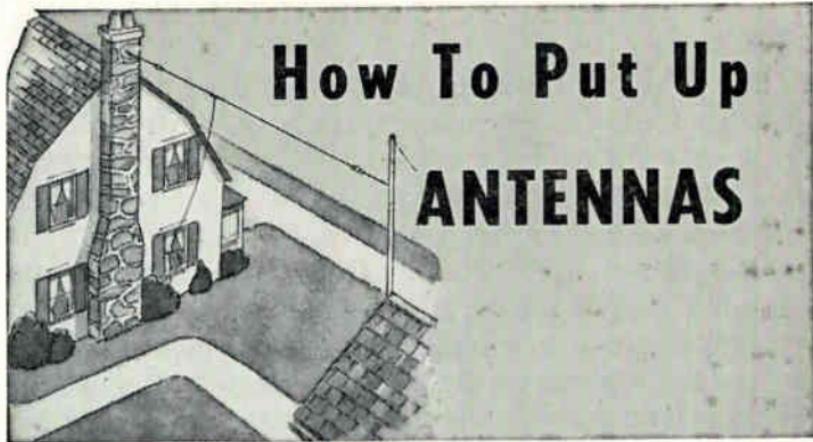
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FM13M1149

1950 Edition

Printed in U.S.A.



# How To Put Up ANTENNAS

ALTHOUGH outside antennas for broadcast-band receivers are no longer as popular as they once were, there are still specific locations in which they can be very useful. One such location is a country section far from broadcast stations; here a good antenna system is needed to increase signal strength. Another is a city where there is considerable interference from electric motors, neon signs, and other electrical devices; here a noise-reducing antenna is necessary to help overcome this man-made static.

There are also certain types of sets that should use outside antennas. Short-wave and f.m. receivers, for example, frequently need them for best reception.

You can see, then, that there are possibilities of your making extra income by installing antennas. Although you will seldom be called in because a customer has decided he wants an antenna, you can get a surprising number of such jobs from your regular service calls. When you find that reception suffers from lack of a good antenna, point out that fact to the customer. Often you can sell him a better installation.

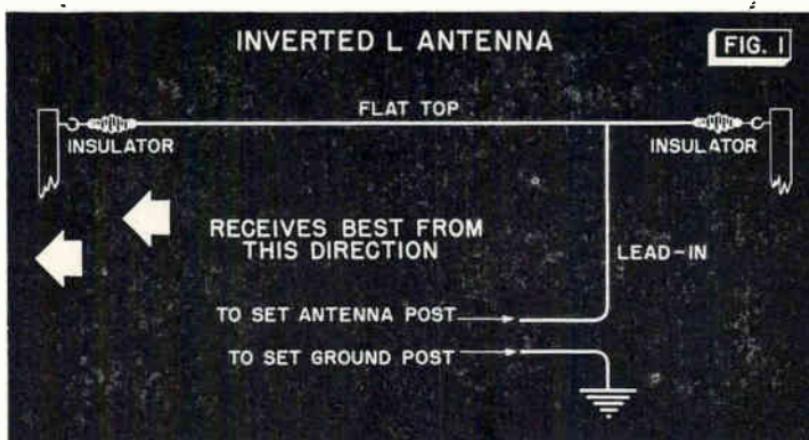
Of course, an antenna installation really involves more construction work than a servicing job, and you may prefer not to take it up. However, you should know something about it, because your customers will expect you to advise them. Installing an antenna is not usually very difficult. In this RSM Booklet, we'll give you instructions for putting up the chief types.

## TYPES OF OUTDOOR ANTENNAS

There are two general types of outdoor antennas in use. By far the more common is the one shown in Fig. 1. This antenna looks somewhat like the letter L upside down—hence it is known as the inverted L antenna. There is a horizontal aerial wire, called the "flat top," and a lead-in wire running from this flat top to the antenna post of the receiver. Another wire goes from the antenna coil to ground. Signals are picked up both by the flat top and by the lead-in wire, with the best reception from stations in the direction indicated by the arrow in Fig. 1. That is, stations are received best in the direction away from the end to which the lead-in connects. For general use, particularly for broadcast-band reception in a noise-free location, the inverted L antenna gives very good results.

► Fig. 2 shows the other common antenna system. This antenna is known variously as a doublet, as an all-wave antenna, or as a noise-reducing antenna. There is a flat-top portion divided into sections by an insulator, which in turn is connected through a transformer to a pair of wires known as a transmission line. The transmission line acts as the lead-in.

The doublet antenna picks up signals only with the flat-top portion of the aerial. Any signals picked up by one wire of the transmission line are also picked up by the other wire, and both try to cause a current flow in



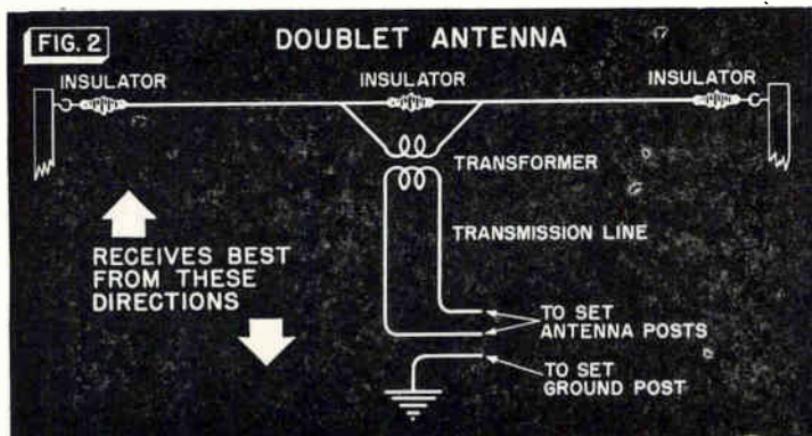
the same direction—either up or down both wires. Therefore, these currents flow in opposite directions through the primary of the set antenna coil, and cancel each other. On the other hand, the voltage induced from the antenna causes a *circulating* current through the transmission line and the set antenna coil. Hence, signal voltages picked up by the flat top will be transferred to the receiver.

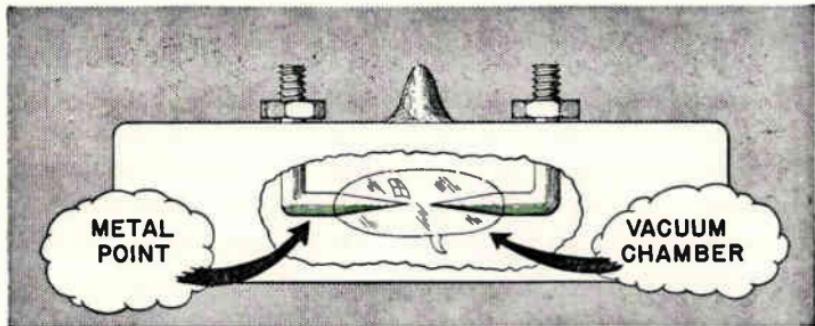
Fortunately, most noise signals exist close to the ground, near their sources. If the doublet is mounted high above them, it will pick up very little noise, and since the transmission line picks up neither noise nor any other signal, the amount of noise fed into the receiver will be small. That is why the doublet is called a noise-reducing antenna.

### PRELIMINARY STEPS

Let us suppose you have tentatively agreed with the customer on the installation of an antenna. Before you can establish any exact price, you will have to survey the location to see just what is necessary.

First of all, is an antenna permitted? Many modern apartment-house developments do not permit antennas. (In most instances of this kind, however, there is a built-in antenna system.) Also, if the receiver owner rents the property instead of owning it, it will usually be necessary to obtain permission from the property owner for the installation of an antenna.





**FIG. 3.** This sketch shows the inner details of one standard model of lightning arrester.

Next, consider whether an antenna can be erected satisfactorily on the premises. It may be necessary to run the antenna onto the property of a neighbor. In such cases, be certain that the customer obtains permission for the erection of the antenna.

You should keep the antenna away from trees, shrubbery, and phone and power lines as much as possible. The lead-in wire should go as directly as possible to the window nearest the receiver location in the home. Be sure to question the home owner about this, because he may want to move the radio to a different location in the room before the installation is completed.

If there is a convenient chimney, it can be used as one support for the antenna or as a support for one of the antenna poles. The other end may have to be mounted on a tree, on a tall mast in the yard, or on a mast on a garage roof, for example.

► Finally, you should plan the installation so that it will meet with the approval of the Fire Underwriters—otherwise the fire insurance of the home owner will not be valid. The first requirement is that the antenna system be kept well away from all power lines, so that it will be impossible for the antenna to fall on the power lines or vice versa. (This is desirable anyway, because power lines carry a lot of interference that may be passed on to the antenna and thus to the receiver.) The lead-in must be securely anchored and kept away from power line leads also, so that it will be impossible for it or the power line to sway in such a manner that they can come in contact.

A lightning arrester is required, because the antenna may act as a lightning rod and may attract lightning discharges. Fig. 3 shows the details of a standard lightning arrester. It consists of two sharp points, close together, in a small vacuum chamber. (Some arresters have the points sealed in gas-filled tubes.) The spacing is such that normal signal voltages cannot cause an arc to form between the points, so radio signals are not affected. However, when a lightning discharge comes along, the extremely high voltage easily bridges the gap and the charge is leaked away to ground.

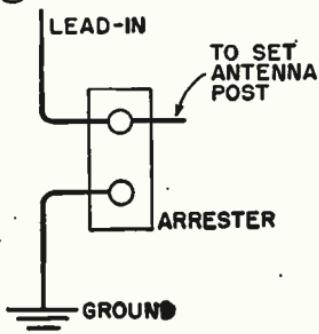
Fig. 4 shows how lightning arresters should be installed in the two common antenna systems. In either, mount the lightning arrester at the point where the lead-in enters the building, and run the straightest possible ground wire from the ground terminal of the arrester directly to the earth or to a cold-water pipe. Then the energy of any lightning discharge will be dissipated directly to ground through the arrester, instead of coming into the house.

► In many cases there are local ordinances about the erection of antenna systems that must be observed. Make sure you learn (from a fire insurance inspector or an electrical inspector) what these requirements are before you start to install any antenna. For example, you may have to drive a certain kind of pipe into the earth for the ground connection of the lightning arrester; this may have to be a certain number of feet from an electrical system ground; and there may be regulations as to the depth to which it should be driven, etc.

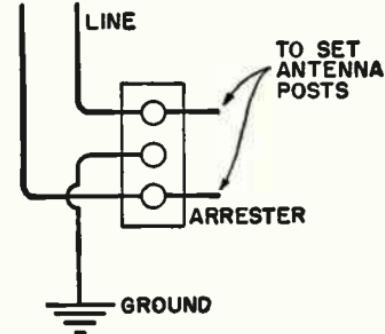
FIG. 4

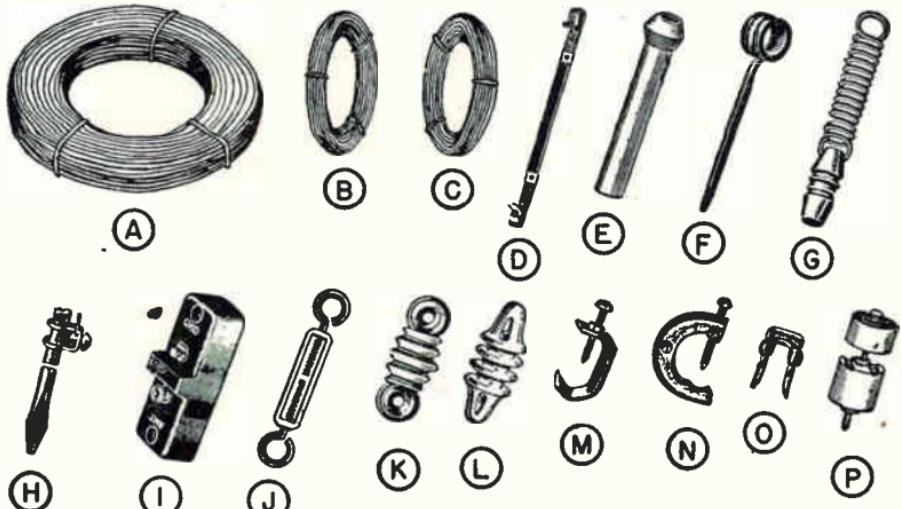
### CONNECTING AN ARRESTER

(A) TO A LEAD-IN



(B) TO A LINE





**FIG. 5.** The parts used in installing an antenna. You can get them from radio supply houses, either separately or in kit form. A, antenna wire; 7-strand bare or enamel copper wire. B, lead-in and ground lead wire; No. 14 or No. 18 rubber-covered tinned copper wire, solid or stranded. C, galvanized steel guy wire for anchoring masts. D, window lead-in strip. E, porcelain wall tube; used to bring antenna lead-in and ground leads through a wall. F, stand-off insulator; used for holding a lead-in wire away from the wall. G, tension spring with insulator; sometimes inserted in antenna guy wire to keep it taut and relieve strain. H, ground rod, 4 to 6 feet long. I, lightning arrester. J, turnbuckle; used to tighten guy wires. K and L, insulators for antenna wire. M, and N, ground clamps. O, insulated staple. P, nail-it knob; used for fastening wires to outside walls.

## INSTALLING AN INVERTED L ANTENNA

The horizontal antenna wire is usually about 50 feet long, although a length of from 20 to 100 feet may be used if the space requires such a value. The amount of lead-in wire necessary will depend upon how high the antenna can be erected. Naturally, the higher it is, the longer the lead-in wire that is needed. It is best to keep the over-all length of the flat top and lead-in under 100 feet if there are nearby stations; otherwise their signals are so strong that they may cause interference. Longer lengths are permissible in remote districts, however.

You can purchase all the needed equipment for the erection of an antenna in a complete kit form, or you can purchase the individual parts you require. Here are some suggestions.

Fig. 5 shows all the parts needed for installing an inverted L antenna. You have a choice of styles of parts in some cases. For example, the lead-in strip D

**FIG. 6.** You can make a good ground rod from a pipe of any convenient diameter by beating one end flat. Screw a top cap onto the other end, then drive the pipe about 5 feet into the ground. Fasten a ground clamp to the exposed end of the pipe.



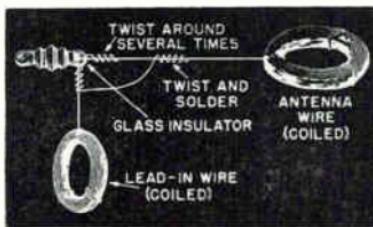
and the porcelain tube *E* give alternate methods of getting the antenna into the house. (These will be described later.) Similarly, the stand-off knob *F* and the nail-it knob *P* are used interchangeably—so are the insulators *K* and *L*, a pair of which will be needed. The ground strips *M* and *N* are both popular types; you may find one or the other required by local electrical codes, but if not, either style may be used.

If you do not obtain the patented ground rod *H*, then you can make a ground rod out of a piece of pipe, as shown in Fig. 6.

► Let's suppose you have completed your survey and have decided how you want the antenna to be installed. The next step is to attach the lead-in wire to the antenna. This should be a soldered connection, so the operation is best done on the ground.

Fig. 7 shows a very good method of fastening these together. First, thread one end of the antenna wire through one hole in a glass or porcelain insulator, then tightly wrap the end of the wire around itself for a length of 6 or 8 inches. Next, thread about 15 inches of the lead-in wire through the same insulator hole and wrap the wire tightly around itself several times to make a strong mechanical joint that will not pull loose. Now remove the insulation from the end of the lead-in wire, and clean the wire with sandpaper or a knife. Clean the antenna wire in the same way at the point where the lead-in is to be attached. Twist the end of the

**FIG. 7.** Here is a good way to fasten the lead-in to the antenna. Twist the antenna wire back on itself enough times to make a very strong joint. If possible, do this work in your shop where it will be easier for you to solder the lead-in to the antenna wire.



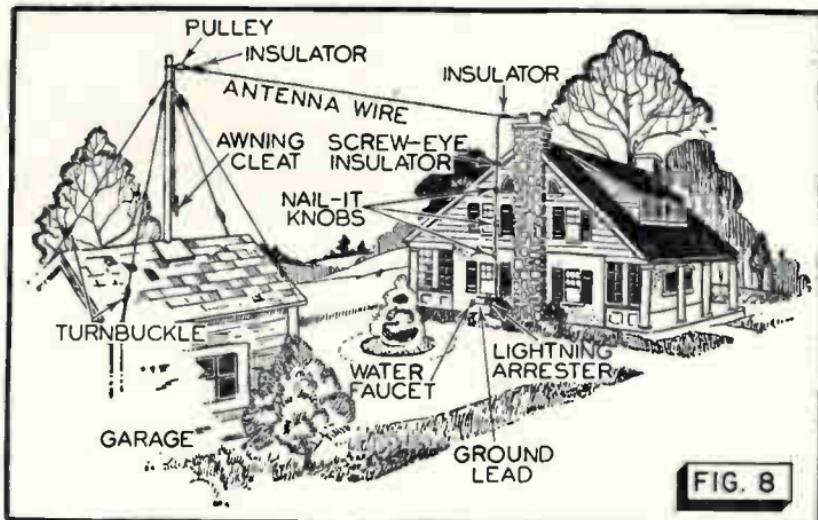


FIG. 8

lead-in wire around the antenna wire, tightening the joint with pliers, then solder the joint. Leave both the lead-in and the antenna wire coiled for the time being, to prevent them from becoming tangled.

► Now, as an example, let's suppose you are making an installation similar to that shown in Fig. 8. A chimney is to serve as one support. To fasten the antenna to the chimney, loop a length of galvanized guy wire (No. 12 or 14 wire) around the chimney. Be careful that the guy wire does not cut between bricks of the chimney, for the mortar is easily cut away, and the guy wire can actually clip the top from a chimney. Fasten the guy wire so that it is against brick all the way around, if possible.

Insert the guy wire through the remaining hole in the insulator to which you have fastened the antenna and lead-in. Next, twist the ends of the guy wire firmly together. You can now un-coil the antenna and the lead-in wires and allow them to drop to the ground.

The installation in Fig. 8 requires a mast—we'll describe how to construct it in this Booklet. For now, let's assume that you have the proper mast assembly ready for erection. It should have a pulley fastened to it near its top. Thread a rope or guy wire through this pulley, then get on top of the garage and set the mast in place. Anchor the mast upright with guy wires fastened to the roof. These guy wires should have turnbuckles in

them so that the wires can be drawn taut to hold the mast vertical.

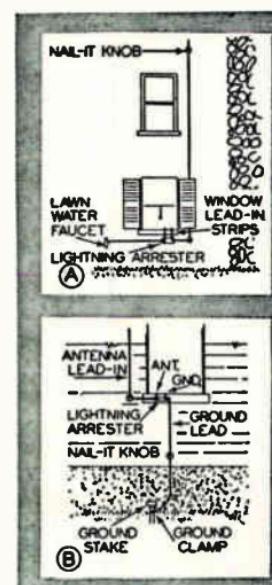
After the mast is erected, attach the rope or guy wire running through the pulley to another glass or porcelain insulator, then fasten the antenna to the other hole in the same insulator. Pull up the guy rope. If you have misjudged the distance and the antenna is too long, let it down and cut off some of the wire. When you have the wire cut to the proper length, pull the guy rope so that the antenna is fairly taut. Don't pull it too tight, however, since allowance must be made for expansion and contraction of the antenna wire with temperature changes. Wrap the end of the guy rope around an awning cleat or otherwise fasten it to the mast.

► Once the antenna has been erected, it is possible to bring the lead-in down to the house and fasten it. (This cannot be done until the antenna has been completely erected, however, as the lead-in will be pulled up and down with shifts in the antenna position.) To prevent antenna movements from breaking the wire, leave some slack in the lead-in when you bring it down to the first fastening on the side of the house. Thereafter, however, fasten the lead-in tight along the side of the house down to the point of entry so that it cannot whip about.

You can thread the lead-in down through a screw insulator, or you can use nail-it knobs. To use the nail-it knob, place the lead-in wire in the groove provided in the knob, and then nail the knob to the side of the house. This holds the wire firmly. Always use a nail-it knob as the first lead-in fastener.

Mount the lightning arrester next, then bring the lead-in down to the arrester and remove enough insulation to permit looping the bare portion of the lead-in wire around one arrester terminal. Tighten the terminal nut on the arrester. Now, run a ground wire from the lightning arrester, as shown in Fig. 9. Incidentally, the lead-in wire should

FIG. 9. Two ways of making ground connections: A, to a faucet; B, to a ground stake.



come straight down to the arrester, and the ground wire should go from the lightning arrester in a straight line to the ground connection. Clean the water pipe or ground rod with sandpaper, then use a ground clamp to make connection to it.

After having made connections at the lightning arrester, you can bring the antenna lead-in into the house. There are three ways of doing this, depending on the installation. In one, you can use a lead-in strip of the type that is placed under a window. This is a flexible strip made so that the window can still close after the strip has been placed across the sill. The lead-in wire is run from the lightning arrester to the outside Fahnestock clip, and then another wire is run from the inside Fahnestock clip to the radio receiver. (To prevent poor connections at the clips, many servicemen solder these connections.) Make the inside wire as inconspicuous as possible by using wire with brown or cream-colored insulation, whichever is closer to the color of the interior woodwork.

Sometimes a receiver has its own ground connection inside the house. However, if there is no separate ground for the receiver, bring in another wire (again, an inconspicuous one) from the ground terminal of the lightning arrester through another strip to provide the ground connection for the receiver.

If the window has been weatherstripped by metal stripping that fits into a groove in the window, you cannot use the window lead-in strip. One way to avoid this difficulty is to drill a hole in the window frame or in the side of the house to bring in the lead. For this purpose, a porcelain wall tube may be used. If you find it necessary to follow this procedure, be sure to drill the hole so that it leads *upward into the house*. This will cause the tube to point downward toward the outside and will prevent rain from coming in through the hole.

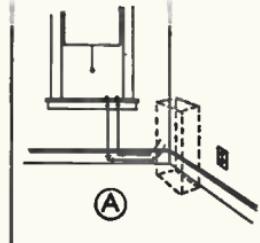
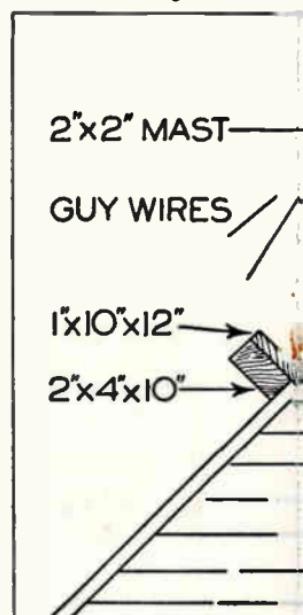
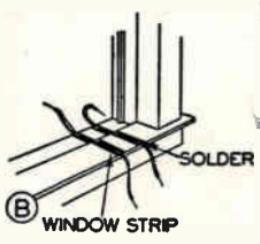


FIG. 10. How to bring a window to ground.

FIG. 11. How to mount peak with





lead-in wires through  
a receiver.

Since drilling this hole is frequently difficult, particularly in brick homes, most servicemen bring the antenna lead-in through a basement window, then run the wire along under the floor and up through the floor to the radio. This requires a small hole in the floor near the radio location. Some owners object to

this, but if there is no better way of getting to the radio, you can explain that the hole need be only a very small one. Drill the hole downward through the floor, using a  $\frac{1}{8}$ " or  $3/16$ " drill, and make the hole inconspicuous by placing it just as close to the base-board as possible.

Fig. 10 shows the lead-in connections when the wire comes through a window. Be sure to nail the wires neatly to the baseboard with insulated staples of about the same color as the baseboard. Keep the antenna and the ground leads separated as much as possible—preferably by at least two or three inches. (When you have to make a hole in the floor, it is not always possible to keep these wires separate at this point.)

This completes the installation of a simple inverted L antenna system. In general, all systems of this kind will be erected in the same manner. Perhaps the major difference between the installations will be in the sup-

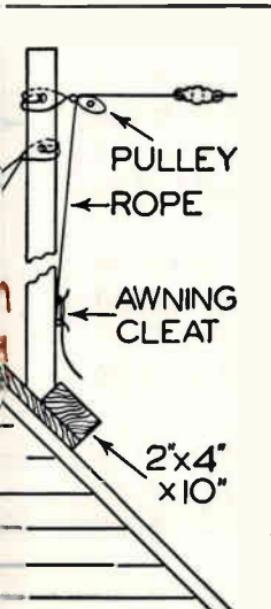
ports of the antenna wire. Sometimes you will have to make one or two masts for the system; in other cases there will be trees in convenient locations. Let's learn more about antenna masts.

## ANTENNA MASTS

The kind of mast shown in Fig. 8 may be made of  $2" \times 2"$  timber in some standard lengths, such as 6, 8, or 10 feet. There must be a support for the bottom end of the mast so that it will not punch its way through the roof. It is possible to use two pieces of wood to make a saddle for the roof, or, if the roof is flat, the mast can be fastened at the butt end on a flat board.

Fig. 11 shows another way of fasten-

nt a mast on a roof  
a saddle.



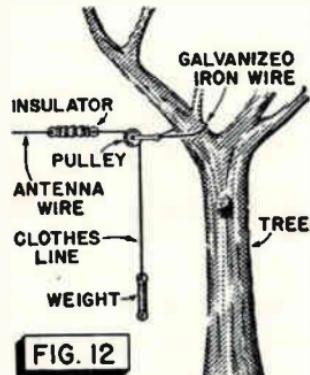
ing the mast at the peak of a roof. Here, two pieces of 2" x 4" are nailed to a 1" x 10" by 12" board. Trim the butt of the antenna mast to fit the saddle snugly. Fasten the mast at its base by driving one nail up through the board into the end of the mast and driving one or two more nails sideways into the 2" x 4" next to it. Be careful not to split the mast.

Then, to prevent the guy wires and the antenna guy from slipping down the mast, drill two small holes through it. Drill one about two inches below the top. Thread the guy wire for the pulley through this one, and thread the mast guy wires through the other. Wrap each guy around the mast once or twice, then fasten it by twisting both parts of it together. The awning cleat shown near the base of the mast may be obtained from any hardware store and is fastened to the mast by wood screws.

► Fig. 12 shows a method of securing the antenna to a tree. A loop of galvanized iron wire is passed around some portion of the tree above a branch crotch so that it cannot slip downward. It is a good idea to thread this wire through a section of an old bicycle tire so it will not cut into the tree. Then the antenna wire can be guyed through a pulley to a heavy weight to hold it upright. It is advisable to use a weight system of this kind, because a tree will sway with the wind and will snap the antenna wire if it is drawn up taut. Another scheme is to use a long spring between the insulator and the tree guy wire instead of using the pulley and weight. The swaying tree stretches the spring.

The antenna wire itself and its insulator must be outside the tree area—that is, no tree branches should rub on the wire. Either use a sufficient length of clothes-line back to the pulley to avoid this possibility, or trim the tree.

**How to Build a Tall Mast.** When there is no nearby house, tree, garage, or barn to which you can attach the far end of the antenna, a mast erected on the ground



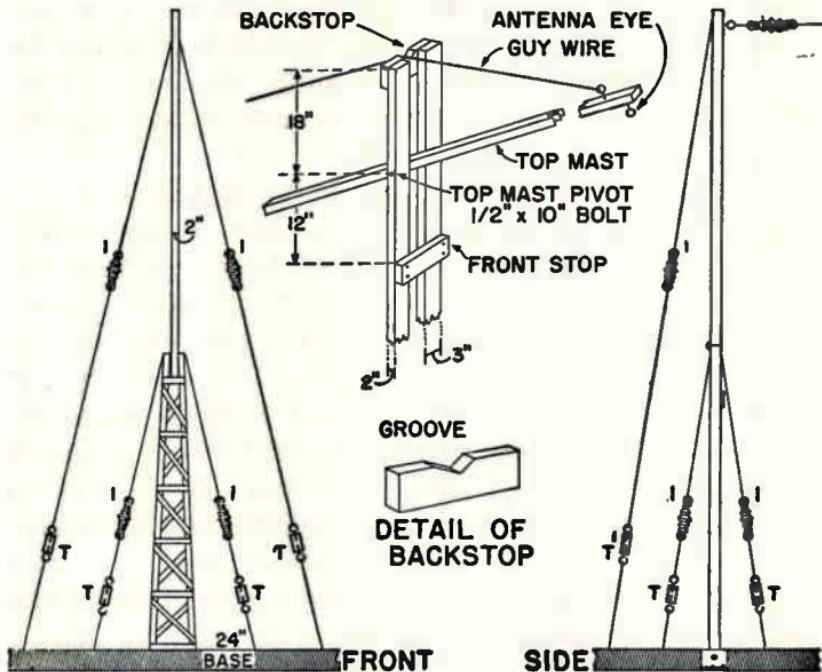
will solve the difficulty. The mast shown in Fig. 13 is very satisfactory. It is strong, inexpensive, and can be built and erected by one man who is handy with a saw and hammer. In addition, it has the useful feature that the antenna can be attached or replaced without lowering the bottom portion of the mast. The following details may not be clear until you build one, but the complete step-by-step procedure is given.

The mast is in two sections. The lower section (we will call it the lower mast) is a light but substantial latticed affair. The upper section (top mast) is a single pole, pivoted to the upper end of the lower section.

The lower mast is made from two lengths of 2" x 3" wood between 12 and 20 feet long. Lay these two pieces on the ground, 3" sides uppermost, spreading the bottom 24" and the other end slightly more than 2". Lattice first one side and then the other with 1" x 2" strips, nailed to the 3" faces. The latticing pieces should stop 36" from the top.

Thirty inches from the top, screw on a piece of board about 1" x 8½". This is shown in Fig. 13 as the *front*

FIG. 13. Construction details of the tall mast.



*stop* for the top mast. The *back stop* is a 2" x 4" piece of wood, screwed or bolted on the other side at the extreme top. Notch the upper edge of the back stop in a broad V about 1" deep.

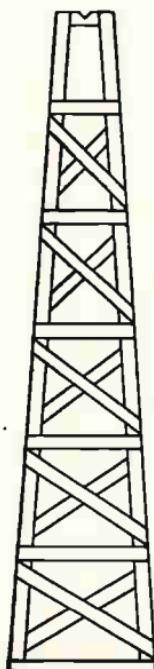
Fasten four large-sized eye screws within 3 feet of the top of the lower mast (drill through the 3" faces of the uprights), and attach a guy wire to each eye. Each wire should be about one-quarter longer than the lower mast, and, if possible, should have a turnbuckle in it near the end farther from the mast. These guy wires are to be fastened in stakes driven in the ground. For this purpose, drive four 2" x 3" stakes (or tent pegs) about 2 feet long into the ground around the place where the mast is to be mounted. Put them in the four corners of a square so that each will be about one-half the length of the lower mast from the base of the mast. Drive each in at an angle so that it will slope away from the mast, then fasten an eyebolt to each.

To make the base for the lower mast, use two 2" x 3" stakes  $2\frac{1}{2}$  feet long. Point one end of each stake with a hatchet and drive them about 2 feet into the ground where the mast is to be erected. Space them 30" apart. The 3" sides of the stakes should be parallel in the same direction as the antenna will run. For permanence the stakes should be treated by dipping them in creosote—if you wish, they may also be set in concrete rather than be driven into the earth.

Cut off the tops of the stakes so that 3 inches of each remain above ground. Drill holes large enough to hold a  $\frac{5}{8}$ " or  $\frac{1}{2}$ " diameter bolt through the 3" faces of each. With the same bit, drill similar holes on both sides of the base (through the 2" faces) of the lower mast. Finally, fasten the lower mast to the base with two galvanized iron bolts. The lower mast is to pivot on these bolts, so don't tighten them too much.

For the top mast, select a 2" x 2" pole about 10 to 15 feet long, free of knots and

Here's how to lattice the base of the mast shown in Fig. 13.



flaws. Drill a bolt hole 18" from one end of the pole and drill corresponding holes through the end of the lower mast.

Attach the pole to the lower mast by slipping a  $\frac{1}{2}$ " diameter galvanized iron bolt through the holes in both masts. Leave the nut on the bolt loose enough for the pole to pivot freely.

Fasten two eyebolts to the other end of the pole, one on the side that will be nearest the house, the other on the opposite side. Fasten three guy wires to the latter eye. These wires should be 25 per cent longer than the entire mast. After making each wire the correct length, cut it in half and attach the cut ends to the holes of a strain insulator. (This is to prevent leakage from the antenna to ground along the guy wires.) Next, install a turnbuckle in each guy near its bottom end.

You are now ready to pull up the lower mast. With the lower end bolted to its anchor, find the two guy wires that will reach their pegs while the mast is on the ground, and make a temporary fastening to the corresponding eyebolts on these pegs. Let these wires be a little longer than they will be when the mast is upright.

Lay one of the top-mast guy wires over the notch in the back stop, then lift the lower mast and swing it into place, allowing it to hang on the guy wires.

Fasten the other two lower-mast guy wires to their anchor-peg bolts, then adjust all four guy wires until the lower mast is vertical. When you have it almost vertical, fasten the wires permanently to their anchor bolts, and make final adjustments with the turnbuckles. See that all four guy wires are taut.

Drive three more anchor posts into the ground for the top-mast guy wires. Each should be spaced from the mast base a distance equal to about half the over-all height of the mast. Place two at the sides, about 3 feet on the house side of the lower mast, and place the third behind the lower mast, right in line with the top mast.

With a short guy wire, fasten the antenna insulator (which should already be fastened to the antenna) to the free eye on the top mast. Arrange the antenna wire so that it can uncoil as the mast is raised. (To prevent kinking, stretch it out along the ground, or arrange

it in loose coils near the base of the mast.)

To raise the mast, first prop the "antenna" end as far off the ground as possible. Use a long pole to push it up. (It helps to have an assistant for this operation.) The upper mast can now be brought into position by pulling on the guy wire laid over the notch in the back stop. (If the wire has slipped from the notch during the raising of the lower mast, either flip it in again, or lift it in with a pole.) When erect, the top mast will rest in place against the front and back stops, and the guy wire will leave the notch. Bring this wire back to its anchor post and fasten it securely, then lead the side guy wires to their anchor posts and fasten them. Take up on the turnbuckles until all guy wires are taut.

This completes the erection of the mast. You can now fasten the other end of the antenna to its support in the manner previously described.

### ERECTING A DOUBLET ANTENNA

Doublet antennas have been made that use a shielded cable or a spaced pair of wires for a lead-in, but practically all those intended for home installations use transmission lines consisting of a twisted pair of wires. This last is the only kind we will discuss here.

In practically all cases, the transmission line is matched to the impedance of the flat top, either by an antenna transformer or by careful design of the line and flat top so that they have the same impedance. Therefore, these units, including the horizontal portion and the transmission line, are always sold as complete kits. Typical systems are shown in Fig. 14.

Notice that the lengths of the various antennas vary. As these wires should not be cut if optimum short-wave reception is desired, it will be necessary for you to

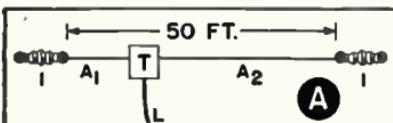
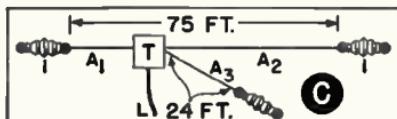
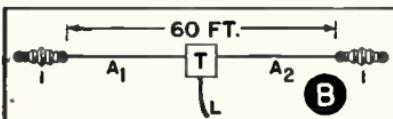


FIG. 14 DOUBLET ANTENNAS

A = ANTENNA WIRE, I = INSULATOR  
L = TRANSMISSION LINE  
T = TRANSFORMER



choose antenna kits that have approximately the right spread between the insulators for the installation you have in mind. (These length variations occur because each antenna represents a compromise between best noise-rejection and best signal-pickup. Some have greater noise-rejection, others have better pickup.)

Another important consideration is the fact that these antennas are directional. As shown in Fig. 2, most of them receive best from the broadside direction, so if a particular short-wave station is to be picked up, it may be necessary to orient the antenna system properly for it. Incidentally, antennas of the type shown in Fig. 14B are also used for television and f.m. reception, except that the horizontal flat top is a metal rod and is much shorter—5 or 10 feet long. A television or f.m. antenna of this kind is supported by a single mast at its center. (Because of special erection problems, we will not cover television and f.m. antennas here.) All other noise-reducing antennas, however, need supports at both ends, just as an inverted L antenna does.

To erect a noise-reducing antenna system, first erect the flat top in the manner described for the inverted L. Get it as high in the air as possible, but, of course, no higher than the length of the transmission line unless you can obtain more of the same kind. Bring the transmission line down to the point of entry into the house, fastening it to the side of the house with nail-it knobs or screw eyes. Do not separate the two wires of the line in any manner until you have brought it to the point of connection with the lightning arrester.

Fig. 15 shows two possible positions for mounting the lightning arrester. Notice that the transmission line

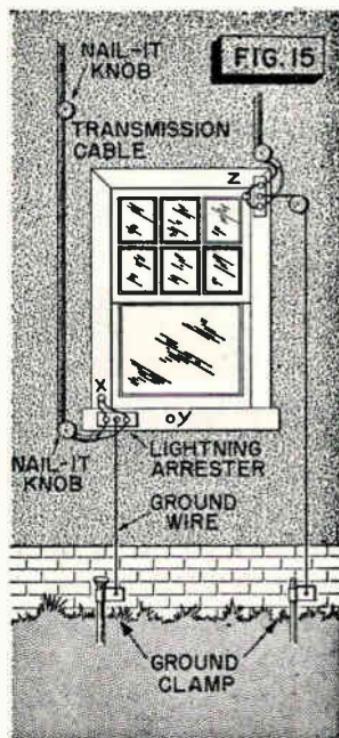
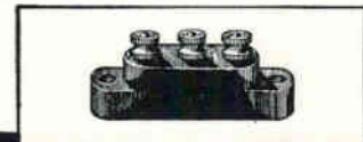
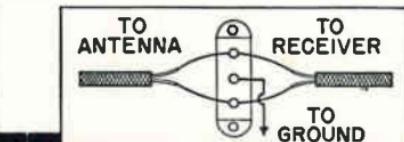


FIG. 16

STEPS IN CONNECTING  
A TRANSMISSION LINETO AN  
ARRESTER

(B) USE A 3-TERMINAL ARRESTER

(C) MAKE CONNECTIONS  
LIKE THIS

is shown entering the house through a hole after being connected to the arrester. The use of a hole allows the line to be kept twisted together, which is always preferable. However, if necessary, the line can be separated and two window lead-in strips used to bring the wires under the window. In any case, the line must be separated to be connected to the arrester. Fig. 16 shows how this is done. A typical arrester and the connections to be made are also shown. Notice that a three-terminal arrester is used.

If the receiver has connections for a doublet antenna, simply connect the ends of the transmission line to the terminals provided, and connect a ground wire to the ground terminal. If the receiver has only antenna and ground terminals, then a matching transformer like that shown in Fig. 17 must be used. This can be purchased with the antenna kit.

## INDOOR ANTENNAS

If it is impossible to erect a worth-while outdoor antenna, and the receiver is not equipped with a loop antenna or a built-in antenna

**FIG. 17.** A typical matching transformer, used when a receiver is not equipped for doublet connections. The wires marked "TO SET" connect to the ground and antenna posts of the set; they are coded to show which is which.



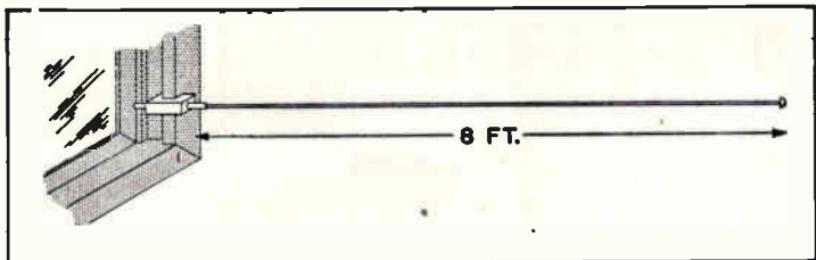


FIG. 18. One common type of fishpole antenna. These are adjustable so that they can be turned horizontally, vertically, or at some convenient angle. Usually angle mounting is best.

of any kind, then frequently some kind of indoor antenna must be used. At best, these give poorer results than any outdoor system, and may prove impractical altogether in buildings having steel in their construction.

Essentially, an indoor antenna is just a length of insulated wire strung up in some convenient part of the house. The wire may be run around three sides of a window frame; it may be run around the baseboard or around the picture molding; or it may be run through the wall up into an attic and then along the length of the house in the attic. Of the three, the last—giving both a longer and higher antenna—is by far the best, but it may be too difficult to install.

► When the building has metal in its construction, none of these indoor aerials may be practical. In such cases, a window fishpole antenna (Fig. 18) can be used. This is a metal rod 6 to 10 feet long that mounts on a window frame. Thus, it gets outside the building area and will pick up better than many of the indoor antenna systems. There are several types available.

Many antenna eliminators are on the market. Most of these plug into the power line, connecting the antenna terminal to the ungrounded side of the power line through a small condenser. The power line then acts as an antenna. Usually, however, so much noise feeds into such devices that their use is not recommended.

### CHECKING ANTENNA SYSTEMS

It is always advisable to look over the antenna system when you are called on any radio service job. Before entering the home, look over the outside antenna

if there is one. See whether the flat top is up and clear of all surrounding objects, and check the lead-in wire as far as you can see it to determine if there are any obvious breaks or defects in the system. Then, when you are within the home, examine the wire on the inside of the house, and check the rest of the lead-in.

The antenna system is a logical suspect whenever the receiver plays more weakly than normal, does not pick up distant stations, and is excessively noisy. If the receiver is in a shielded location, a broken lead-in may even make the receiver dead.

Whenever a defect is found in an antenna system, determine the age of the system. If it is more than three years old, it is usually better to replace the system rather than to repair it. This is particularly true if the trouble involves the transmission line of a noise-reducing antenna system. These lines become brittle with exposure to weather, and the insulation deteriorates. Also, collections of soot and dirt on the insulators may cause excessive leakage.

You can check with an ohmmeter for leakage from the antenna system to ground. However, before using an ohmmeter, be very certain that the antenna system does not touch any power line. In fact, many servicemen take the precaution of first checking between the lead-in and ground with a voltmeter capable of measuring line voltage.

To make this check, disconnect the antenna and ground leads from the receiver. Then connect your voltmeter probes between these two leads. Use a range higher than 110 volts at the start. If you get a voltmeter reading, the antenna system is in some manner shorted to a power line. Such a short circuit could burn out the antenna coil of the receiver. In fact, if you get a very high reading, it is advisable to have the power company come out and clear the short circuit rather than attempt to do it yourself.

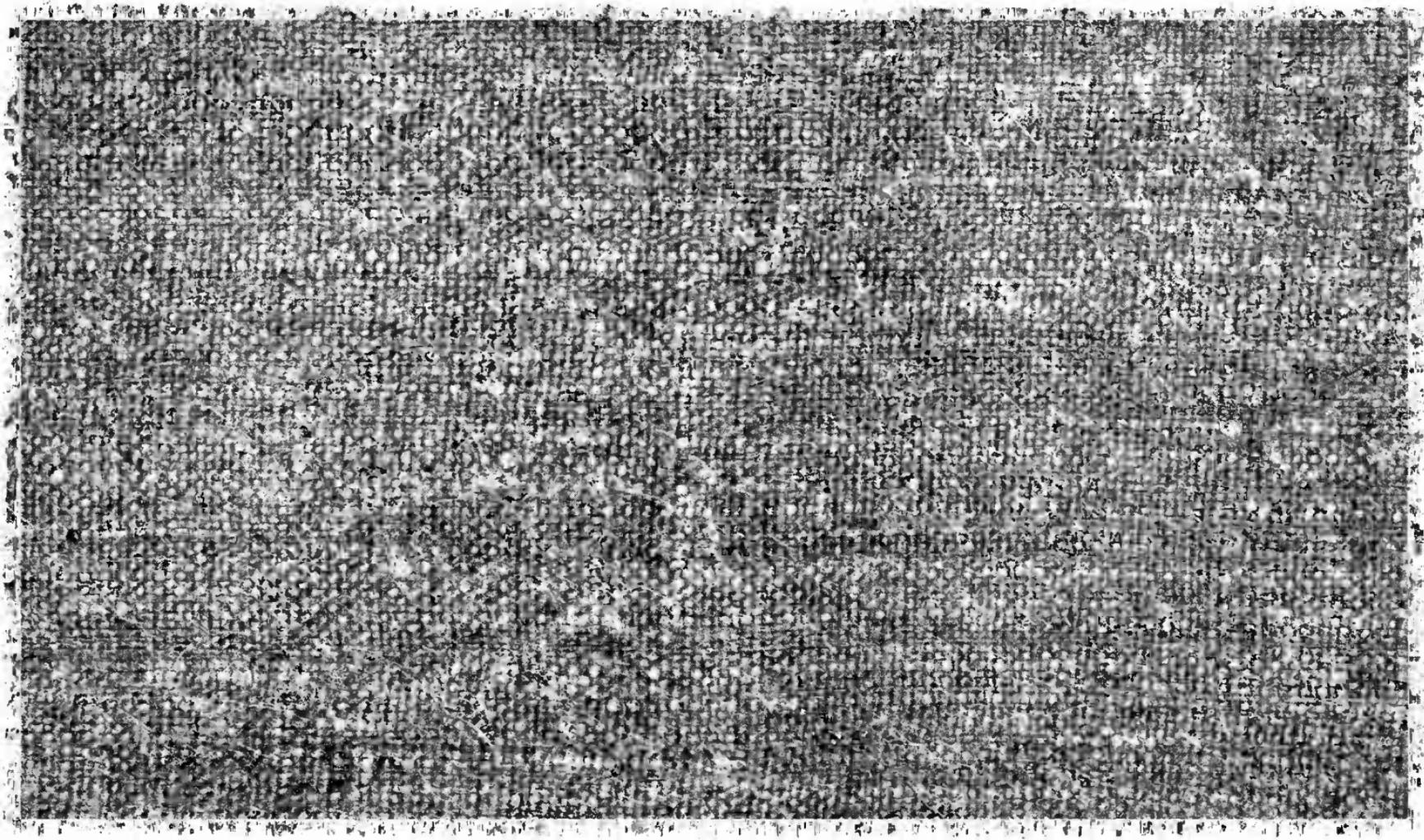
If you get no voltmeter reading, then it will be safe to use your ohmmeter and make a test between these two points. If you get an ohmmeter reading, the antenna is leaky and should be replaced. Use a high ohm-

meter range, because you should get no reading whatever.

Such an ohmmeter check will not show if there is a break in the lead-in. You can find this only by shaking the lead-in wire and pulling on it to see if you can part it at some point.

A transmission line should have continuity through the two wires of the line. If the transmission line is matched to the flat top by a transformer, there should be continuity through the transformer and line. In this case, measure between the two wires at the receiver end, and you should get a reading above 10 ohms (but not more than 100 ohms in the average installation). If the reading is lower than 10 ohms, there is a possibility of a short circuit between the wires of the line; on the other hand, no reading indicates an open. Of course, if there is no transformer, you will get no reading, because the transmission line is not joined at its upper end. If it is easy to get to the upper end, you could temporarily short together the antenna end of the transmission line. Then, by measuring between the receiver ends, you will get a reading of 10 to 100 ohms. If it is too difficult to get up to the top, then replace the system if it seems at fault. (The best test of this is to try the receiver on another antenna. If it works normally on a system known to be in good condition but operates poorly on the suspected system, then that system is defective.)

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

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 13      How To Repair Marred  
                  Radio Cabinets

RADIO SERVICING METHODS



# NRI TRAINING PAYS...

Dear Mr. Smith:

When I started this Course, I never thought of learning as much as I did. After finishing the twelfth lesson, I started to repair radios. Radio selling, servicing, and electrical repair work in my spare time earned about \$427 for me by the time I graduated. I now have my own radio shop at home and am steadily taking on new customers. My equipment is the best in town, and it was all paid for by the money I earned while studying the Course.

D.H., New York



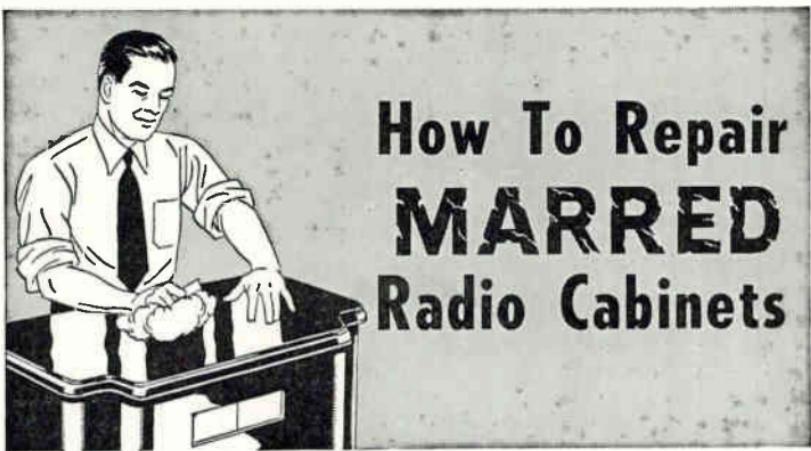
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## How To Repair **MARRIED** Radio Cabinets

**M**AKING repairs to marred radio cabinets can be a profitable source of extra income for you. The cabinet of a modern radio is often a fine piece of furniture that the owner is proud to have in his living room. By the same token, he is anxious to preserve its beauty, and very often, when he has called you in to make a repair, he will readily agree to let you fix up any damage that the cabinet may have suffered. Doing such work can add a surprising number of dollars to your servicing profits.

If you have a tie-in with a radio dealer, you may also find it possible to pick up extra money preparing his sets for display. Cabinets are often damaged in shipment—usually not badly enough to warrant calling in an expert cabinet refinisher, but enough to require a “touch-up” before they are placed on the sales floor. If you are able to do the work, most dealers will gladly pay a reasonable fee for the service.

Given the proper equipment, you can repair such defects as small scratches right this minute even if you have no experience as a refinisher. More difficult work requires experience and skill, but if you enjoy working with wood there is no reason why you cannot learn to refinish a cabinet completely. In this RSM Booklet, we will give you practical instructions for making all surface repairs, both large and small.

***Things to Remember.*** There are two things you should always keep in mind when you are dealing with cabinets. The first is—*don't bite off more than you can*

*chew.* If the job is too big for you, don't be afraid to say so. After all, you are a radio repairman, not a cabinetmaker. Fine refinishing requires care and experience. If you are a novice, don't say "Sure, I can fix it" when the cabinet is badly damaged. In all probability, you can't—not in a professional manner, anyway—and the customer will seldom appreciate an amateurish job. It's a good rule never to accept any cabinet job that you have not already done successfully. GET YOUR EXPERIENCE ON AN OLD CABINET OF YOUR OWN, not on a customer's. (Buy an old cabinet for practice if you do not have a suitable one. It does not have to be a radio cabinet, but it should have a varnish finish like that of a radio cabinet rather than a painted finish.)

► The second point to remember is—*don't damage a cabinet yourself.* Perhaps this sounds obvious, but many a serviceman has earned customer ill-will by carelessly allowing his hot soldering iron or a heavy tool to strike a cabinet. Accidents are particularly liable to happen when you are taking a cabinet to your shop. For this reason, you should leave all large console cabinets in the customer's home if possible—take the receiver and loudspeaker out, and leave the cabinet.

If you must take the cabinet to your shop, be sure to protect it against damage in transit. Cover it with a soft pad like those used by furniture movers. A heavy blanket will do almost as well. Wrap the set in the pad, and fasten it securely in place, before you start to move the set from the customer's home. Then, if you happen to hit a doorway on the way out of the house, you will not suffer the embarrassing experience of damaging the cabinet before the customer's eyes. If you are going to carry out the cabinet in bad weather, cover the pad with a piece of canvas. Be sure to fasten the set securely in your car or truck so it cannot bang around if you make a sudden stop or start. Use wide straps to fasten it, rather than ropes (ropes may bite through the pad and cause damage when tightened). Such careful handling is bound to impress the customer.

**Refinishing Materials.** From any radio supply



Courtesy General Cement Mfg. Co.

**FIG. 1.** Unless you do a great deal of cabinet repair work, this kit contains everything you will need. It is small enough to be carried to the job easily, yet contains material for any job short of a complete refinishing.

house, you can buy prepared kits containing all the repair supplies you need. One such kit is shown in Fig. 1, and others are pictured on later pages. (These are put out by the General Cement Mfg. Co., Rockford, Illinois.) Kits of this sort are not expensive, and are probably your easiest way of getting the supplies that you need. It is usually advisable to have a small touch-up kit to carry with you to make small repairs in the customer's home; and a more complete one for use in your shop.

If you prefer to assemble your supplies yourself, the materials mentioned in our instructions can be purchased at paint and hardware stores. However, it is more economical to buy them in kit form (unless you do a great deal of refinishing), for the smallest quantities available at stores are generally far larger than you need. Excess quantities must be thrown away, since paints and other materials deteriorate once their containers are opened. Kits contain such small quantities that there is little loss—you can afford to buy new supplies when needed.

## REPAIRING SCRATCHES

Fine scratches that do not penetrate far into the finish are easy to remove. If there are many of them, rub the whole cabinet down with scratch-removing polish. Apply the polish with a soft cloth, then rub the surface with another cloth until it is thoroughly dry, and finally polish the cabinet with a wax-base polish. In this final polishing, polish one section (panel, side, or top) at a time instead of trying to do the whole job at once.

Scratch-removing polishes are available for use on both light and dark woods; those intended for light woods are clear, but those to be used on dark woods contain stains. Be sure not to use a polish that is darker than the original finish.

► If there are only a few small scratches, you can usually repair them with a scratch stick. This is a small stick containing solid stain at one end and a felt cork in a bottle of liquid at the other. Just rub the stain over the scratch, then reverse the stick and buff the scratched area with the felt. This is a particularly useful piece of equipment to carry in your pocket or your touch-up kit for use in the customer's home. It is not

If the cabinet has many small scratches, remove them with scratch-removing polish, then finish off with a wax polish.

Courtesy General Cement Mfg. Co.





Courtesy General Cement Mfg. Co.

**Remove small scratches with a scratch stick.**

practical to use if there are many scratches, however; the scratch-removing polish is quicker and does an equally good job. Neither works well on deep scratches.

**How to Use Stick Shellac.** Scratches too deep to be covered up with polish, but not so deep that the bare wood is exposed, can be repaired with stick shellac. There is a definite technique involved in using stick shellac; *you should not try to use it on a customer's set until you have practiced a few times on a piece of wood or some of your own furniture.*

The series of pictures in Fig. 2 shows how this shellac should be used. First, select a stick that is a little lighter than the color of the cabinet (the shellac will darken slightly when it is heated during application). Next, heat the blade of a spatula in the blue part of an alcohol flame. (Alcohol is specified because it will cause the least depositing of carbon on the blade.)

When the blade is hot, wipe it clean with a dry cloth. The blade must be clean to prevent foreign substances from getting into the shellac. Do this quickly so the blade will not cool off too much.

Touch the shellac stick to the hot blade and allow some of it to melt onto the blade. If the shellac bubbles on the blade, *it is too hot*; wait until it stops bubbling

before applying it to the cabinet. If the shellac is applied when it is too hot, bubbles or pin points will appear in the completed job.

Apply the shellac on the blade sparingly to the scratch. *Be careful not to allow the hot blade to touch the unmarred surface*, or you will have a burned spot as well as a scratch to repair. If the spatula becomes too cool for the shellac to flow, reheat it. Fill in the scratch completely, then allow the shellac to harden thoroughly.

When the shellac is hard, carefully cut off any excess with a razor blade. Again, be sure not to damage the surrounding surface; if necessary, you can leave a slight ridge of shellac. Saturate a piece of heavy felt or an ordinary blackboard eraser with shellac-stick rubbing fluid, and rub it over the repaired area until it

**FIG. 2. Follow these steps to use stick shellac.**

Courtesy General Cement Mfg. Co.



1  
HEAT SPATULA  
IN LAMP FLAME.  
WIPE CLEAN.



2  
TOUCH HEATED  
SPATULA TO  
SHELLAC STICK.

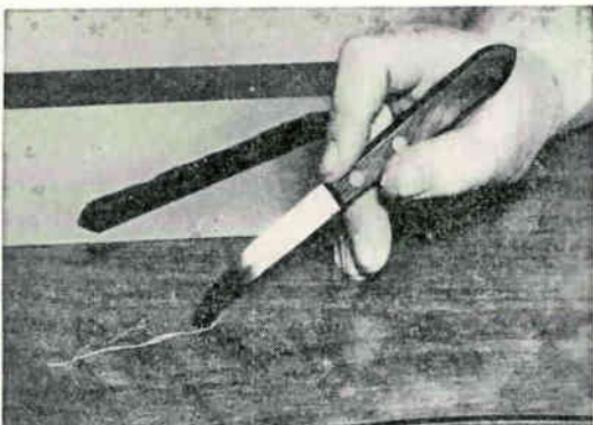
is smooth and level with the surrounding surface. If you prefer, you can smooth the repair with fine steel wool, fine sandpaper, pumice, or rottenstone, but you will have to be careful with these not to mar the surrounding area. Rottenstone or pumice may be applied by sprinkling the powder on a piece of felt (or black-board eraser) that has been saturated with rubbing oil, then rubbing it over the surface to be smoothed. *Always work with the grain of the wood.* To get a really good finish, use pumice first, then repeat with rottenstone.

After the scratch has been filled in and smoothed, complete the job by cleaning the surface and polishing the whole area with wax polish.

► Notice—the pictures in Fig. 2 show the repair materials placed on top of the cabinet. It is necessary to do this so you can take the heated spatula directly to the

APPLY SHELLAC  
TO SCRATCH  
WITH SPATULA.

RUB DOWN WITH  
SHELLAC-STICK  
RUBBING FLUID.



scratch without giving it time to cool off too much. However, be sure you put a smooth piece of wood (or a heavy cloth and a piece of wood) under the lamp and the shellac to prevent damage to the cabinet. And, of course, be careful not to move so quickly that you upset the lamp. Don't fill the lamp over the cabinet; alcohol will spot or ruin almost all finishes.

It is not too difficult to make a repair of this sort after you have practiced a few times. However, it is very easy to cause more damage than the original scratch if you are careless.

► If you are going to use transparent shellac to fill in a scratch so deep that it exposes the wood, you will usually have to stain the wood first to the proper shade. (Staining is optional if you use a colored shellac, provided the shellac is the proper shade.) Use a stain that is considerably lighter in shade than the cabinet finish. Apply several coats with a brush until the shade matches the desired one. Allow each coat to dry about three hours before applying the next one. If you happen to stain the wood too dark, you can lighten it to some extent by rubbing it lightly with a cloth moistened in alcohol. This will remove some of the coloring matter (but remember that the alcohol will probably also injure the original finish if you rub over it much).

After the stain is thoroughly dry (overnight drying is desirable), complete the repair in the manner already described for a deep scratch.

### **REPAIRING GOUGES, NICKS, AND CUTS**

Any injury that actually removes some of the wood from the cabinet is considerably more difficult to repair than a scratch, chiefly because the hole must be filled in.

Clean all foreign matter from the hole with a knife, then mix a little Savogran Wood Putty with water to the consistency of a thick dough, and immediately fill in the hole as neatly as possible. Smooth the wood putty with a knife blade or spatula while it is still soft. Wait at least 24 hours for it to dry, then shave off any excess with a razor blade. Smooth the repaired area in the manner previously described for the stick-shellac repair, using fine sandpaper, steel wool, pumice, or rot-



Courtesy General Cement Mfg. Co.

This is a complete touch-up kit, suitable for all touch-up jobs but not for major repairs.

tenstone. Finally, stain the repair with several coats of light stain until the desired shade is reached. If the repaired area is large, it will probably have to be refinished completely. Instructions for such refinishing are given later in this Booklet. If the area is small, and the repair neat, a good rubbing with wax polish will complete the job.

► It is possible to make a satisfactory repair in this manner if the cabinet wood has no noticeable grain pattern. If it has a marked grain, however, the repair will show—although it will probably not be as noticeable as the hole was. Until you have had considerable experience with repairs of this sort, don't lead the customer to expect too much if the area to be repaired is large.

Savogram Wood Putty can also be used to replace bits of ornamental work that have been knocked off. Follow the instructions given for filling in a hole, but instead of smoothing the wood putty before it hardens, mold it at least roughly to the desired shape. After it hardens it can be carved to the shape you want. In carving it, be careful not to exert much pressure in a direction that will tend to knock off the material.

## REPAIRING SPLITS

If the cabinet is badly damaged—split through, or broken apart at a corner—or if the veneer is checked, peeling, or split, the repair is really a job for an expert cabinetmaker. However, if the customer does not want to go to the expense of having a cabinetmaker do it, you can do a reasonably good job if you are careful. There are too many possible repairs for us to go into detail on all of them, but here are some hints that will be helpful.

If a piece of wood is split through, coat both edges to be rejoined with glue. Use a good grade of wood glue, such as casein, hide, or fish glue. Never use a lacquer-base cement if the surfaces next to the split are finished, for such cement is apt to cut into the finish and make it necessary to refinish the whole surface.

After applying the glue, press the split together several times with your hands to work the glue in well. Wait about five minutes until the glue becomes tacky, then press the split together as firmly as possible and clamp it tightly with an adjustable clamp. Do not let the clamp bear directly on a finished surface, for it will probably mar the finish; instead, place a fairly wide block of smooth wood between the clamp face and the finished surface before tightening the clamp. When you have finished clamping, wipe off any excess glue with a damp cloth.

Allow the glue to harden at least 24 hours before removing the clamps. If any glue has oozed out of the joint, remove it with a razor blade, then smooth the joint with fine sandpaper or steel wool.

Whenever possible, don't depend on glue alone to hold a split together. Use screws, finishing nails, or corrugated fasteners to help hold it if these can be driven in without spoiling the finish. If screws or finishing nails must be driven in from the outer surface of the cabinet, be sure to sink them below the surface. Then treat the holes thus produced as you would any other hole.

Corners that have broken apart will require reinforcement. Sometimes dowels can be run into both



Courtesy General Cement Mfg. Co.

This large kit contains everything you need to refinish a cabinet completely.

pieces and glued in place; sometimes small steel brackets or glue blocks can be used. Remember that the cabinet should be as sturdy as possible, for it is subjected to surprising amounts of vibration from the speaker.

Veneer that has come loose along an edge of the cabinet can often be glued back in place. Treat it as you would a split, but do not move the veneer any more than necessary; it is very thin and can be split rather readily. Apply as much pressure as you can when you clamp it, and be sure to place a smooth wood block between the clamp and the veneer.

Veneer that has bubbled up in the middle of a panel is almost impossible to fix. About all you can do is cut out the bubbled section and fill in the hole with Savogran Wood Putty. Usually this will not look right, for nearly all veneers have a pronounced grain that will be missing in the repaired spot. Sometimes it is possible to flatten the bubbled section after removing it and then to glue it back; however, the result produced is seldom worth the effort involved.

### REPAIRING LARGE SURFACES

In our descriptions of the preceding repairs, we assumed that only a small section of the cabinet surface was marred and that no general cabinet refinishing was



Courtesy General Cement Mfg. Co.

This is a patch kit, used for filling in deep scratches or nicks in cabinets or porcelain-covered appliances.

necessary. However, sometimes damage is so extensive that a panel, or perhaps the whole cabinet, must be refinished. Such jobs are something you should avoid until you have developed considerable skill, for they are by no means easy.

The first step in refinishing a large surface is to remove every trace of the old finish with varnish remover. Paint the remover over the surface with a paint brush. Allow it to stand until the varnish begins to curl up, then scrape or rub off the varnish with a putty knife or a scrubbing brush. Apply a second or even a third coat, if necessary, to get off every bit of the old varnish.

After all the original finish has been removed, sponge the wood thoroughly with turpentine to remove all chemicals. When the surface has dried, carefully sand it with medium-fine sandpaper or steel wool until it is perfectly smooth. Remove all dust from the work with a soft cloth.

If the cabinet is to have a dark finish, stain it to the desired shade with an alcohol-base stain. Use several light coats (three hours apart) to build up to the proper shade, rather than one dark one. Apply the stain with a clean, soft brush, and take care to make it uni-

form over the whole surface. You will have to work rapidly, for alcohol-base stains dry fast.

If the customer wants you to convert a dark-finished cabinet into one of the modern bleached finishes, apply several coats of a commercial bleach solution to the wood after the old finish has been removed. Follow carefully the instructions accompanying the bleach. When every trace of the old color has been removed, stain the wood to the desired shade with the proper color of light stain. Be sure not to get the wood too dark.

When the wood is stained to the shade you want, and the stain is perfectly dry, you are ready to apply the finish. Finish is put on to give the work a hard, smooth surface. Excellent finishes are produced in factories by spraying on clear lacquer with a spray gun. Spraying equipment is expensive, however, and requires expert handling. You can produce just as good a finish by hand if you work carefully, although the process will be far more laborious than spraying.

We are going to describe three methods of finishing, listed in the order of increasing difficulty. Any one of them will give good results if you are careful. The brush finish, using white shellac or clear varnish, is the only one of the three that can be used on a light-finished cabinet; the other two will darken the surface.

► There are some general rules you should observe in putting on any finish. Work in a dust-free room, so the finish will not pick up dust particles as it dries. Make sure a surface is thoroughly clean before you apply the finish. (Rubbing naptha or gasoline over the surface is a good way to clean it—but be careful! Be sure there are no open flames near, and do not smoke.) Don't try to rush matters; a good refinishing job takes time, and you may ruin all your efforts if you get impatient near the end.

Finally, try not to apply a finish on extremely damp or hot and muggy days. If finish is applied when the air is full of moisture, it may dry with a cloudy or whitened surface. This is called "blushing" or "bloom." Small spots of blushing can usually be removed by wip-

ing lightly with alcohol, but if a large area is affected you will probably have to refinish it.

**Brush Finish.** Apply an even coat of white shellac or clear varnish to the wood with a fine, soft brush. Use the best brush you can get; a good brush makes a tremendous difference in the quality of your work. Make sure it is thoroughly clean. Wait until the shellac or varnish is thoroughly dry (overnight, at least), then sand it lightly with medium-fine sandpaper or steel wool. Remove all dust with a soft cloth or a tack cloth, then apply a second coat, and again let it dry. (A tack cloth is a cloth dipped in varnish and allowed to dry. It should feel sticky, but the varnish should not come off.) Sand and dust again, then apply a third coat, and allow it to dry. Rub this last coat lightly with rotten-stone and lemon oil until all brush marks have been removed and the surface is glass-like and shiny. This will give a glossy surface. If you want a semi-gloss surface, use fine steel wool or fine sandpaper for the final finishing; or, if you want a flat finish, use pumice and oil. (If the finish is light-colored, it is best to use pumice and water or the finest grades of sandpaper rather than rottenstone or an oil, because these latter will darken the surface.)

Three coats are usually sufficient to produce a satisfactory finish. If you want a deeper finish, you can apply more coats. Be sure to let each dry at least overnight, and be sure to remove all sanding dust before you apply a new coat.

**Dip-and-Rub Finish.** This finish is applied with a pad rather than a brush. To make the pad, roll up soft, lint-free muslin or cheesecloth into a ball about twice the size of a golf ball. Tie the ends of the cloth together on top of the ball so it will keep its shape. Fill a shallow tin or saucer about two-thirds full

Courtesy General Cement Mfg. Co.  
This small touch-up kit is handy  
for making last-minute repairs of  
small defects.



with French varnish and a similar tin about two-thirds full with a lubricant such as turpentine or French emulsion. Place these where they can be reached readily.

To apply the finish, dip the pad first into the lubricant, then into the French varnish, and begin to rub over the surface of the wood with a circular motion. Use light pressure and go over the entire surface of the wood. The finish will dry almost immediately and will be practically free from streaks. When the pad begins to stick to the surface, dip it again in the lubricant and the varnish and continue rubbing. When you have covered the surface completely, and it is thoroughly dry, sand it lightly with fine sandpaper. Remove all sanding dust, then apply another coat.

After several coats have been applied in this manner, the surface will take on a rich, soft gloss. To heighten this gloss, allow the finish to dry for 12 to 18 hours, then rub over it with a soft cloth dipped in French emulsion or linseed oil.

**French Polishing.** French polishing is considered the most beautiful of finishes. It has been used for generations to finish pianos and fine furniture. You can get wonderful results with it if you care to spend the necessary amount of time.

For materials, you need a pad like that used in dip-and-rub finishing and a saucer of French varnish.

Dip the pad in the French varnish, then rub it over the wood with rapid, straight strokes. Rub with the grain and use very little pressure. When you have applied a coat, allow it to dry thoroughly, then sand it smooth with medium-fine sandpaper or steel wool. Remove all sanding dust, then repeat the process several more times. Allow each coat to dry thoroughly, and sand and dust before applying the next.

Eventually, a light shine will appear on the surface. When it does, add a few drops of French emulsion or linseed oil to the varnish, and give the surface another coat, this time rubbing with a circular motion instead of with the grain. Allow the coat to dry, then sand and dust it. Add a few more drops of emulsion or oil to the varnish, then repeat the process. Continue to add more

coats in this manner, putting a few more drops of emulsion or oil into the varnish each time, until you have a finish as good as you want. After the first few coats, rub the surface with rottenstone and lemon oil instead of sanding it. Each coat will make the finish a little better.

## APPLYING GRILLE CLOTH

When a grille cloth over the speaker is torn or faded, a customer will often allow you to replace it if you suggest doing so. This can be either the final touch to a cabinet repair job or a profitable separate job if the cabinet requires no work.

You should always use genuine grille cloth for the repair, not just any cloth that happens to be available. Grille cloth is heavy, flexible, and porous, and does not interfere with the sound waves coming from the speaker. Ordinary tight-woven cloth will usually muffle the sound, and, if it is one of the stiff kinds (like chintz), it may rattle when a note of a particular frequency is sounded. You can get grille cloth from any radio supply house.

Select cloth that is artistically suitable for the cabinet. Usually it is best to get a shade that is near the cabinet color, although some customers may prefer a vivid contrast. A large pattern will look all right in a large console, but will not be suitable in a table model. If possible, get swatches of the various available cloths from your supplier so the customer can select the kind he prefers.

To apply the cloth, first remove the speaker or chassis so you can put the cloth on from inside the cabinet. Remove all the old cloth, and smooth the surfaces on which the new cloth is to be put. Cut the cloth to the proper size, allowing enough for it to overlap the cabinet opening by an inch or more on all sides. (When you cut the cloth, be careful to consider the pattern and the way you want the design to run.)

Coat the area to which the grille cloth is to be attached with fabric cement (you can get suitable cement from your supplier) and apply the cloth over the opening. (Some cloths fasten in the cabinet; others are fas-

tened to a removable baffle board.) Stretch it enough to make it taut and free from wrinkles, then put a tack through each corner (if fastened to wood) to hold it in place until the cement dries.

## REPAIRING NON-WOOD SURFACES

Most of your profitable repair jobs will be on wood cabinets, for they are the most expensive, and the ones that owners are most anxious to have look nice. However, repairing plastic or portable cabinets can be profitable enough to you to make it worth while to learn the simple techniques involved.

**Plastic Cabinets.** A badly damaged plastic cabinet is almost impossible to repair. If a piece of the cabinet is missing, don't try to fix it—instead, try to sell the owner a new one. In most cases, duplicate cabinets can be obtained from the set manufacturer.

If the cabinet is only cracked, you can probably repair it with plastic cement. Your supplier has this, too. Ordinary wood glue can't be used, because it will not adhere properly to the surface. To repair a crack, ap-

**Small cracks in plastic cabinets can usually be repaired with bakelite cement if no pieces are missing.**

Courtesy General Cement Mfg. Co.



ply a liberal coat of cement to both sides of the crack and allow it to dry. After it is dry, apply a heavy coat to one side of the crack and press the crack shut immediately. Clamp it tightly until the joint has dried thoroughly. It is usually best to allow it to dry overnight.

Small nicks, chips, and scratches often can be filled in with stick shellac in the manner described earlier in this Booklet. (Be sure not to let the hot spatula blade touch the plastic.) Remove excess shellac with a razor blade and polish the cabinet to blend the repair into the surface. You can get heavy lacquer enamels from your supplier that can be used to touch up colored plastic cabinets. Plastic knobs and handles can be repaired in the same manner as cabinets.

**Portable Cabinets.** Many portable sets are covered with leatherette or airplane luggage fabric. Often this material becomes torn or frayed after the set has been in use for a while, and most owners are willing to pay a reasonable sum for a repair.

The necessary cloth or leatherette can usually be gotten from your supplier or from an upholstery shop. If you can match the pattern of the material on the set, and only a small part needs repairs, simply cut out a patch of the proper size (considering the design, of course), coat the area with fabric cement, and set the patch in place. Match the pattern lines of the patch carefully to those of the original cover, then press the patch hard and smooth it out.

If you can't match the pattern of the original material; or if a very large area needs repairs, it is best to re-cover the cabinet completely. Remove all the original covering, and sand off any glue that remains on the cabinet. Next, cut the new material into pieces of the

Courtesy General Cement Mfg. Co.  
This small patch kit is intended to be used for repairing nicks and dents in refrigerator or other porcelain-covered appliances.





This plastic cabinet touch-up kit contains six shades of lacquer enamel for touching up marred spots on plastic cabinets.  
Courtesy General Cement Mfg. Co.

proper size for the job. You should use as few pieces as possible so there will be a minimum of seams. Plan the cuts so that no seams will have to be made at edges or corners of the cabinet, for it is difficult to make the covering stick well at such corners. Allow for an overlap of at least one inch at all seams. You may find it worth while to cut out a paper pattern before you cut the material.

When you have the new material cut out, lay it over the cabinet to make sure it will fit in the way you intend. See that the pattern lines will match reasonably well at the seams. When you are sure the new fabric will fit, apply cement to the cabinet and put the new covering in place. Where one piece must lap over another, apply the cement to the under side of the upper piece. As you put each piece on, press it down firmly and smooth it out.

**Other Repairs.** When you are in the customer's home, you can ask if he would like you to touch up the surface of his refrigerator or washing machine. These often have nicks and scratches that you can readily repair. From your supplier you can get refrigerator repair kits that will contain everything you need for such work, including complete instructions. Nicks and scratches are filled in with white stick-shellac or porcelain glaze. Since these surfaces are often "off-white," it may be necessary to tint the filler blue or yellow, depending on the color of the original surface. Try a small amount on an inconspicuous spot before touching up the surface, to be sure you have matched the color.

### RETURNING THE SET

Take just as many precautions in returning a repaired cabinet to the owner as you did in removing it

from his house. Be sure to pad it well, and don't remove the pads until you have placed the set where it is supposed to go. Remember that the customer is paying you for improving the appearance of the cabinet *in his home*; he won't care how beautiful you had it in your shop if you happen to scratch it bringing it in through the door.

After you have put the set in place, give it a final wiping off with a soft cloth to remove any dust it has gathered in transit. If you have done a particularly good job, don't hesitate to say something like "Doesn't it look good now?" It is always a good idea to "sell" the customer a little on how fine a job you have done for him (although, of course, you should avoid bragging).

► Inspect the place where the set is to be used. If the radio is placed too near a fire or a hot radiator, the heat may dry out the glue and allow the joints to separate or may cause warpage or surface damage. Similarly, putting the set in a damp spot or near an open window may cause the veneer to swell or produce other surface damage. Point out these facts to the customer; he will appreciate it.

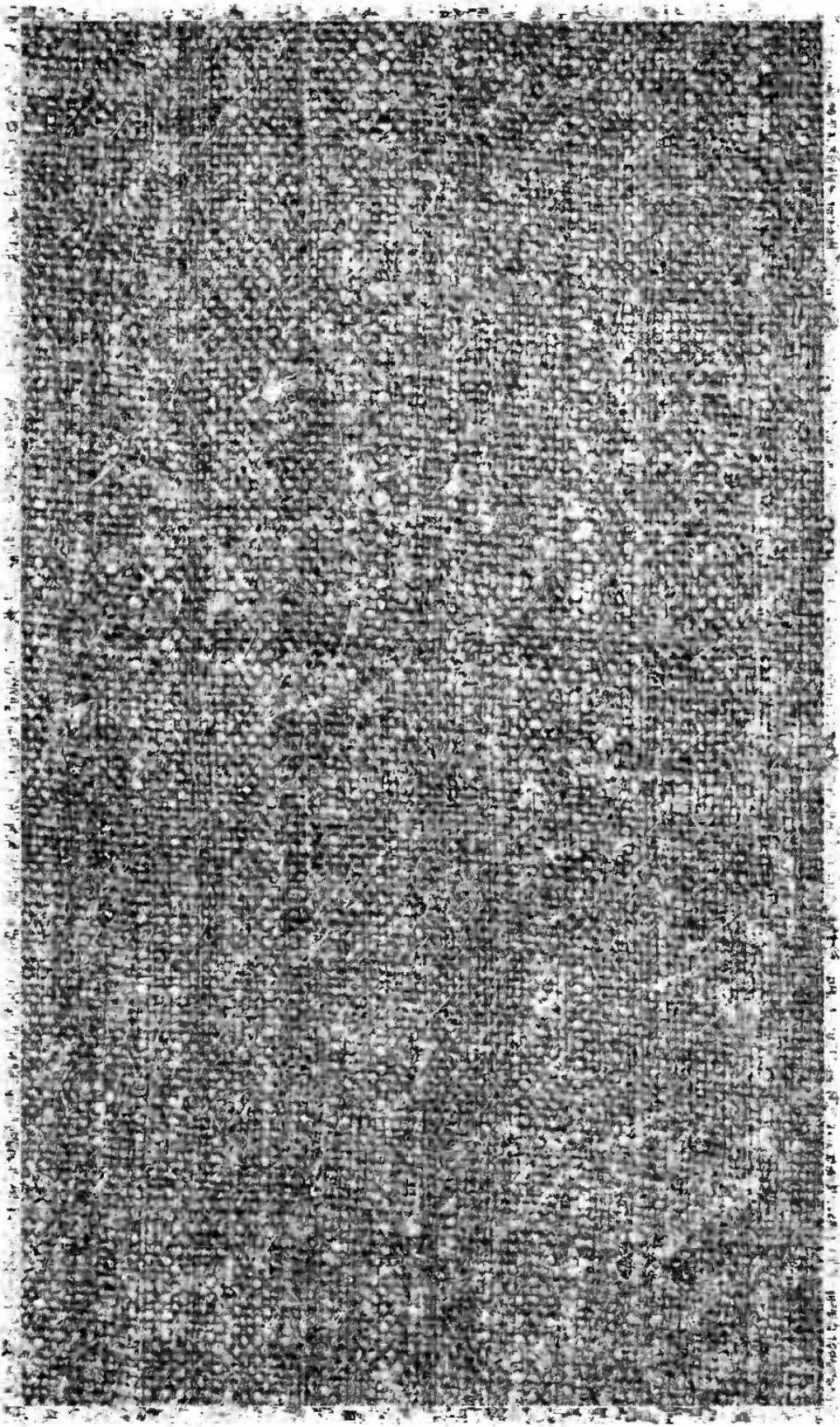
Finally, remember that the rest of his house furniture is just as apt to be nicked and scratched as his radio. If you have made minor repairs in front of his eyes with just a simple kit of polishing supplies, he is apt to be very much interested in getting a similar kit for use on his other furniture. You can often make a neat extra profit by selling him one at retail prices.

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THE N.R.I. COURSE PREPARES YOU TO BECOME A  
**RADIOTRICIAN & TELETRICIAN**

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

NATIONAL RADIO INSTITUTE, WASHINGTON D.C.

No. 14 How To Start a Spare-Time  
Service Business

RADIO SERVICING METHODS



# NRI TRAINING

# *Pays...*

Dear Mr. Smith:

About six months after I enrolled I started making money in Radio. Now I am doing part-time Radio work - I am farming, and just work on Radios evenings and stormy days. I am very thankful I enrolled with your school when I did, and only regret that I didn't do it several years before. By taking your Course in Radio I have made myself a very profitable spare time business.

B.L.A.. Iowa



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



# HOW TO START A SPARE-TIME SERVICE BUSINESS

THIS Booklet is intended for the man who wants to start a real business in spare-time servicing. If you look on radio more or less as a hobby, perhaps intending to service a few sets when you feel like it, but with no intention of carrying your servicing any further than that, you need no business information. But if you intend to make spare-time work a steady source of income—with an eye, perhaps, to an eventual full-time servicing job—you must learn a few simple business facts.

This Booklet gives you some of the information you need. It shows you what you need in the way of training and equipment to get started, how to get business, and how to handle it. Later Booklets will complete the picture of the business side of servicing.

## ARE YOU READY?

Before you even consider starting a service business, you should ask yourself one question—"Do I have enough technical knowledge to be a serviceman?"

The radio training you have received so far makes you the equivalent of a good radio mechanic. That is, you know how to test parts and replace defective ones. You can, therefore, repair any radio that has a part defect, although it may take you quite a while to locate the defective part unless you are lucky. You have not yet learned, however, how to align (adjust) a receiver to correct the defects that are caused by improper adjustment of the tuned circuits, nor have you learned the quick, professional procedures for locating defects.

These are subjects for future RSM Booklets—things you will study when you have learned more about radio circuits and stages in your Course in Radio Fundamentals.

On the basis of your NRI training to date, then, you are now equipped to do the simplest service jobs. So, if you start a spare-time servicing business right now —*be careful in selecting your customers*. Do work for your relatives, friends, and acquaintances—people with whom you can be candid about your present abilities. Don't be afraid to tell them if the job is too much for you to handle right now. Since they know you, they will be ready to make allowances for the fact that you have not yet completed your training. Then, if you find the job is more than you can handle, your servicing reputation will not be harmed; your friends will realize that you will be able to do the job later on when you have progressed further in your studies.

Remember, though, that you can't expect a stranger to be as understanding. That's why you should do your first work for people who know you. Be sure you can handle every job you do accept, and do as good work as you can on each one. In that way, you'll get off on the right foot, and enjoy a good reputation among your customers.

## **GETTING PRACTICAL EXPERIENCE**

Before you can advance much further as a serviceman, you must have some practical experience to round out your training in theory. There is a vast difference between reading about how to make a test and actually making the test. Even when you know all the theory involved, the only way you can locate and repair a defect with professional speed is to have done it several times before.

One way you might get the necessary experience would be to take any servicing job you could get—do the best you could on it—and depend on some friendly and experienced serviceman to rescue you if the job proved too tough. This is a possible way, but not a good one. For one thing, few servicemen are willing to help a potential competitor. And for another, the practice you

got would tend to be concentrated on the more common defects—you might have to service hundreds of sets before you got the all-around experience a real Radio-trician needs.

However, there is no need for you to try this difficult method of getting experience. The NRI Practical Training Plan will give you practical servicing experience on an actual receiver. You'll learn exactly how to make professional tests to track down all kinds of defects—and you'll learn them by doing them with your own hands on a real set. This Plan will be fully explained to you in RSM Booklets you will receive soon.

► We do not recommend that you try to get experience by starting work in some radio shop as an apprentice. This is not a good idea for two reasons: (1) you are not apt to learn much, and (2) the starting pay will be very small. If you enter a shop when you are still only part way through your NRI training, you will undoubtedly be expected to follow the service methods used by the shop owner. In many cases, these will not be nearly as good as the methods you will learn in your NRI Course. In fact, a student very often retards his progress rather than advances it if he attempts to get experience in a shop. Even if the shop owner is himself competent, he

### TRAINING IN THEORY



+ PRACTICAL EXPERIENCE



= PROFESSIONAL ABILITY



will seldom have time to teach you much; remember, he is working for a living, and his time means money to him. He will expect you to assist him, to change parts, and in general to do the "dirty work" of servicing. You will be far better off to get your technical knowledge from your Course and gain experience from the NRI Practical Training Plan. Also, you will probably make far more in your own spare-time business than you could get working as an apprentice for someone else.

Of course, these words of caution about starting a servicing business apply to you only in your *present* state of training. If you study your Course and these Booklets carefully, it will not be long before you'll be able to service almost any job you may happen to get. When you have progressed that far, there will be no reason for you to lack confidence in your ability as a serviceman.

Whether you want to start your business at once or wait until you have had more training, now is the time to begin planning your spare-time business. This RSM Booklet will show you how to get started the right way. Other Booklets will give you details on how to charge for your work, how to plan a professional shop, and how to go into full-time servicing—all of them subjects that require too much description to be included here.

## WHAT EQUIPMENT YOU NEED

When you go into spare-time servicing as a business, you will need a shop or place in which to work, right from the start. You will soon receive another RSM Booklet that will tell you how to set up a shop and equip it with the necessary workbench, storage shelves, and stock cabinet.

You will also need tools and test equipment before you can do much servicing. You will find a list of all the necessary tools in one of your earlier RSM Booklets; buy those described as basic tools when you are ready to start, and add others as you make enough profit out of your servicing to pay for them. Always buy the best tools you can afford—cheap tools are no economy.

The basic servicing instruments you need at the start are a multimeter and a signal generator. If you can af-

ford it, a tube tester will prove very handy; however, it may be possible for you to take the tubes to some store to have them tested if you do not wish to invest in a tube tester at once. The tester you built in your second Experimental Kit will be an adequate, serviceable test instrument for your bench work at first. However, since it is not easily carried, you will probably want to buy a commercial instrument in a carrying case before very long.

These instruments are all you actually need when you start servicing. However, you should get a signal tracer as soon as your servicing profits will pay for it, because a tracer will speed up your work considerably.

**Basic Stock.** You should have a certain amount of replacement stock in your shop. It is, of course, possible to service on a "hand-to-mouth" basis, buying parts only when you need them; however, you can complete repairs faster if you have a few of the most frequently used parts in your shop and replace them as you use them up. (Plan to invest the profit of your first jobs in equipment and supplies, and you will be enabled to earn greater profits on later jobs.) Table 1 shows a good basic stock. ► Besides these parts, you will need a fair assortment of tubes. The kind and quantity for you to get will depend to some extent upon your location. That is, if a.c.-

**Table 1**  
**BASIC STOCK OF RADIO SUPPLIES**

**Paper Condensers**—six each of 600-volt condensers in these capacities: .001, .002, .005, .01, .02, .05, .10, .25, .50 (all capacities in mfd.).

**Tubular Electrolytics**—two 20-20 mfd., 150-volt with separate leads; one 10 to 100 mfd., 25-volt; two each of 450-volt condensers in these capacities: 8, 20, and 40 mfd.

**Resistors**—one kit each of  $\frac{1}{2}$ -watt and 1-watt carbon resistors (these kits contain the sizes used most often).

**Volume Controls**—one kit of assorted controls.

**Output Transformers**—one universal, one a.c.-d.c. (designed to match 50L6 output tube to 6-ohm speaker).

**Tubes**—See text.

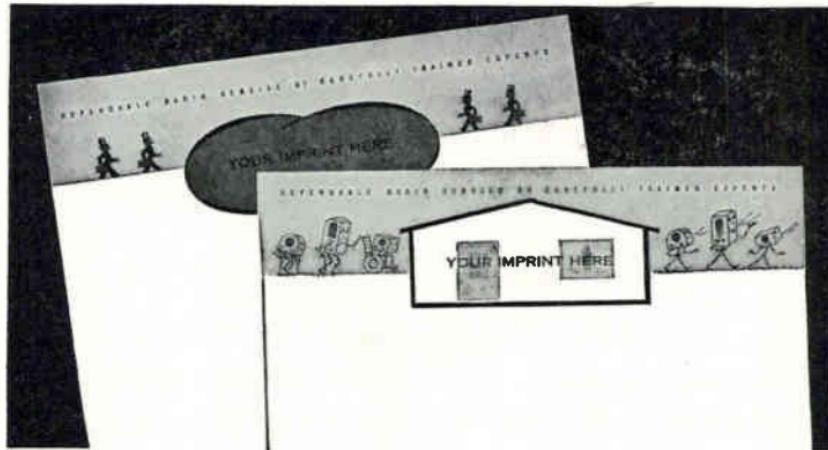
**Miscellaneous**—roll of rosin core solder, roll of friction tape, assortment of spaghetti (varnished cambric insulating tubing), tube of speaker cement, can of cement solvent, pilot lamps.

d.c. sets are the most common types in use around you, your tube assortment should feature tubes with 12, 25, 35, and 50-volt filament voltages. Or, if you are in a farm district, you may find that the 2-volt and 1.4-volt battery tubes are the ones most commonly used. If there is a wholesaler in your town, he can probably recommend a good basic tube assortment for you, based on his experience with other servicemen. If not, you will learn rather soon what kinds of tubes you need most. If there is no wholesaler near you, write to a mail-order wholesale house or directly to a tube manufacturer and ask what tubes are recommended for your locality.

► The assortment in Table 1 will give you the basic supplies you need to start a part-time business. Get other parts from your wholesaler or wholesale mail-order supply house only as you need them; do not stock other parts until experience shows that you need them often enough to justify it. Re-order stock items frequently enough so that you are never completely out of any one of them (or, in the case of one-of-a-kind items, as soon as you use the one you have).

If you are quite a distance from a wholesaler, or intend to buy exclusively from mail-order houses, we suggest you increase this basic stock by getting a larger and more varied stock of electrolytic condensers and ½-watt, 1-watt, and 10-watt resistors. (Remember, though, that electrolytic condensers have a *shelf* life of only about a year, so don't buy so many that you will have to throw them away.) Eventually, you might also stock two 5-inch PM speakers, and perhaps two universal replacement transformers with 6.3-volt filament windings. Get one with a 70-ma. output rating for 6- or 7-tube sets and one with a 90-ma. rating for 8- or 9-tube sets. (These are for emergency use only; you should use an exact duplicate replacement for a power transformer when you can. Finally, you might stock two 456-kc. standard replacement i.f. transformers. Get an input and an output transformer or a pair of general purpose transformers.

Remember—stock other materials only if you really need them. You are a serviceman, not a supply house; don't tie up too much of your money in stock.



Courtesy Sylvania Electric Products, Inc.

Tube companies will supply you with stationery imprinted with your name and address at prices far less than what a local printer would charge you. The illustration above shows two kinds of stationery supplied by Sylvania.

**Where To Buy.** It is no longer necessary for the serviceman to deal directly with numerous radio manufacturers to get a supply of parts. Today, you can deal with the local wholesale supply houses or with distributors that cover your area, or you can order from the mail-order supply houses. The names and addresses of wholesale supply houses and of parts distributors in your locality can be found in your local telephone book. Look in the classified section.

► If you do not know the names and addresses of the large mail-order supply houses, we will be glad to send you a list of them.

By dealing with a local wholesaler or with a mail-order house, you will automatically get a trade discount.

**Business Supplies.** A neat, well printed business letterhead is one of the first things you should get when you start a business. At the beginning, you won't need many—250 will last you a long time unless you use them also for submitting bills to your customers. A local job printer can make up your letterheads, or you can buy them by mail from one of the firms that advertise in mechanical magazines or from mail-order stores like Sears Roebuck and Montgomery Ward. Tube companies often offer, at very reasonable rates, business stationery imprinted with your name and their ad.

## KEEP THIS CARD IN YOUR RADIO SET

For a limited time we are offering a free inspection of all radios in this neighborhood. This is being done so that we may get acquainted. We want you to know our service.

Though your set is in perfect order it should be checked periodically—just to make sure. Physical examinations help people keep fit—and radios are like that, too.

This service is free—there is no obligation. With our modern testing equipment, we can give you an accurate report on the condition of your set.

Just call Fairhaven 2-2563, telling us when our expert may call.

Fairhaven, Virginia

DON'S RADIO SERVICE

**KEEP THIS CARD! IT WILL SAVE YOU MONEY**

**FIG. 1. Many of our students have found that a free offer like this is a good way of getting new business.**

You can also get other business supplies from tube companies. These include business cards, billheads, stickers to put on tubes you have tested, price cards, repair tickets, prospect cards, service order pads, and record books. These are usually of good quality and very inexpensive. Of course, all carry an ad for the company that supplies them to you, so it is best for you to get such supplies from the company whose tubes you use.

Your wholesaler probably has a catalog of the sales aids available from different tube manufacturers, or you can secure such catalogs by writing directly to the manufacturers. We suggest you get one or more of these right away to see what is available. Remember, however, that you do not need everything shown. In fact, printed stationery and business cards, and perhaps billheads, are about all you need at the start. Later, you may find some of the other material useful.

**Transportation.** You should have a car or truck, or the use of one, to pick up and deliver sets. Sometimes it is possible to walk or use public transportation to make your service calls, but usually you have to carry too much equipment to make this practical. If you do not now have a car, plan to get one as soon as possible. In the meantime, see if you can arrange with someone who has a car to take you to and from your calls.

**Telephone.** You must have telephone service in your

shop. Most telephone companies insist that you have a business phone when you run a business, even in your own home. A business phone usually costs a little more than a private phone, but you get the advantage of being listed in the classified section of the phone book.

## HOW TO GET BUSINESS

One of the first things you should do is to give your business a name. Naturally, the name should identify your business as a *radio repair shop*; for this reason, we suggest you keep away from such names as "Electronics Laboratory"—particularly since you are not starting a large, elaborate shop, but only a spare-time business. Keep the name simple. You might use something like: "Bluffton Radio Repair Shop"; "Jones Radio Fix-It Shop"; "Uptown Radio Service Shop"; "Sam the Radio Man"; or some other name that shows what your business is.

**Should You Advertise?** Generally speaking, your best single ad is a satisfied customer. A man for whom you have done a good job is very apt to recommend you to his friends. A personal recommendation of that kind is almost sure to get you business.

► Since you will have a business phone, you will, as we said, automatically be listed in the classified section of your telephone book as a radio serviceman. This classified section is a real business-getter for servicemen, because it is the first place most people turn to when they want service. Just being listed there is helpful, but you will probably get considerably more business if you take at least a small display ad in that section. (The telephone company will be glad to help you write it.)

► Other forms of advertising are something you should consider only after you have made a fairly good start. You might experiment with circulars and direct mail advertising to find out whether they are profitable for you. When you are just starting out, or when you are entering a new territory, you may find that a free-inspection offer along the lines of the one shown in Fig. 1 will bring results. These offers can be printed on post cards and mailed to the people near your shop, or can be distributed from door to door. (If you distribute ad-

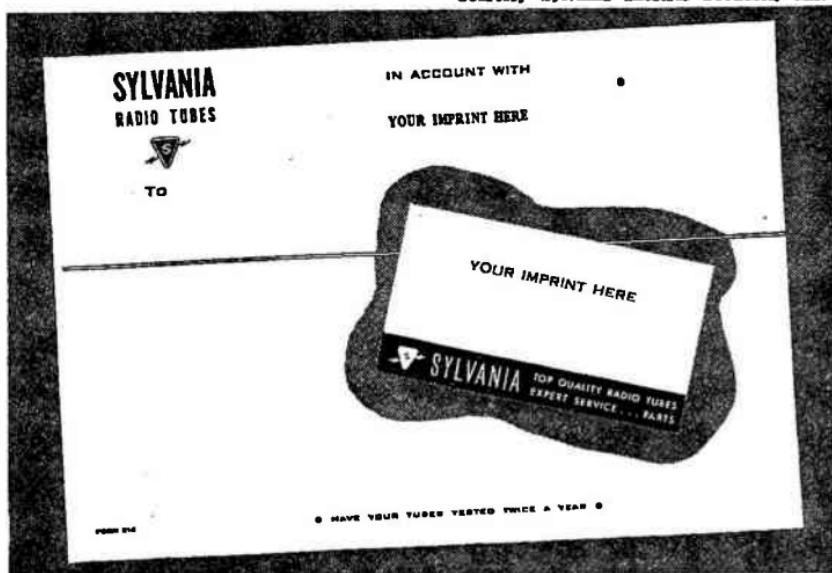
vertising matter from door-to-door, don't put it in the mail boxes. It is illegal for anyone but the postman to put anything in these boxes.) If you make such a free offer, be sure to limit it to a brief period—say two weeks or a month. Remember, it is purely an introductory offer; we do not advise you to give free inspection service as a regular thing.

► If you are a good salesman, you may find it profitable to make a personal canvass of the neighborhood near your shop. If you attempt this, be sure to have a short sales talk prepared in advance; introduce yourself, say that you are starting a radio servicing business in the vicinity, and ask that you be allowed to fix the radio when it goes out of order. Be sure to leave a business card as a reminder of your name and address, since you will seldom get business at the moment you call. If the prospect will permit you to do so, place your card inside the back of the set where he can find it when the set needs servicing. Choose your canvassing time carefully; don't call around meal times, or at any time that the prospect seems to have company.

If you are not the salesman type and find door-to-door canvassing difficult, don't attempt it. A poor impression caused by a stumbling sales talk can do you more harm

**Billheads and business cards are also furnished to servicemen by tube manufacturers at very low cost.**

Courtesy Sylvania Electric Products, Inc.



than good, since it is apt to make a prospect feel that you might do an equally poor job on his radio. Of course, it is no reflection upon you if you find it difficult to meet the public; that is true of a great many technical men. If you are one of them, you will be wise to start building up your business through mail advertising instead.

► Your personal appearance is one thing you must always keep in mind when you are in business, whether or not you use door-to-door canvassing as part of your business-getting methods. People very often accept you at your own valuation: look and dress like a back-alley mechanic, and that is what they will consider you to be; have the neat, clean appearance of a successful business man, and you'll be accepted as such. Don't over-dress, however. Wear a plain business suit outside the shop. To protect your clothes, wear a shop coat or jacket when you are at the bench.

► Good manners are just as important as a good appearance. If you feel ill-tempered and out of sorts, be careful not to let your customers know it. Be courteous always; never attempt to be high-hat with a customer; never argue with one. It is unprofitable to win an argument if it loses you a customer. On the other hand, you'll do well not to be too much of a "glad-hander"—many people resent that just as much as they resent surliness.

► The appearance of your shop is also something to consider. Some, at least, of your customers will see it from time to time, and you should be careful to have it in as good condition as possible. A neat, orderly shop does much to prejudice a customer in your favor and make him consider you a real professional.

## HOW TO HANDLE BUSINESS

There are two general ways of handling a spare-time service business. One is to have the customer deliver the set to your shop and pick it up when it is finished. This is an ideal system, but you won't very often get customers to do it except on midget or portable receivers.

More usually, you will pick up the set at the home of the customer, take it to your shop, repair it, and then return it to the customer. When the repair to be made is slight—the replacement of a tube or some other minor

repair—you can do the work in the customer's home. But if the job requires much work, by all means take the set to your shop unless the distance between the shop and the location of the receiver is too great. It is difficult to make any major repairs in the customer's home, as you can well imagine.

If you are servicing at night after spending a day on a regular job, you will have to budget your time carefully to get much done. When you have several jobs to do at a time, try to arrange things so that you pick up sets one night, repair them the next, and return them the third. This will enable you to do a much greater volume of business than you can handle if you bring each set back to the shop, repair it, and return it before you go on to another one.

► You should have someone (a relative, perhaps) in your shop to take calls for you while you are out picking up and delivering sets. Whoever does this for you should be courteous—remember, most of your customers will make their first contact with your business over the telephone. If the impression made is unfavorable, very likely the prospect will call someone else. The person answering the phone should find out where the set is, the nature of the complaint, the make, the model number (if the customer knows it—most do not), and when it will be convenient for you to check the set. If possible, a definite appointment should be made, or at least a time should be set when you can call back to make the appointment yourself.

When you are out picking up or delivering sets, call your shop from time to time to see if any service calls have come in during your absence. Use a public phone to do so—not a customer's. Although most customers will allow you to use the phone if you ask, many of them do not like it. Better use a nickel and save a customer.

Of course, what we said about courtesy in answering phone calls applies to you as well as to anyone who may answer your phone in your absence. You will do well to develop a good "telephone voice." Have two or three friends criticize the way you speak over the phone, and correct the faults they agree on. Be sure your voice is clear and distinct; if people often ask you to repeat

something you have just said over the phone, train yourself to speak more clearly.

## GUARANTEEING YOUR WORK

Servicemen differ in the guarantees they give their customers. A few don't guarantee anything unless the customer insists on it. Most voluntarily guarantee their own work (but not the whole set) for a short period—usually ninety days. Others guarantee the whole set for thirty, sixty, or ninety days.

Legally, you are not forced to make any guarantee, but making one is often a good sales feature. Many customers have had unhappy experiences with sets that were repaired one day and broke down the next. The fact that you guarantee your work helps give such customers more faith in you.

What you do about a guarantee will depend at first on how much you have learned about fixing radios. It would be foolish for you to guarantee the whole radio until you have learned how to spot parts that are apt to become defective soon. Once you have learned to do so—in other words, when you have become a professional serviceman—you would do well to guarantee the

**These printed postcards are examples of advertising literature furnished by tube manufacturers. Advertising folders and mats for newspaper ads are also available.**

Courtesy Sylvania Electric Products, Inc.



# COMPLETE RADIO SERVICE

WE RECOMMEND  
**SYLVANIA**  
**RADIO TUBES**



Courtesy Sylvania Electric Products, Inc.

This is a weatherproof banner for display use. Other display items, such as window transparencies, dummy cartons, etc., are also offered by tube manufacturers.

whole set rather than just the part you work on.

► There are several reasons for giving a complete guarantee instead of just a partial one. For one thing, a customer almost invariably assumes that any defect that occurs in a radio after you have serviced it is your fault. If the defect is not your fault, and you refuse to repair it free, you will probably lose a customer. On the other hand, if you say the defect is not your fault and repair it anyway, the customer will believe that you must have been wrong or you would not have repaired it. You can't win in either case.

However, if you guarantee the whole receiver, the customer usually doesn't care whether the defect is your fault or not. He knows that you will repair it anyway, and, as long as you do so promptly, he will have no hard feelings toward you. However, you should always be careful to point out that the defect was not caused by your work, but by some part that proved defective without any previous indication that it was going to.

You should make such an over-all guarantee only if the customer allows you to make all necessary repairs to the set. This means: (1) that he lets you replace any part that seems to be liable to break down within the guarantee period, and (2) that no other serviceman is allowed to work on the set during the guarantee period.

Naturally, it will cost him somewhat more to have you check the whole receiver for actual or possible defects than to have you fix just the part that is causing trouble at the moment.

Unfortunately, many customers are unwilling to spend more than is absolutely necessary to get the radio playing again. You should attempt to convince such a customer that he will be better off in the long run to allow you to check the radio thoroughly; in fact, you will do well to give some time and thought to working up a sales talk on this point. If the customer cannot be convinced, all you can afford to do is guarantee the work you have done. Never guarantee the whole radio in such a case—you will very often lose money by doing so. Only the most unreasonable customer would expect you to guarantee a whole set without checking it.

► You will soon get an RSM Booklet that will show you how to figure out what to charge a customer. That Booklet will take up the question of how much a full guarantee costs you—that is, how often you will be obliged to give free service because you have guaranteed operation of the set for a certain length of time. Of course, how many "call-backs" you have on a job depends chiefly on how well you do the job in the first place; you should not give any guarantee except on your own work until you have had enough training and experience to be an accomplished serviceman.

When you do guarantee a set, make it clear to the customer that your guarantee does not include tubes. There is no way for you to know how long a tube will last, so you will just be losing money if you do guarantee them. However, you can point out to the customer that new tubes themselves carry a guarantee—usually for ninety days.

## KEEPING RECORDS

There are three kinds of records you should keep as a spare-time business man. You should have a record of your income and expenses, a record of the work you have done, and a record of your customers. We'll discuss each of these in order.

***Financial Records.*** You need a record of the finances

of your business—its income and its expenses—both so that you can make your income tax reports properly and so that you can know how much money you are making from your business. Right now, when you are just starting a servicing business, this record can be very simple. You can keep it in any notebook you happen to have, or you can buy a journal-ruled account or "cash" book in any five and ten cent store. Head one page "Income," head another "Expenses," and make suitable entries on the pages each time you receive income or incur expenses. For example, each time you are paid for repairing a set, enter the amount you receive for the job on the page headed "Income." At the same time, enter any amount you pay for parts on the page marked "Expenses." Of course, you should date each entry and make some note of what it is for—"Parts," "Rent," "Received from Mr. Jones," etc. Just be sure you enter *all* income and *all* expenses connected with this business on these pages, and you will have an adequate record as far as your income taxes are concerned.

A simple bookkeeping system of this kind is good enough at the start. Later you will probably want to keep more detailed records that will show you the same facts, but present them in a form that is more convenient when you want to analyze the operation of your business. You will learn more about these other forms in later Booklets and Lessons.

**Job Records.** You will want to keep a record of each job you do. The easiest way to do this is to make a carbon copy of each bill you submit to a customer. Present the original to the customer, and retain the carbon for your file. On the back of the copy you keep, note the cost to you of the parts used and the number of hours you worked. *Do not put this information on the customer's bill, however.* Keep all carbon copies in some convenient place where you can get at them when you want them.

We will not go into the subject of bills any further here. A later Booklet will tell you how to make charges.

**Customer Records.** Finally, you should keep a record of your customers. A convenient form for doing this is shown in Fig. 2. The regular 3" by 5" file card, sold by all stationers and five and ten cent stores, is fine for

Name _____	Tel. No. _____	
Address _____	First Call _____	
Set Maker _____	Model _____	Type _____
Tubes _____ _____		

**FIG. 2.** You can have cards printed up in this form for your customer file, or you can type the headings yourself. Use the blank space for recording service calls.

making such a record. List on the card the name and address of the customer, his phone number, the date of your first call, the make and model number of his set, the type of set (a.c., a.c.-d.c., d.c., battery, portable, auto), and the tubes used in it. If you have a diagram and other service information for this particular receiver, it will be unnecessary for you to list tubes; in this case, note on the card that you have the diagram.

Make up a card like this for each of your customers; if a customer has more than one set, make up a card for each set. This file will prove valuable to you in several ways. For one thing, such a record of your customers will be handy if you decide to use mail advertising. Furthermore, when you receive a repeat call from a customer, you will be able to find out from your records what set he has, what tubes are in it, and what previous defects it has had. You will then be better prepared to service the set when you arrive at the customer's home, or at least better equipped to estimate what is the matter with it.

### **YOUR PAY AND PROFITS**

There is one rule you must always follow if your business is to grow. You must keep your business finances separate from your personal finances. If you simply

# PROMPT RADIO SERVICE CALL

"Your Imprint Here"

WE SPECIALIZE IN SYLVANIA RADIO TUBES

Courtesy Sylvania Electric Products, Inc.

Many servicemen fasten a service sticker like this to the back of each chassis they repair. Tube manufacturers furnish them at low cost in rolls of one or two thousand.

pocket everything you receive in payment for your services, you will have a source of income, but you will not have a business.

The right way to treat a business is to consider that you are working for it, just as if it were owned by someone else. This means that your salary must be listed as a business expense like rent, replacement of test equipment, upkeep of your car, etc. However, to get your business off to a good start, you should charge only a very small salary for yourself at the beginning. In fact, you will do well not to draw any salary at all for a while. Instead, leave the money in the business until a reasonable cash reserve is built up.

Such a cash reserve is absolutely necessary to a business. It represents money that can be used to meet unexpected expenses and to buy parts and equipment you will need for expansion. The more money you allow the cash reserve to accumulate, the better the financial health of your business will be.

When the reserve is large enough to take care of anything you are apt to use it for, draw a reasonable salary from the business each month. Make sure you do not draw so much that the business loses money in any month. This will allow the cash reserve to keep growing. From time to time—say every three months—you can withdraw from this reserve any amount in excess of what you feel the reserve should be. This you can consider to be your profit on the business. (We will say more about profit and your salary in a later Booklet.)

► One of the best ways of separating your business finances from your personal finances is to establish a separate bank account for your business. If you do this, deposit every cent earned by the business in the bank, and pay all bills (including your salary) by check. This method will both remove temptation to spend the business money for your personal expenses and also give you a record (by way of your check stubs) on the income and expenses of the business. Of course, you will sometimes have to pay cash for small bills. In this case, pay the bills out of your own pocket, and keep a record of the total. When the total becomes a few dollars, pay yourself by check from the bank account.

Your business may be too small at the start to justify a checking account at a bank. If so, you can achieve the same effect by depositing all income in a strong-box or other secure place and treating it just as if it were a bank. Pay bills and your salary from the money deposited, but do not allow yourself to draw on it for personal expenses. Eventually, when you have built up a sufficient cash reserve, you can start a bank account.

**Looking Ahead.** You have now learned the basic steps to take in setting up a spare-time business. Soon you will get RSM Booklets that will give you more of the

This is the shop of an NRI graduate who is a part-time serviceman. A future RSM Booklet will show you how to build a neat, professional-looking bench resembling this one.

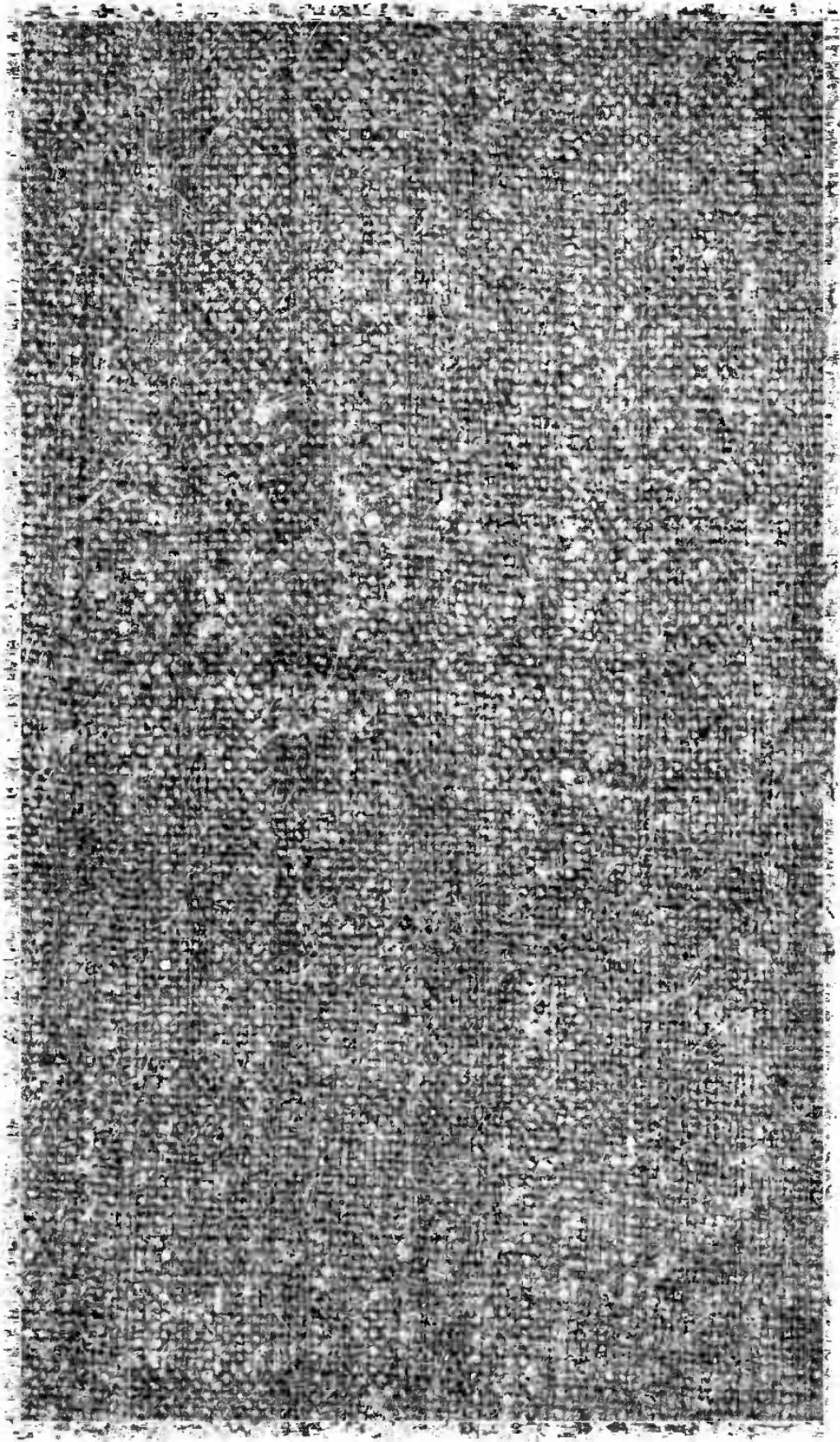


**practical information you need to get started. These will give you the details of how to charge for your work, how to plan a professional workshop, how to service various kinds of defective receivers, and how to get servicing experience in your own home.**

**As we said in the beginning of this Booklet, you are now able to do a certain number of servicing jobs. Further training will increase your ability until you will be able to service any receiver for any defect.**

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THE N. R. I. COURSE PREPARES YOU TO BECOME A  
**RADIOTRICIAN & TELETRICIAN**  
REGISTERED U.S. PATENT OFFICE      REGISTERED U.S. PATENT OFFICE



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

NATIONAL BOARD FOR TELETELEGRAMS WASHINGTON D.C.

No. 15 How Much To Charge  
for Your Work

RADIO SERVICING METHODS



# NRI TRAINING

# *Pay A . . .*

Dear Mr. Smith:

I am now employed by the FCC and have worked up to the position of a Monitoring Officer. Without the benefits of your Course it would have been tough going, and to this day the lessons and textbooks are proving their worth. Having had the opportunity to look over other Courses before and after graduating, my advice and recommendations are, and always will be, to any person interested in Radio - the NRI.

C.J.G., Rhode Island



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**

FM10M150

1950 Edition

Printed in U.S.A.



## How Much To Charge For Your Work

**S**ETTING a fair price for your work is a problem you will meet as soon as you start to service receivers. Determining a fair price is not hard, yet surprisingly few servicemen seem to know how to do it properly. As a result, many a technically competent radio man has not been successful, because he made his prices either too high or too low.

When the price charged is too low, the serviceman gets a reputation for cut prices that attracts a lot of business. However, he will soon give up the business if the return per job is not sufficient to pay the expenses. On the other hand, if the serviceman charges too much, he will drive away business. It is important, therefore, for the serviceman to charge just the right prices—high enough to keep the business prosperous, yet low enough so that his customers are satisfied that his charges are honestly arrived at and reasonable.

There is nothing mysterious about determining what such a fair charge should be, once you know your expenses. Naturally, at the beginning, you can't know just what your expenses will be. Therefore, until such time as you do know your costs, you will be wise to follow a flat-rate schedule like the one described later in this RSM Booklet. In fact, you may find that the flat-rate schedule meets all your business requirements, particularly if you intend to operate a small spare-time business. Once you have established a flat-rate schedule, you should review it from time to time to be sure that it is providing the necessary income. Before you can do this,

you must know how to determine what your charges should be.

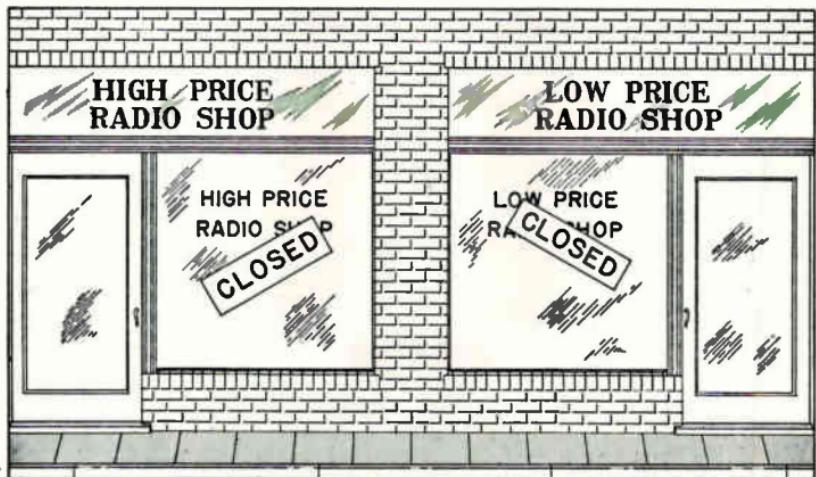
► This RSM Booklet is intended to show you how to charge correctly for your work. It contains a flat-rate charge schedule that should come reasonably close to the charges you should make in the average case. In addition, it shows you how to calculate an hourly rate that will let you work at a fair profit. Before we go into either of these, let's learn a few facts about what determines the cost of staying in business.

### WHAT IS PROFIT?

For a business to expand and grow, it must make money over and above the cost of doing business. This extra earning is called a profit.

Perhaps one of the greatest mistakes of a beginner in a radio-servicing business is to consider all the money over and above the cost of a part as profit. Nothing could be further from the truth. For example, suppose that you replace a by-pass condenser and charge \$2 for the job. If the condenser costs you twenty-five cents, you may think that you have a profit of \$1.75. Actually you have no such thing—the cost of the part may be only a small fraction of the expenses of doing this job. Let's suppose that you spent an hour, and that your salary is \$1 an hour. This \$1 labor charge added to the twenty-five cent cost of the part leaves only seventy-five cents of the \$2. Furthermore, even this seventy-five cents is not all profit. Your business has operating expenses—things like rent, electricity, heat, insurance, car expenses, and supplies such as stationery. A proportionate share of all these costs must be paid for out of the seventy-five cents. What remains will then be profit.

Notice—as we pointed out in an earlier RSM Booklet, your salary is not a part of the profit of your business. On the contrary, it is an expense—part of the cost of doing business. For the purposes of finding out whether or not your business makes a profit, you must consider yourself to be an employee. As such, you are entitled to a salary for your services. Your business makes a profit only when it earns more than enough to pay your salary and all other expenses.



**High prices mean a large profit per customer, but very few customers; low prices attract many customers, but the over-all profit is too small. To be successful, a radio serviceman must charge prices that give him a good profit but appear reasonable to his customers.**

As a beginner, working in your own home, you may feel that you don't have any operating expenses worth mentioning. This is true while you are doing only one or two service jobs a week. However, if you intend to go after a considerable volume of spare-time business, or intend eventually to operate a full-time business, then you should start right from the beginning to keep track of all expenses. That is the only way for you to get on a firm business basis.

For example, you should charge the business a rent even if you are operating from a room in your house. If you use one room of a five-room house, the business should pay one-fifth the house rent (or, if you own the house, one-fifth the rent you would have to pay for a similar house). By watching your electric bills and comparing them with the bills before you started your service work, you can see how much the electricity used by your business costs. Similarly, by keeping a record of mileage or of car operating expenses, you can determine what proportion of the operating cost of your car can be charged to the business.

► After you have deducted all operating expenses, you still have business costs such as taxes, licenses, and de-

preciation to compute. Your test equipment is a good example of the need for making a depreciation charge. Let us suppose, for simplicity, that you have spent \$100 for test equipment. The average life of this kind of equipment is about four years. In other words, you will want to replace the equipment in four years because it will be obsolete (or, even if it is still usable, will probably be so battered or out-of-date in appearance that it does not make a favorable impression on customers). Therefore, each year you should set aside 25% of the cost of replacing the equipment. Then, in four years, the business will have the necessary money to buy new equipment.

Similarly, you should set aside money to pay for lost or broken tools. And, since your business mileage is hastening the end of the life of your car, the business should pay a fair share of the cost of replacing the car.

► Anything that is left over after *all* expenses have been paid may be considered as profit. This is the "salary" earned by the business itself—money that you can use to buy new equipment (not just replacements for present equipment) and to expand your business. When the profit is more than enough to take care of such needs, you can draw some of it out—pay yourself a dividend, in other words. However, unless you are exceptionally fortunate, you will probably be "plowing back" the profit into your business for some time.

## DETERMINING AN HOURLY RATE

As we have already said, you can charge for your work by following the flat-rate schedule that we give later in this Booklet. However, you will want to be sure that the flat-rate schedule fits your needs—you may have to adjust some of the charges up or down to meet your own local conditions. Then, you may find other jobs you would like to add to the flat-rate schedule, or you may decide to work more on an hourly rate basis.

To do any of these things, you must work out the actual per-hour cost of doing business. This means you must estimate your expenses for a certain period (a month, three months, or a year), and also the amount

## SERVICE GUARANTEE

....., 19....

Your .....receiver, Model ....., is unconditionally guaranteed to operate satisfactorily for three months from the above date PROVIDED no change or adjustment is made on the receiver by anyone other than the undersigned during the period of the guarantee. This guarantee covers tubes only to the extent of the manufacturer's guarantee.

If the receiver does not operate satisfactorily during the guarantee period, it will be repaired FREE OF CHARGE by us.

.....(Signed)

Fairhaven, Virginia      DON'S RADIO SERVICE

Many experienced servicemen find it good business to give an unconditional guarantee like this to their customers. However, until you have acquired sufficient experience, you should guarantee only your own work, not the whole set (see FIG. 1, page 15).

of time you will spend on service work in that period. These figures will let you determine the hourly rate charge that will pay expenses and give your business a fair profit.

Of course, you realize that this hourly rate pays all your expenses, including your salary—it is not your salary alone. In other words, if you charge an hourly rate of \$2, perhaps only \$1 of this amount will go to you as salary.

► To show how to determine the hourly rate, suppose we examine the operating expenses of a full-time radio service shop. (Whether you work full-time or spare-time, you can follow the same general procedure in determining your own costs). Table 1 lists the operating expenses of a typical one-man radio service business. Many of the items are self-explanatory, but the following notes will help you to see how some of the figures are determined. Let's assume that you are working out a table similar to this, and go over the points as we come to them.

To get your figure for fixture depreciation, estimate what your lights, parts cabinets, workbench, etc., were worth (what they would have brought if sold) at the beginning of the year. Estimate their value at the end

of the year. The difference between the two figures is the depreciation.

Since the average piece of test equipment has a useful life of four years, depreciation of service equipment can be figured at 25% of cost per year.

In this case, the owner estimates his salary on a basis of \$35 per week (with pay for vacation weeks). The yearly income he desires, then, for direct repair work is 52 x \$35, or \$1820.

Something should be paid to the person taking your phone calls, even if it is your wife, your mother, or another close relative. A modest \$70 per year is allotted by Mr. Jones for this purpose.

Zeros are shown for heat, window decoration, and newspaper advertising because Mr. Jones spent nothing for these items. If you have such expenses, enter the amounts paid for each in the proper places.

Item No. 6 in Table 1 lists a total of zero because in a one-man business you do not have to pay these taxes. However, if there are taxes for business licenses in your community, they should be placed in this column.

The Jones financial investment built up over a period of years is, let us say, \$1600. The owner thinks he is entitled to a ten per cent return on that investment, or \$160. (At the beginning, when your investment is small, you can choose an arbitrary figure as the desired profit —say \$25 or \$50).

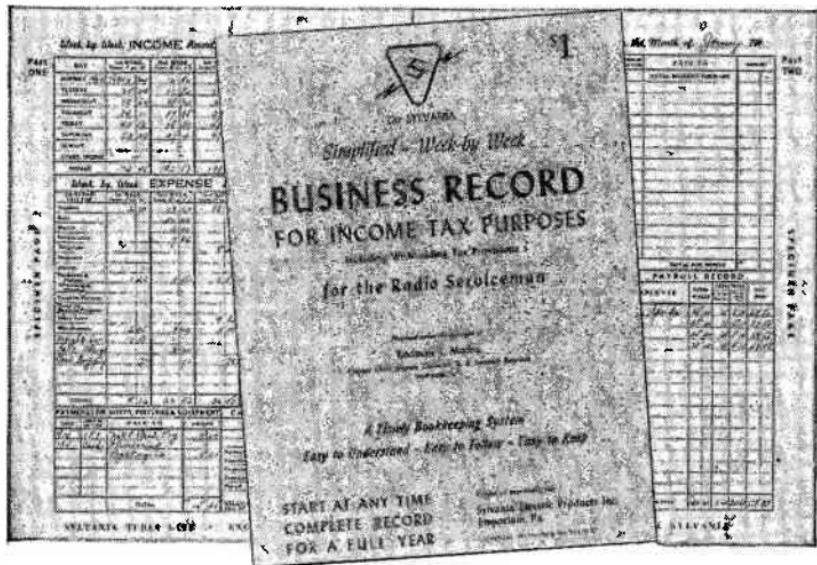
► Adding together these items, we find that the Jones Radio Service must yield \$3445 to meet its operating expenses and pay a profit.

The owner puts in 50 hours per week, but he estimates that only about 35 hours will be directly paid for by the customers or will be actually spent on radio repairs. The rest of his time is non-productive—spent in ordering parts, or in building racks and doing other shop tasks, or just plain wasted when there is nothing to do. A total of 35 hours per week productively used in repair work for 50 weeks (two weeks vacation and holiday time) comes to 1750 hours per year.

The owner subtracts from this figure the total number of hours spent on "call-backs"—say about 2 hours per week, or roughly 100 hours per year. This brings the

**Table 1**  
**YEARLY OPERATING EXPENSE, JONES RADIO**  
**SERVICE**

Shop Expenses		Wages	
Rent .....	\$600.00	Help for handling phone ...	\$ 70.00
New shop fixtures .....	20.00	Salary .....	1820.00
Fixture depreciation .....	25.00		
Redecoration, shop improvement .....	20.00	Item No. 5 .....	\$1890.00
Electricity .....	60.00		
Heat .....	0.00		
Sign painting, lettering .....	5.00		
Window decoration .....	0.00		
Stationery supplies .....	10.00		
Telephone .....	60.00		
Fire and theft insurance .....	10.00		
Item No. 1 .....	\$810.00	Item No. 6 .....	\$ 0.00
Advertising Expenses		Losses	
Stickers .....	\$ 2.00	Bad Debts .....	\$ 10.00
Calling cards .....	2.00	Damage to parts and chassis through carelessness .....	15.00
Newspaper Advertising .....	0.00		
Phone book ads .....	25.00	Item No. 7 .....	\$ 25.00
Circulars .....	3.00		
Penny post card ads .....	13.00		
Item No. 2 .....	\$ 45.00	Parts Replaced Free Under Guarantee	
		Parts (net cost) .....	\$ 55.00
		Item No. 8 .....	\$ 55.00
Car Expenses		Time Input	
Garage .....	\$ 60.00	Total number of hours worked by owner per week .....	50
Gas .....	55.00	Number of hours spent by owner on actual service work .....	35
Oil .....	20.00	Vacations and holidays .....	2 weeks
Repairs and service .....	35.00	Hours spent on "call-back" service work per year .....	100
Tires .....	20.00	Total number of Paid-For Hours spent on Service Work Per Year	
Auto license .....	10.00	$35 \times 50 = 1750 - 100$ hours on call backs = 1650 ... (Item No. 11)	
Auto insurance .....	25.00		
Depreciation .....	60.00		
Item No. 3 .....	\$285.00		
Service Equipment			
New instruments .....	\$ 50.00		
Instrument repairs .....	20.00		
Instrument depreciation (25% of cost) .....	75.00		
Tools .....	10.00		
Service books and manuals ..	15.00		
Solder, wire, tape, etc. ....	5.00		
Item No. 4 .....	\$175.00		



Courtesy Sylvania Electric Products, Inc.

This book gives you a handy, easy way to keep complete business records for one year.

estimated total of paid, productive hours down to 1650 hours per year.

Dividing the required total income by the paid productive hours gives the hourly rate that must be charged to yield this total income. When we divide 3445 by 1650, we get approximately \$2.10 as the hourly service rate.  
 ► It should be clear that this is the minimum hourly rate at which the proprietor of the Jones Radio Service can operate profitably on his estimated number of paid hours of operation. If business is poor, so that he doesn't get paid for 1650 hours, he can lose money at this rate. To be safe, he will probably charge \$2.25 per hour.

Of course, if the volume of business is considerably smaller than estimated, Mr. Jones will soon find he cannot increase the hourly rate enough, since there is a limit to the amount that customers will pay. Now, to break even, Mr. Jones must go out after more business or must reduce his expenses. On the other hand, if he is swamped with work, he may have to hire an assistant. This may allow him to reduce his rate, or may force him to increase it, depending on how efficient the assistant is and how much business the shop has.

**Guarantees.** Mr. Jones' losses on call-backs are

worth some attention. Many service shops make no unconditional guarantees of set operation on repaired radios, limiting themselves to guarantees of the specific parts replaced and adjustments performed. However, Mr. Jones unconditionally guarantees repaired sets for three months. He estimates the losses resulting from this policy to amount to \$55 in parts and tubes supplied free, and to 100 hours of unpaid service.

Let's see how much of the hourly rate is caused by these losses. In other words, how much less could be charged if he didn't offer an unconditional guarantee policy? One hundred additional hours of paid-for service time would be available per year, making a total of 1750 hours, instead of the previous total of 1650 hours. A reduction of \$55 in the operating costs would bring down the total income necessary from \$3445 to \$3390. The hourly rate, then, would be  $3390/1750$  or about \$1.94.

Comparing this with the original rate of \$2.10, we can see that for a difference of only 16 cents in his hourly rate, Mr. Jones can offer his customers an unconditional 3-month guarantee on all repaired sets no matter what type of trouble may develop. Naturally, an unconditional guarantee is a real selling feature—unquestionably worth the small difference it causes in the rate.

**Customer's Bills.** You may have noticed that Table 1 does not list any costs for the radio parts and tubes used in repairing sets. This expense is paid as each part is used, because Mr. Jones follows the system we recommend of charging separately for parts. In other words, the customer gets a bill for parts and for professional services. The parts are billed at the regular list prices established by the manufacturer. The bill for services is figured out either from the flat-rate schedule (given farther on) or by multiplying the hourly rate by the time consumed on the job. Later in this Booklet we will give some billing examples.

**Record Keeping.** Mr. Jones can find out whether he is making money, by keeping an accurate but simple record of his expenses and his income. Such simple listings give all the information needed to fix charges and to figure taxes. Special record books, containing complete directions for use, are available for the small busi-

# FLAT-RATE SCHEDULE OF PROFEES

All charges in this chart are for professional SERVICES only. Radio parts should be billed at list prices.

Each bill should include one of the three following charges, to cover testing of tubes, check-up of set, and tests needed to determine the nature and extent of the trouble.

## I Check-up and test at customer's home .....

\$2.50  
This covers up to 1 hour of time including trip to and from home; charge for extra time at Hourly Rate specified in schedule.

## II Check-up and test at shop, including pick-up and delivery of set .....

3.50  
This includes time and transportation expense for two round trips to a customer located up to 2 miles away from shop; charge for greater distance at Mileage Rate specified in schedule of charges.

## III Check-up and test at shop, when customer brings set in and takes it away 1.50

## Alphabetical Schedule of Charges

**NOTE:** The word "install" rather than "replace" is used in describing certain service jobs in which a defective part is replaced, to emphasize that parts are NOT included in the charges.

**AERIAL**, built-in loop—install ..... \$3.75  
—repair broken wire ..... 1.00

**AERIAL**, auto—install complete unit .. 2.25  
—install new lead-in wire ..... 1.50

**AERIAL**, home—simple outdoor installation not requiring ladder or poles ... 5.00  
—job requiring installation of poles .. 6.50  
—difficult installation: at Hourly Rate, with minimum of ..... 10.00

**ALIGNMENT**, t.r.f. set ..... 1.00

**ALIGNMENT**, superheterodyne set:  
1-band ..... 2.00  
additional bands, per band—add ..... .50  
High-fidelity i.f. amplifier—add ..... 1.50  
Complete f.m. set ..... 4.50

**AUTO RADIO**—install aerial, with reasonable interference elimination  
—remove set from car after bench work (Check-up and)  
—interference elimin at Hourly Rate, wi

## AUTOMATIC RECO

—clean and oil only  
—adjust or replace Rate, with minimu

## COIL installation:

Osc. or r.f.—1-band .....  
—2-band .....  
—multi-b  
R.F. choke .....  
A.F. choke .....  
Filter choke .....

## CONDENSER installat

Single paper by-pass .....  
Each additional paper .....  
Trimmer or padder .....  
Gang tuning unit .....  
Single electrolytic .....  
Dual electrolytic .....  
Multi-section electro .....  
Filter block .....

**DIAL DRIVE** cable or (easy job) .....  
—install (normal) .....  
—install (special job hours) .....

## DIAL DRIVE—repair

**DIAL** pointer or scale ment .....

## HOURLY RATE .....

**INTERFERENCE**, h power line filter ..  
—install and adjust .....  
—eliminate interfere at Hourly Rate

**INTERMITTENT T** your estimate on pa observed symptoms. the job, be sure to enough to cover at l

**LINE CORD**, plain 2-

# IONAL RADIO SERVICE CHARGES

ation of set and amount of inter-  
..... 7.50  
; and re-install done ..... 1.50  
it are extra)  
tion:  
h minimum of .. 3.00

**D CHANGER:**  
part; at Hourly of ..... 1.00  
..... 3.00

..... 3.25  
d ..... 3.50  
..... 4.00  
..... 2.25  
..... 2.75  
..... 2.75

on:  
cond. or fixed res. 3.00  
..... 1.50  
..... 3.00  
..... 4.00  
..... 2.50  
..... 3.00  
ic ..... 4.00  
..... 4.00

belt—install ..... 1.50  
..... 2.50  
taking over 1½ ..... 4.50

iction type ..... 2.25

epair or replace-  
..... 1.00  
..... 2.50

e radio—install ..... 1.50  
ve trap ..... 1.50  
e at source:

UBLE — base  
experience and  
If you guarantee  
ke charge high  
t one call-back.

re—install ..... .75

	<b>LINE CORD RESISTOR (Cordohm)</b>
	—install ..... 1.50
	<b>LOUDSPEAKER</b> —install ..... 2.00
	—recenter voice coil ..... 2.00
	—replace cone, small ..... 2.50
	—replace cone, over 6" ..... 3.50
	—replace field coil ..... 3.50
	<b>MILEAGE RATE</b> , per extra mile ..... .10
	<b>PHONO MOTOR</b> —clean and lubricate ..... 1.00
	—replace ..... 3.00
	<b>PHONO PICK-UP</b> —replace ..... 2.50
	<b>PUSH-BUTTONS</b> , automatic tuning, reset:
	Simple mechanical type, per station .. .20
	Telephone dial type, per station ..... .40
	Electrical (trimmer) type, per station .. .25
	Motor-operated type, per station ..... .40
	<b>RESISTOR</b> installation:
	Single resistor ..... 3.00
	Each additional small resistor or paper by-pass condenser ..... 1.50
	Voltage divider or bleeder ..... 3.50
	<b>SWITCH</b> —install simple on-off type ..... 1.50
	—band changing, per section or deck .. 2.00
	—push-button tuner, install ..... 3.00
	—push-button tuner, minor repairs ... 1.50
	<b>TONE CONTROL</b> —install ..... 3.00
	<b>TRANSFORMER</b> installation:
	A.F. transformer ..... 3.00
	Antenna coupling transformer:
	—at aerial ..... 3.50
	—at set ..... 1.00
	Antenna coil—same as r.f. coil
	I.F. transformer ..... 3.25
	Oscillator coil—same as r.f. coil
	Output transformer ..... 3.00
	Power transformer—mounting charge .. 3.00
	—connection charge, per lead or terminal ..... .25
	R.F. coil (transformer)—1-band ..... 3.25
	—2-band ..... 3.50
	—multi-band ..... 4.00
	<b>TUBE SOCKET</b> —mounting charge ..... 2.75
	<b>TUBE TESTS</b> —included in shop or home check-up and test.
	<b>VIBRATOR</b> —test ..... .50
	—install non-plug-in type ..... 3.00
	<b>VOLUME CONTROL</b> —install ..... 3.00

nessman. Some of these books are obtainable from stationery stores, others from radio supply houses.

## BEGINNER'S RATES

Many beginners make the mistake of charging too little because they feel they are "learning" or are "taking too much time" on each job. This is a wrong attitude; any repair you make is worth as much as if it were done by an expert. That is, if an expert would charge \$5, and you do the same job, then you have done \$5 worth of work. True, the expert may have taken only half as long as you did, but this merely means that he has earned more per hour than you. Your *total price* for the job should be the same as his. (How will you know this total price? The flat-rate schedule in this RSM Booklet can again be used as a guide.)

In other words, you should adjust your per-hour *salary* to your ability. When you are starting out, figure your salary rate fairly low to compensate for the length of time it takes you to make repairs. When you have learned enough to work faster, increase your salary rate in proportion; this will keep your total price for any particular job the same at all times. This is fair both to your customers and to yourself.

Understand—when we say that you as a beginner should get the same pay as an expert for a repair job, we are assuming that you will do as good work as the expert. The only difference between your work and his should be that yours took longer—your finished repair should be just as good as his. There is no place for a botched, half-done job in radio repairing. If you can't make the repair perfectly, either return the set without charge, or have an expert do the work for you.

A good business and a good reputation can be built only upon a policy of honesty and fairness. Your charges must be honest ones for services rendered, and your charges must be fair both to yourself and to your customers. When people bring their radio sets to you and say "Fix it up; I'll be back day after tomorrow" without even asking how much the charge will be, then you'll know you have the right kind of reputation.

## HOW TO USE THE FLAT-RATE SCHEDULE

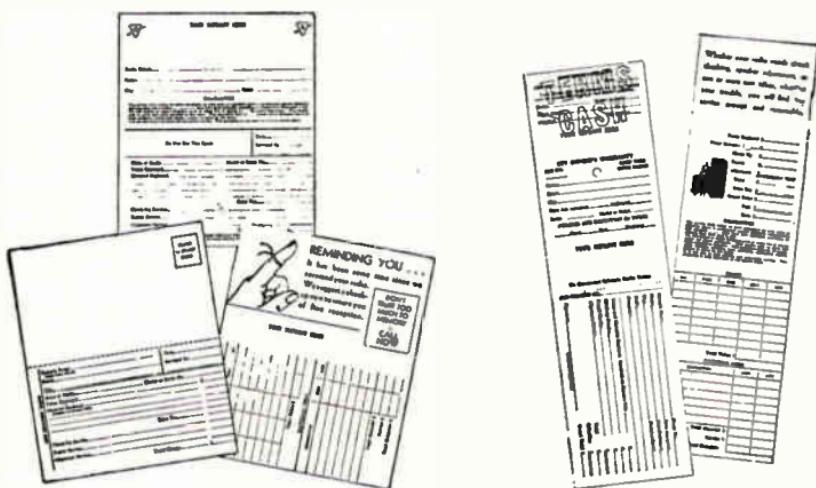
The schedule shown in Table 2, (pages 10 and 11) is based on an hourly rate of \$2.50. This may seem high at first thought, but remember that the hourly rate includes all expenses (except the cost of parts), so your actual per-hour earnings may be only about \$1 per hour.

The table makes allowances for the following factors:

1. *The amount of skill and knowledge required to locate the trouble and figure out the remedy.* Thus, automatic-record-changer repairs are higher than other equivalent mechanical repairs.

The hourly rate will pay the expert \$1 per hour or more. As a beginner, you will take longer, so your hourly earnings will be somewhat less. However, the flat-rate price is about right for the job, regardless of the hourly salary earned by the serviceman.

2. *The average time a competent, fully equipped Radiotrician would need to complete the job.* The check-up and test charges cover only the time required to determine enough about the trouble to give an estimate. On jobs usually requiring additional time to isolate the exact trouble, the price takes this into account.



Courtesy Sylvania Electric Products, Inc.

These are back and front views of two kinds of record cards that Sylvania furnishes at low cost. The card on the left gives you a job record and an addressed reminder postcard, as well as a bill and guarantee for your customer. The longer card on the right gives you a job record, a bill and guarantee, and a receipt for the set.

On jobs that require exact duplicate replacement parts, the extra time that may be required to secure the correct part is likewise considered. You are *not* taking a pleasure trip when you drive from one radio jobber to another in search of a part.

*3. The possibility of complications that might be encountered on the particular job.* Some troubles, particularly squealing, distortion, or too-frequent burn-out of tubes or some other part, require actual changes in circuit designs, and consequently take longer than normal to repair. This possibility was considered in setting the charges for such jobs. Hum is another example of a complaint that may become complicated to fix. Many a customer who complains of hum becomes so hum-conscious that he expects the Radiotrician to eliminate hum that was never noticed when the set was new. Of course, you should charge more than the fixed rates for this or for any other jobs if the customer is unreasonably finicky about the results he wants. In such a case, you should discuss the matter of charges thoroughly with the customer before you get too involved, and make sure he is willing to pay for what he wants.

► The possibility of call-backs has been considered in practically every charge. Rare indeed are the jobs where you can collect extra when the set fails within your guarantee period, and still keep the good will of your customer. The charges in this schedule allow you to handle most call-backs cheerfully without asking for more money, regardless of the reason for the call-back.

Any system of professional charges is based on average conditions. It is intended that you adapt the rates and billing method to special cases whenever necessary, as illustrated by the examples at the end of this Booklet.

All special jobs that do not come up often enough to justify listing in this schedule should be charged at hourly rates, or the rate should be used as a guide for estimating the charge.

**Material Prices.** All radio parts and materials are to be billed at regular list prices as established by the manufacturer.

► When no list price is known, the easiest way to figure it for billing purposes is to divide your cost price by .6;

Unless otherwise indicated, all repairs and materials listed above are guaranteed for 90 days, just as for a new radio set. Work and materials covered by the guarantee will be replaced without charge within this time limit if defective.

Guarantee starts on: .....

By: .....

**YOUR FIRM NAME PRINTED HERE**

**FIG. 1.** This is an example of a guarantee of work and materials. You should offer a guarantee of this sort when you do not feel you are experienced enough to guarantee a whole set, or when a customer will not allow you to replace parts that you believe will eventually become defective. However, it is preferable to offer an unconditional guarantee whenever possible. An example of an unconditional guarantee is shown on page 5.

this is equivalent to the customary 40% discount you get if there is an established list price. If the result is an odd value, make it come to the nearest 5 cents.

When the list price of a part is 50¢ or less, and you are making a separate installation charge for that part, it is usually better business just to list the part without a charge. Thus, you would usually make no charge for small resistors or condensers. This emphasizes the value of your knowledge and skill. On small parts like pilot lamps or replacement control knobs, which have no installation charge, use your own judgment in each case.

Billing parts at list prices will usually take care of the cost of the small parts for which you make no charge, and will pay for the time spent getting parts. There may even be a small amount of extra profit from the parts you sell, over and above your profit on professional service charges.

**Guarantees.** A suggested guarantee to be printed on your statement of charges is shown in Fig. 1.

**Credit.** Here's a factor that has ruined many a serviceman. All radio service work should be on a cash basis, collected at the time you deliver the set, unless you know

Uncalled-for radio sets are subject to a storage charge of 25¢ each per week, starting one month (30 days) after receipt of the set. Storage charges for your set will begin on .....

Radio sets left here over two months after the date storage charges start will be disposed of. Failure to call for your set on or before ..... will constitute permission to sell or junk this set without recourse to its owner.

Type of receiver .....  
We are not responsible for sets left over 30 days.

By: .....

FIRM NAME AND ADDRESS HERE

**FIG. 2. A notice of overdue charges like this one is sufficient legal notice in many states, but not in all. Be sure that the form you use complies with your state laws—otherwise you may be liable for damages if you sell the set.**

definitely that the person has a reputation for paying his bills promptly. It is a sad but true fact that whenever debtors are hard-pressed, bills for radio servicing are usually the last to be paid. You'll be a lot better off to turn down a job politely and let your competitor risk the loss, rather than to do the job on credit and then perhaps make an enemy through attempts to collect for the work.

**Storage Charges.** When a set is left at your shop beyond a reasonable length of time, you can collect storage charges or dispose of the set, provided you notify the customer in the manner required by the laws in your state. One form of notification used by a large firm is a postcard that reads as in Fig. 2.

### EXAMPLES OF BILLS

**Case No. 1.** Five-tube table-model t.r.f. in walnut cabinet, brought to shop by customer. Put in new dual electrolytic filter condenser, type 6F6 tube, and pilot lamp. Realign set. Brush out set thoroughly and polish cabinet.

As an example, suppose the 20-20 mfd. filter condenser costs you 91¢. Dividing 91¢ by .6 gives \$1.51, so you set its list price at \$1.50 as in Fig. 3. Always bill

BILL

Check-up and test at shop.....	\$1.50
Install dual electrolytic	
filter condenser.....	3.00
20-20 mfd. electrolytic	
filter condenser.....	1.50
Type 6F6 tube.....	1.05
Pilot lamp.....	.15
Total.....	<u>\$7.20</u>

FIG. 3

tubes at list prices. If the pilot lamp costs you 10¢, set its list price at 15¢. No charge is made for cleaning the chassis and polishing the cabinet, or for aligning the set, because all this work should easily be done within the one-hour time allowed for check-up and test.

**Case No. 2.** Go to nearby home, remove chassis and speaker of 7-tube, 1-band superhet from console cabinet, bring to shop and replace volume control, realign completely and recenter voice coil, return to home and reinstall in cabinet, polish cabinet, and replace antenna lead-in window strip.

The flexibility of this rate schedule is clearly evident in the bill in Fig. 4. The total charge of \$11.50 is fully justified on the average job, where the customer wastes a lot of your time in conversation on each call, or you have to make an extra trip because the customer wasn't home when she promised to be ("just dashed over to the store—never thought you'd come when you said you

BILL

Check-up and test at shop,  
including pick-up and  
delivery of set.....\$ 3.50  
Install volume control..... 3.00  
Realign 1-band superhet..... 2.00  
Recenter voice coil..... 2.00  
One exact replacement  
volume control unit..... 1.00  

---

Total.....\$11.50

FIG. 4

would," explains the lady!). If things go fine and the job takes considerably less time than usual, however, you could justifiably omit the voice coil recentering charge.

**Case No. 3.** Go to nearby home, install new 35Z5 rectifier and new pilot lamp (which you happen to have with you), and readjust 6-station mechanical push-button system. The bill is shown in Fig. 5.

Repairs are possible in the home on the first trip only when you have the required repair parts with you, and only when the repair is simple. If the customer refuses to let you take the set to your shop, and you have to make an extra trip to get parts, use the two-trip rate of \$3.50 for check-up and test. Whether to do the job in the home or at your shop is a debatable question. Experience will tell you which is best. In the beginning you can work far more efficiently in your shop because you have all data, materials, and test equipment at hand, and a

## BILL

Check-up and test at home.....	\$2.50
Readjust push buttons.....	1.20
New 35Z5 tube.....	.80
New pilot lamp.....	.15
	_____
Total.....	\$4.65

FIG. 5

bench to work on, with no one to upset you, if you run into a "stickler."

**Tubes.** Tube sales are an important source of income when a radio shop has store traffic, because customers will bring in tubes to have them tested. In this case the tube tester is a merchandising device and the "good-bad" meter allows the customer to see for himself which tubes should probably be replaced. When you work spare-time, however, customers will seldom if ever visit your shop to have tubes tested or to buy tubes. Any tubes you sell will be in conjunction with your set-servicing jobs and will be added to your total bill.

Incidentally, when you service a low-cost set, the need for new tubes can cut into your profits or even cause you to lose the repair job. Let's take an example. Suppose you have an a.c.-d.c. receiver for repair that originally cost the customer \$10.95. You find that three electrolytic condensers must be replaced and that the

BILL

Check-up and test at shop.....	\$1.50
Install multi-section	
electrolytic filter unit....	4.00
30-30-50 mfd. electrolytic	
filter condenser.....	2.10
Type 35Z5 tube.....	.80
Total.....	<u>\$8.40</u>

FIG. 6

defective electrolytics have ruined the rectifier tube, making its replacement necessary. After installing the condenser and new rectifier, you find that the receiver performs satisfactorily on local stations but that distant reception is poor because of loss in emission of the other tubes. Your bill would be as in Fig. 6.

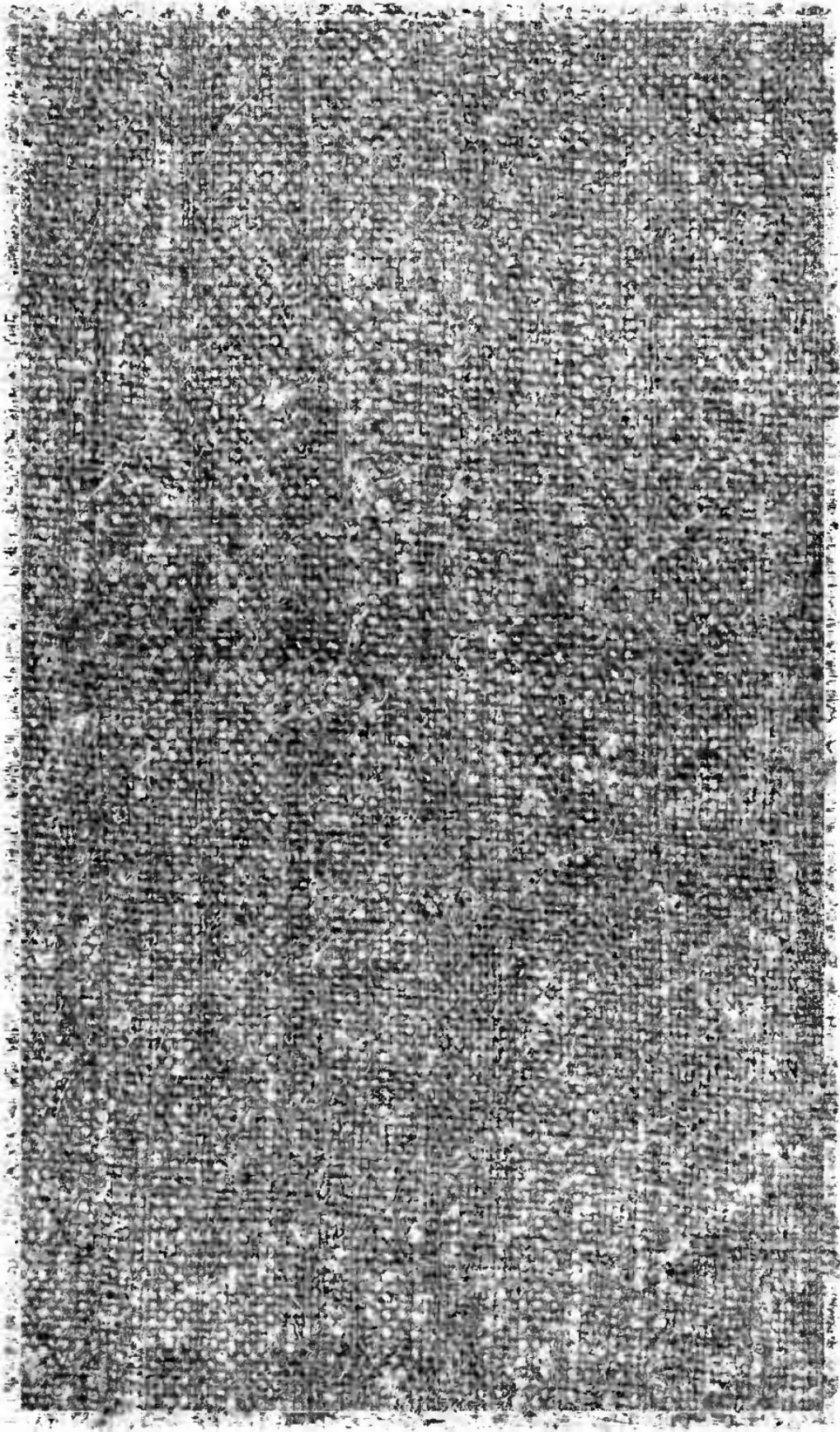
The customer may consider this charge pretty "healthy," taking into account the original cost of the receiver, but a little "salesmanship" will usually make the average customer realize the fairness of the charge. Point out, for example, the high quality of the electrolytics you installed. The manufacturer of course had to skimp to make the receiver for \$10.95, and the cost of the new electrolytics can be considered a good investment against a quick repetition of the trouble.

However, replacing the remaining tubes would add about \$4 to the bill, making the total charge approximately \$12.50—more than the price of the set. Naturally,

if you quote such a price, the customer will usually prefer to buy a new set rather than have you make any repairs. On the other hand, if you install the tubes and cut your labor charge to bring the price down to, say, \$9.50, you may lose money on the job.

In such a case, the best thing to do is to make the other repairs and put a sticker marked WEAK on each of the low-emission tubes. Point them out to the customer, telling him that he will probably get many months of good local-station reception, but will eventually have to replace these tubes.

THE N. R. I. COURSE PREPARES YOU TO BECOME A  
**RADIOTRICIAN & TELETRICIAN**  
(REGISTERED U.S. PATENT OFFICE) (REGISTERED U.S. PATENT OFFICE)



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

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 16

How To Plan a  
Professional Workshop

RADIO SERVICING METHODS



# NRI TRAINING PAYS...

Dear Mr. Smith:

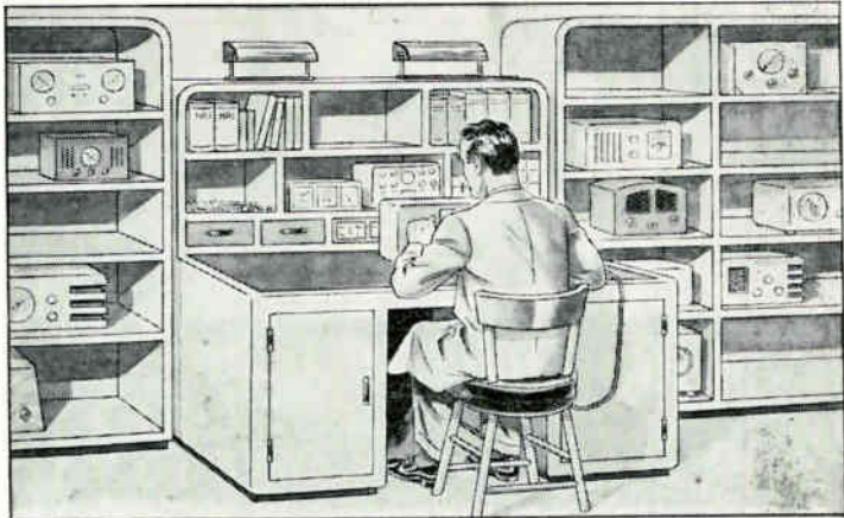
I was in the restaurant business, earning very little. I enrolled for the NRI Course and started earning money repairing radios about the twentieth lesson. Made enough in spare time to finish paying for the Course; now I work full time in my own business. I think the NRI Course is grand, and I can't praise it enough. I am sorry I did not enroll five years earlier.

E. W. B., Alabama



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



## *How To Plan a* **Professional Workshop**

WHEN you start servicing as a business, you will need space to work in and a good bench to work on. It is all right to perform your laboratory experiments and gain practical experience in any location available, but you must have a real shop—even if only a small one—to do professional work. You need such a shop both for your own convenience in working and because your customers will expect you to have one. The second reason is just as important as the first—perhaps more so, since you must get and keep the confidence of your customers to make money out of servicing.

We don't mean that you need an elaborate, expensive shop before you can start earning money as a serviceman. Your first shop can be right in your own home—in fact, many servicemen never have any other location—and your equipment can be very inexpensive. This RSM Booklet will show you how to set up a neat, professional-looking, efficient shop at minimum expense.

Of course, we are not going to tell you in exact detail what you should have in your shop, how it should be made, and where it should be placed. These things depend on your own circumstances and desires. Instead,

we are going to give you general, practical information that you can adapt to your particular needs.

## LOCATING THE SHOP

The prime rule to remember in locating and outfitting your shop is that you should *keep the expense within your income*. Many servicemen are over-ambitious at the start and invest far more in equipment and rent than they can hope to get back in a reasonable time. Remember that you are going into business to *make a profit*, not just to have a large shop. Start small, and expand only when you have built up your volume of business to where you can afford it.

For this reason, the best place to set up your first spare-time service shop is right in your own home. Almost any extra space can be converted into a workshop. Your basement, your garage, or a spare room on the first floor is best, because these locations let you keep your business and your home activities separated. Have your shop as near an outside entrance as possible, so customers will not disturb your household.

If you plan to work in your basement or garage, we suggest you partition off a space 8' x 10', and cover the walls of the partition, and the ceiling, with insulating wall board (Celotex, for example). This not only gives the shop a finished appearance, but also helps to conserve heat (an important factor in a garage location) and to absorb a good deal of sound.

If no space is available in your home, or if local ordinances prevent commercial enterprises in residential areas, look for space you can rent at a reasonable cost. A single-car garage, or space in someone's store, may be a good choice. When you are estimating costs, remember to include such items as payments for heat, electricity, a phone, and fire and theft insurance in your estimates. Remember, too, that you will make a fair amount of noise in your radio testing, so make sure there will be no complaints after you have set up your shop.

## EQUIPPING THE SHOP

Your shop equipment should include a workbench, test instruments, hand tools, storage shelves for incom-

ing and finished work, stock cabinets for replacement parts and miscellaneous hardware, lighting fixtures, electric power outlets, antenna and ground installations, heating facilities (if required), and a telephone.

► There are several requirements a bench must meet if you are to work efficiently. It should have ample work space at the proper height, shelves for your test instruments, convenient electric power outlets, and suitable drawers or racks for your test leads and hand tools. If your space is limited, you will also want your bench to provide space for your NRI Textbooks (in suitable binders), reference books, tube charts, and the circuit diagrams and service manuals that are published yearly. You will also want a convenient place to keep your catalogs of radio parts and equipment.

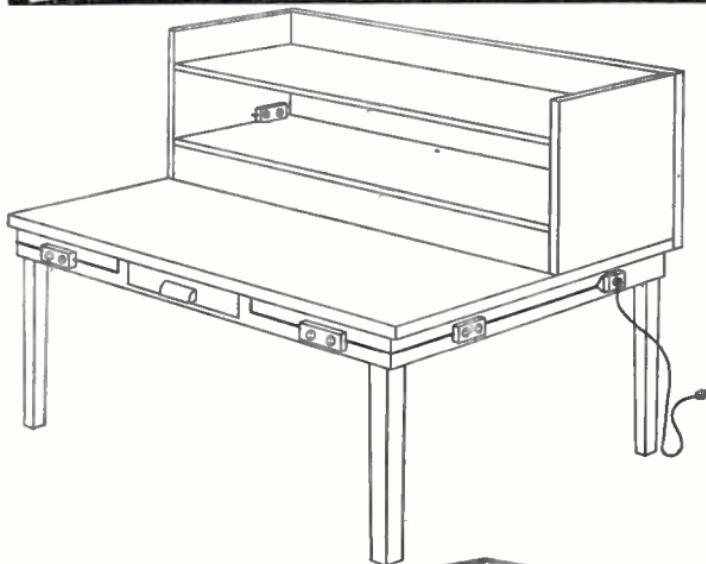
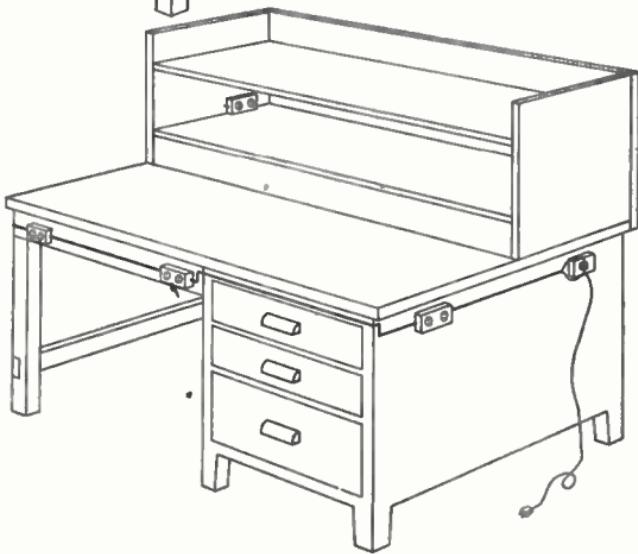
► To help you keep your shop in order, plan to build storage shelves for your incoming and finished work, and cabinets for your stock of replacement parts. These shelves may be placed on either side of your test bench, on the opposite side of the room, or across one end of the room. Keep your stock cabinet close to your bench.

► Any of the antennas described in a previous RSM Booklet will serve your shop. If you live in an industrial area where the noise level is high, erect one of the noise-reducing types of antennas. Otherwise, an ordinary inverted "L" type will be satisfactory.

► Be sure to arrange for telephone service right in your shop if possible. A telephone is an absolute necessity for a radio servicing business, since most customers want to call you, rather than come to your shop, when they need service.

## SIMPLE WORKBENCHES

Almost every serviceman would like a workbench with all sorts of test instruments built into a panel above the bench. Plan to have one some day, but, unless you have some capital you wish to invest, start out with something simpler. (It is often a good idea to make even your first shop fairly elaborate *if you can afford to do so*, because a well-appointed shop helps increase the confidence of your customers in you, and therefore soon brings in more business.)

**FIG. 1****SIMPLE WORKBENCHES****(A)**  
**TABLE WITH  
SHELF  
UNIT****(B)**  
**DESK WITH  
SHELF  
UNIT**

An excellent first bench may be made by adding a shelf unit and a number of electric power outlets to any sturdy table or desk whose top surface measures 30" x 48" or larger. Two examples are shown in Fig. 1: in "A" a shelf unit has been added to a table; in "B" the base unit is a single-pedestal desk. The standard 34" x 60" double-pedestal office desk also makes a good foundation unit.

The average desk or table top is approximately 30" above the floor level. This is a satisfactory height if you want to work sitting down. A height of 36" to 38"

is more generally convenient, however, for it permits the average man to work in a comfortable position either standing, or seated on a high (24" to 26") stool. If you build the table, make it this high (or you can put your table or desk on a platform to raise it to this height). It is better to have a bench a trifle low than too high; a high bench makes you work with your arms held up at an awkward angle. Remember, when you place a receiver chassis on the bench, the place where you do most of your work is about one-half the depth of the chassis above the bench.

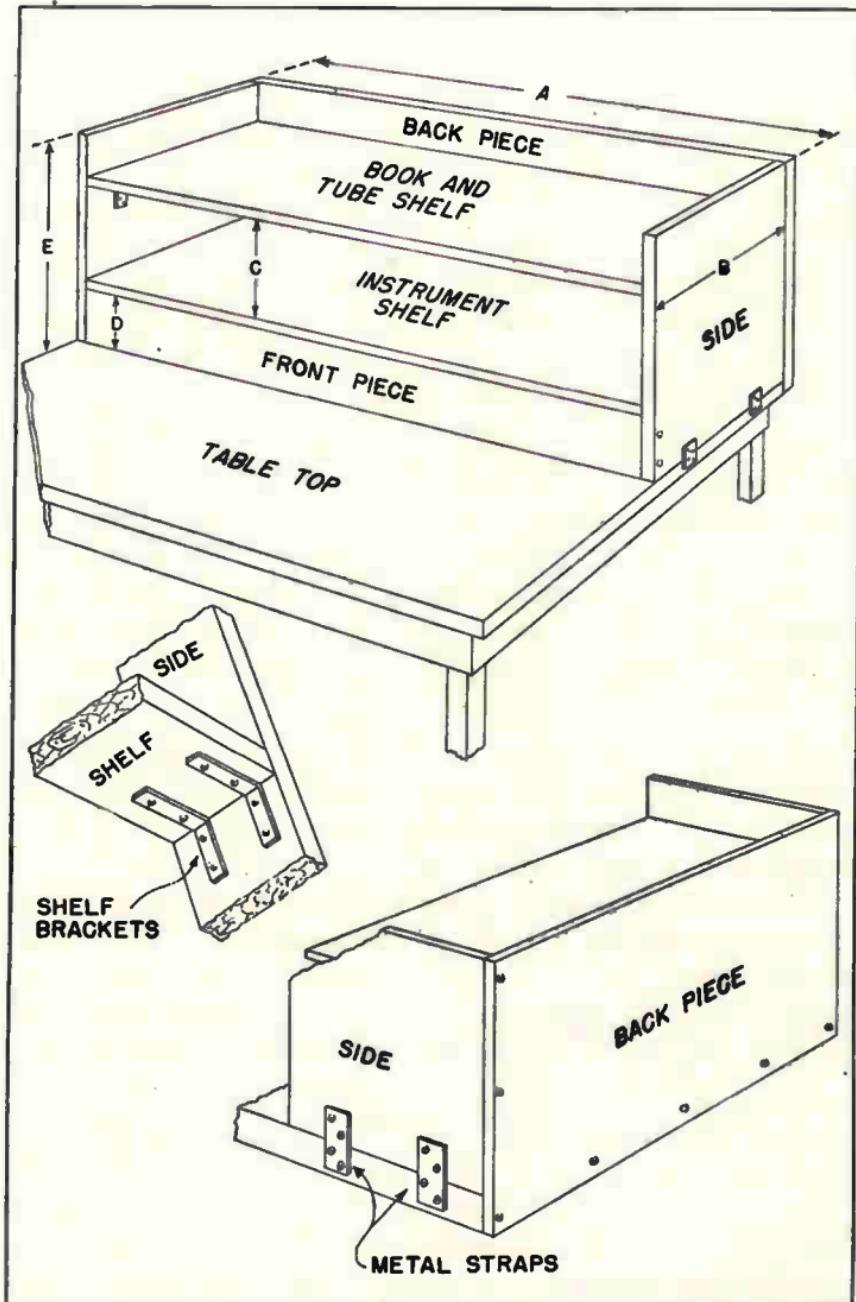
If the surface of the desk or table is marred, improve its appearance by painting it with a good grade of flat paint. Choose a fairly dark color so there will be no strong reflections from overhead lights. If you want a more finished job, cover the top with a dark, plain linoleum. Cement the linoleum in place, and bind the edges with any of the modern plastic or stainless steel binding strips commonly used on kitchen cabinet and sink tops.

► Next, add the shelf unit. The major construction details and approximate\* dimensions are given in Fig. 2. After you have the shelf unit finished, fasten a piece of  $\frac{1}{4}$ " plywood or Masonite to the back to provide strength and to keep things from falling behind the bench. Make this back piece as wide as the shelf unit, and 24" high so that it will extend two inches below the upright end pieces. After you have finished the shelves, sand all surfaces smooth, fill all nail holes, cracks, and poor joints with Savogran Wood Putty or some similar crack filler, and then paint or stain the unit to harmonize with the finish of the table or desk. Hints on painting are given later in this Booklet.

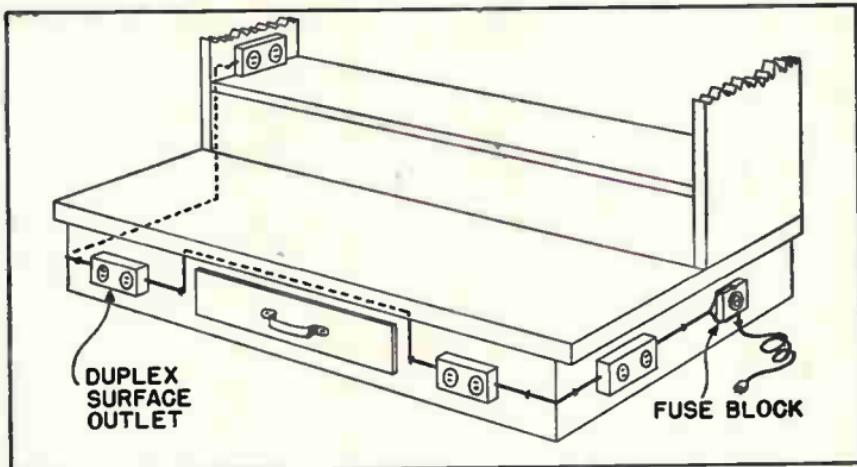
Use wood screws and small angle brackets to fasten the shelves to the upright end pieces. Fasten the whole assembly to the top surface of the bench with wood screws and metal straps. Also run several wood screws

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\*We say "approximate" dimensions because the actual width and thickness of finished lumber is always slightly *less* than the stated sizes. Thus, a 10" board may measure only 9 $\frac{1}{4}$ " to 9 $\frac{5}{8}$ ". Keep this important fact in mind when you measure and cut lumber to make the various benches, shelves, and cabinets described in this RSM Booklet.



**FIG. 2. Construction of shelf units.** Dimensions: A, full width of table or desk; B, 10"; C, 13"; D, 5"; E, 22". Use 1" clear white pine for shelves, sides, and front piece,  $\frac{1}{4}$ " Masonite or plywood for back piece. Secure the shelves to the sides with angle brackets, as shown in the detail sketch at the lower left. Secure the whole unit to the bench with metal straps, and by screwing back to bench, as shown in the lower right sketch. Fasten the front piece in place with screws run in through the side pieces.



**FIG. 3. Suggested wiring for bench.** An extra duplex surface outlet can be installed on left-hand end of bench if desired. Connect all outlets in parallel. Staple cords to table with insulated staples. Above drawer, staple cord to top overhang. Split cord at the fuse block and connect fuse into one wire. Be sure to staple cord to bench between the fuse block and the free end of the cord.

through the back piece into the back edge of the table or desk for additional support. Make sure that both your shelf unit and your table or desk are firm; if they wiggle, brace them appropriately.

You will need several electrical outlets on the bench to supply power for your soldering iron, your tube tester, and the radio being tested. For convenience, the outlet for the tube tester should be mounted on the instrument shelf. It is a good idea to have several more outlets than are absolutely necessary, so you won't have to lead power cords across your working surface.

A suggested wiring system for this bench is shown in Fig. 3. Underwriters-approved rubber-covered lamp cord (#18 wire) is satisfactory, but there will be less power lost in your lines if you use #16 or #14 wire. Fasten the wire to the bench with insulated staples. Notice that a 5-ampere fuse is shown in the line; this is not absolutely necessary, but it may save you a trip to the main fuse box if you happen to short your power line. (House wiring is usually fused at 15 amperes.)

If you wish—and know how—you can install outlet boxes and use BX wiring instead of using the open wiring shown. The more elaborate wiring will look

neater, but is not otherwise any better for your purposes than the wiring shown in Fig. 3.

► Provide antenna and ground connections at some convenient point on the bench. A handy way of doing so is to bring the lead-ins to a bakelite strip on the bench. Then you can use flexible leads with alligator clips when you want to connect the lead-ins to the antenna and ground posts of a receiver. Mark the lead-ins so you can tell them apart readily.

## LIGHTING THE WORK SPACE

Your bench should be well lighted. You can, if you wish, use incandescent lamps in hanging reflectors. However, fluorescent lamps are better, since they give a cool, even light over a large area. We suggest you install one of the factory or industrial units that contains two 20-watt lamps in a white enamel reflector. When you buy the lamp fixture, be sure to get the high power-factor type.

The fixture may be hung on supports projecting from the wall or may be suspended from the ceiling. Don't have it so low that it will interfere with your work, but bring it close enough to the bench to give a good light intensity over the whole working surface. Your objective is to illuminate the bench, not the room. Use other lamps for general room lighting.

Fluorescent lamps sometimes cause radio interference, especially as they approach the end of their useful life. This interference may be radiated directly from the lamp to the receiver, may be radiated from the power supply lines, or may be fed to the set by the power lines. Filters are available (from electrical supply houses) that should help in the second and third cases. Instructions for their use are supplied with them. Direct radiation from the lamp itself can best be eliminated by installing a new lamp.

► In most places, it is perfectly legal for you to install lamps and wiring of the kind suggested for the bench power supply by yourself as long as you plug them into a wall outlet. (It is usually *not* legal for you to connect them directly and permanently to the house wiring unless you are a licensed electrician.) However, unless you

have had some experience with wiring, you may be wise to have a licensed electrician do both jobs for you. Electricians' charges are not usually high—and perhaps you can make a deal with one to do some servicing in exchange for his help on your wiring.

## STORAGE SHELVES

You should not pile repaired or unrepairs sets on the floor beside the bench. For one thing, it looks messy; more important, such careless handling may damage sets and cabinets. Instead, you should have storage shelves on which you can place the receivers—preferably two sets of shelves, so you can separate your incoming and your finished work.

These shelves can be mounted on brackets against the wall, or you can make a simple self-supporting case like that shown in Fig. 4. The dimensions are not critical, and the shelves need not be fancy affairs, but they should be sturdy and deep enough to hold large receiver chassis and record changer mechanisms. If you make the case, put a plywood back on it or cross-braces to keep it upright. Simple blocks or brackets will hold the shelves, and center-bracing is unnecessary if the shelf length is not more than 4 feet. Paint the shelves to correspond to your work-bench.

Any ordinary clear lumber may be used, although this means two boards must be used to get the width. Five-ply plywood (1" thick) can be used also for the

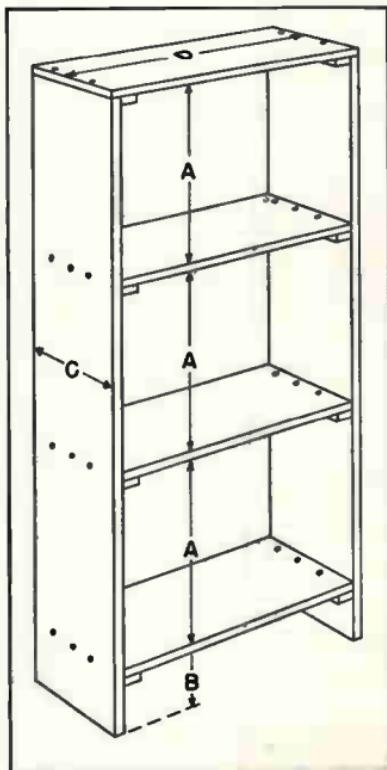
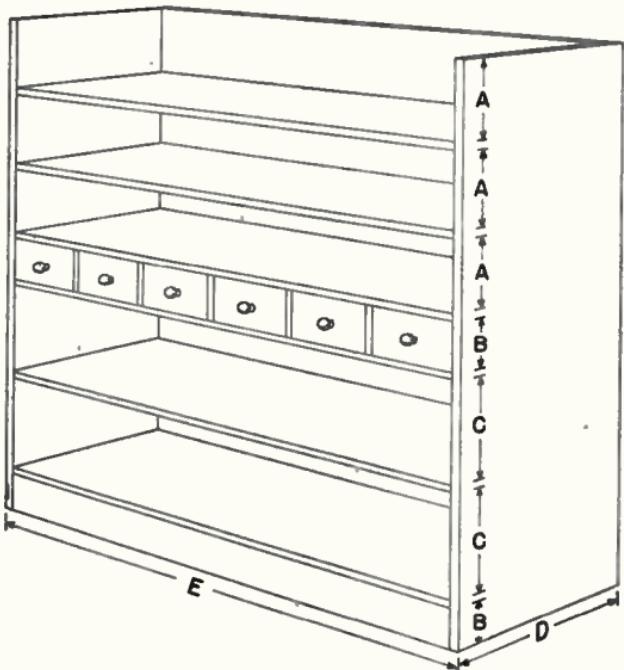
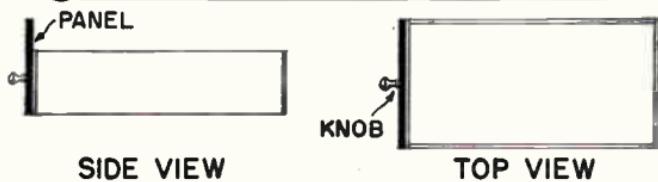


FIG. 4. Storage case. Approximate dimensions: A, 24"; B, 6"; C, 18" to 24"; D, 48". Use 1" clear pine for shelves and sides,  $\frac{1}{4}$ " Masonite or plywood for back. Fasten support blocks to sides and shelves with screws.

**A ASSEMBLED VIEW OF CABINET**



**B DETAIL OF CIGAR-BOX DRAWERS**



**FIG. 5. Stock cabinet.** Approximate dimensions: A, 10"; B, 6"; C, 15"; D, same width as shelf of work bench; E, 38". Use 1" clear pine for shelves, sides, and bottom pieces. Use  $\frac{1}{4}$ " plywood or Masonite for back and for panels on cigarbox drawers. Remove tops from cigar boxes.

shelves. For extra sturdiness, the upright pieces may be anchored to the wall (if this is practical), although this won't be necessary if a back is used.

### STOCK CABINETS

You should also have a stock cabinet that provides for all your replacement parts. One convenient form of stock cabinet is shown in Fig. 5. Make this unit as high as the top shelf of your workbench (or top storage shelf, if you prefer) and make its shelves approximately the same in

depth as the shelf unit on your workbench. The unit should be sturdy but need not have the strength required for the storage shelves.

The drawer unit for small parts, such as resistors and condensers, volume controls, dial drive belts, etc., may be made from cigar boxes (all the same kind of box, if possible, to get uniform size) as shown in Fig. 5B. Remove the tops from the boxes. The  $\frac{1}{4}$ " plywood or Masonite panels on each box give it a finished appearance. The knobs may be obtained from any hardware store. Six such boxes should be ample for the average spare-time business. Be sure to have the shelves above and below the boxes close enough together so that the boxes are well enclosed.

We suggest that you keep your miscellaneous small hardware, such as machine screws, wood screws, washers, solder lugs, rivets, nuts, etc., in small glass jars. These may be obtained already filled with the parts you want from almost any radio wholesale firm. Label each jar with small gummed stickers to show what is in it.

## CATALOG AND DIAGRAM FILES

From time to time you will get catalogs and bulletins from various radio wholesale firms, and you will gradually acquire individual circuit diagrams. Steel or cardboard box letter files (letter size), like those illustrated in Fig. 6, are handy for filing material of this sort. Reserve one for circuit diagrams, another for catalogs, and a third for your business correspondence. It's a good idea to index the diagram file so that you'll know at a glance whether or not you have a particular diagram. Keep this file primarily for miscellaneous diagrams;

whenever you get a bound volume of circuit diagrams, remove any duplicates from this file.

Keep your job records, etc. on individual 4" x 6" cards in a card storage case like that shown in



FIG. 6. Use inexpensive box letter files like these for storing diagrams, catalogs, and business correspondence.

**FIG. 7.** Use a storage case like this for keeping job record cards, etc. The size that will take a 4" by 6" card is best.

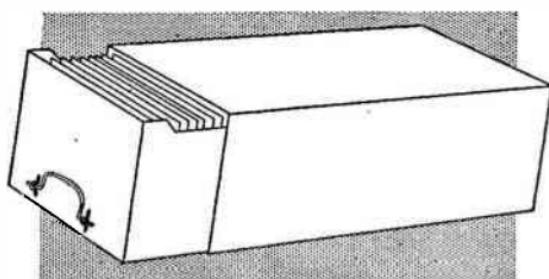
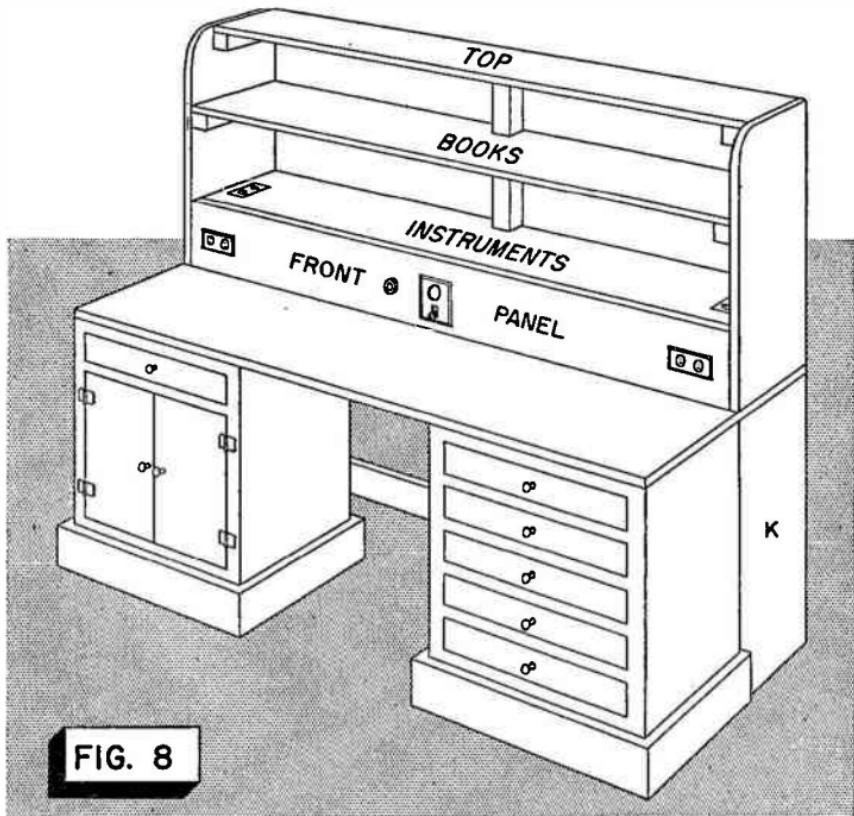


Fig. 7. You can also keep stock record and inventory cards in this sort of file.

### A MORE PROFESSIONAL BENCH

Although either of the simple benches just described will probably be adequate for all your needs for some time to come, you may prefer to start out with the more elaborate bench shown in Fig. 8—or you may eventually decide to replace a simpler bench with one of this sort. This bench is more expensive than those described earlier, but it is not very much harder to build. A good carpenter could make it for you in less than a day; how-



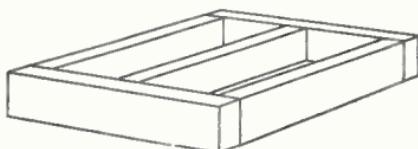
**FIG. 8**

FIG. 9

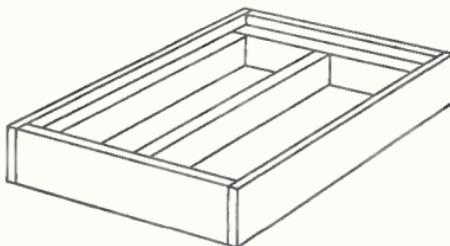
INNER SUPPORT FRAME



CABINET WITH SUPPORTS  
IN PLACE



FRAME WITH  
RETAINING LIPS ADDED



much longer it would take you depends on your skill with tools.

This bench is made up of a base unit and a shelf unit. We shall describe the construction of each in turn.

**Making the Base Unit.** The base unit consists of two pedestals, a top piece, a brace, and enclosing pieces. (These last are used to fill out the outline of the bench behind the pedestals.)

The pedestals are kitchen cabinet base units mounted on supports to bring them to the proper height. The first step in making the bench is to get these cabinets, since the dimensions of the rest of the bench depend to some extent on their sizes. Most mail order houses, and many furniture and department stores, carry suitable cabinets. Get two; one should have as many drawers as possible, the other should have only one drawer and a large cabinet space. We will assume, for our description, that the cabinets you get are 24" wide, 21" deep, and 32½" high (a standard size). If the cabinets you get have different dimensions, make corresponding corrections in the directions that follow.

Make supports for these cabinets as shown in Fig. 9. The height of the inner support frames should be enough

to make the top of the bench nearly 38" high. The bench top is to be 1" thick, so, since the cabinets are 32½" high, the inner support frames may be made from 2 x 4 timber. Make each frame just the size of the bottom of the cabinet it is to support. See that the frames are strong and rigid.

After making a frame, secure four boards to it (see Fig. 9) to act as lips to hold the cabinet on the frame. These boards should come about 1" above the top of the frame.

Next, fasten the bench top to these pedestals. The top is a piece of 5-ply plywood, 72" wide, 32" deep, and 1" thick. Place the pedestals about 24" apart and lay the top on them. (If the sides of the plywood do not have equally good finishes, make sure the better side is up.) Line up the pedestals and the top so that the *front* and *side* edges of the top are flush with the *fronts* and *outer sides* of the cabinets. Drill  $\frac{1}{4}$ " bolt holes through the top piece and through the tops of the cabinets, four holes to each cabinet. Counter-sink these holes, then run  $\frac{1}{4}$ " flat-head stove bolts through them. Fasten the bolts with nuts, tightening them enough to draw the heads of the bolts below the surface of the top piece.

(CAUTION: You must be careful not to allow the top to slip when you are drilling the bolt holes. A good way to prevent slipping is to clamp the top to the cabinets with woodworker's clamps or C clamps before you start drilling. If you have no clamps, be very careful when you drill.)

Next, fasten a length of 1" x 2" wood across the backs of the two cabinets as a brace. Locate the brace about an inch above the lips of the base supports. Fasten it to each cabinet by running wood screws through the cabinet back into the brace.

Finally, enclose the sides of the bench behind the pedestals. (Since the cabinets are not as deep as the bench top, the sides are "filled out" by the pieces marked K in Fig. 8.) The pieces used for this should be at least  $\frac{3}{4}$ " thick, since they will help support the shelf unit when it is placed on top of the bench. If your cabinets have the dimensions we have given, each enclosing piece will have to be 11" wide and 37" high. Undercut the

pieces at the bottom to fit over the retaining lips of the cabinet supports and also to fit over the moulding (if there is one) along the base of the wall where the bench is to stand. If the rest of the bench base is not absolutely square, you may have to plane the enclosing pieces to make them fit tightly along the edges. Fasten each piece to one cabinet and the bench top with small angle brackets held by screws. Of course, place the brackets inside so that they will not show. It is not necessary to enclose the back of the base, since it will be against the wall. This completes construction of the base unit.

**Making the Shelf Unit.** The shelf unit consists of several shelves and supports, plus a sheet of  $\frac{1}{4}$ " plywood (or Masonite) 24" x 72" that is used as a back. An assembled view of the shelf unit, and details of the pieces used to make it, are shown in Fig. 10. Cut all pieces (including the shelf support blocks) from the same stock as shown. The dimensions given are based on the assumption that stock 1" thick (finished size) is

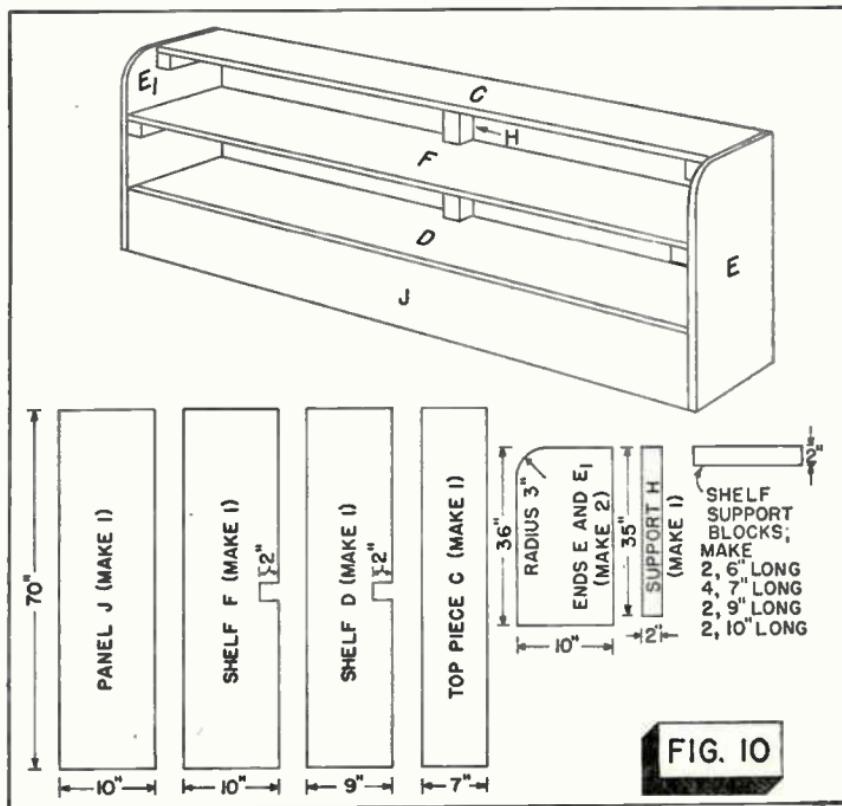
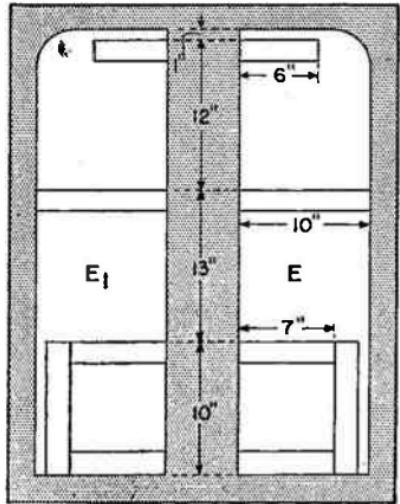


FIG. 10



**FIG. 11.** This view shows the inner surfaces of the end pieces.

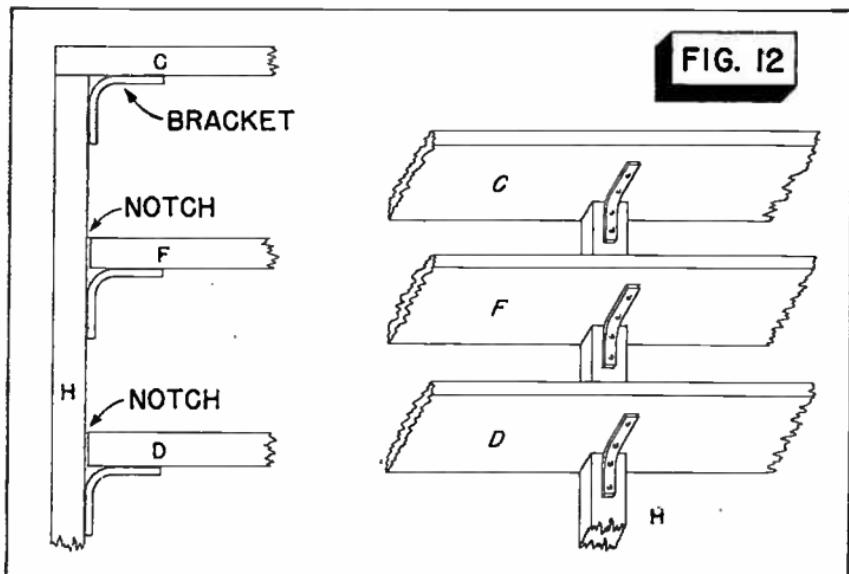
used; make appropriate corrections if your lumber is thicker or thinner. Do not use material thinner than  $\frac{3}{4}$ ". Clear white pine is the best wood to use.

To assemble the unit, first screw the shelf support blocks to the end pieces *E* and *E*<sub>1</sub> in the positions shown in Fig. 11. Be sure to place the 2" sides of the blocks against the end pieces.

Screw small angle brackets to the undersides of shelves *D*, *F*, and *C* (one bracket to each).

These brackets are to be used to fasten the shelves to support piece *H* as shown in Fig. 12. Locate the brackets on shelves *D* and *F* so that they are flush with the inner edge of the notched section. On shelf *C*, which is not notched, locate the bracket so that it is just the thickness of piece *H* in from the back edge.

Next, set the end pieces *E* and *E*<sub>1</sub> on edge on a flat surface, front edges up. Space them 70" apart (between their inner edges) and have them parallel. Lay shelves



*D* and *F* in place. True up the shelves, then fasten them loosely to their support blocks (or to the end pieces *E* and *E*<sub>1</sub>) with countersunk flat-head screws. Slide piece *H* in place, positioning it carefully in the notches so that its top will just hit the underside of shelf *C* when the latter is in place. Fasten the brackets on shelves *D* and *F* to piece *H* with wood screws.

Now set the shelf unit on end. True it up, then tighten the screws holding the shelves to the support blocks until the unit is rigid. Tighten the screws holding the shelf brackets to piece *H*. Fasten front panel *J* to its support blocks with countersunk flat-head screws, setting them up tight. Finally, set shelf *C* in place and fasten it to its support blocks and to piece *H*.

This completes assembly of the shelf unit, except for the Masonite or plywood back. Fasten this panel to the back of the unit. It should project 2" below the unit; the projecting part is used to fasten the shelf unit to the bench top and to the enclosing pieces. Fasten the back to the unit with screws.

You are now ready to wire up the bench. This must be done before the shelf unit is fastened to the bench top.

**Wiring the Bench.** We suggest that you install two duplex receptacles in the front panel and two in the top of shelf *D* as shown in Fig. 13. Those in the panel are to be used to supply power for your soldering iron, the receiver under test, etc., and those in the shelf top to supply power for test instruments. These outlets should all be connected in parallel, and a switch and a 5-ampere fuse should be connected in series with the parallel combination. If you wish, an indicator lamp can be connected in parallel with the receptacles to show when the power is turned on. The schematic diagram in Fig. 13 shows the connections.

Unless you have had some experience with electrical wiring, it will probably be best to have your bench wired by an electrician. He will cut holes for the receptacles, and his price will include all materials. If you decide to do the work yourself, use wire no smaller than #12 in making your connections. The power cord, which is used to bring power from the wall outlet to the bench, should

be heavy-duty rubber-covered appliance cord. Lead it into the bench by drilling a hole in the back piece of the shelf unit under shelf D.

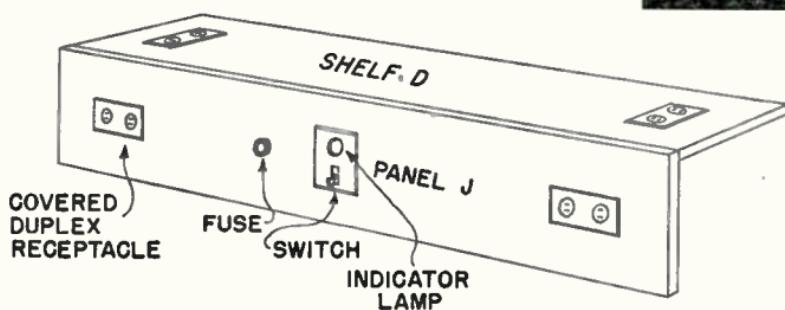
You can, of course, use exposed wiring and receptacles mounted on the outside of the panel and shelf D. We suggest the more elaborate hidden wiring because it is more in keeping with the general appearance of the bench.

When the wiring is complete, fasten the shelf unit to the bench top by running screws through the unit back into the top. Run a screw through the back into the edge of each enclosing piece K also.

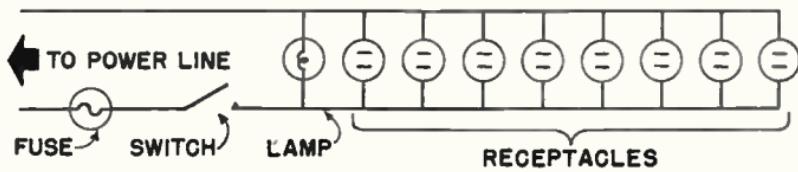
**Making the Tool and Accessory Racks.** For convenience, you should mount your most frequently used hand tools (cutters, pliers, socket wrenches, and screwdrivers) on a board near your work and arrange your test leads neatly on a rack of some sort. Handy tool racks are shown in Fig. 14. To make them, you need two pieces of clear lumber, each 26" x 2" x 1". Drill or notch them as shown in Fig. 14. Make the notches large enough to hold your pliers and cutters easily. The drilled holes

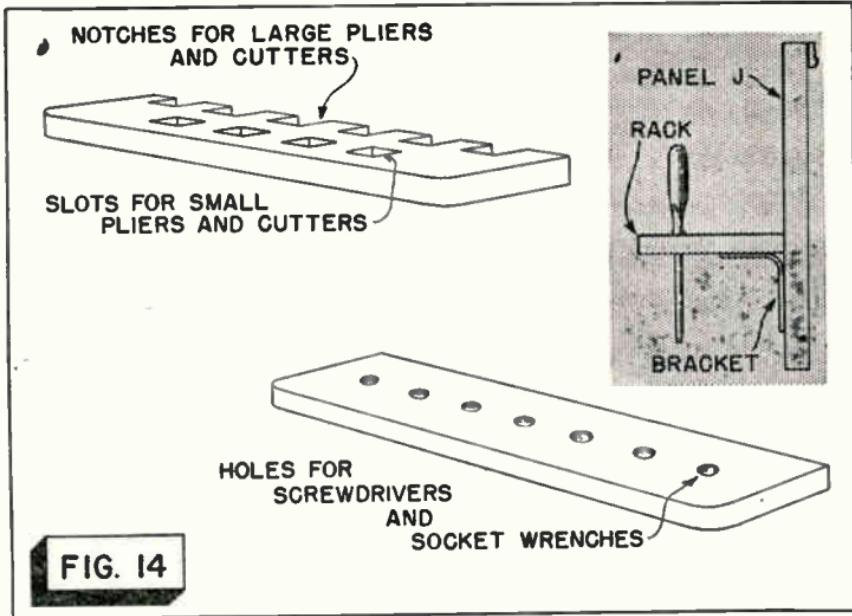
PICTORIAL LAYOUT

FIG. 13



SCHEMATIC DIAGRAM





**FIG. 14**

should be large enough to permit easy removal and insertion of screwdrivers and spintite socket wrenches, but should be too small for the tool handles to enter.

When the racks are made, fasten them to the front panel *J* with small angle brackets (three to each). Position the screwdriver-spintite wrench board so that the tool handles won't project above the level of the test instrument shelf, and so that the bits of long screwdrivers won't drag on the bench. Mount the cutter-plier board on a level with the screwdriver board and on the opposite side of the central switch plate.

A suitable rack to hold your test leads may be made by attaching a small towel or wash cloth bar (don't use glass) to the right end of the bench. Don't put it in place until the bench has been finished, however.

### **FINISHING THE WORKBENCH**

First, fill all cracks, poor joints, the various screw holes (so as to conceal the screw heads), and the counter-sunk holes for the bolts in the bench top with Savogran Wood Putty or some similar crack filler. Allow it to dry thoroughly, then sand down any rough spots. At the same time, round off all sharp corners and edges with sandpaper so as to present a smoothly finished surface.

Remove sanding dust with a soft cloth moistened with turpentine. The bench can now be painted. (If you plan to use a linoleum top, don't paint the top of the bench.)

You may finish the bench in a single color (white, grey, dark green, brown, etc.) or you may use two contrasting colors. If two colors are used, paint the drawers and panels of the cabinet doors in the darker of the two colors. Finish the inside of the shelf unit in the darker of the two colors (outside a light color) or in a high gloss white or cream. Apply one color at a time and allow it to dry thoroughly before applying the other.

Use a clean brush about 2" to 3" wide with high-grade bristles. Clean the brush thoroughly with turpentine each time you finish using it, then suspend the brush in turpentine. Use a different brush for each color if you want a good two-color job.

Before painting, mix the paint thoroughly. Follow carefully the paint manufacturer's instructions about thinning and using his product.

► To get a good paint job, proceed as follows: First apply a coat of flat paint in the color chosen to all inside and outside surfaces of the bench. Always paint in one direction on a single surface, and never apply so much paint or enamel that it begins to run. Before leaving the job, go over all corners carefully with the brush to remove any surplus paint. Allow at least two days for this to dry. Smooth any rough spots in the paint with fine sandpaper or steel wool, remove all sanding dust, then apply another coat of flat paint, and allow two more days for drying.

Use a high-grade enamel as the finish. Before applying it, rub down the entire bench lightly with fine sandpaper to remove irregularities and dust particles. Wipe the surface carefully, then apply the enamel. Although most quick-drying enamels will feel dry to the touch in 4 to 8 hours, they will mar easily if used too soon. Allow at least a week for the enamel to harden before using the bench. (As you see, a considerable amount of time is consumed in applying an enamel finish. Remember, though, that your bench will get a lot of punishment; a good, hard finish, therefore, is essential.) During this

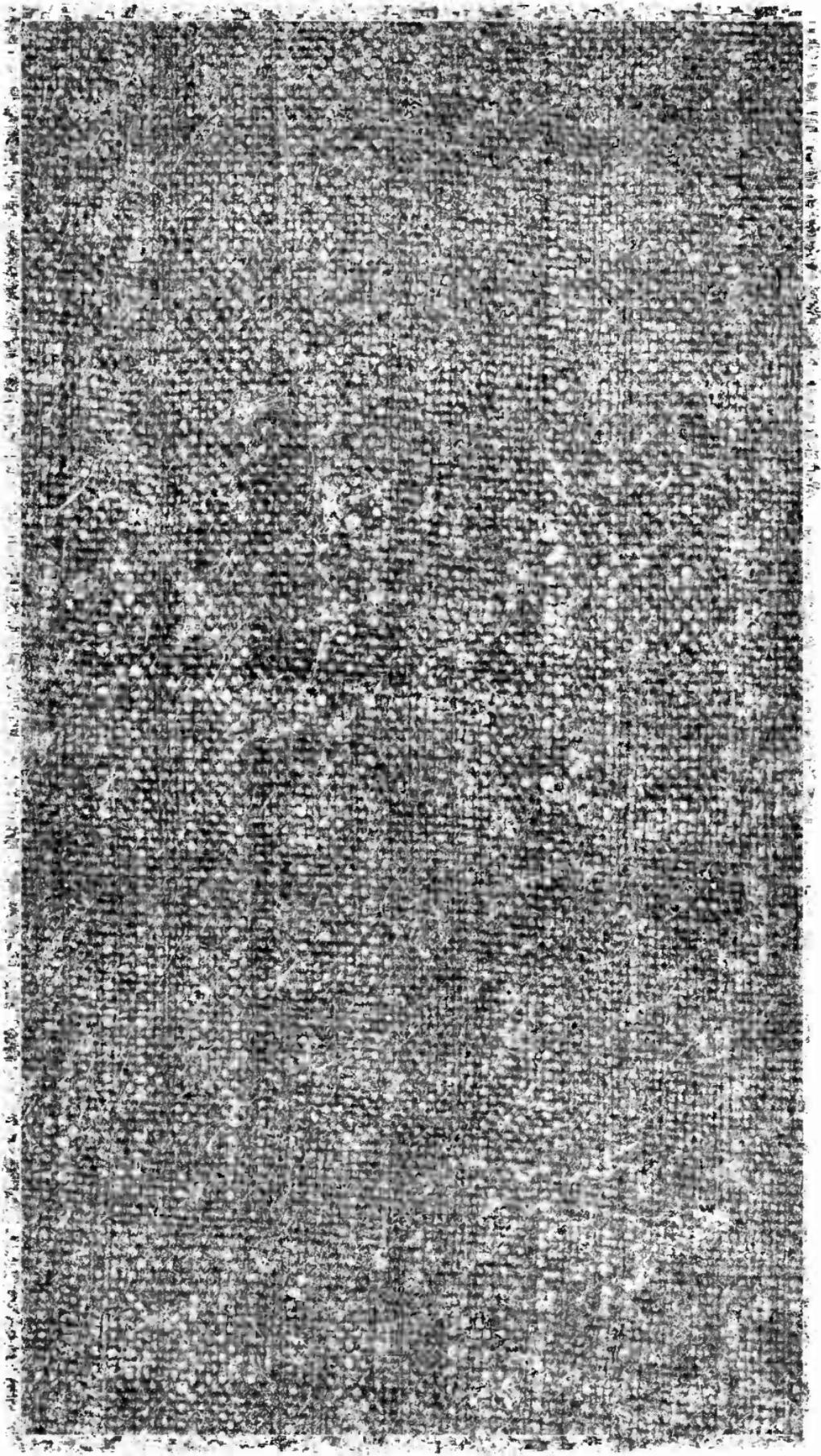
time, if you wish, you can cement a good grade of linoleum to the top and bind the edges with plastic or stainless steel binding. If you prefer, you can probably find an expert linoleum layer who will do this for you.

► For the final step, apply several coats of good floor wax to the bench, rubbing each down briskly with a soft cloth. Fasten the test lead bar to the side of the bench, and insert the drawers. Your bench is now complete except for antenna and ground connections. Bring these to the bench after you have put it in its permanent location. As we suggested earlier, bring these leads to a bakelite strip fastened to the bench top, and label the leads plainly.

### CUSTOM-BUILT TEST PANELS

As your business grows, you probably will add additional test equipment and will want to mount it permanently on your bench. You may then keep your portable equipment for home service calls. When that day comes, consult the literature put out by the manufacturer of your test equipment. Many manufacturers can supply complete units holding the basic pieces of equipment in an attractive panel. Others have plans for constructing panels. You are free to use your own ideas and should not hesitate to mount your equipment in any order that works out well for its use. In fact, it is a good idea to try several arrangements on bare shelves to see what instruments should be placed in the center or on the upper or lower shelves, before you make the final panel.

THE N. R. I. COURSE PREPARES YOU TO BECOME A  
**RADIOTRICIAN & TELETRICIAN**  
(REGISTERED U.S. PATENT OFFICE) (REGISTERED U.S. PATENT OFFICE)



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

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

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



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**

FM12M1149

1950 Edition

Printed in U.S.A.



**T**O 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.

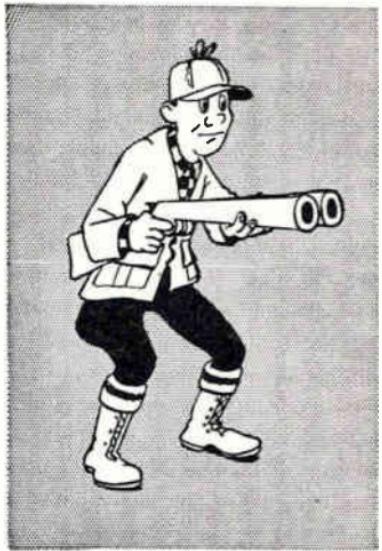
**Effect-to-Cause Reasoning:** Effect-to-cause reasoning is the "use your head" step of radio servicing. When you turn on the receiver you are to service, you find that it operates in some peculiar manner, or else fails to operate at all. This is the *effect*, and you reason back from this effect to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

tion 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. How-

ever, 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

### STAGES OF A TYPICAL SUPERHETERODYNE

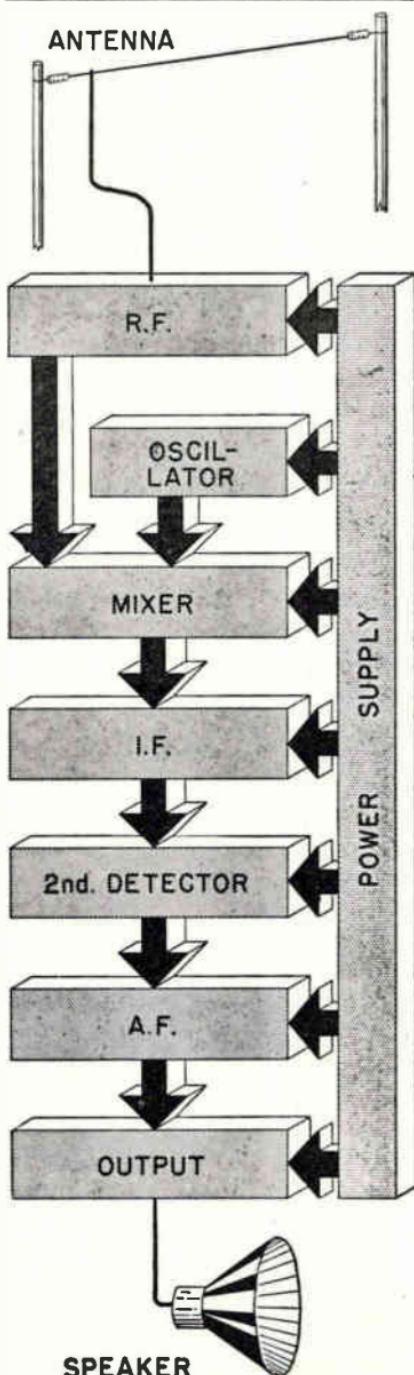


FIG. 1. This block diagram shows the basic stages of either an a.m. or an f.m. superheterodyne. An a.m. set might have an extra i.f. stage and an extra a.f. stage. Usually an f.m. set will have at least three i.f. stages, one of them known as a limiter stage. Also, the second detector stage in an f.m.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

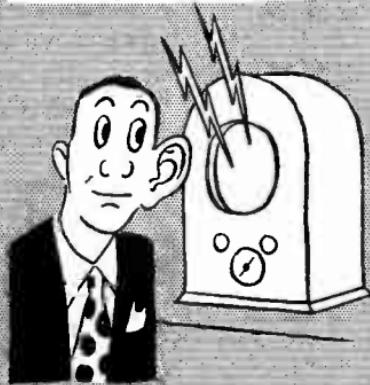
## BASIC LOCALIZATION PROCEDURES

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.

FIG. 2

## THE NRI SIX-STEP SERVICING METHOD

1. CONFIRM THE COMPLAINT



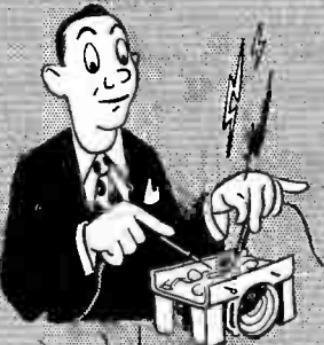
2. LOOK FOR SURFACE DEFECTS



3. LOCATE THE DEFECTIVE SECTION



4. LOCATE THE DEFECTIVE STAGE



5. LOCATE THE DEFECTIVE CIRCUIT



6. LOCATE THE DEFECTIVE PART



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.

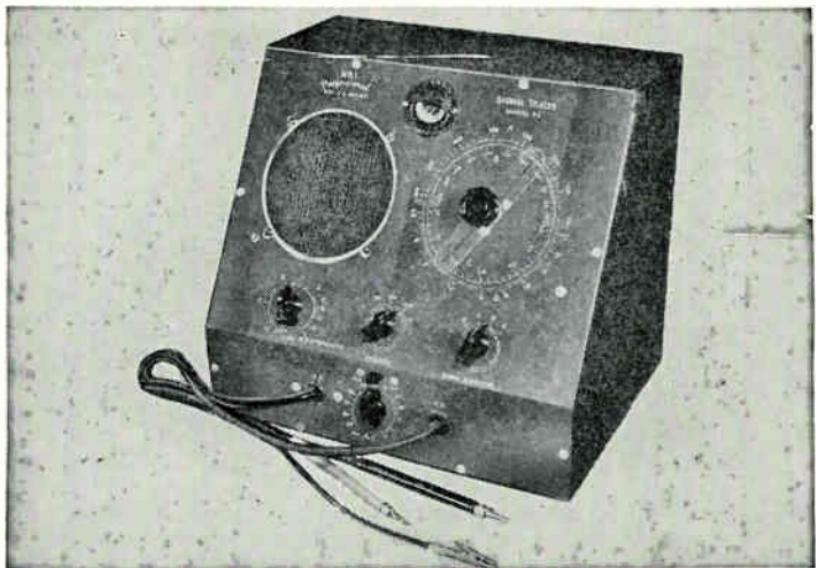
The following *brief* descriptions of these methods will make you acquainted with their general uses. Future RSM Booklets will go into more details, particularly on their uses for specific service complaints.

## 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



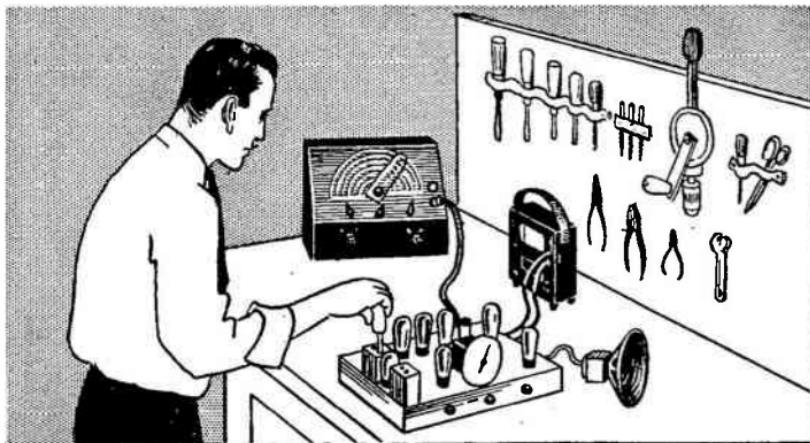
This is the NRI Model 33 Professional Signal Tracer. It has two output indicators—a tuning eye and a loudspeaker—so it can be used in locating any defect.

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.

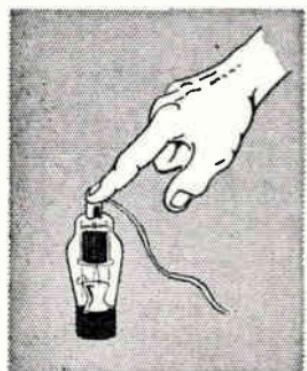
There are several basic methods of creating an electrical disturbance in the stage. These disturbances will be reproduced by the loudspeaker as a buzz, a thud, or a click. To create the disturbance, you can :

- 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.

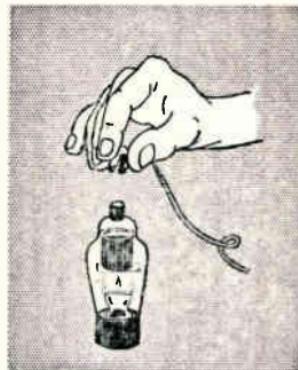
If the first audio tube is one of the type having a top cap, turn on the set, allow it to warm up,



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

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

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.



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.

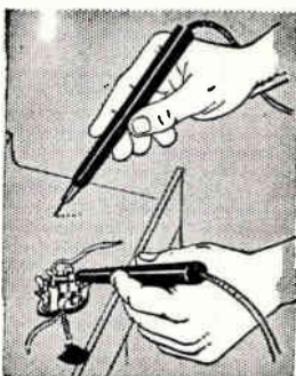
The voltmeter method works because the voltmeter draws current when it is connected into the circuit. Thus, there is a sudden surge of current when you touch the voltmeter probes to the circuit, and an equally sudden stopping of this current when you withdraw the probes. Each of these effects usually 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.

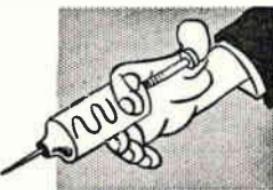
To locate the defective stage, you can:



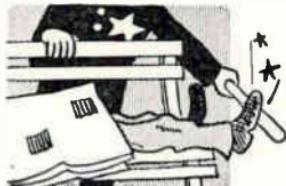
## *1. Trace the signal.*

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.

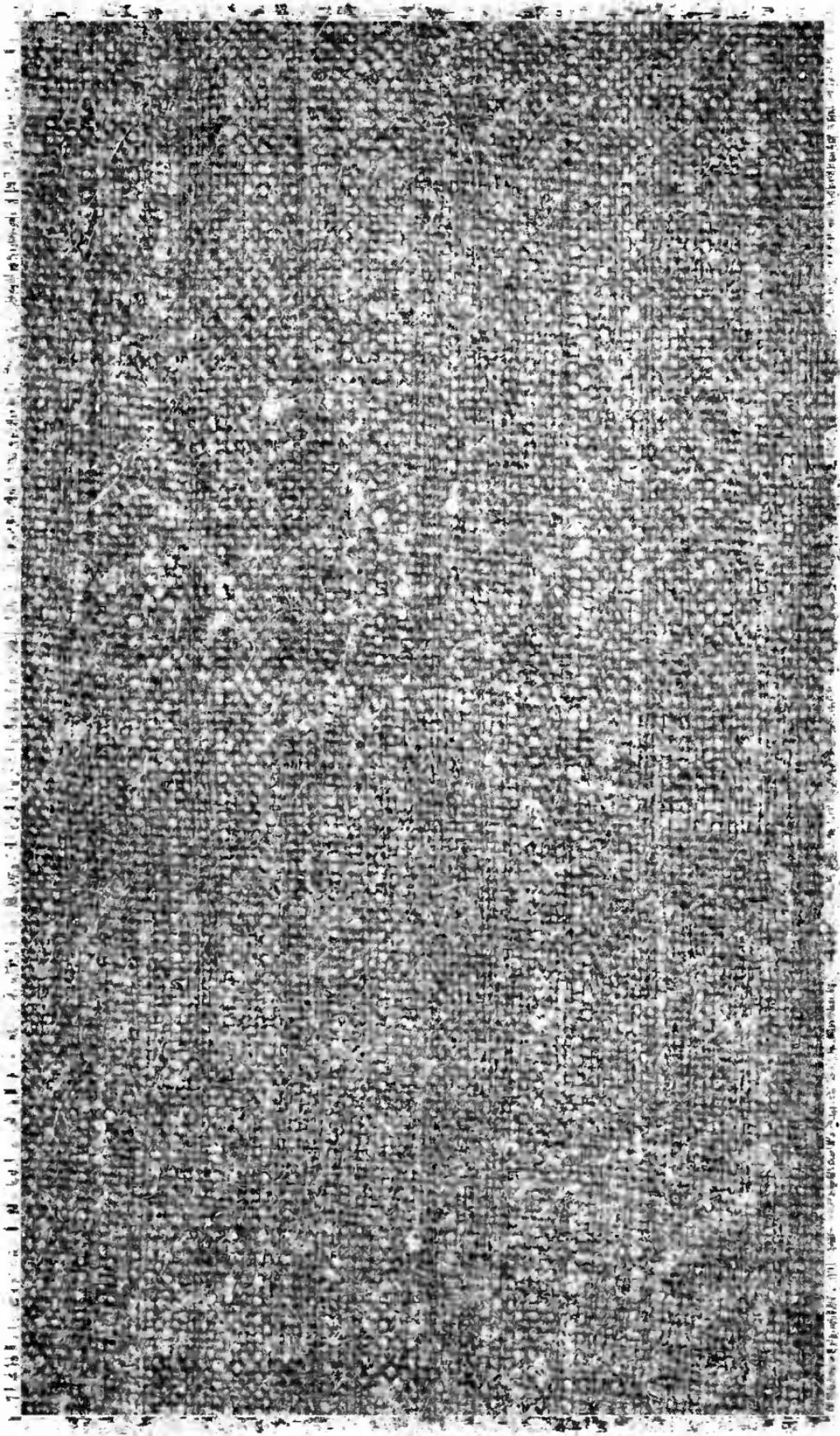
You don't need a new set; in fact, one that is a few years old will be better suited to your needs. If possible, get a well-known make, such as RCA, General Electric, Zenith, Airline, Silvertone, Truetone, etc., for we can usually supply you with complete service information on them, often including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

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THE N. R. I. COURSE PREPARES YOU TO BECOME A  
**RADIOTRICIAN & TELETRICIAN**  
(REGISTERED U.S. PATENT OFFICE)      (REGISTERED U.S. PATENT OFFICE)



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

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 18 How Circuit Diagrams Are  
Used in Servicing

RADIO SERVICING METHODS



# NRI TRAINING

## *Pays off...*

Dear Mr. Smith:

When I started your Course I did not know thing about Radio, but my spare time Radio work now is very profitable. I have more than I can handle. I can't praise the NRI Course highly enough for what it has done for me throughout the Course and after I graduated. There is only one thing I regret - that I didn't enroll with NRI ten years sooner.

M.R., New Jersey



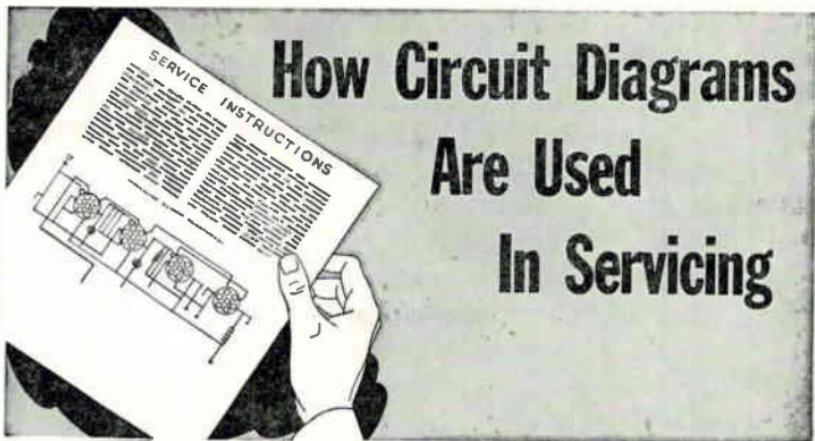
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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**

FM10M1149

1950 Edition

Printed in U.S.A.



# How Circuit Diagrams Are Used In Servicing

ONE of the important steps in becoming a professional serviceman is learning to use the servicing aids furnished by set manufacturers. Schematic wiring diagrams, pictorial layouts, tube layouts, alignment information—the professional uses them all, for he knows they help him to service receivers better.

Schematic wiring diagrams are particularly helpful. A receiver holds few secrets from the expert who has a diagram. Without even examining the set itself, he can often locate the probable cause of a defect and determine how to test for it just by glancing at the diagram; in fact, this is precisely what members of the Instruction Department here at NRI do many times a day.

The reading of circuit diagrams and other servicing aids is so important a subject that it is treated at length in your Course in Radio Fundamentals. This RSM Booklet is your introduction to the sources, uses, and forms of this helpful information. It also contains a continuation of the NRI Plan for giving you practical servicing experience in your own home.

**Where To Get Service Manuals.** In a radio service shop where one or more men service sets on a full-time basis, a complete set of service manuals for all receivers is kept on hand as a part of the shop equipment, and is considered just as essential as the multimeter, the signal generator, and the tube tester. You will not need these manuals at once, for NRI maintains a file of receiver circuit diagrams. When you need a diagram for your early service work, tell us the make and model number

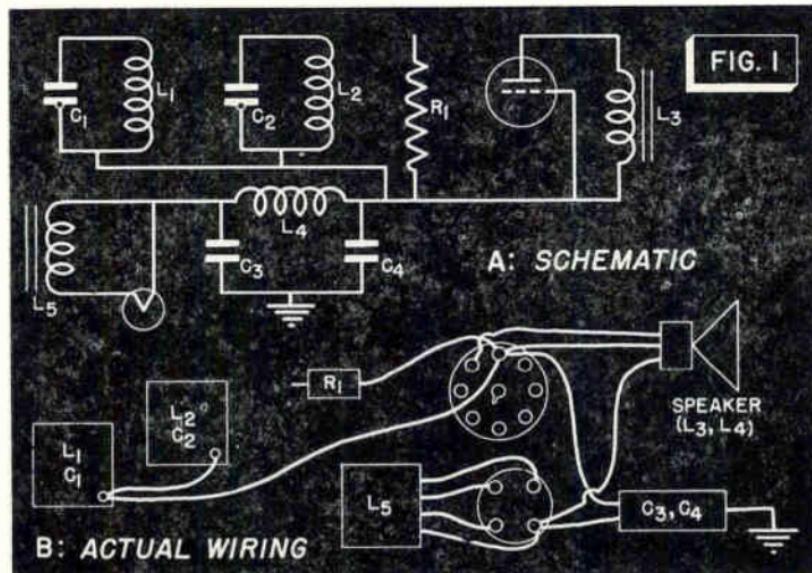
of the receiver, and the tubes used in it, and we will send the circuit diagram to you.

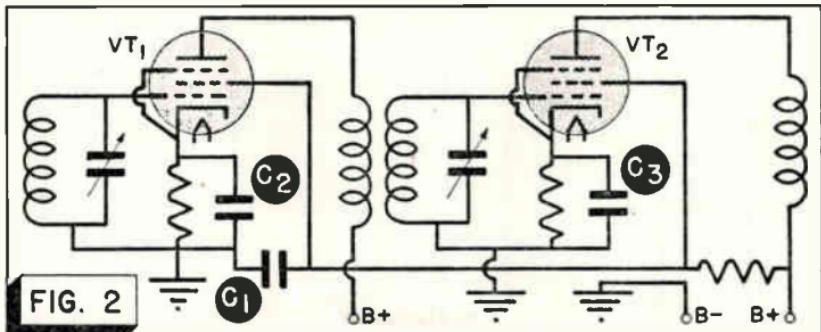
As your service business grows, however, you will eventually want to speed up your service by having the necessary information on hand. Invest some of your earnings in manuals at that time. You can buy the complete yearly manuals that cover many different sets (such as the Rider Manuals), or you can obtain the yearly manuals published by the larger manufacturers of radios. The latter cost less, but, of course, they cover only the products of one manufacturer. Manufacturers' manuals will be satisfactory if only three or four makes of receivers are popular in your service area. However, if you service a wide variety of brands, it will be worth your while to get the more inclusive manuals.

### SCHEMATIC DIAGRAMS

The most important of the service helps is the schematic circuit diagram. This shows the *electrical* connections of a receiver in their simplest form. However, it does *not* show the exact *physical* connections.

There is a very important reason for not showing the actual wiring in a schematic diagram: the circuit is much clearer in the schematic form. For example, Fig. 1A shows a B+ supply circuit as it might be shown on





a schematic. See how easy it is to trace from the filament of the rectifier through  $L_4$  (the speaker field coil) to the i.f. transformers  $L_1-C_1$  and  $L_2-C_2$ , to resistor  $R_1$ , and to the output tube screen grid and plate circuit (through  $L_3$ ). But now try to trace the same B supply circuit in Fig. 1B, which shows the *actual wiring*! Although the electrical connections are exactly the same in both circuits, the schematic is far easier to read. This is because the schematic is drawn to show the *purposes* of the circuit connections, whereas the wiring layout is simply a picture of the way wires are led around to make the desired connections in a particular chassis.

Each type of diagram has its uses. The schematic is very useful when you are trying to find out just how a set works. On the other hand, the wiring layout is far handier when you are trying to identify parts and wires (although, as we will show later, it is perfectly possible to identify parts from a schematic, too). Let's pass over other kinds of diagrams for the moment and investigate the uses of schematics.

► One important way in which a schematic helps a trained serviceman is by pointing out possible causes of a defect. For example, suppose an experienced Radiotrician is servicing a receiver that oscillates (squeals). He at once suspects that a by-pass condenser is open, or that one or more tubes have excess screen voltages. Does he then proceed to check all the by-pass condensers and all the screen voltages? No—first he glances at the diagram, and from it decides which part (or parts) is most likely to be defective.

An open in the screen by-pass condenser marked  $C_1$  in Fig. 2, for instance, might well be the cause of regen-

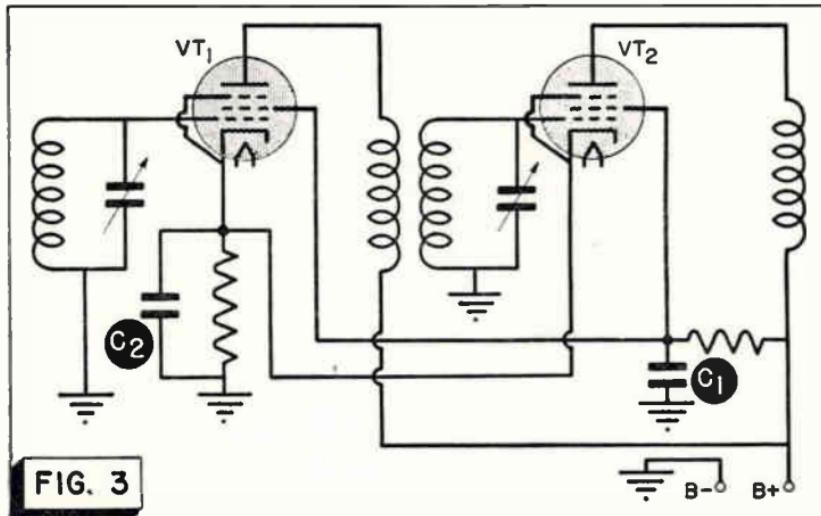


FIG. 3

eration and squealing. The cathode by-pass condensers marked  $C_2$  and  $C_3$ , however, could not cause regeneration even if they were open; rather, degeneration (the opposite of regeneration) would occur if these condensers were open. This is always true of a cathode by-pass condenser used for a single tube.

However, all cathode by-pass condensers are not incapable of causing oscillations. If two tubes operating at the same frequency use a common cathode by-pass condenser and bias resistor, as shown in Fig. 3, an open in the condenser  $C_2$  will allow feedback from  $VT_2$  to  $VT_1$  to occur, and, if the phase relationship is proper, oscillation may result. You can see how valuable a schematic is, in this case. With the aid of a schematic, you can determine at once whether you have a circuit like that in Fig. 2, in which condenser  $C_2$  cannot be at fault, or a circuit like that in Fig. 3, in which a similar condenser  $C_2$  may well be the cause of the trouble. Either way, your testing is made simpler because you know what to test. Without a diagram, it would be more difficult for you to determine which type of circuit you have, so you would probably test all the by-pass condensers in the defective stage or section.

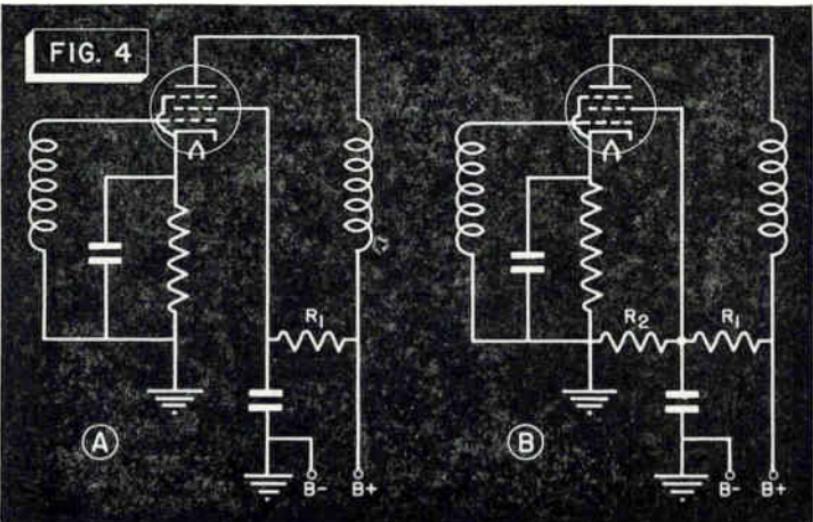
► To carry our example further, suppose that a by-pass condenser is not at fault, and suppose that the screen voltage of a stage is excessive. Again a Radiotrician would look at the diagram to see where the defect

might be. If the circuit were like that in Fig. 4A, resistor  $R_1$  would have to decrease in value before the screen voltage could increase. He would therefore check the value of this resistor with an ohmmeter. However, if the circuit were like that in Fig. 4B, excess screen voltage most likely would be caused by an open in bleeder resistor  $R_2$ . In this case, then, he would check from the screen to ground with an ohmmeter to see if he measured the correct resistance value. (Incidentally, ohmmeter tests are always made with the set turned off—otherwise, the meter might be ruined by being connected across a high voltage.)

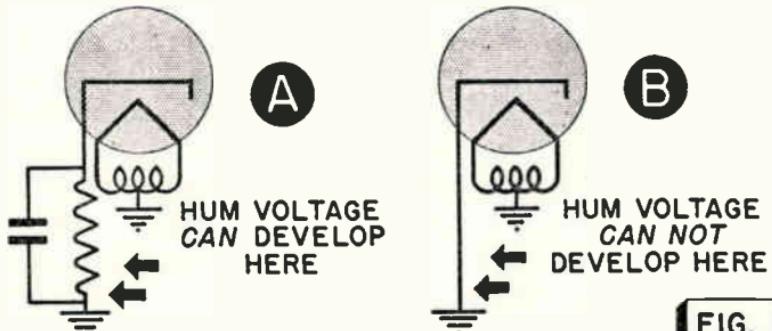
As you see, the serviceman must know the circuit before he can tell which test to make. He has two choices—he can find out what the circuit is by glancing at a diagram, or he can spend several minutes attempting to trace the circuit through the set wiring. Naturally, he prefers to use a circuit diagram whenever one is available to him.

► Although we have chosen an oscillating set as an example in showing you how a schematic diagram is used to speed up servicing, do not assume that oscillation is the only complaint in which a schematic is helpful. We might equally well have chosen some other complaint, for a schematic can be used profitably in a great variety of servicing jobs. For instance, you know that hum may be caused by cathode-to-heater leakage in an

FIG. 4



## IF CATHODE - TO - HEATER LEAKAGE OCCURS



audio tube. But hum can result *only* if there is an impedance between the cathode and ground, across which the hum voltage can develop. If the complaint is hum, then, you can use a schematic to see if such an impedance exists. In a cathode circuit like that in Fig. 5A, leakage will cause a hum voltage to exist across the bias resistor and its by-pass condenser, because the leakage will allow part of the filament voltage to be applied to this combination. On the other hand, if the cathode is directly grounded as in Fig. 5B, leakage cannot cause hum; there is no impedance in the cathode circuit across which a hum voltage can develop. Thus, a glance at the schematic will show you whether you need to consider cathode-to-heater leakage.

**Appraising Receiver Performance.** Schematic diagrams can also be used for purposes other than locating probable defects. For instance, a quick survey of a circuit diagram will give you sufficient information to appraise the performance of a radio receiver. This appraisal will tell you whether you can expect good distant reception, or whether the set is intended only for local and semi-distant reception; it will also tell you what to expect in the way of fidelity and selectivity, once you know the factors that determine these performance characteristics. Customers sometimes demand receiver performance far beyond that which the set can give. To prevent your wasting time trying to improve a set, you should know when a receiver is performing as well as can be expected of it. This ability to appraise receiver performance from a circuit diagram will come to

you almost automatically as you progress with your Course.

**Use of Diagrams in Aligning Receivers.** A circuit diagram reveals the various circuits that must be adjusted during a receiver alignment (tune-up) procedure. With this information, the Radiotrician can generally locate the various adjustments on the chassis and carry out the alignment (though sometimes he needs special alignment information furnished in other service aids). You'll learn more about alignment in later Booklets.

► Of course, the Radiotrician almost never reads a *complete* receiver circuit diagram while servicing any receiver. The professional servicing technique enables him to isolate the defect almost at once to one section of the receiver, and that section is the only one he studies in detail.

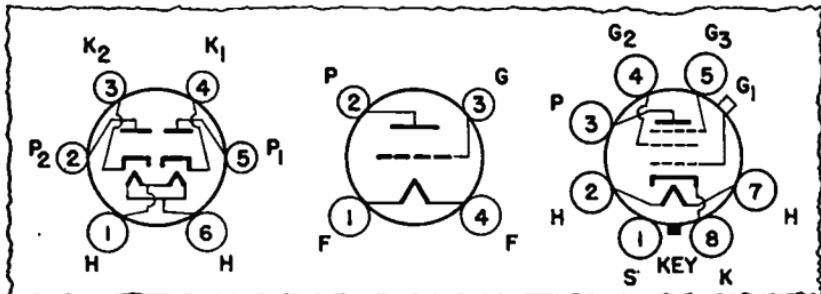
Now that you've learned the major uses of schematic diagrams, let's see what other service information is available, and how it is used.

## LAYOUT DIAGRAMS

There are several types of layout diagrams that are usually a part of the service manual. One of these is the tube layout diagram.

This tube layout diagram tells what tubes are used, shows exactly where they will be found on the chassis, and indicates the stage in which each is employed. A tube layout diagram generally indicates tube positions as seen from the top of the chassis, but with a little experience you can make this diagram serve just as well when you work on the bottom of the chassis. A tube is also readily identified by its relation to adjacent, easily-recognized parts.

**Tube Charts.** When you turn over the chassis of a receiver to get at the socket terminals for a particular tube, you are confronted with the problem of identifying the various socket terminals. Some schematic circuit diagrams provide this information by using a combination pictorial and schematic diagram for each tube, in place of the usual schematic symbols. Some manufacturers give tube socket connections on the tube lay-



**FIG. 6.** Tube manufacturers supply diagrams showing connections between the base pins and the elements of each tube type. Bottom views of the tube bases are shown in all cases.

out diagram; others give the connections on the pictorial layout diagram (which we will take up in a moment). You can identify tube socket terminals even without these diagrams, however, because *tube manufacturers* prepare charts for servicemen that show the socket connections for all tubes. An example is shown in Fig. 6. When you are ready to begin actual work on radio receivers, secure one of these tube charts from your local radio parts distributor. As you acquire experience, you will become familiar with socket connections for the more common tubes and will be able to work on them without referring to any chart or diagram.

**Pictorial Layouts.** In many service manuals, you will find, in addition to the diagrams just described, a pictorial layout diagram that shows the approximate position of each part on the chassis, and may also show the actual wiring. An example of a service manual containing a schematic diagram, a tube layout, and a parts layout is shown on pages 10 and 11 of this Booklet.

The pictorial diagram is useful in that it shows the physical *position of parts*. In the type shown in Fig. 7, only the parts are identified and positioned, but others show the wiring also.

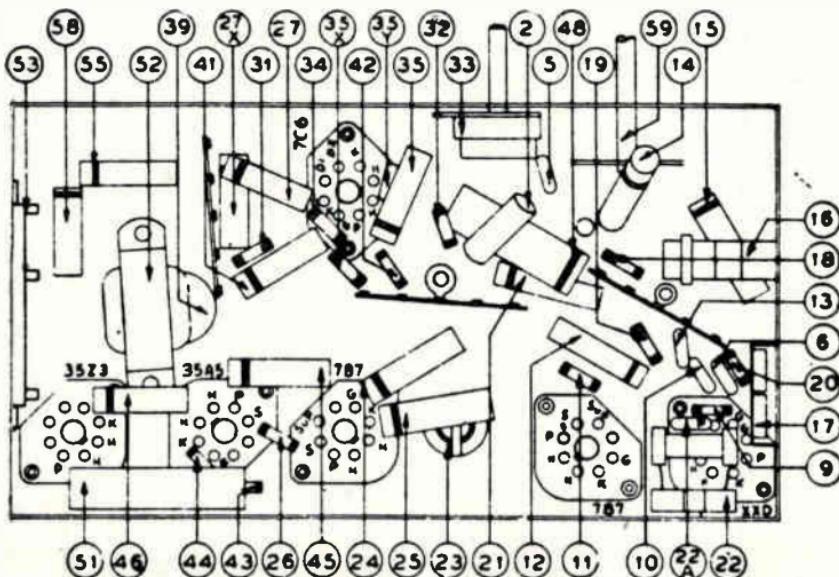
It is not always *necessary* to have all these forms of servicing data; in fact, most of the time a schematic is all you really need, and an experienced man can get along even without this type of diagram. You, too, will learn how to get along on a minimum of service information whenever such information is not available. Of course, it is very convenient to have all this information,

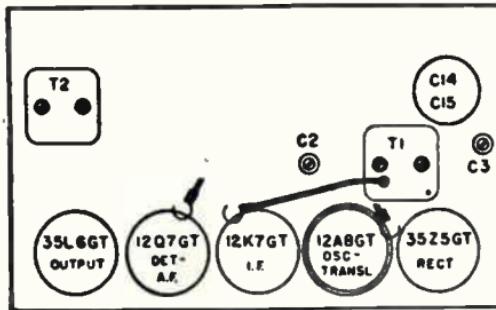
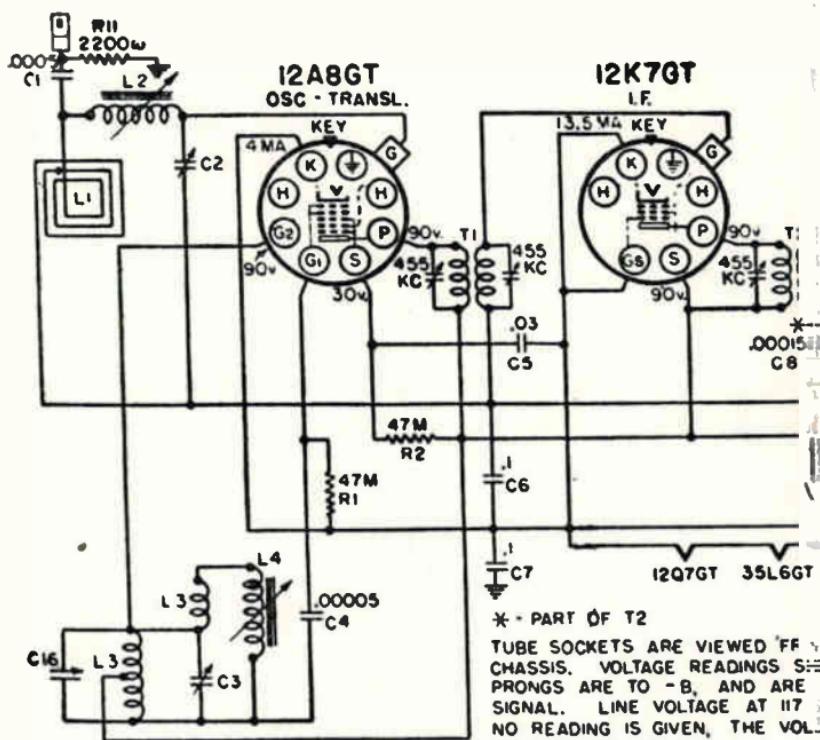
because, to check a receiver, you will have to identify stages so that you can introduce circuit disturbances and trace signals; you will have to locate reference points from which to test; and you will have to locate the suspected parts you wish to test. All these steps are speeded if you have the complete service data.

For example, to locate a part, you can use the circuit diagram to find the number by which the part is identified; then you can refer to the parts layout diagram to determine the location of the part having that number. It is then a simple matter to locate the part on the actual chassis. If identifying numbers are not given, you can note the tube socket terminal to which the part is connected on the circuit diagram, then can locate the same terminal on the pictorial diagram, and can trace the wiring from that terminal until you come to the desired part.

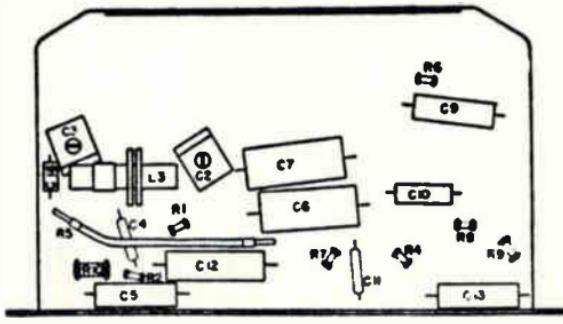
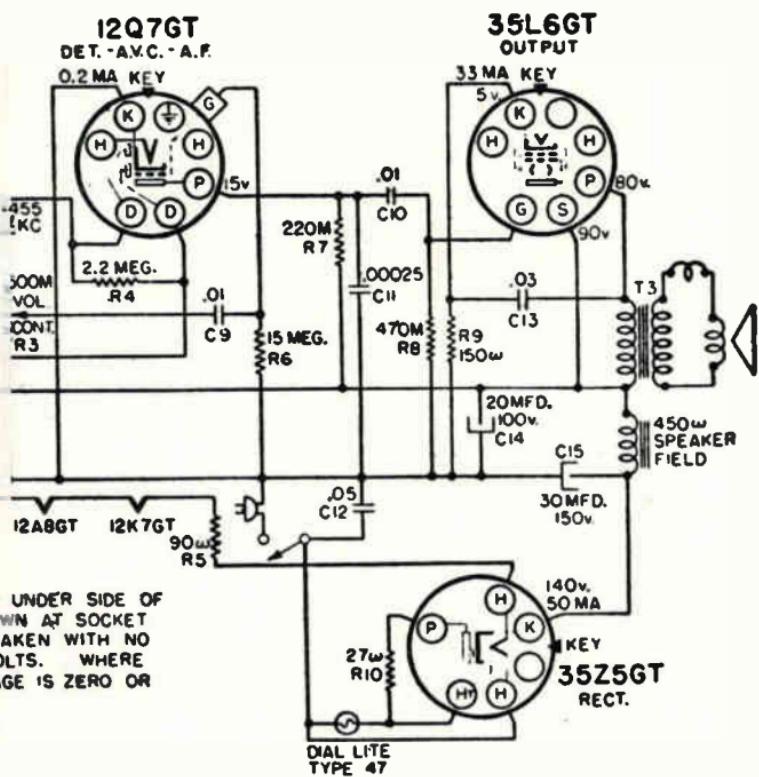
The service information has other uses too. When you have located the defective part, the schematic diagram or an accompanying parts list will usually give you its correct electrical value. Knowing the value will frequently save you the trouble of ordering an exact duplicate resistor or condenser from the receiver manufac-

**FIG. 7. One kind of pictorial layout. Numbered parts are identified elsewhere in the manufacturer's service manual.**





# TYPICAL SERVI



# ING DIAGRAMS

turer, because, once you know what value the part should have, you can generally get an acceptable substitute from your local radio distributor. You must be careful, though, to get a resistor with the same or a higher wattage rating, and a condenser with the same or higher voltage rating. These ratings are not always given on parts lists, but you can estimate them readily, once you have mastered circuit theory.

## HOW TO IDENTIFY RECEIVER TYPES

Perhaps the best way to show the value of service information is to show what you must do when it is not available. Let's take up the ever-present problem of identifying stages and parts. To show all the steps, we will suppose that you do not have a diagram.

Many of the tests to be made on a receiver depend on its power supply and its type (t.r.f. or superheterodyne). Therefore, let's first see how to identify the power supply.

The first step toward this identification is to look for a power cord equipped with a two-prong plug; whenever you see it, you know the receiver operates from a power line. Today, except in rare instances, this means the receiver is either an a.c. or an a.c.-d.c. type. (Once there were a few d.c. receivers in use in large cities, but almost all of these have been replaced by a.c.-d.c. sets.) The following rules will further help to identify the kind of power supply:

A. The set is an a.c. type if—

1. It has a power cord, and
2. it has a power transformer, and

GROUP I		TABLE I		GROUP II	
RECTIFIERS USED IN AC SETS		RECTIFIERS USED IN AC-DC SETS			
5T4	5U4-G	12Z3	25Z5		
5V4-G	5W4-G	25Z6	35Z3		
5X4-G	5Y3-GT	35Z4-GT	35Z5-GT		
5Y4-G	5Z3	45Z3	45Z5-GT		
5Z4	6X5	80	50Z7-G	117Z6-GT	

3. it uses one of the rectifier tubes in Group I of Table I.
- B. The set is an a.c.-d.c. type if—
1. It has a power cord, and
  2. it has NO power transformer, and
  3. it uses one of the rectifier tubes in Group II of Table I. (Exception: the set may meet all these requirements and still be a straight a.c. type if it uses one of the Group II full-wave rectifiers in a voltage-doubling circuit. You studied voltage doublers in one of your lessons on power supplies.)
- C. The set is an older d.c. type if—
1. It has a power cord, and
  2. it has NO power transformer, and
  3. it has NO rectifier tube.

► Receivers designed for battery operation are usually equipped with a multi-lead cable having a battery clip or terminal lug at the end of each cable wire. There will usually be tabs or a color code to indicate the proper connection for each wire. Some battery receivers are designed to operate from a single 6-volt battery; these have only two leads in the battery cable. Others require B and C batteries in addition to an A battery, and will have many more leads in the cable. A battery receiver does not use a rectifier tube (except some auto-radio receivers and those portable receivers that operate either from batteries or from the power line).

Identification of the type of power required by a receiver is essential when the most positive terminal and the most negative terminal in the power supply are to be located and used for electrode continuity-checking purposes. (You will learn about this later.) The lessons in your regular Course dealing with receiver power supply systems will be quite valuable to you in locating these terminals on circuit diagrams and on actual receivers.

**Super or T.R.F.?** There are a number of clues that identify a receiver as a super; if these clues are absent, you know that you have a t.r.f. receiver. If the tuning dial indicates that you have an all-wave or a 2-band receiver, it is safe to say that it is a super. In the case of a single-band receiver, the presence of one or more i.f. transformers shows that it is a superheterodyne.

Most i.f. transformers are housed in small aluminum cans having one or (more often) two adjusting screws on the top, the bottom, or one side. Occasionally, however, the trimmer condensers and their adjusting screws will be located on the chassis near the transformer shields; in this case, identification of the transformer is somewhat more difficult. If there is a flexible lead going from a metal can to the top cap of a tube, but no lead going from the can to the tuning condenser gang, you can be sure the can houses an i.f. transformer.

You can also be sure that a single-band receiver is a super if it has six or more tubes but only two sections in its variable tuning condenser, if the rotor plates in one variable condenser section are shaped differently from those in the other, or if it uses a pentagrid converter tube.

Single-band receivers that do not have pentagrid converters or i.f. transformers are t.r.f. sets. *Four-tube* universal a.c.-d.c. receivers sometimes use a t.r.f. circuit, but you should always make sure by looking for the i.f. transformer, since there are some supers in existence that have only four tubes (including the rectifier tube). Receivers having four or even five sections in the gang-tuning condenser are generally older t.r.f. sets.

## HOW TO IDENTIFY STAGES

With a little actual experience in servicing old and new radio receivers, you will find yourself able to identify the type of circuit and the power requirements of a radio receiver almost at a glance. Identification of the individual stages in a receiver is not quite so easy, but a knowledge of what to expect in t.r.f. and superheterodyne receivers, which you will get from your regular Course, will help considerably.

Tests for isolating the defective stage in a receiver may be carried out more or less readily without a schematic circuit diagram, once you locate and identify the various stages correctly. The tube used in each stage will be your most valuable clue. Its type number, its size and shape, and the appearance of its electrode structure (if it is a glass tube) should all be noted; and tube charts

(supplied by various tube manufacturers) should be referred to in order to find the most common functions of a particular tube.

The identification of stages *without a circuit diagram* is to a certain extent a process of elimination. You eliminate first the easiest stages to identify, so that you can concentrate on the remaining stages. It is common practice to identify the power supply first; this is done by locating the rectifier tube (if the set has one). The rectifier is usually the largest tube in an a.c. receiver, but this is not true in other sets. However, typical rectifier tube type numbers are given in Table I, so you can identify the tube if the type number on it is readable.

Incidentally, examine a tube carefully for this number. It may be on the top or on the side of the glass or metal envelope, or it may be on the side of the base. Other numbers may also be on the base of the tube; these are usually factory identification codes and are NOT the type number if they do not correspond to any standard listing. (Sometimes the socket on the chassis will be marked to identify the tube that is supposed to be used in it.)

Next you locate the power output stage. This will have either one tube or two identical power output tubes, and these will quite often be just as large as or larger than the rectifier tube. You will learn eventually to recognize these tubes by their numbers. (Whenever you find three tubes that tube charts classify as power output tubes, one is acting as a driver for the other two.)

Now locate the receiver input stage. This is always connected to one section of the variable tuning condenser. If there are only two sections in the gang tun-

### BENCH HINTS

To unwind antenna wire from a coil and get it straight, first take three turns from the outside of the coil, turn the coil and take off 3 more outside turns, turn the coil over again and take off 3 more outside turns, and so on until the coil is unwound. Be sure to turn the coil over each time you take off 3 turns; then the coils will oppose one another, and the wire will come straight.

ing condenser, you know from circuit study that there is no r.f. amplifier stage, so you should look for the mixer-first detector. If you find a pentagrid converter tube, you have identified the oscillator-mixer-first detector stage.

If the gang tuning condenser has three sections, either the receiver has an r.f. stage, or there is a band-pass input circuit to the mixer-first detector tube. Usually, you can identify the r.f. tube as a variable-mu pentode (or screen grid) tube, and its control grid circuit will be connected to one section of the gang tuning condenser. When the tube has a top cap, you will see a wire going to the stator of one of the condenser sections.

You can now tentatively identify any other variable-mu pentode (or screen grid) tubes as i.f. amplifier tubes. For a more positive identification, locate the i.f. transformers (remember that an i.f. transformer is in a small aluminum can having adjusting screws on the top, bottom, or side). You must be able to distinguish between the i.f. transformers and the shielded r.f. coils (used in preselector-mixer-first detector and oscillator circuits); when in doubt, you can identify the latter coils by the fact that they are connected under the chassis to the tuning condenser or to the wave-band switch.

► You can also identify i.f. stages by tracing circuits under the chassis. Start at the mixer-first detector tube, which you have already identified, and trace from its plate terminal to an i.f. transformer. From the secondary of this transformer you will be able to trace to the grid of a tube either through a flexible top-cap connection coming from the transformer, or through a lead to the grid terminal of a tube socket. That tube will then be the first i.f. amplifier tube. If there are two i.f. stages, you will be able to trace from the plate of the first amplifier tube to the primary of another transformer, and from the secondary of that transformer to the grid of the second i.f. amplifier tube.

You can identify the second detector at once when you have located the i.f. stage or stages. In most cases, it will contain a diode tube (or a triode connected as a diode), which will be connected through a transformer to the plate of the last i.f. tube.

A triode tube that is located near the second detector tube or near the output tube can be identified tentatively as an audio, or driver, tube; it may or may not have a top cap. If there is a signal path from the load of the second detector to the grid of this triode, you have an additional identification; and if you can trace from the plate of this triode tube through a coupling condenser or through an audio transformer to the grid circuit of a power amplifier, you can positively identify the tube as the first audio amplifier tube.

The set may not contain a separate audio, or driver, tube. If not, the second detector will be a dual-diode-triode and will use the triode as the audio amplifier. In a few of the older receivers, the second detector is a triode or pentode tube and may feed directly into the power output stage, which you have already learned to identify.

► If there are still some unidentified tubes left on the chassis after you have completed the identification of stages up to this point, they are probably phase inverters or special control tubes. These are not easily identified even by an expert until their circuits are traced. If you must know their functions, the best procedure is to secure a circuit diagram for the receiver. Cathode-ray tuning-indicator tubes (magic eyes) can, of course, be identified by their appearance.

► A t.r.f. receiver will have one or more tuned r.f. amplifier stages, a demodulator (detector), and a power audio output stage. The r.f. stages are easily located, for the grid of each r.f. tube will be connected to one of the stators of the gang tuning condenser (*not* the rotors; the rotors are invariably grounded). If there

### BENCH HINTS

You need three hands to do some soldering jobs - one to hold the wires together, one to hold the iron, and one to hold the solder. When you must handle such a job alone, cut off a piece of solder about a foot and a half long and hold one end of it in your teeth. You can then move your head to bring the other end of the solder to the spot where you want it.

are three sections in this condenser, there will be two r.f. amplifier tubes, and the third section will connect to the detector tube. If there are four sections, there will be three r.f. amplifier tubes, unless two sections are used in a band-pass circuit. All these facts will be clear to you when you study these circuits in your Lessons on Radio Fundamentals.

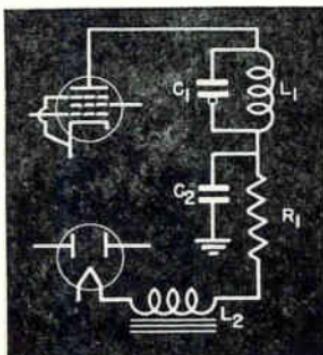
► When you have identified the stages in a receiver in this manner, you can make tests for isolating the defective stage, even though a schematic circuit diagram is not available. You can then proceed to make continuity tests between tube electrodes and the most positive and most negative d.c. supply terminals, since you know the type numbers of the tubes in the receiver and can determine their socket connections by referring to a tube chart.

You will learn in detail how to make continuity tests in a later Booklet. In the next section we refer to these tests; if you don't understand all that is said about them, review this section after you have learned more about continuity testing.

## HOW TO IDENTIFY PARTS

When you locate a tube electrode circuit that lacks continuity, you then proceed to locate the part or connection that is open. If a circuit diagram is available, you can trace out this particular electrode circuit on the diagram and can note the parts in it, then you can locate these parts on the actual chassis (possibly with the aid of a pictorial layout diagram). For example, if an ohmmeter test reveals lack of continuity in the plate circuit of an i.f. amplifier stage, the schematic circuit diagram (see Fig. 8) may indicate that the circuit traces from the plate terminal of the tube through the primary ( $L_1$ ) of an i.f. transformer, through resistor  $R_1$  that is used in conjunction

FIG. 8. If this plate circuit opens, then  $L_1$ ,  $R_1$ , or  $L_2$  might be to blame, but not  $C_1$  or  $C_2$ .



with by-pass condenser  $C_2$  as a filter, and then through choke coil  $L_2$  in the power-pack filter system to the cathode of the rectifier tube. If you suspect resistor  $R_1$  of being open, then locate it on the pictorial diagram so that you can find it easily on the chassis. Once you have located it, check it with an ohmmeter.

The procedure for locating an open in an electrode circuit when a circuit diagram is not available is much the same, though not as easy; you will have to learn more circuit theory before you can locate defects readily without a diagram. When you have acquired the necessary knowledge, here's how you'll find the defective part:

Since resistors and coils are the only parts that can provide continuity in an electrode supply circuit, these are the only parts you look for on the chassis. For example, let's say you have isolated a defect to the plate circuit of the i.f. amplifier stage as in the last example.

There are three ways to find the defective part with an ohmmeter. You can use the ohmmeter to test the parts individually; the one that does not show continuity is open. Another way is to check the circuit for continuity by placing one ohmmeter probe at a "reference" point (the plate of the i.f. tube, for example), and to move the other probe from this point, terminal by terminal, to the other end of the circuit. In this case, you will get readings until you have passed over the defective part; then the ohmmeter will show no continuity. The third way is the reverse of the second; the ohmmeter probes are touched to the ends of the circuit, then one is moved toward the other. In this case, there will be no reading (an open circuit or infinite resistance) until you have passed over the defective part—then there will be a reading.

Don't worry if you don't understand completely the continuity testing method just described; as we said, you'll learn all about it in a later Booklet. What we want you to learn now from the preceding description is that it is possible to check a circuit without having a diagram, once you know what parts are normally found in various electrode circuits. Naturally, however, the process of locating and identifying parts takes longer

without a circuit diagram, since there are often a great many possible variations of electrode circuits, each of which you must check. When you are a full-fledged Radiotrician, you'll be able to test any circuit without a diagram if necessary—but you'll still use a diagram whenever possible because it will save you time.

## NRI PRACTICAL TRAINING PLAN

This is a continuation of the NRI Plan for gaining practical servicing experience at home. If you do not yet have the receiver recommended in an earlier RSM Booklet, we suggest that you get it as soon as possible. Then write to us for complete service data on the receiver. (Complete service information will be furnished at no charge when you want it for carrying out this Plan.) When you have the service data and the receiver, go through the following steps carefully:

**Step 1. Get Acquainted With the Circuit Diagram.** When you receive the circuit information, go over the circuit diagram, and study it carefully. Now trace the signal from the antenna terminal to the loudspeaker, remembering that a change in carrier frequency occurs at the mixer-first detector, and that demodulation takes place at the second detector. Trace through the power supply circuits to see how each tube gets its electrode voltages, and trace through special control circuits such as a.v.c., a.f.c., tuning indicator circuits, tone control circuits, etc.

**Step 2. Redraw the Circuit Diagram.** On a large sheet of paper, redraw the schematic circuit diagram of your receiver two or three times the original size in the following manner: First draw all the tubes, in their usual schematic form, in the same relative positions as on the diagram sent to you. Now put in the signal circuit parts and connections, working from the antenna toward the loudspeaker. Use schematic symbols just like those on the original diagram. Do this slowly, visualizing the function of each part and circuit as you draw it. Alongside each part, indicate its electrical value; sometimes you can get this directly from the original circuit diagram; sometimes you will have to refer to the parts list. Put in the power pack next; then draw each electrode

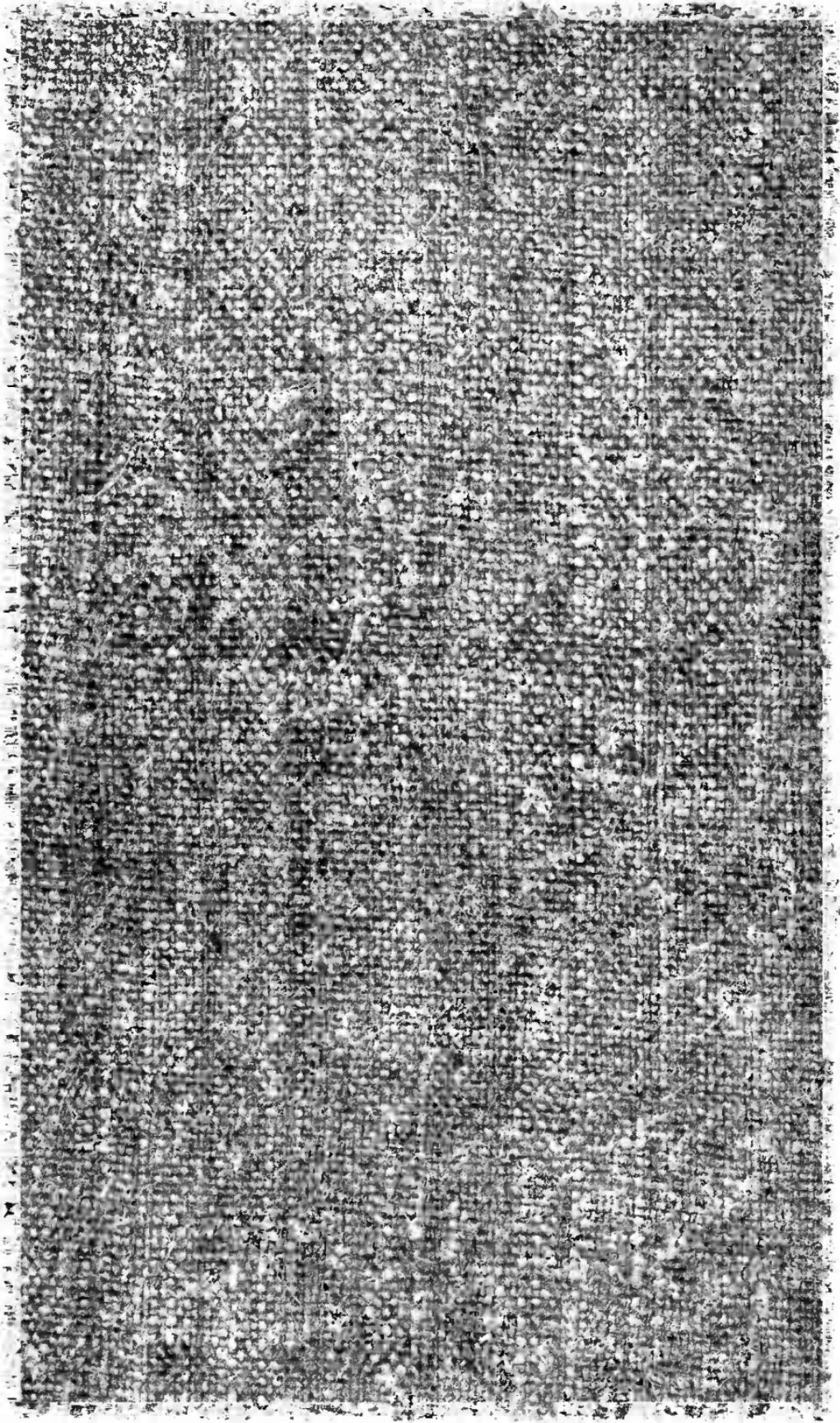
supply circuit. Insert the condensers that keep signal currents in their correct paths, add all special control circuits, then check your enlarged diagram against the original.

**Step 3. Make A Tube Socket Connection Diagram.** Draw an actual-size bottom view of each tube socket in the receiver, showing the terminals and tube prongs in their proper relation to each other. Label the terminals P, K, C<sub>G</sub>, S<sub>G</sub>, S<sub>T</sub>, and H, for plate, cathode, control grid, screen grid, suppressor grid, and heater, respectively; and label the electrodes on your enlarged circuit diagram in the same way. Use either a tube chart or the socket connection diagram of your receiver as a guide.

**Step 4. Identify All Stages On The Chassis.** Identify each stage on the chassis, and mark the function of each stage on your enlarged diagram.

**Step 5. Identify All Parts On The Chassis.** Locate on the chassis each part that is indicated on your enlarged circuit diagram; use the pictorial layout diagram (if you have one) as a guide when necessary, but try to get along without it as much as possible.

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

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 19 How To Find the Defective  
Part with an Ohmmeter  
**RADIO SERVICING METHODS**



# NRI TRAINING PAYS...

Dear Mr. Smith:

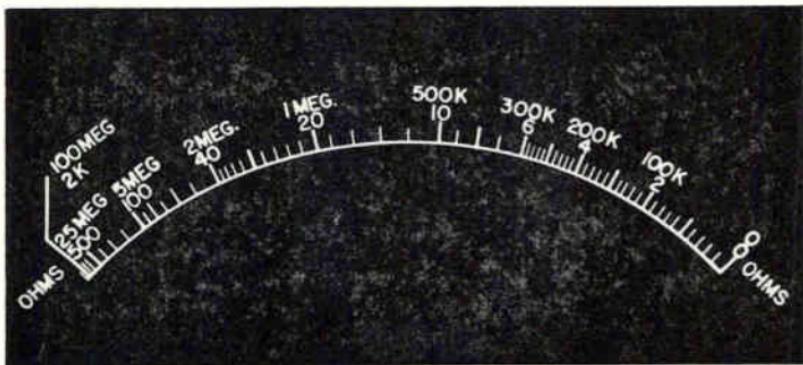
I started to earn money about six months after enrolling and earned about \$150 by the time I graduated. During the past 12 months I have made enough from spare-time Radio work to have paid for the Course several times. I always have 15 or 30 radios on hand to repair. I am convinced your Course is the finest available, and I am proud to be a graduate.

W.W.D., Wisconsin



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



## How To Find the Defective Part with an OHMMETER

**A**S you know, the ohmmeter and the voltmeter are tools that all servicemen use. In earlier RSM Booklets, you learned something of their uses in testing individual parts. Now you are ready to learn how to use these meters to test complete circuits for the purpose of locating defects. Such circuit testing is one very important phase of the professional servicing technique.

Voltmeter testing will be taken up in a later RSM Booklet; in this one, we shall deal entirely with the ohmmeter. Read these Booklets carefully. If you do not yet have a multimeter, be sure to come back to these Booklets and use them as the basis for practice just as soon as you do have the necessary test equipment.

### CONTINUITY TESTING

In earlier RSM Booklets, we have described the ohmmeter as a device for testing individual radio parts. However, it is entirely logical to use the ohmmeter to test a group of parts—that is, a circuit—all at the same time. Then, if the circuit shows continuity and has the proper resistance, you know that the individual parts in the circuit must be all right and need not be tested. Obviously, such a procedure can save a great deal of time.

An added advantage of testing whole circuits at once is that you need not bother tracing or locating individual

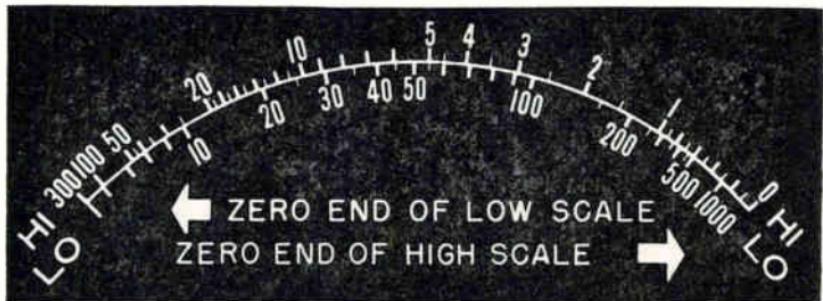
parts in the circuit (unless, of course, your test shows the circuit to be defective). Practically all circuits begin and end at easily recognizable points—tube terminals or power supply terminals, for example. To check the whole circuit, you need only to connect your meter to the two end points of the circuit. This, of course, lets you work much faster than you could if you had to trace out the whole circuit before testing it. The name "reference points" is given by servicemen to the circuit "landmarks" that permit such rapid circuit testing. You will learn more about them as we proceed.

**When To Use an Ohmmeter.** Obviously there are some radio complaints for which ohmmeter tests are not practical. For example, any condition that shows up only when the parts are heated by the passage of relatively heavy currents may not be present when you make ohmmeter tests. Thus, cathode-to-heater leakage in a tube may never be found with an ohmmeter. Sometimes, too, by-pass condensers will break down only when they are subjected to full operating voltages. Since the ohmmeter battery is low in voltage, such condensers may test all right when you check them with an ohmmeter. Finally, there are circuits in which an ohmmeter test is reliable only when you have disconnected some part or section to prevent false readings caused by other parts in parallel. In such circuits, ohmmeter tests are possible, but often inconvenient. We have already discussed some of these possibilities when we described the testing of individual parts.

However, a great many radio troubles involve an open circuit or a short circuit. These are found readily by continuity tests.

**Ohmmeters.** As you have learned, an ohmmeter consists of a meter, a source of voltage, and a variable resistance. These parts are arranged so that the voltage source (usually a battery) forces a current through the meter. The circuit resistance, introduced through the test probes, changes the amount of current flow. The meter scale is calibrated to read resistance values directly.

Remember, there are two general types of ohm-



A combination scale like this is found on ohmmeters that use both series (high-ohm ranges) and shunt (low-ohm ranges) connections. Always be sure you read the proper scale.

meters. The series type reads full-scale when the ohmmeter probes are touched together; thus, zero ohms is at the *right* of the scale. The shunt type reads full-scale when there is infinite resistance between the probes; zero ohms is, therefore, at the *left* of the scale. Since both types of ohmmeter circuits are often included in the same multimeter, always be sure you know how to read the meter scale for the particular range that you intend to use.

## HOW TO MAKE CIRCUIT CONTINUITY TESTS

Circuit continuity testing is basically very simple. There are two general rules that are true in every case, with the exceptions noted:

**Rule 1.** The plate or screen grid of any amplifier tube must show continuity (a d.c. path) back to the most positive point in the circuit, the B+ terminal. Notice that we said *amplifier* tube. The statement does not hold true for rectifiers, diodes, and triodes used as diodes (that is, those with the plate connected to the grid or cathode).

**Rule 2.** Any cathode, control grid, or suppressor grid must show continuity back to the most negative point in the circuit, the B— terminal. There is one exception to this—the cathode of a rectifier tube is connected to B+ instead of to B—.

► To make continuity tests of the circuits in a receiver, apply these rules. For example, you can check the plate circuit of an amplifier tube for continuity simply by

touching one probe of your ohmmeter to the plate terminal of the tube socket, and the other probe to B+. (CAUTION: To prevent damage to the ohmmeter, you must always turn OFF the receiver during continuity tests.) If the ohmmeter gives any reading other than "infinite resistance," you know that there is continuity in the circuit. Remember, you don't have to *read* the meter—just notice whether the needle moves. Since many tube circuits have fairly high resistance, you should always use one of the high-resistance ranges of your meter; you use the low range principally to check low-resistance parts, such as coils.

Similarly, make a continuity check of a control grid circuit by touching one probe to B-, and the other probe to the control grid terminal of the tube socket. An ohmmeter deflection indicates continuity.

Notice that this checking involves the use of what we earlier called "reference points"—the tube electrodes and B+ and B-, in this instance. Naturally, you have to be able to locate these reference points before you can make the tests. The tube electrodes are easy to find. You can readily identify the desired terminal for any tube by referring to the base layout for that tube in a tube manual.

Finding the power supply reference points (B+ and B-) is usually just as easy if you have a schematic diagram of the receiver. That is one reason why schematic diagrams are so helpful in servicing. However, it is generally possible to locate B+ and B-, or equivalent points, even if you do not have a diagram. To show you how this is done, we will now describe how to find continuity reference points in various kinds of receivers, assuming that you have no diagram.

**A.C. Receiver Reference Points.** Fig. 1 shows the power supply circuit most widely used in a.c. receivers. Here, B- is the center tap of the high voltage winding. This terminal is not easy to find, but notice that it connects directly to the chassis. Therefore, all control grids, cathodes (except the rectifier), and suppressor grids must show continuity to the chassis. For example, the control grid of tube VT<sub>1</sub> shows continuity to the chassis

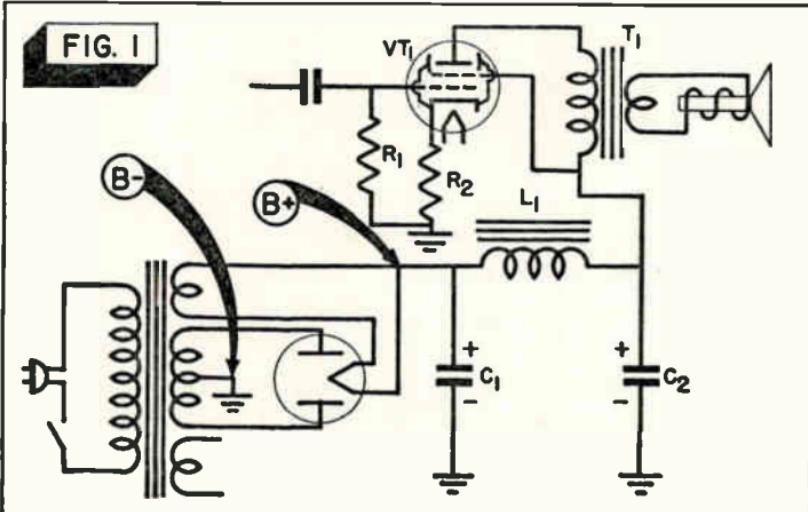
through resistor  $R_1$ , and the cathode connects to the chassis through resistor  $R_2$ .

The most positive point in this circuit ( $B+$ ) is the *cathode of the rectifier tube*. You can easily find the cathode socket terminal with the aid of a tube chart. The positive terminal of condenser  $C_1$  is usually easy to find, and, since it connects to the rectifier cathode, it can also be used as a reference point. Both the plate and the screen of  $VT_1$  should show continuity to the rectifier cathode or to the positive terminal of condenser  $C_1$ , whichever you choose as the  $B+$  reference point. This is also true of all other amplifier tubes in the set.

► Notice that the d.c. path between the plate and  $B+$  is not the same as the d.c. path between the screen and  $B+$ . The plate circuit is completed through the primary of transformer  $T_1$ , whereas the screen circuit does not include this primary. Therefore, if you were to find continuity between  $B+$  and the screen of  $VT_1$ , but not between  $B+$  and the *plate* of  $VT_1$ , you would know that the primary of transformer  $T_1$  was open. That is, you would know this to be true if you had a diagram of the set; without one, you would have to check to find the open through the plate circuit. This is one more illustration of how a diagram can speed up servicing.

► Fig. 2 shows another power supply circuit often found in a.c. receivers. Here the filter choke  $L_1$  is placed in the *negative* side of the circuit.

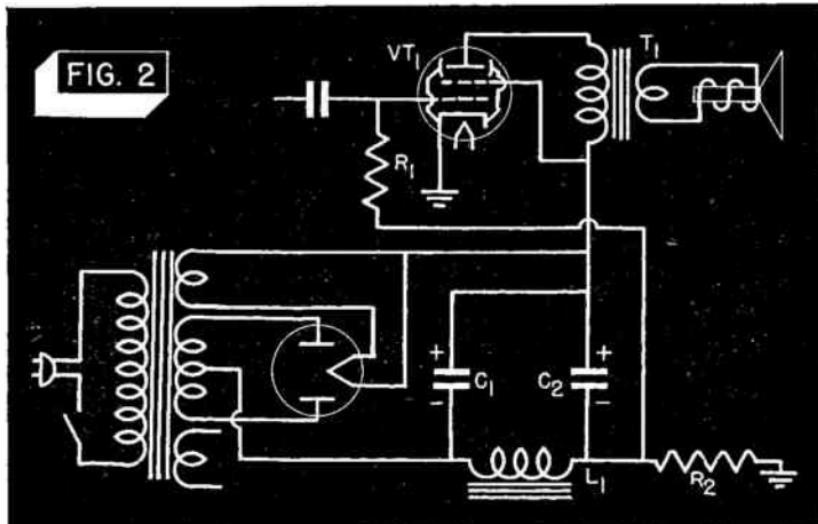
FIG. 1



The cathode of the rectifier remains the common reference point for B+. Both positive leads of the electrolytic filter condensers connect directly to this point, as does the screen of tube  $VT_1$ . Therefore, any of these easily identified points can be used as the B+ reference point. The plate of  $VT_1$  and the plates of all other *amplifier* tubes should show continuity back to B+; failure to obtain continuity indicates that an open exists in the circuit, just as in Fig. 1.

The B— terminal is not connected *directly* to the chassis of the receiver in this example. However, as in every receiver using a power transformer and a rectifier tube, B— is the center tap on the high-voltage winding of the power transformer. This terminal connects to the chassis, through  $L_1$  and  $R_2$ , but you must establish continuity between these points before you can use the chassis as the B— reference terminal. To do this, check from either of the *rectifier plate* socket terminals to the chassis. If continuity is established, the chassis may then be used as the B— reference point. The control grid should show continuity (through resistors  $R_1$  and  $R_2$ ) to the chassis. The cathode of  $VT_1$  is already connected to the chassis, but you can check from the cathode socket terminal to the chassis to make sure that the connection has not opened up.

► If you do not have a diagram to guide you in selecting B+ and B— reference points in an a.c. receiver,



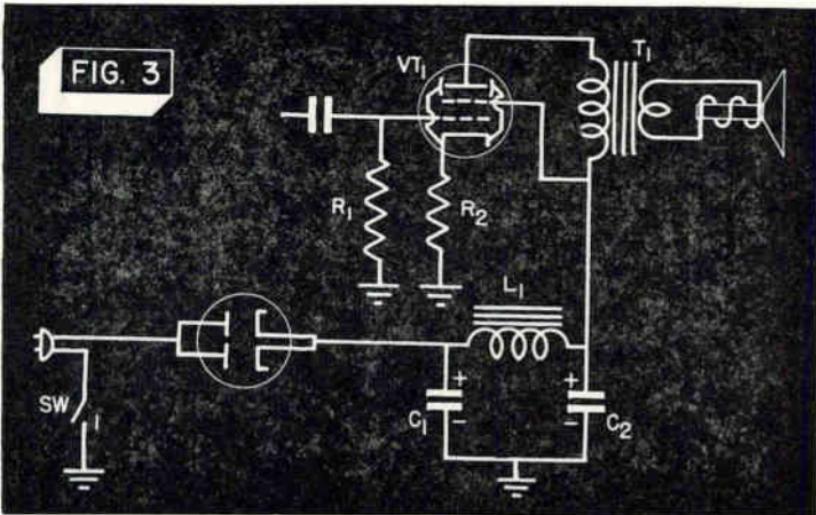
usually you will do best to use the rectifier cathode as B+ and the chassis as B-. However, as we just said, you must make sure that the rectifier plate is connected to the chassis before you can use the chassis as B-.

**A.C.-D.C. Receiver Reference Points.** In the typical a.c.-d.c. receiver shown in Fig. 3, the common reference point for B+ is the cathode of the rectifier tube. The positive terminal of the input filter condenser  $C_1$  could be used also, but it is usually easier to locate the cathode socket terminal.

The negative leads of the electrolytic filter condensers can be used as B- reference points. Since the diagram shows that these leads go to a "ground" symbol, you might assume that the chassis can also be used as a B- reference point. However, in a.c.-d.c. receivers, ground connections are not necessarily made to the chassis; often, in fact, the chassis is not an electrical part of the circuit. The points shown as being grounded may, instead, be connected together with hook-up wire.

However, the easily located on-off switch is always in the negative side of the circuit, so it may be used as the B- reference point. Turn ON the switch (naturally, the set must be UNPLUGGED from the power outlet!), so that both switch terminals will be connected to ground. Now you can use either switch terminal as your B- reference point. If one of the switch terminals shows continuity to the chassis, then you can also use

FIG. 3



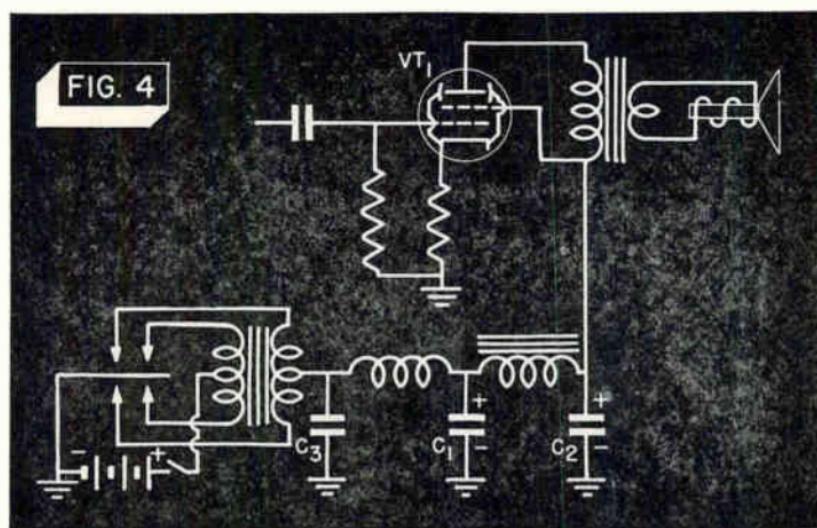
the chassis as the B— reference point.

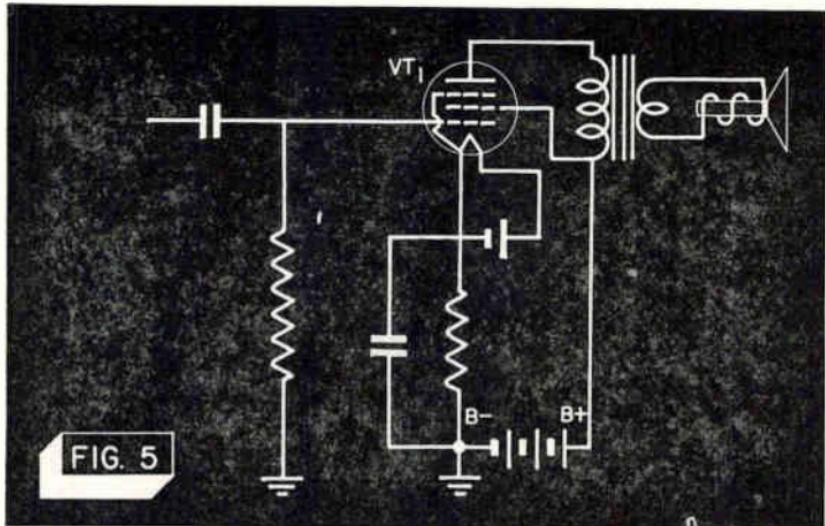
**Vibrator-Powered Receiver Reference Points.** Two kinds of vibrator power supplies may be found in auto radios and in certain farm sets. One uses a rectifier tube; this type can be checked in exactly the same way as an a.c. receiver. However, the other kind, shown in Fig. 4, does not use a rectifier tube. (This is known as a synchronous vibrator.).

In Fig. 4, B+ is the *center tap* on the high-voltage winding of the power transformer. This is exactly *opposite* to the condition found in an a.c. receiver, where the center tap of the power transformer high-voltage winding is always B—. The center tap is not easy to locate, so a serviceman would generally use the positive terminal of filter condenser  $C_1$  as his B+ reference. The B— terminal is the chassis.

It is best to remove the vibrator before making continuity checks, because one of the outside leads of the high-voltage winding may be grounded through a vibrator contact to the chassis. Such a connection between B+ and B— might cause puzzling test results. Many vibrators plug in like tubes and can be removed easily. However, others must be disconnected by being unsoldered. It is usually easiest to unsolder the connection to the center tap on the secondary of the power transformer in the latter case. Then, of course, the positive terminal of  $C_1$  must be used as the B+ reference point.

FIG. 4





**Battery Receiver Reference Points.** Fig. 5 shows the power output stage of a typical battery receiver. Here the B+ and B— connections are the battery cable leads. Remember to *disconnect* the batteries (not just to snap off the set) before making tests; otherwise, you may ruin your meter.

### CHECKING A STAGE

To summarize what you have learned about continuity checking, let's see how you can locate an open with your ohmmeter. Let's suppose that you have a receiver with a stage in which an open exists.

First, place the chassis (with the loudspeaker connected to it) on the workbench. Turn the chassis upside down or on its side so that the parts and the tube socket of the defective stage can be easily identified and traced.

Locate both B+ and the plate prong of the tube in the defective stage. Place the ohmmeter probes on these two points.\* You should get a reading. If the stage is not resistance-coupled, the reading should not be more than 10,000 ohms, but it may be as low as 1 or 2 ohms. In a resistance-coupled stage, the reading may be as much as 500,000 ohms.

► Suppose you do not get any reading—the meter indi-

\*When using any ohmmeter or continuity tester, you must detach the power cord of the set from the line, or, if the set uses batteries, you must disconnect the cable from the batteries. THIS IS IMPORTANT.

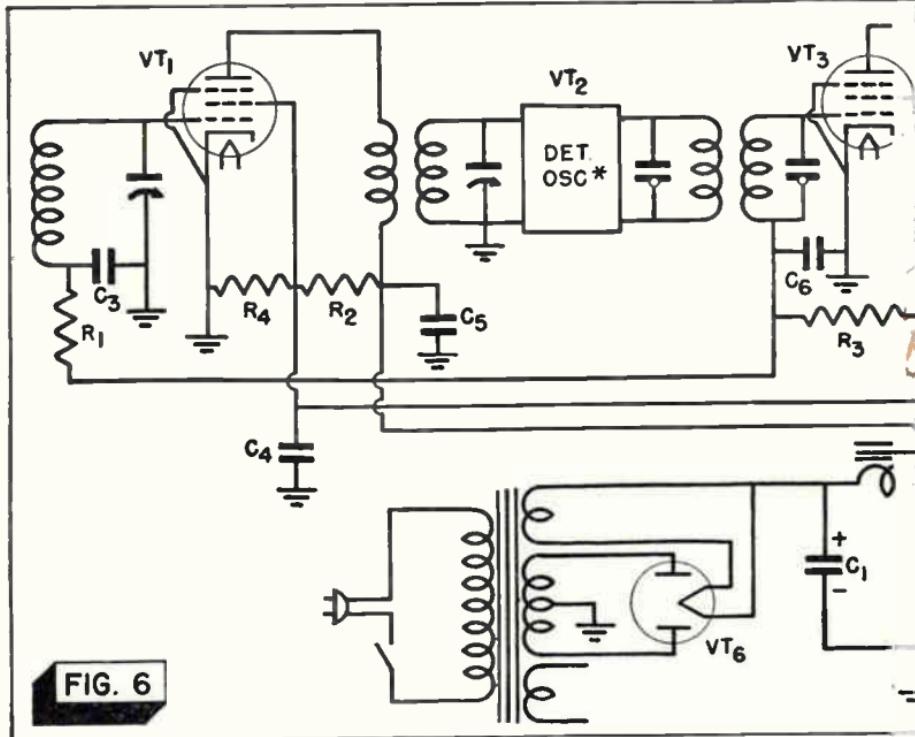
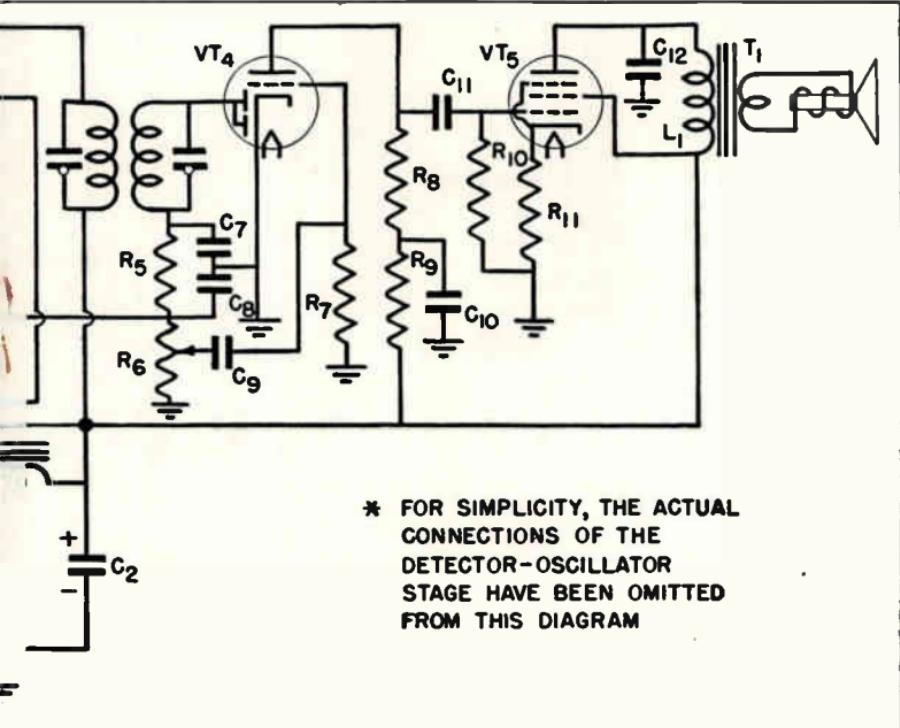


FIG. 6

cates infinite resistance. You know then that the open is in the plate circuit. Find the wire that is connected to the plate socket terminal. The other end of this wire will be connected to the tube plate load, which may be a resistor, a transformer, or a choke. Whatever the load is, place the ohmmeter probes directly across it. If you get no reading, you have found the defective part.

If you get a reading across the plate load, follow the plate supply circuit to the next part. Check that part in the same way. If you find that it is not defective, continue checking each part until you have found the defective one.

If you prefer, you can check the parts in the plate circuit by keeping one ohmmeter probe on B+ and touching the other probe to each parts junction in the plate circuit in turn, starting from the tube. *Before* you reach the defective part, your meter will indicate infinite resistance; *after you pass it*, the meter will show continuity. You can use the same method to check other electrode circuits, working from the electrode toward the reference point.



► If the plate and screen grid circuits test O.K., the next check should be for continuity between B— and the control and suppressor grids. Except in resistance-coupled circuits and a.v.c.-controlled stages, the resistance will be rather low. If continuity is not found, the individual parts must be checked.

If you have not yet found the defective part, check for continuity between B— and the cathode or filament. If an open exists in the stage, it must be in this circuit, since you have eliminated all others.

### TESTS FOR SHORT CIRCUITS

An electrode circuit can show *continuity* and yet be defective if there is a short-circuit path across the circuit. Such a low (or zero) resistance path can be just as effective as an open in preventing voltage from being applied to the tube electrodes. Let's see what may happen, and how the short can be found with an ohmmeter. Fig. 6 will serve as our example.

Suppose that a short exists in screen by-pass condenser  $C_4$ . This will connect the screen grids of tubes

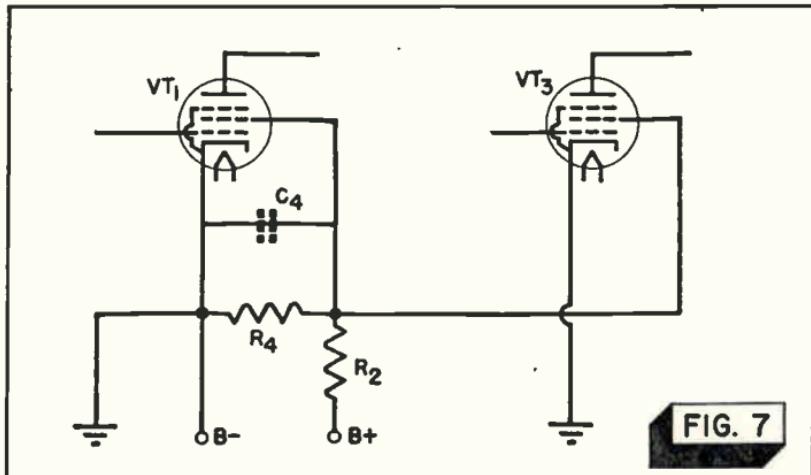


FIG. 7

$VT_1$  and  $VT_3$  to  $B^-$  (or to the chassis of the receiver).

The circuit, for all practical purposes, then will be like the one shown in Fig. 7. Here the screen is connected to  $B^-$  through shorted condenser  $C_4$  (indicated by dotted lines). This connects screen resistor  $R_2$  directly across the  $B$  supply, so the full  $B$  supply voltage will be applied across it. If the wattage rating of resistor  $R_2$  is not high enough for the current that will flow, the resistor will burn out. If it does burn out, there will be no continuity between  $B^+$  and the screen socket terminals of  $VT_1$  and  $VT_3$ . If the resistor does *not* burn out, there will be no voltage between the screens and  $B^-$ , because, with  $C_4$  shorted, the screens and  $B^-$  are connected directly together, and no potential difference can exist between them.

You can find out if a short exists by measuring the resistance between the screen socket terminals and  $B^-$ . With  $C_4$  broken down as shown in Fig. 7, the resistance will be nearly zero, whereas the screen-to-ground resistance should equal that of bleeder resistor  $R_4$  (usually 10,000 to 50,000 ohms).

In a case of this sort, if you find no continuity between the screen socket terminal and  $B^+$ , because  $R_2$  has burned out, *always check condenser  $C_4$  for a short*. If you replace  $R_2$  while  $C_4$  is shorted, the new replacement resistor will probably burn out also.

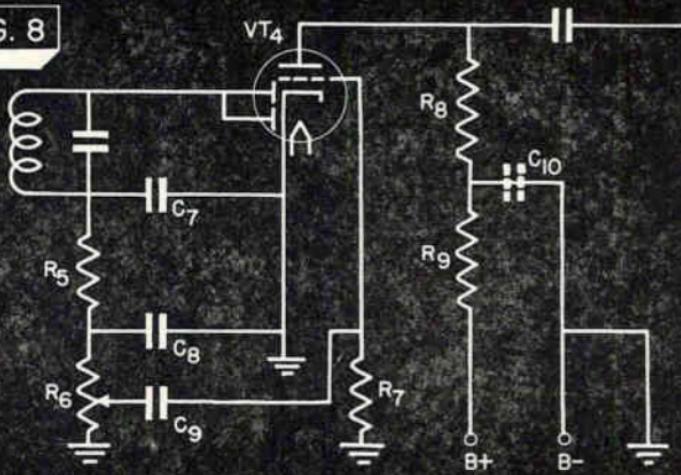
Now suppose a short circuit occurs in  $C_{10}$  (in the plate supply circuit of  $VT_4$  in Fig. 6). This will place  $R_9$

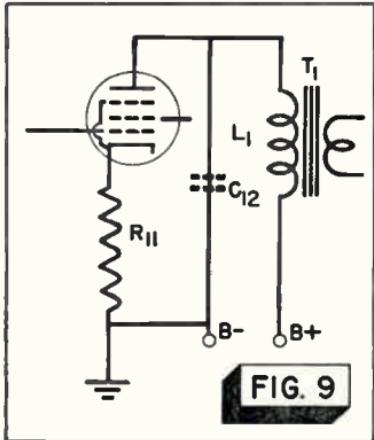
directly across the B supply, as shown in Fig. 8. All of the source voltage will be dropped across  $R_9$ , and none will be applied to the plate of  $VT_4$ . Unless  $R_9$  burns out, continuity will be found between the plate socket terminal  $VT_4$  and B+. However, a check from the plate socket terminal to the chassis may show a resistance reading lower than normal. That is, the reading from the plate of  $VT_4$  to the chassis will be the value of  $R_8$ , whereas the lowest expected reading should be greater than  $R_8$  and  $R_9$  together.

If  $R_8$  has a high value, you may not suspect your readings unless you know the exact resistor values; this is a case in which a diagram giving parts values may save you time. (Also, a check from B+ to the chassis may show a lower-than-normal resistance reading. The reading will be equal to the value of  $R_9$ , although it should be much higher.) In any case, a check from the junction of  $R_9$  and  $R_8$  to the chassis will show a zero resistance if condenser  $C_{10}$  is broken down. If  $R_9$  is burned out, it must not be replaced until an ohmmeter test of  $C_{10}$  has been made.

If  $C_{12}$  in Fig 6 is shorted, the plate of tube  $VT_5$  is effectively connected to B-, and no voltage will be applied to the plate of the tube. The primary  $L_1$  of output transformer  $T_1$  will be connected across the B supply, as shown in Fig. 9, and all the supply voltage will be applied directly across  $L_1$ . This will cause  $L_1$  to over-

FIG. 8





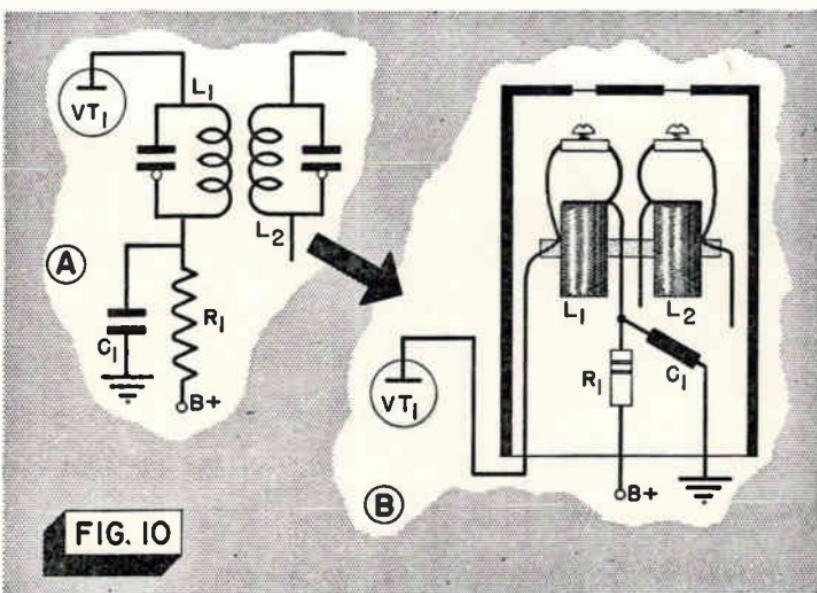
heat and perhaps to burn out. The plate by-pass condenser on the power output tube must be checked before an output transformer with an open primary winding is replaced.

Another short-circuit condition that is frequently found is shown in Fig. 10A. Here, condenser  $C_1$  and resistor  $R_1$  form a filter. If condenser  $C_1$  shorts, resistor  $R_1$

$R_1$  will almost always burn out.

The filter  $R_1-C_1$  is often placed inside the i.f. transformer shield can, as shown in Fig. 10B. If continuity is not obtained from the plate socket terminal of  $VT_1$  to  $B+$ , your ohmmeter can be used to check from the plate socket terminal to the chassis. A low resistance reading will show that  $C_1$  is shorted.

On the other hand, if a check from the plate socket terminal of  $VT_1$  to the chassis does not show a low resistance reading, then  $C_1$  is not shorted. In this case,  $L_1$  rather than  $R_1$  is probably open, although you can be sure of this condition only if you remove the shield can



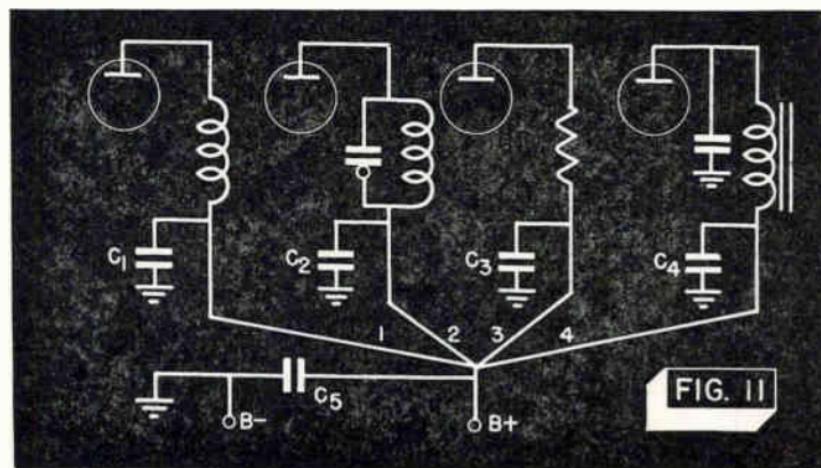
and check both  $L_1$  and  $R_1$  for continuity.

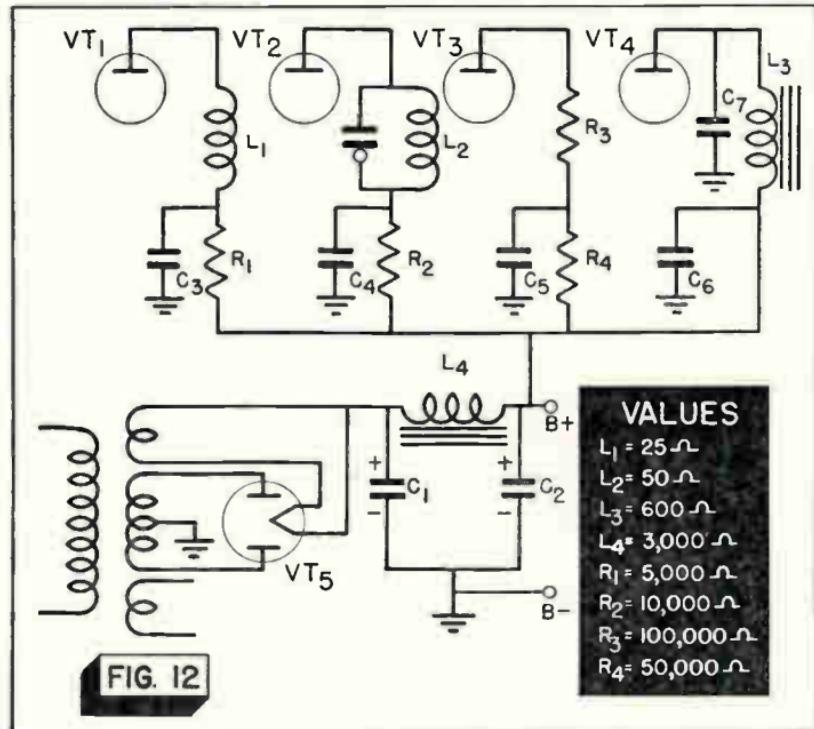
Remember this rule for testing for *short circuits*: The ohmmeter is *not* placed between a tube element and its *proper* reference point; instead, it is used *across* the reference points. Thus, a shorts test in a power supply is made from  $B+$  to  $B-$ , and a shorts test for a plate or screen grid is made to  $B-$  instead of to  $B+$ . If everything is normal (*no shorts*), the shorts test will show the resistance of any bleeder used, or will show the leakage of the electrolytic condensers. Either of these readings will be far higher than a short-circuit reading.

### LOCATING SHORT CIRCUITS IN PARALLEL CIRCUITS

A parallel by-pass arrangement is shown in Fig. 11. Here you may find that a short exists between  $B+$  and  $B-$ . (By a "short," we really mean a low resistance—even a shorted condenser usually will have some resistance, although this will seldom be as much as 100 ohms, and often will be almost zero ohms.) Any of the five condensers shown might be broken down, and the problem is to find the defective condenser.

You can do this by unsoldering leads 1, 2, 3, and 4 at the point where they are joined to  $B+$ . Now check from  $B+$  to  $B-$ . If you still get a short-circuit resistance reading,  $C_5$  is probably defective, since it is still in the circuit. Disconnect this condenser and check it by itself with the ohmmeter, replacing it if it is bad.





If the short between B+ and B- is not present with leads 1, 2, 3, and 4 disconnected, you know that the short to B- is in one of these leads or in a part connected to one of these leads. Therefore, check in turn between each lead and B-. The lead giving the short-circuit reading contains the defect. First, locate the condenser in the circuit that has the short, then disconnect and test it. If the condenser is defective, install another. (If the condenser is all right, faulty insulation on the lead may be allowing the bare wire to touch the chassis.)

► The B supply leads may not always come to a common point, such as in Fig. 11. Actually the circuit may appear as shown in Fig. 12. Here, you can see, there is generally a resistance between each by-pass condenser and B+. Even if one of the by-pass condensers shorts completely, you will not find a zero resistance when you check between B+ and B-; instead, you will get a reading approximately equal to the value of the resistor that is between B+ and the defective condenser. For example, if C<sub>3</sub> were to short, an ohmmeter check between B+ and B- would give you a reading of about 5000 ohms

(approximately the value of  $R_1$ ), for  $R_1$  would then be connected directly between B+ and the chassis (B-) through  $C_3$ .

This fact makes it possible for you to decide which condenser is probably defective from both your ohmmeter reading and the diagram. If a check between B+ and B- in the circuit of Fig. 12 gives you a 5000-ohm reading, you should suspect that  $C_3$  is shorted, as we just said; if the reading is about 10,000 ohms (the value of  $R_2$ ), you should suspect  $C_4$ ; and if the reading is 50,000 ohms (the value of  $R_4$ ), you should suspect  $C_5$ . In other words, just look at the diagram and see which plate circuit resistor has about the resistance you have measured between B+ and B-; the by-pass condenser connected between that resistor and the chassis is probably defective.

If the plate load connected between the plate and the suspected by-pass condenser has a fairly low resistance, you can confirm your suspicions by measuring the resistance between the plate and the chassis. This resistance should, of course, be very high if the by-pass condenser is not defective. If it is defective, however, you will get a reading about equal to the resistance of the load between the plate and the condenser. Thus, if  $C_3$  is shorted, you will measure only about 25 ohms (the resistance of  $L_1$ ) if you check between the plate of  $VT_1$  and the chassis; if  $C_4$  is bad, the resistance between the plate of  $VT_2$  and the chassis will be only about 50 ohms (the value of  $L_2$ ). However, it would not be much use to make a similar check between the plate of  $VT_3$  and the chassis, because the value of  $R_3$  is so high that your measurement would not show definitely whether or not  $C_5$  was shorted. In this case, it would be best to locate  $C_5$  and to test it directly. For that matter, you should always make a direct check of a suspected condenser before condemning it.

If a very low resistance between B+ and B- is measured, you cannot tell whether it is  $C_6$ ,  $C_2$ , or  $C_7$  that is shorted until you disconnect each one. (If the resistance measures about 600 ohms—the resistance of  $L_8$ —in this test, then  $C_7$  is probably faulty. Check for this by measuring from the plate of  $VT_4$  to the chassis. A zero or

very low resistance reading clearly indicates that  $C_7$  is the offender.)

## INTERPRETING OHMMETER READINGS

As you have just seen, the resistance *value* is often valuable information in making shorts tests. Measuring resistance, rather than just noticing whether the meter needle moves, is sometimes a good idea also when you are making the circuit continuity tests described earlier.

Suppose, for example, you check the resistance between the cathode of the rectifier and the plate of the first tube in Fig. 12. This circuit contains  $L_1$ ,  $R_1$ , and  $L_4$ , and should have a total resistance of about 8000 ohms. If your measurement shows a resistance much higher than this—say, 15,000 ohms—you might suspect that  $R_1$  had changed in value. On the other hand, a low measurement—5000 ohms or less—would indicate that either  $R_1$  or  $L_4$  was shorted. Thus, measuring the resistance will give you more information than a simple continuity check would give.

► Notice, however, that measuring the resistance will not tell you whether or not  $L_1$  is shorted, for its resistance is so low that it could be shorted completely without affecting the total circuit resistance noticeably. In other words, as far as  $L_1$  is concerned, an ohmmeter test of the circuit can show only whether or not continuity exists. To find out if  $L_1$  is shorted, you must measure its resistance directly. This is always true of circuits containing high-resistance and low-resistance parts in series.

► There are certain precautions you must take to be sure that your resistance measurements show actual circuit conditions. For example, a measurement between  $B+$  and  $B-$  in the circuit in Fig. 12 should give a reading of over 100,000 ohms, if no defects exist. This is the normal leakage value of electrolytic condensers  $C_1$  and  $C_2$ , in parallel. These condensers, since they are electrolytics, have polarities (which are marked on the diagram). As you learned in an earlier Booklet, your resistance measurement will be accurate only if your ohmmeter is connected so that the lead that goes to the positive side of the built-in ohmmeter battery connects to

the positive side of the condenser. Therefore, if you are not absolutely sure of your ohmmeter lead polarity, you should always make *two* measurements of the resistance of electrolytics, interchanging your ohmmeter leads in between these measurements. Accept the *higher* resistance reading as the correct one.

► There is another factor that you should keep in mind. As you know, ohmmeter tests are always made with the receiver turned off. However, if you are checking between a grid and the chassis in a receiver that has only recently been disconnected from the power lines, you may find a very low resistance reading that gradually increases in value. This can happen when the ohmmeter battery makes the grid positive while the cathode of the tube is still warm enough to emit electrons; electrons flow from the cathode to the grid and through the ohmmeter. Reversing the ohmmeter test probes will make the grid negative and prevent this flow of current. If you prefer, you can wait until the cathode cools off or remove the tube from its socket.

► One final suggestion: whenever possible, use a diagram when you are making ohmmeter tests. You can work far more intelligently—and, therefore faster—when you *know* exactly what you are measuring and what you should expect to find. This is information that a schematic diagram will give you.

► Our descriptions of tests have been made with the assumption that you were working under the chassis. However, you can check the circuits (not parts) without removing the chassis from the cabinet; simply remove the tubes and insert your ohmmeter probes in the proper socket terminals. This procedure, which will enable you to discover what *circuit* is faulty, is useful if the cus-

### BENCH HINTS

You can make yourself a handy trouble light for looking into the tight spaces in a radio by soldering a pair of flexible wires to an ordinary one-cell flashlight bulb. Solder the other ends of the wires to a flashlight cell and a switch. A small dentist's mirror will also be helpful for examining the hidden sections of a set.

tomer demands an estimate before the chassis is removed from the cabinet.

## NRI PRACTICAL TRAINING PLAN

You will need an ohmmeter and a receiver to carry out the following practical training steps. If you do not yet have them, study the procedures carefully now, and follow them when you have secured the necessary equipment.

**Step 1. Make electrode continuity tests.** Make a continuity test of each electrode circuit with an ohmmeter by connecting one ohmmeter probe to a tube socket terminal and by placing the other probe on the correct power supply terminal. Referring to the circuit diagram each time, estimate what the resistance should be, then compare your estimate with the observed value. When discrepancies occur, try to figure out the reason; remember that variations of up to 20% in resistor values are often permitted in receivers, and remember that, when parts are in parallel, their combined resistance must be considered.

**Step 2. Check electrode supply circuits part by part with an ohmmeter.** Repeat the electrode continuity test described in Step 1, but this time, move the probe at the tube along the circuit toward the other probe, part by part, and observe the ohmmeter reading for each step. Check the reading each time against the circuit diagram.

**Step 3. Check all resistors with an ohmmeter.** Check the value of each resistor on the chassis with an ohmmeter, and record the measured value either on your enlarged circuit diagram (described in an earlier RSM Booklet) or on a separate chart. When a resistor cannot be checked because it is shunted by another part, unsolder one lead of the resistor, make a direct measurement, then resolder it.

**Step 4. Check all coils with an ohmmeter.** Check the continuity of each winding on each coil in the receiver, using the lowest range of your ohmmeter. Look through your service information for coil connection diagrams; if these are not given, use your ohmmeter to locate the terminals for each winding. Locate the terminals of power transformer windings in the same way, and

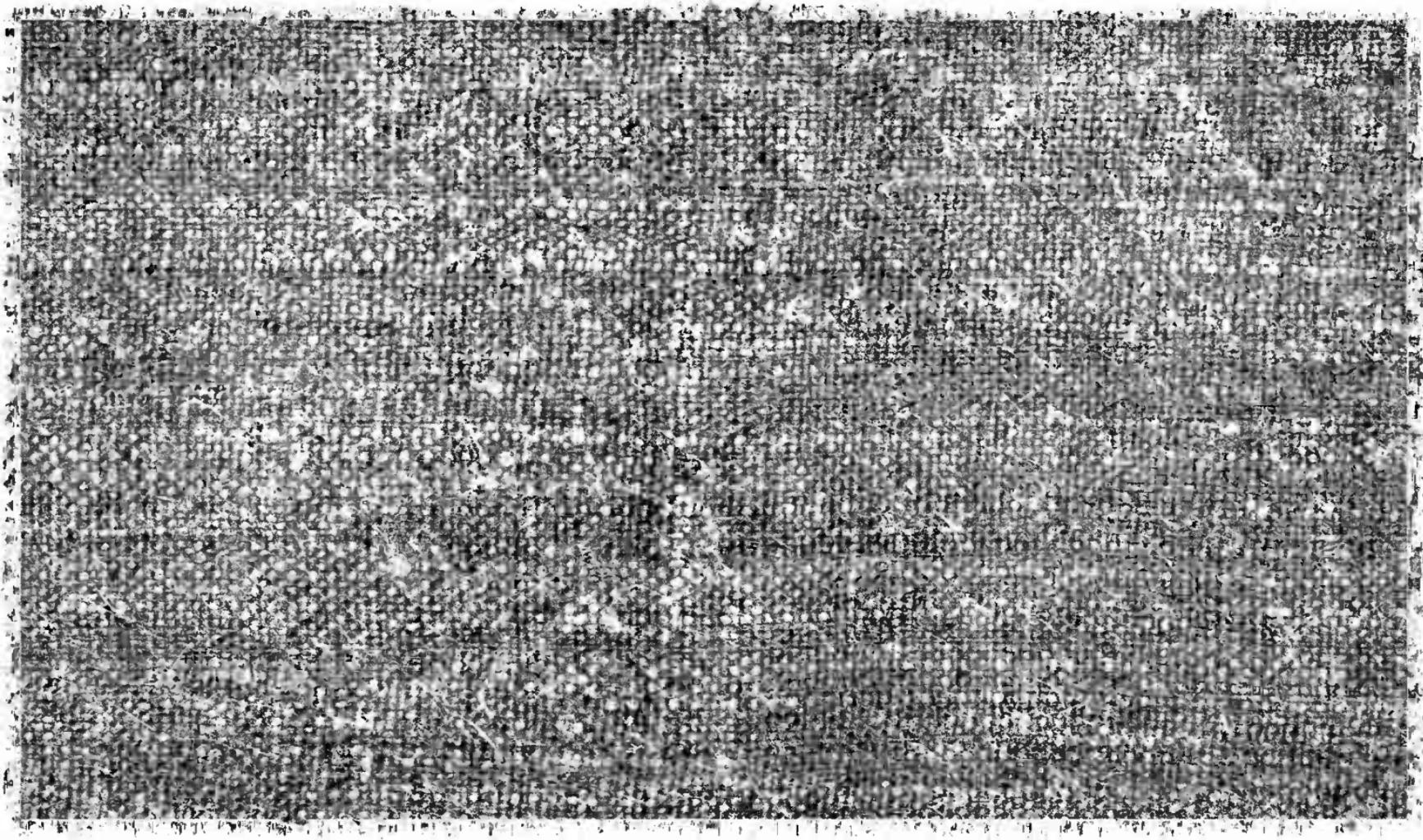
measure the resistance of each winding. Before checking the filament winding, remove all tubes. If a center-tap filament resistor is used, unsolder one lead of it temporarily. Record all readings for future reference, after comparing them with the d.c. resistance values specified on the circuit diagram.

**Step 5.** *Check all condensers with an ohmmeter.* Connect your ohmmeter across each condenser in the receiver, using the highest ohmmeter range, and note the amount of the initial flicker of the ohmmeter needle. Unsolder one lead when a condenser is shunted by some part; be sure to resolder the lead after the test. For electrolytic condensers, take one reading, then reverse the ohmmeter probe and take another reading; the higher resistance value will be a true indication of the condition of the condenser. Record both values.

**Step 6.** *Test for short circuits.* Follow the suggestions given earlier in this RSM Booklet, and make tests for short circuits by testing between B+ and B-. The exact readings you get in each instance will depend upon the kind of circuits, whether or not a bleeder resistor is used, the condition of the electrolytic condensers, and the polarity of your ohmmeter test probes. Record all readings for future reference.

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

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 20 How To Find the Defective  
Part with a Voltmeter

RADIO SERVICING METHODS



# NRI TRAINING

# Pays . . .

Dear Mr. Smith:

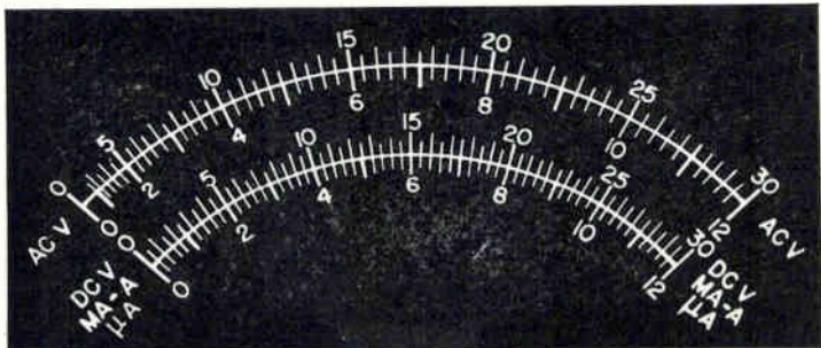
I for one surely endorse your Course of study. It covers Radio and Electronics with an exceptional degree of interest and profit. It prepares one for a profession of which he will not be ashamed. Persons so trained need not fear depression times. I can recommend your Course of study to any industrious person.

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**NATIONAL RADIO INSTITUTE  
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## How To Find the Defective Part with a VOLTmeter

LIKE the ohmmeter, the voltmeter is one of the basic radio servicing instruments. The professional serviceman uses both, for each can make tests that the other cannot. In this RSM Booklet, you will learn how a voltmeter can be used by itself and with an ohmmeter to locate defective *circuits* and *parts*. (Locating defective *stages* with a voltmeter will be taken up in a later Booklet.) Only the standard voltmeter found in most multimeters will be considered; the vacuum-tube voltmeter will be treated elsewhere.

**Voltmeter Characteristics.** As you know, a voltmeter is a milliammeter in series with a fixed resistor of known value. When this combination is connected across a voltage source, a current flows through the meter, causing a deflection. Since this current depends on the value of the source voltage and on the resistance, we can determine the source voltage by Ohm's Law ( $E = I \times R$ ). Therefore, it is possible to mark the meter scale in terms of voltage instead of in current units.

In fact, that is basically how all voltmeters are made. Each also is usually equipped with some means of changing the value of the resistance (called the "multiplier resistance") in series with the meter; this permits the voltmeter to have several ranges.

Voltmeters are rated by their sensitivities as well as by their ranges—the smaller the current necessary to

cause a certain meter deflection, the more sensitive the meter. Sensitivity is commonly expressed by the term "ohms-per-volt." The ohms-per-volt rating of a meter can be determined by dividing the total multiplier-meter resistance by the voltage range. Thus, if a meter has a 10-volt range and a total resistance of 10,000 ohms, its ohms-per-volt rating is 10,000 divided by 10, or 1000 ohms-per-volt. The higher the ohms-per-volt rating, the greater the meter sensitivity.

The meters used in the early days of radio required large currents to give readable deflections. Very low sensitivities, such as 60 to 200 ohms-per-volt, were common. Today, however, practically all servicing instruments are rated somewhere between 1000 ohms-per-volt and 25,000 ohms-per-volt.

► To show why meter sensitivity is important, let's suppose we have a circuit like the one shown in Fig. 1. With 200 volts applied, a current of 1 ma. will flow, and the voltage drops across the resistors will have the values shown. Now let's suppose we connect a voltmeter across  $R_2$ , as shown in Fig. 2. Will we read 150 volts?

No—for now the resistance of the voltmeter is in parallel with  $R_2$ , and the combination has a total resistance less than the value of  $R_2$ . Therefore, the circuit voltage will divide differently—more voltage will be across  $R_1$  than is shown in Fig. 1.

► Let's suppose we have three voltmeters with 200-volt ranges, one having a sensitivity of 150 ohms-per-volt, another 1000 ohms-per-volt, and the third 20,000 ohms-

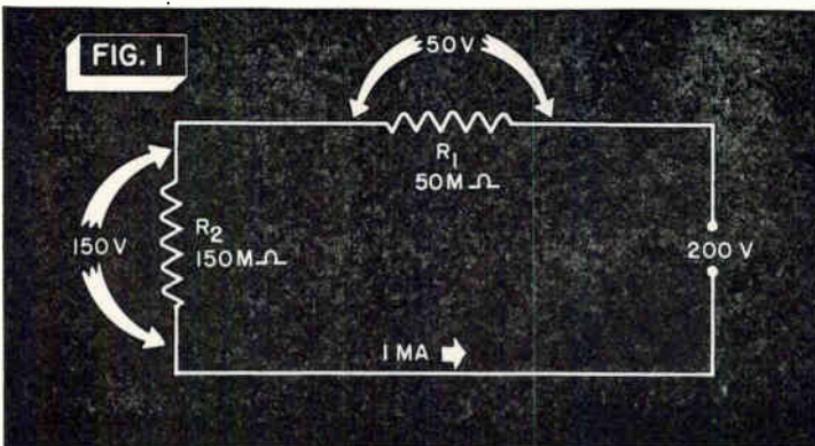
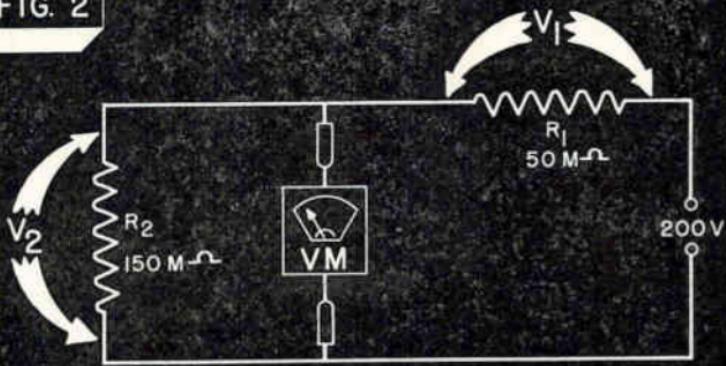


FIG. 2



per-volt. Table 1 shows what will happen in each case when we make the measurement shown in Fig. 2.

The total resistance of the 150 ohm-per-volt meter is 30,000 ohms. When this is connected in parallel with  $R_2$ , the parallel combination will have a total resistance of about 25,000 ohms. The voltage will divide in the ratio of the resistance of this parallel combination to the total resistance in the circuit. Therefore,  $V_2$ , as indicated by the voltmeter, will be about 67 volts, and there will be 133 volts across  $R_1$ .

Now let's repeat the same measurement with the 1000

TABLE I

METER OHMS/VOLT	150	1000	20,000
TOTAL METER RESISTANCE FOR 200 V RANGE (OHMS)	30,000	200,000	4,000,000
COMBINED METER- $R_2$ RESISTANCE (OHMS)	25,000	86,000 (APPROX)	144,500 (APPROX.)
$V_2$ (VOLTS)	67	127	148
$V_1$ (VOLTS)	133	73	52
TOTAL I (MA.)	2.66	1.47	1.0+

ohm-per-volt meter. This meter's resistance is 200,000 ohms, which, in parallel with  $R_2$ , makes a combined total of approximately 86,000 ohms. Now the  $V_2$  voltage will be about 127 volts, and the voltage across  $R_1$  will be 73 volts.

The 20,000 ohm-per-volt meter has a total resistance of 4,000,000 ohms. When it is connected in parallel with  $R_2$ , the  $V_2$  voltage will be 148 volts, and 52 volts will be found across  $R_1$ .

From this, you can see that connecting any meter across part of a circuit changes the circuit conditions, with the result that the voltage indicated by the meter is lower than the voltage that appears across that part when the meter is not present. However, a high-resistance meter has less effect than a low-resistance meter, and so gives a reading closer to the voltage that will actually be present when the meter has been removed. Therefore, when you want to learn fairly accurately what the normal voltages in a circuit are, use a high-sensitivity voltmeter if the circuit contains high resistance. (If the circuit resistances are low, any meter will do.)

► This does not mean that the readings obtained in a high-resistance circuit with a 1000 ohm-per-volt meter, for example, are useless. They may be perfectly satisfactory as long as you realize that the meter affects the readings. When set manufacturers give voltage readings in their service information, they usually specify the sensitivity and range of the meter used. If you use a different sensitivity or a widely different range, don't be alarmed by even considerable differences between the listed readings and those you obtain, as long as your readings are reasonable. For that matter, most difficulties that occur in radio receivers upset the voltages *so radically* that you can easily tell when the reading is abnormal.

Now let's see how to use a voltmeter in servicing.

## HOW TO MEASURE SUPPLY VOLTAGES

Since the electrode voltages applied to the *amplifier tubes* are always d.c. (except for the filament voltage), we shall devote most of this RSM Booklet to the problem

of making d.c. voltage measurements.

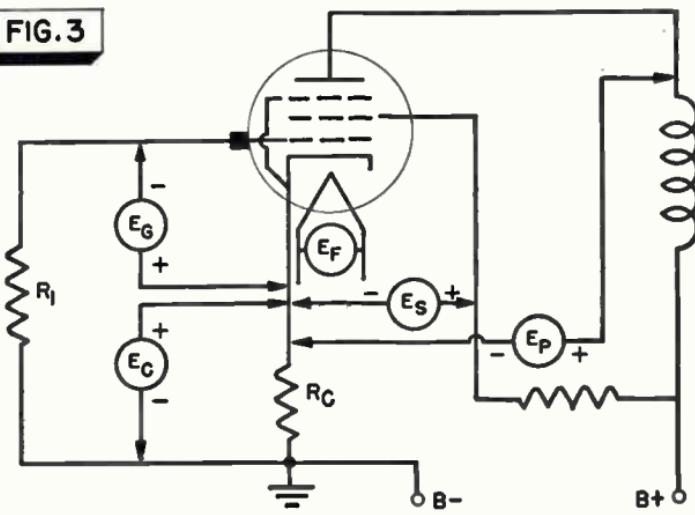
There are two very important rules to remember when you are using a d.c. voltmeter:

1. The voltmeter will read up-scale only when current flows through it in the proper direction. Therefore, all meters have colored test probes. It is standard practice to apply the *red* test probe to the positive side of the circuit and the *black* probe to the negative side. Should your meter read down-scale when you connect it, merely interchange the test probes.

2. If you connect the voltmeter between points where the voltage is much higher than the range of the instrument, you will bend the meter pointer (at least) and may even burn out the meter coil. It is easy to avoid this—always start with a very high voltage range first, and switch to lower ranges only after you are sure that the lower range can handle the voltage.

**Where To Put the Test Probes.** As you know, voltage is measured between two points that are different in potential. Therefore, the receiver must be turned on, and the test probes must be touched to the two points between which you wish to measure. The logical point of reference for the negative side of the circuit of an amplifier tube is the cathode. As shown in Fig. 3, connecting the voltmeter between the cathode and any other element of the tube will indicate the supply volt-

FIG. 3



age for that element. (The filament is an exception in this case—we will discuss filament voltage measurements when we take up the a.c. voltmeter.) Thus, meter connection  $E_g$  measures the grid bias voltage (the voltage between the control grid and the cathode), and meter connection  $E_c$  measures the cathode voltage (the voltage between the cathode and B—). Incidentally, these may be very nearly the same if grid resistor  $R_1$  has a low value, and the voltmeter has a high sensitivity. However, if  $R_1$  has a high resistance, it will act as a voltage divider with the meter  $E_g$  so that  $E_g$  indicates a far smaller voltage than actually exists across  $E_c$ .

In some receivers, resistor  $R_c$  will not be present, and the cathode will be connected directly to the chassis (B—). In this case all measurements can be made with respect to the chassis; touch the negative voltmeter probe to the chassis, and the positive probe to the other element where you want to make the measurement. If the cathode bias resistor is used, however, you cannot measure the grid bias voltage by connecting a voltmeter between the control grid and the chassis. The reading will be zero because there is normally no d.c. voltage across resistor  $R_1$ . In a.c.-d.c. receivers, the chassis may not be a part of the electrical circuit. If not, make your measurements with respect to the cathode of the tube in the stage under test whether or not a cathode bias resistor is used.

## INTERPRETING YOUR MEASUREMENTS

Knowing what your measurement means is just as important as knowing how to make it. To figure out the meaning of the voltage measurements you make, a thorough understanding of voltage distribution is necessary. The distribution of voltage in a circuit follows Kirchhoff's Voltage Law, which says that the voltage rise in a complete circuit must equal the sum of the voltage drops. The voltage rise is the source voltage (the output of a battery or a power pack) : a voltage drop is the voltage that appears across a resistive part in the circuit.

A fundamental voltage distribution circuit is shown in Fig. 4. A voltmeter may be connected across the

source  $E$  to measure the source potential, or across the parts  $R_A$  or  $R_B$  to measure their respective voltage drops. Supposing some defect exists in this circuit, let's see what we can find from voltage measurements. Say we find the  $R_B$  voltage is: 1, zero; 2, lower than normal; or 3, higher than normal.

► If the voltage across  $R_B$  is *zero*, other measurements may show:

1. No voltage across  $E$  or across  $R_A$ . This indicates a source defect.

2. Full source voltage across  $R_A$ . This means either that  $R_A$  is open or that  $R_B$  is shorted.

► If the voltage across  $R_B$  is lower than normal, but not zero, we may find:

3. Lower-than-normal voltages across  $E$  and across  $R_A$ . This indicates a source defect.

4. Higher-than-normal voltage across  $R_A$ ,  $E$  voltage normal. This means either  $R_A$  has increased in resistance or  $R_B$  has decreased.

► Finally, if the voltage across  $R_B$  is *higher* than normal, we may find:

5. Higher-than-normal voltage across  $E$  and across  $R_A$ . Again, this indicates a source defect.

6. Lower-than-normal voltage across  $R_A$ ,  $E$  voltage normal. This means either that  $R_A$  has decreased in resistance or  $R_B$  has increased.

► Notice the one fault with the voltmeter check. In cases 2, 4, and 6, you cannot tell exactly which of *two* troubles exists—your readings have merely eliminated other possibilities. In most cases of this kind, you will use an ohmmeter to show which of the two possibilities actually exists.

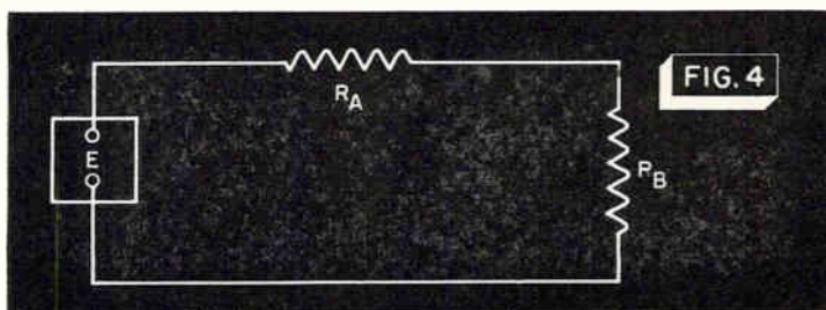


FIG. 4

► The basic circuit shown in Fig. 4 occurs again and again in practical radio circuits. For example, let's consider the power supply in Fig. 5. We may consider the power transformer and rectifier tube as the source of voltage. In this case, the speaker field  $L_{11}$  becomes comparable to the series part  $R_A$  of Fig. 4, and  $C_{19}$  and all the tube circuits connected across it correspond to  $R_B$  of Fig. 4.

If the entire power supply up to  $C_{19}$  is all right, you can consider the voltage across  $C_{19}$  to be the source of voltage for each tube circuit. In this case, the parts in series with the plates, screen grids, or other elements correspond to  $R_A$ , and the tubes correspond to  $R_B$ . For example, in the plate circuit of the 6F6 output tube, if the voltage across  $C_{19}$  is considered the source voltage, then the primary of transformer  $T_2$  corresponds to  $R_A$ , and the plate-cathode resistance of the tube corresponds to  $R_B$ . Each other plate circuit can be considered in the same way.

Considering parts this way, all the conditions we described in the basic circuit of Fig. 4 are possible in each of the practical circuits of Fig. 5. Let's take some examples.

## ZERO VOLTAGE

One measurement of voltage across  $C_{19}$  will tell whether the B power supply is in good condition or not. If normal voltage is found, you need make no further measurements in the power supply circuit and can go right on to tube circuits. However, let's first see what to do if no voltage is found across  $C_{19}$ .

**Power Supply Defects.** If you measure *no voltage* across  $C_{19}$ , check the voltage between the filament of the

### BENCH HINTS

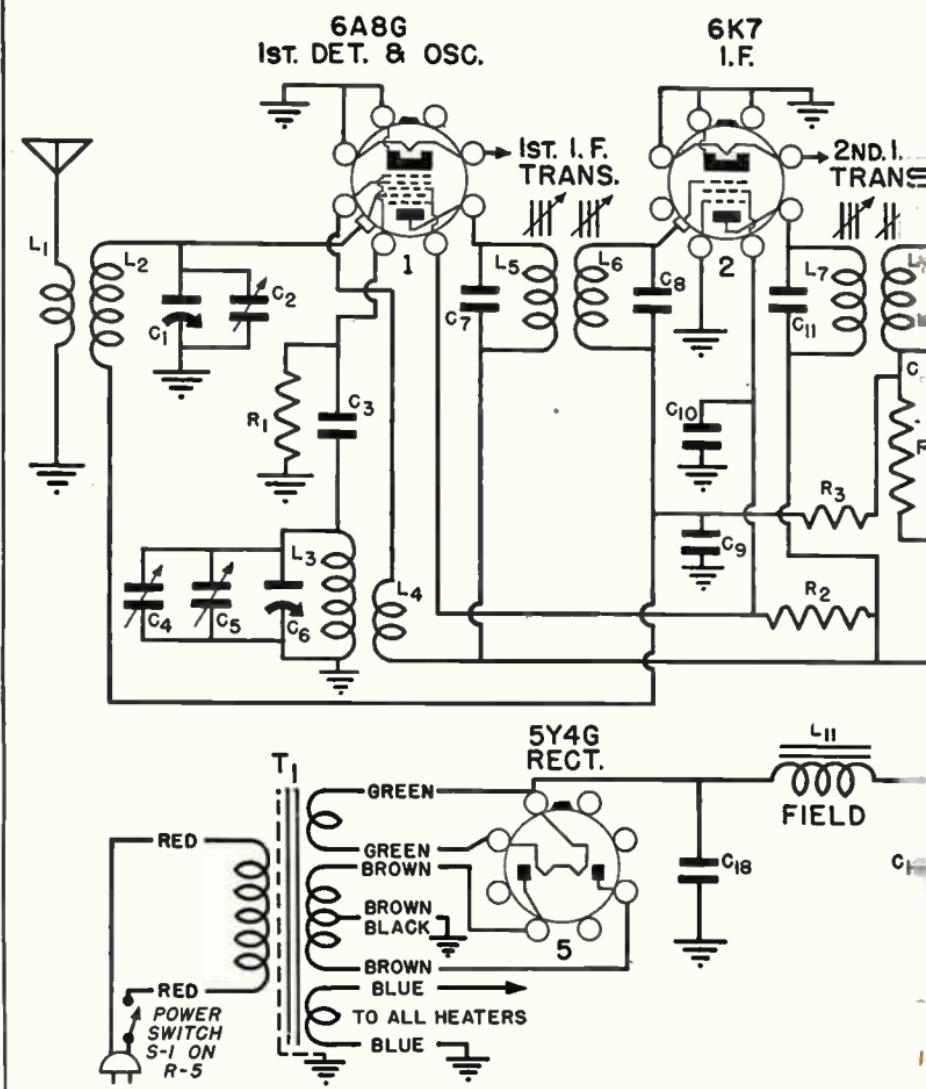
Whenever you remove the leads from a defective part preparatory to replacing it, be sure to identify the various leads so that you will connect them properly to the replacement. One simple way to identify leads is to stick small pieces of adhesive tape to them, marking the tape to indicate where the lead is supposed to go.

rectifier tube and the chassis. If you measure a voltage here, there may be an open in the speaker field  $L_{11}$  or a short circuit between B+ and B— ( $C_{19}$  shorted, for example). In this case, use an ohmmeter to check the continuity of the speaker field, and check for a short circuit across  $C_{19}$ . (Turn off the receiver before you use the ohmmeter!)

If you find no voltage between the filament of the rectifier tube and the chassis, the trouble may be in the power transformer or in the rectifier tube, or  $C_{18}$  may be short-circuited. Since the last is the most usual trouble, use your ohmmeter to check this condenser next. (A short circuit in  $C_{18}$  will cause the rectifier tube to overheat; its plates may even turn red.) If  $C_{18}$  is O.K., use your a.c. voltmeter (we will explain how later) to measure the voltage between each plate of the rectifier and the chassis. Lack of voltage may mean a burned-out high voltage winding, particularly if the tube filaments light up. If normal voltage is measured, the rectifier tube may be defective. However, if none of the tube filaments light up, make certain that voltage is available at the power line outlet by measuring it with your a.c. voltmeter. Also, unplug the set and check for continuity through the line switch and primary of the power transformer with an ohmmeter.

**Zero Plate Voltage.** Now let's suppose we find normal voltage across  $C_{19}$ , but that some tube has no plate voltage. This means there must be an open in the plate circuit or a short circuit across it. For example, a lack of voltage between the chassis and the triode plate terminal of tube 3 may be the result of an open in  $R_7$ , a short circuit in condenser  $C_{15}$ , or a tube or socket defect that grounds the plate terminal of the tube. An ohmmeter check should be made across  $R_7$  to determine whether it is open, or from plate to chassis to determine if there is a short circuit.

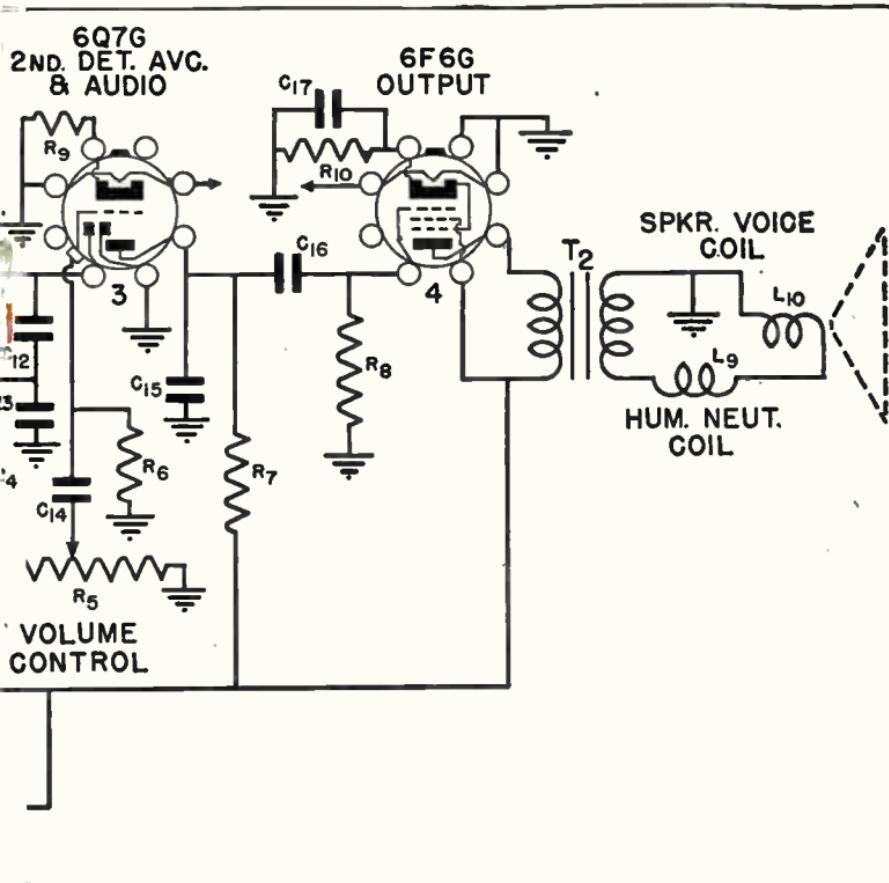
One point of interest—you might find voltage between the chassis and the plate of tube 4, but no voltage between the plate and the cathode of the same tube. Since, as the diagram shows, your first reading is actually across both  $R_{10}$  and the tube, and the second is across only the tube, finding voltage on the first reading



but not on the second means  $R_{10}$  is open. You can check on this by connecting the positive voltmeter probe to the cathode of the tube, and the negative probe to the chassis. If the resistor is open, a very high voltage will be found across it. Here is a case where a measurement between plate and cathode proves more valuable than one between plate and chassis.

### VOLTAGES LOWER THAN NORMAL

Just where you should start to measure voltage in a radio receiver depends on what the complaint is and on



**FIG. 5.** This is the schematic diagram of a single-band a.c.-operated superheterodyne of standard design. It is typical of a large class of receivers—so typical, in fact, that we shall use it as our chief example in showing you how to locate defects with a voltmeter. When you are locating points in this circuit, be sure to notice that the tubes are drawn upside down from the conventional position; that is, the plates are on the bottom, and the cathodes on the top.

how far you have localized the trouble. If you have localized the trouble to some particular stage, take your readings in that stage first. On the other hand, if you have not localized the trouble to a stage, then you may measure either plate voltages or the voltage at the output of the power supply first.

Usually it is best to check the power supply first. You will have to check it anyway if you find a plate voltage is low, since a reduced source voltage is a likely cause for a low plate voltage, so you might as well get the power supply measurement over with at once.

**Power Supply Troubles.** If the voltage across  $C_{19}$  is low, check the voltages across  $C_{18}$  and across the speaker field. Should the speaker field voltage be unusually high, and should the voltage across  $C_{19}$  be far lower than that across  $C_{18}$ , then probably  $C_{19}$  is leaky, or there is a partial short circuit (or leakage path) across the B supply. There is also a chance that the speaker field resistance has increased; check this by turning off the receiver and measuring the field resistance with an ohmmeter. (Incidentally, the field resistance increases as the field heats up: some circuit diagrams list the field resistance cold, whereas others give the hot value, so there may be some variation between your measurement and the listed value.)

► The voltage across  $C_{19}$  may be pulled below normal if the output tube draws excessive current. This will increase the voltage drop across the speaker field and also across the primary of transformer  $T_2$ . An upset of the tube bias could cause this increased current. For example, if condenser  $C_{17}$  short-circuits, it will short-circuit bias resistor  $R_{10}$ , removing bias from the tube and making the tube draw far more plate current than normal. To check for this short circuit, measure the bias voltage across  $R_{10}$  by connecting the positive terminal of the voltmeter to the cathode of tube 4, and the negative terminal to the chassis. If there is no voltage, then  $C_{17}$  must be short-circuited.

The bias for tube 4 can also be upset by leakage in condenser  $C_{18}$  or by gas in the tube. Either of these conditions will cause a current flow through  $R_8$  in such a direction that the grid end of  $R_8$  is made positive. To check for this, place the positive terminal of the voltmeter on the grid of the tube, and the negative terminal on the chassis. You should get no reading. If you do get a reading, then either condenser  $C_{18}$  is leaky, or tube 4 is gassy. To determine which of these is at fault, pull out tube 4. (This can be done only in a standard a.c. receiver.) If the voltage across  $R_8$  disappears when the tube is out of the socket, then the trouble is gas in tube 4. On the other hand, if the voltage still remains, then condenser  $C_{18}$  is leaky. (In a.c.-d.c. receivers, you can-

not pull out the tube. Instead, unsolder one lead of the coupling condenser. Now if the voltage disappears, the condenser is leaky, but if it remains, the tube is gassy.)

Always check the output stage first before suspecting others. Other stages cannot usually draw enough current to affect the power supply much unless a complete short circuit occurs in one of them.

► If the field voltage is below normal, and the other voltages are low also, then the trouble is not caused by excess current drawn from the power supply unit. In this case, check the rectifier tube. Then, substitute another condenser for  $C_{18}$ . Loss of capacity, increased leakage, or development of a high power factor in the input filter condenser are the most frequent causes of low d.c. supply voltage.

However, if a new condenser and a good rectifier tube do not clear up the trouble, then check the power line voltage. Finally, consider the possibility that the power transformer is defective.

## HIGH VOLTAGES

There are not many defects that will cause most or all voltages to be far higher than normal. High power-line voltage, of course, can cause this condition. You will also find high voltages if some other serviceman has installed a replacement power transformer that has a higher output than the original. These, however, are rather rare causes; the most probable cause of the existence of high voltages is some defect that reduces the current flow through the speaker field  $L_{11}$ . A lowered current through this field reduces the voltage drop across it, and therefore makes more voltage available for the plates and screen grids of the tubes.

### BENCH HINTS

When you want to check the speed of a phonograph turntable and do not have a stroboscopic disc, place a small strip of paper beneath a record on the turntable. Allow the paper to project only enough to be visible. You can then judge the speed by counting the number of times per minute the paper passes any convenient reference point.

Since the output tube normally draws most of the current that passes through the field, suspect the output stage first if you find abnormally high voltages. The tube may be defective, or its bias resistor  $R_{10}$  may have opened and thus reduced or cut off the plate current. If so, there will be considerably less current flowing through the speaker field, and the plate voltages on all tubes (except the rectifier) will be high.

Once in a great while you may find that the speaker field is shorted. This will cause all plate and screen voltages to be high; the set, of course, will be dead or very weak, since the speaker will not be operating properly.

► As we said before, your readings may appear high if you are using a meter with a higher sensitivity than specified. Table 2 gives the voltages listed by the manufacturer for the receiver shown in Fig. 5. Notice that a 1000 ohm-per-volt meter is specified. If you use, say, a 20,000 ohm-per-volt meter, the plate-to-chassis voltage for tube 3 will be higher than the listed value.

TABLE 2		SCREEN GRID	CONTROL GRID	FILAMENT
TYPE	PLATE			
6A8 DET.	210V	135 V	0 V	6.3 V (AC)
6A8 OSC	210V	----	---	-----
6K7	210V	135V	0 V	6.3 V (AC)
6Q7G AMP	100V	----	0 V	6.3 V (AC)
6F6G	190 V	210V	0 V	6.3 V (AC)
5Y4G	PLATE 1 OR 2, 282 V	----	---	5 V (AC)

The manufacturer's literature gives the following information in addition to this table of voltage measurements: The above measurements are all made to chassis. Measurements made with set tuned to quiet point, volume control set at minimum, using 1,000 ohm-per-volt meter, having ranges of 10, 50, 250, and 500 volts. (Use nearest range above the specified measured voltage.) All the above values should hold within approximately  $\pm 20\%$  for 115 volt, 25-60 cycle supply.

However, the readings in the other circuits should be close to the values listed. Therefore, you should not assume that your higher-than-normal reading indicates trouble unless you have reason to suspect that tube 3 is defective or that its bias resistor  $R_9$  is open.

**What Is Normal Voltage?** Determining whether a voltage is high, low, or normal is sometimes difficult. First there is the matter of meter sensitivities we just mentioned. You can assume that if your meter is more sensitive than the one the manufacturer lists, your readings will if anything be higher than his readings. On the other hand, if your meter is less sensitive, your readings will be lower than his in any circuit containing considerable resistance.

You can check the general agreement of your readings with those listed by making measurements in the power output stage, where the resistances of all parts associated with the power output plate and screen grid circuits are very low. Readings made in this stage with any service multimeter having a sensitivity of 1000 ohms-per-volt or higher should be close to the values listed in the manufacturers' tables.

By "close," we mean within  $\pm 20\%$ . This is the tolerance usually specified by manufacturers (see Table 2). Therefore, if the voltage is listed as 250 volts, you can consider any reading between 200 and 300 volts to be reasonable unless the operation of the receiver definitely proves otherwise. This wide permissible variation is another reason why it is sometimes difficult to be sure if a voltage is high or low.

## GENERAL RULES

As you become experienced, you will develop your own general servicing procedure. Whether you use an ohmmeter or a voltmeter more will be largely a question of your own preferences—because, as you have probably noticed by now, it is very often possible to use either instrument to locate the same defect. There will be times, however, when you must use a voltmeter; and, when you do, be sure to keep the following general rules and precautions in mind:

1. Always know what you intend to measure.

- 2.** Know where to put your probes—refer to a tube chart to locate the various tube socket terminals.
- 3.** Start out by using a voltmeter range that will measure the highest voltage that could exist in the circuit. Switch to a lower range only when you find it is safe to do so.
- 4.** Don't make measurements to the chassis until you know that continuity exists between the chassis and the cathode of the tube whose circuits are being tested.
- 5.** When you get an abnormal reading, look at the diagram and figure out the possible causes of the trouble. Then make tests that will prove or disprove your conclusion.

### A.C. VOLTAGE MEASUREMENTS

Normally, a serviceman reserves his a.c. voltmeter for use as an output meter when aligning the receiver. (We will tell you all about this when we take up receiver alignment.) However, the a.c. voltmeter may also be used to measure the filament voltage, the high voltage supplied to the plates of the rectifier tube, and the power line voltage, even though none of these measurements are made very often.

In practically all service multimeters, the same meter is used for both a.c. and d.c. voltage measurements; a rectifier is switched into the circuit to make the meter read a.c. Most a.c. voltmeters have sensitivities of 1000 ohms-per-volt, which is entirely satisfactory for all purposes where a.c. voltage readings are made. The meter always has several ranges.

To measure the power line voltage, simply insert the test probes into the socket outlet. Be sure your meter is set to an a.c. range greater than 115 volts.

You can measure the high plate voltages of the rectifier tube by checking between each plate and the set chassis (or B—, if the chassis is not a ground). This voltage is high—frequently as much as 400 volts—so be sure to use a high-voltage meter range and be careful not to touch the bare test probes with your hands while making the measurement.

Tube filament voltages are measured directly across



**BE CAREFUL** when you make voltage measurements in the power supply—don't allow your probes to touch each other—don't touch the uninsulated parts of the probes.

each tube filament. (Incidentally, you do not have to worry about polarity in any of these measurements; as long as the meter is connected across the a.c. voltage you want to measure, the meter will read up-scale.) Generally speaking, the only reason why a filament voltage is incorrect is that the filament resistance has changed. In the standard a.c. receiver using a power transformer, like that shown in Fig. 5, you cannot detect a change in filament resistance by making a voltage measurement. All the tube filaments are in parallel, and the voltage you measure will be that of the filament winding of the transformer.

However, filament voltage measurements are sometimes useful on battery receivers and on a.c.-d.c. receivers. For example, in the a.c.-d.c. receiver shown in Fig. 6, the tube filaments are all in series, and their voltage drops add to equal the line voltage value. If the resistance of some one tube filament increases, the drop across that tube filament will increase, and the drops across the other tube filaments will decrease. If the tube does not burn out, you can find this trouble by measuring the filament voltages down the string. Conversely, if a filament resistance decreases, the drop across that tube will decrease, and the drops across the others will in-

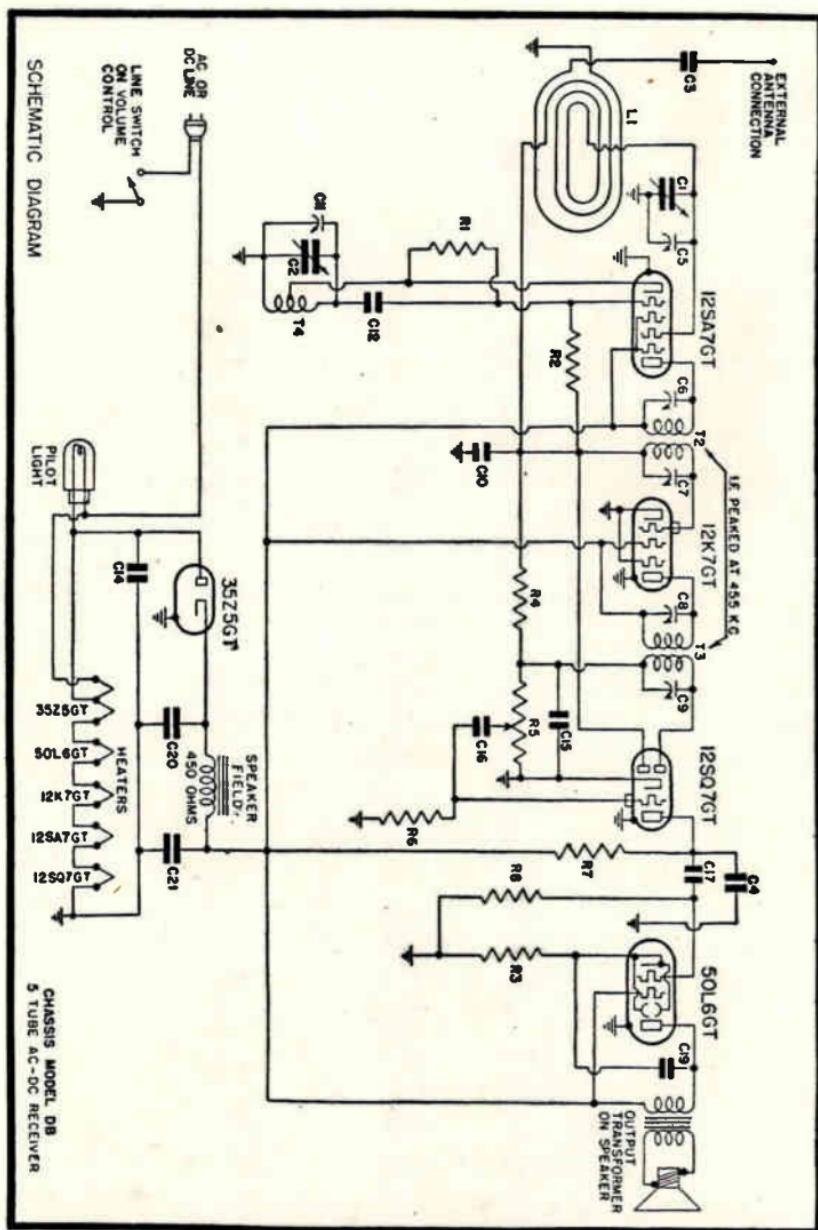


FIG. 6. This is a typical a.c.-d.c. receiver. Many midget and small table-model sets use this circuit or one much like it.

crease. This condition, too, can be found by voltage measurements if none of the other tubes burn out.

This trouble is more likely to occur in a high-voltage filament such as is used in the 50L6 (50 volts) and the 35Z5 (35 volts). These filaments are made by folding

the filament wire back and forth, and it is possible for a loop or two of this folded filament to short-circuit. As you just learned, this may raise the filament voltage on other tubes and may perhaps cause one of the other tubes to burn out.

► The circuit shown in Fig. 7 is unusual in that the filaments of the tubes are in series, but they are operated from the d.c. plate current of the output section of the 70L7 tube when the set is connected to a power line. The only exception is the filament of the 70L7 tube itself, which operates from the a.c. power line voltage. Therefore, you must use an a.c. voltmeter to measure the 70L7 filament voltage, and a d.c. voltmeter to measure any of the other filament voltages.

Incorrect filament voltages may be caused in this set even if the filaments do not change in resistance. Notice that the 70L7 tube filament is in series with a resistor,  $R_{13}$ . If  $R_{13}$  changes in resistance, the voltage drop across the 70L7 tube filament will also change (increasing if the resistance decreases). When the set is operated from a power line, a change in the plate current of the 70L7 tube will change the drops across the filaments of the other tubes. The drops will increase if the plate current increases. (Gas in the 70L7 tube or leakage in condenser  $C_{18}$  will upset the bias and cause an increase in plate current.)

When this receiver is operated from batteries, however, the 70L7 tube is not used; the 3Q5 becomes the output tube, and the tube filaments all operate from the A battery. Filament voltages will then be normal if the battery is in good condition and the filaments remain constant in resistance.

### NRI PRACTICAL TRAINING PLAN

Continuing now with the NRI Practical Training Plan, carry out the procedure given below on the receiver you have obtained for practical experience.

**Measure All Electrode Voltages.** Insert the receiver power cord plug into an a.c. wall outlet, turn on the set, set the volume control at its maximum setting (no station tuned in), and measure each d.c. electrode voltage with respect to the cathode (or with respect to the chas-

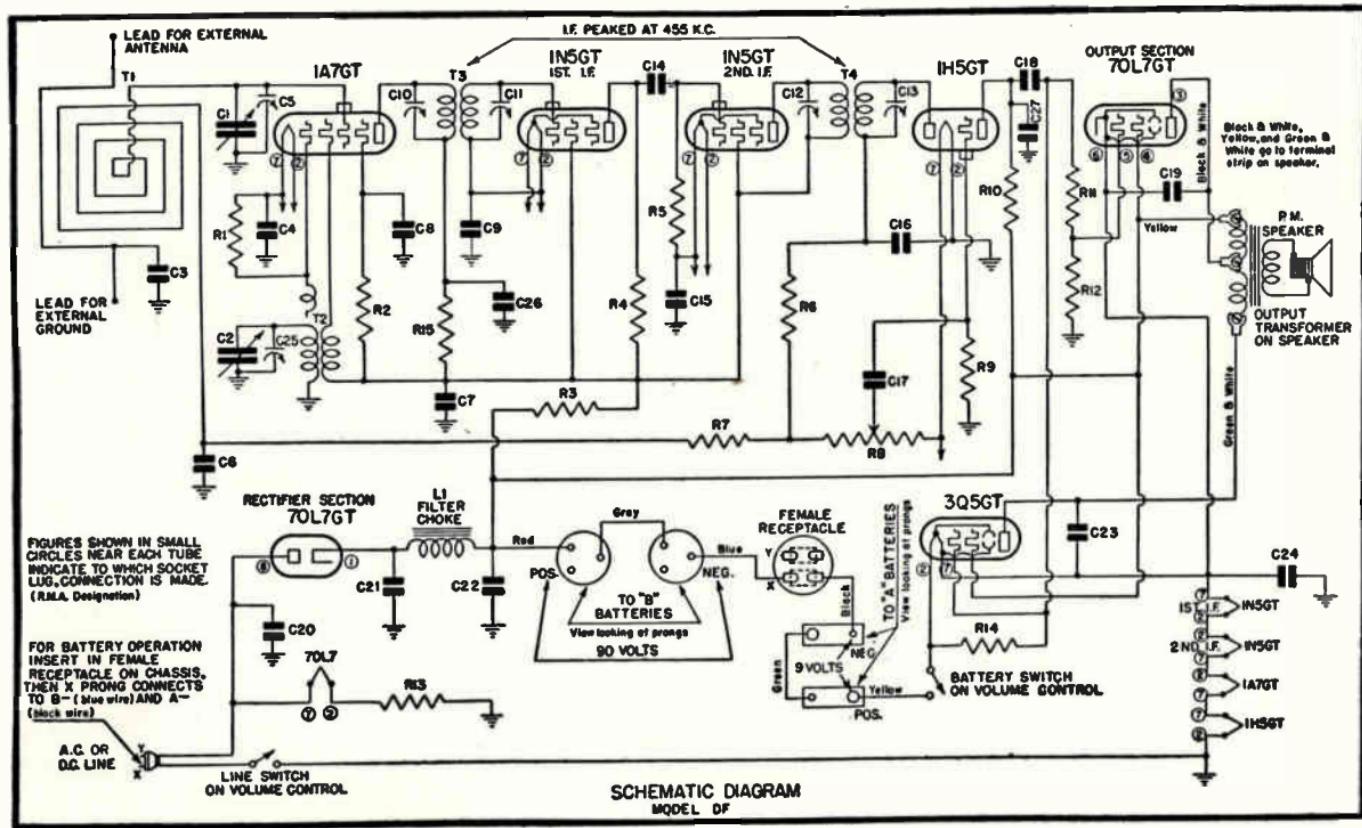


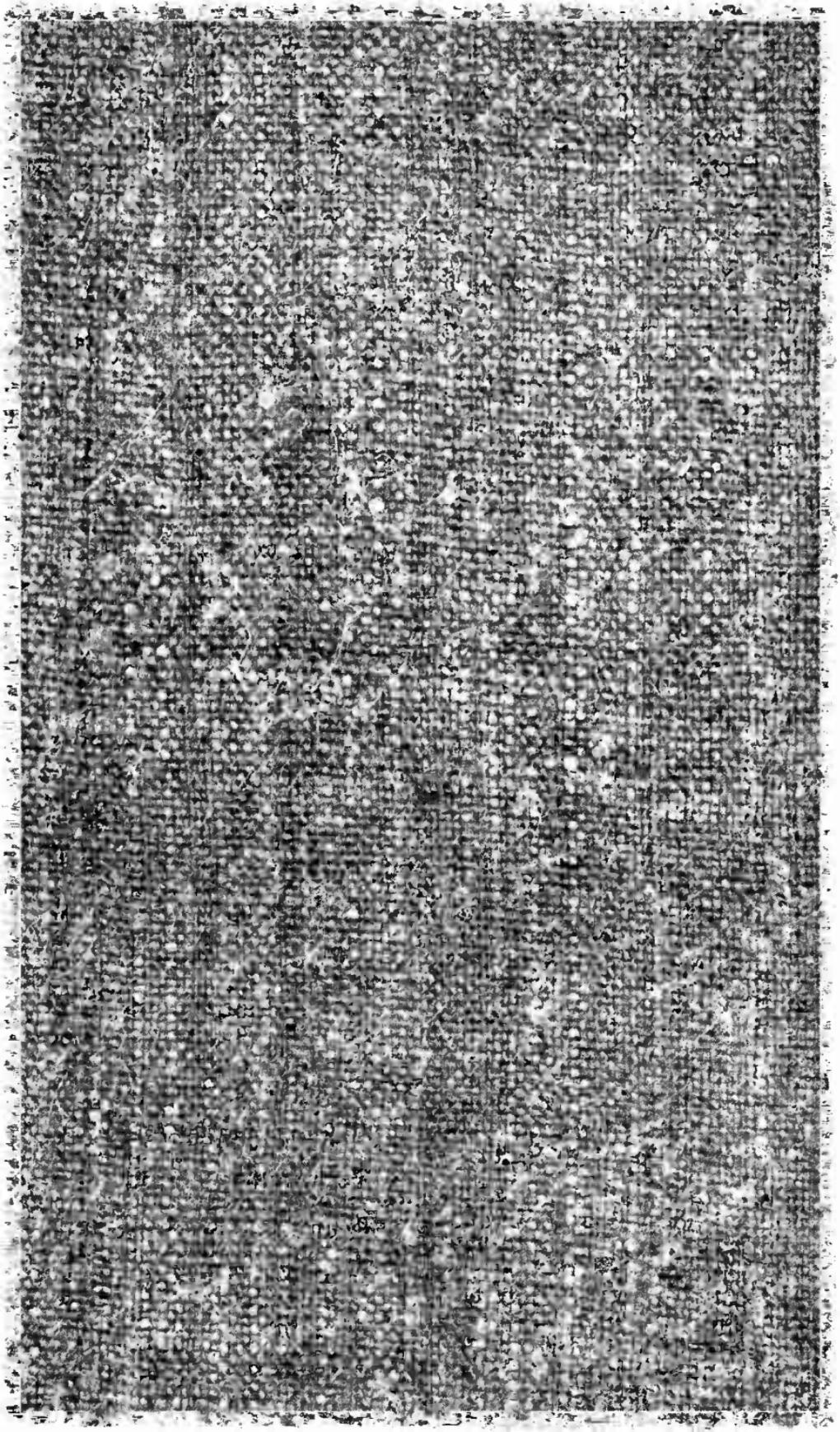
FIG. 7. This schematic shows the connections for a typical three-way portable. This receiver operates either from self-contained batteries, or else from a.c. or d.c. power lines. When operating from a power line, the rectifier supplies power for the tube filaments as well as the usual B and C voltages.

sis if the voltage values in your service information are given that way). Record each measured value. Compare your readings with those given by the manufacturer so that you can see the results of parts variations and meter sensitivity differences.

Measure also the total rectified d.c. output voltage of the rectifier tube by testing between the rectifier cathode (+) and the center tap of the power transformer secondary (-).

Be sure to use a high range first on all measurements.

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

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 21

How To Fix a Dead  
Receiver

RADIO SERVICING METHODS



# NRI TRAINING

# *Pays . . .*

Dear Mr. Smith:

I doubt if you have ever had a student who was more doubtful about your Course than I. Before enrolling, I wrote to several graduates to ask them about the Course. They all answered that you could swear by it, and no truer words were ever written. The Course paid for itself long before I finished, and frankly I say it is worth ten times what it cost. The extra money I have earned has certainly been a great help.

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FM10M949

1950 Edition

Printed in U.S.A.



# 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 certain tests. Reasoning is important as a means of short-cutting steps in the already short series in the localization plan. However, if there are no clues leading to reasoning, 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 succeeding 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 procedures now, for not until you know all about them will

## DEFECT LOCALIZATION

- |                              |                              |
|------------------------------|------------------------------|
| 1. Confirm the complaint.    | 4. Locate defective stage.   |
| 2. Look for surface defects. | 5. Locate defective circuit. |
| 3. Locate defective section. | 6. Locate defective part.    |

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.)

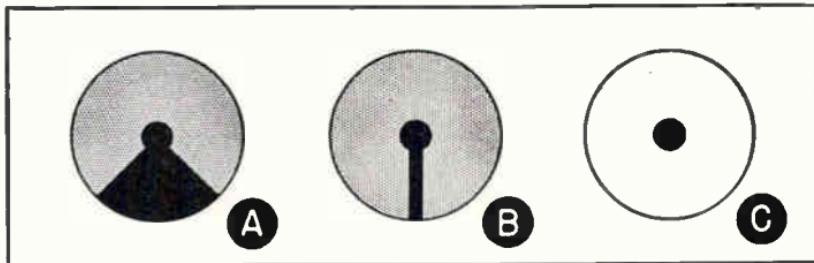
► If the receiver is alive from the first detector to the speaker, you will *usually* hear a hissing or frying noise along with the hum when the volume control is turned up high. This hiss is the normal converter noise produced in the first detector tube. Its presence indicates that everything past the 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.v.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



**FIG. 1.** The shadow of a tuning-eye tube is broad (A) when no signal is applied, and becomes narrower (B) when a signal is fed to the grid. If d.c. plate voltage is not applied to it, the eye does not become green (C) and no shadow appears.

detector, becoming smaller as the strength of the signal becomes greater. When a strong local station is tuned in 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 signals 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 phono-radio 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.

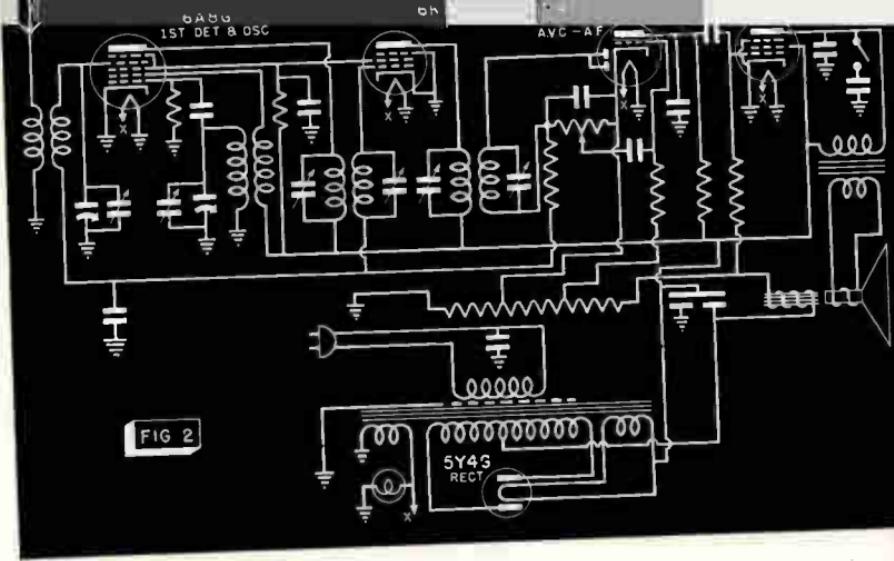
If no click is heard when the i.f. stage is disturbed, you won't know whether it is the i.f. stage or the second-detector stage that is at fault. You should make a tube test, and then proceed to *circuit* localization tests; these will be explained later.

### 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. 3 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. 3. 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 multi-band 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 the moment the probe touches*, the meter starts drawing current through the output trans-

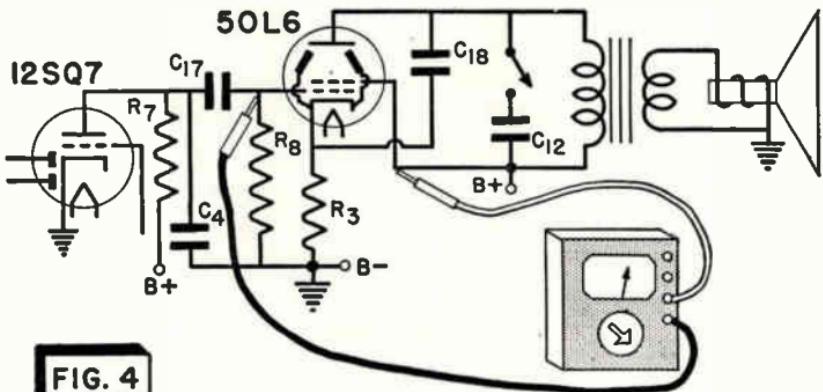


FIG. 4

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  $C_{18}$ .

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*,  $R_7$  may be open, or  $C_4$  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  $R_8$ , producing a voltage across it. This will cause the

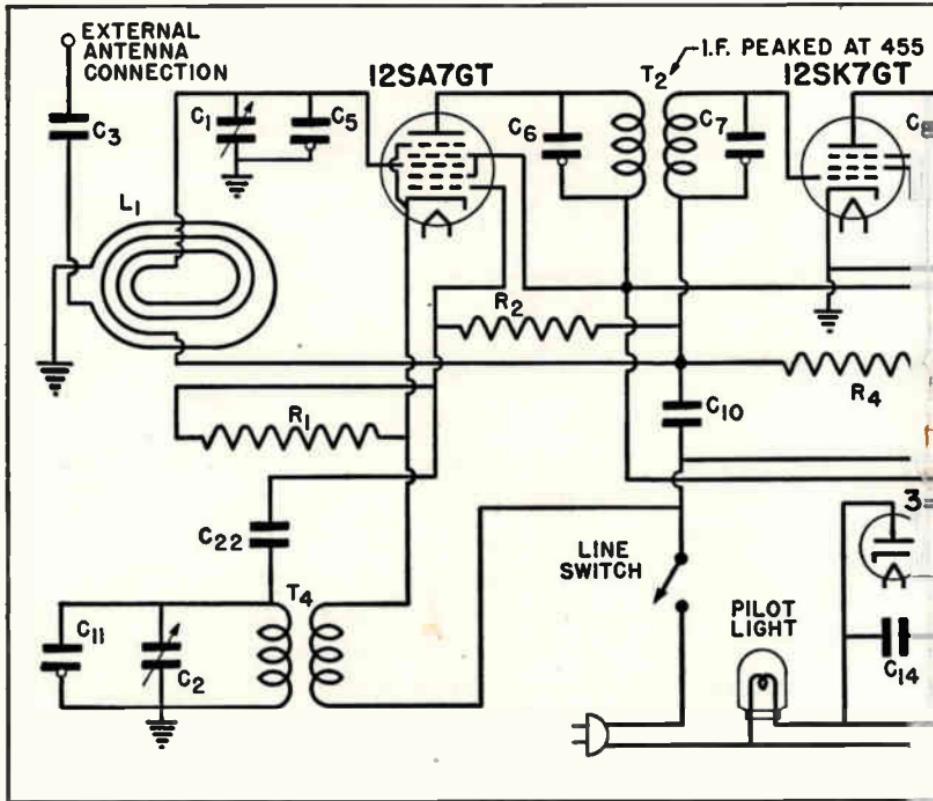


plate current of the tube to change, and should make a click in the speaker.

Notice that since the negative voltmeter probe connects to the grid side of  $C_{17}$ , this click signal does not go through  $C_{17}$ . If you hear the click on the grid side of  $C_{17}$  but 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  $R_3$  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. 3 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

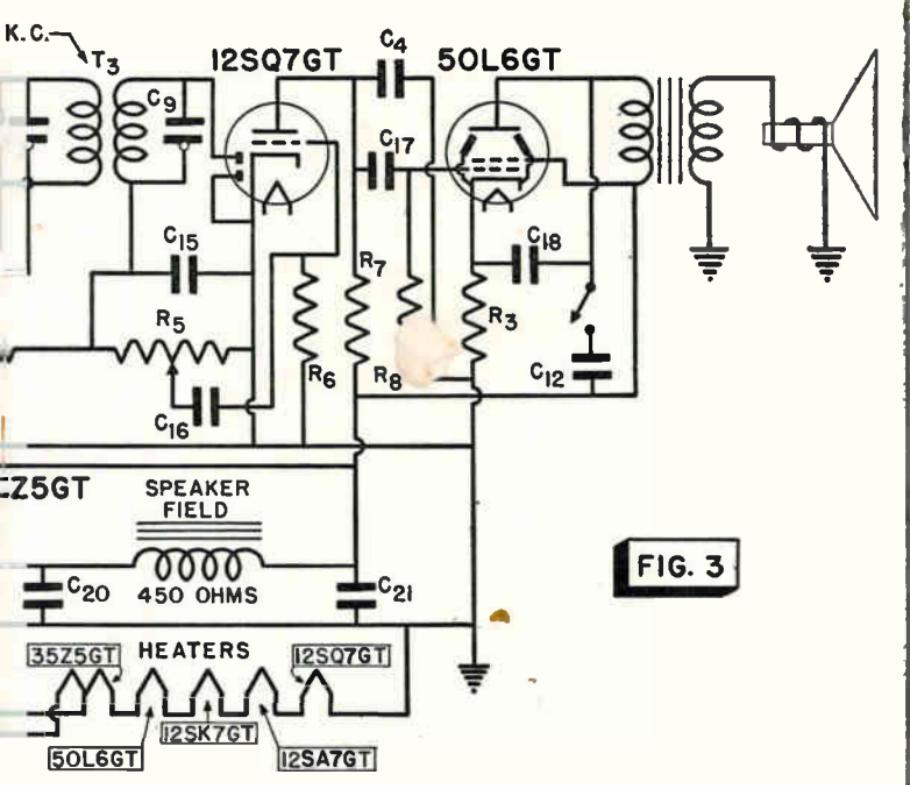


FIG. 3

hear a click signal. No voltage indicates an open primary in  $T_3$ . If you find voltage but fail to get a click, the trouble is between this point and the volume control  $R_5$ . Transformer  $T_3$  may have an open or shorted secondary,  $C_9$  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

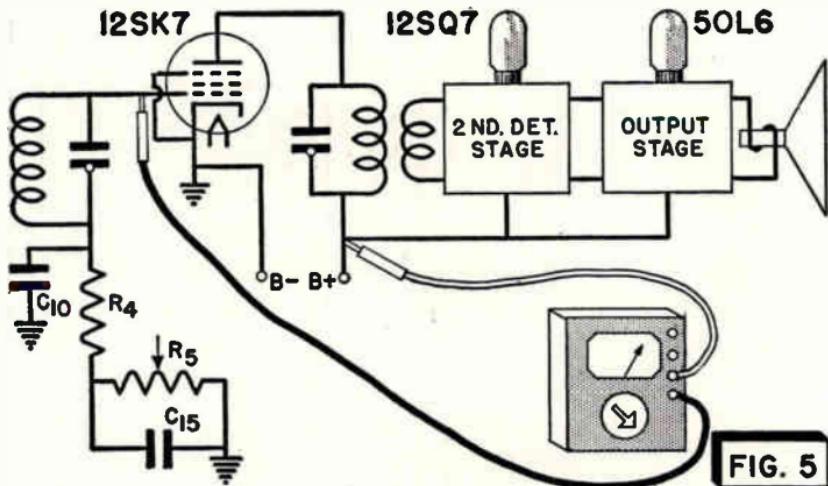


FIG. 5

an open in the  $T_2$  primary. However, a voltage reading but no click might mean that condenser  $C_{10}$  is open, that  $C_6$  or  $C_7$  is short-circuited, or that  $C_6$ ,  $C_7$ ,  $C_8$ , and  $C_9$  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 12SA7, 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 12SA7 tube, a change in value of  $R_1$ , a short in oscillator condenser  $C_2$ , or a defect in  $T_4$  (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.

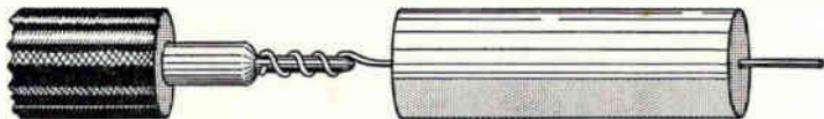
Now let's study still another method of localizing the defective stage.

**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



The easiest way to put a condenser in series with the hot lead of an s.g. is to wrap one lead of the condenser around the probe as shown, then use the other condenser lead as the probe.

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  $T_3$  or the diode section of the 12SQ7 tube is defective. (Condenser  $C_8$  or  $C_9$  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.

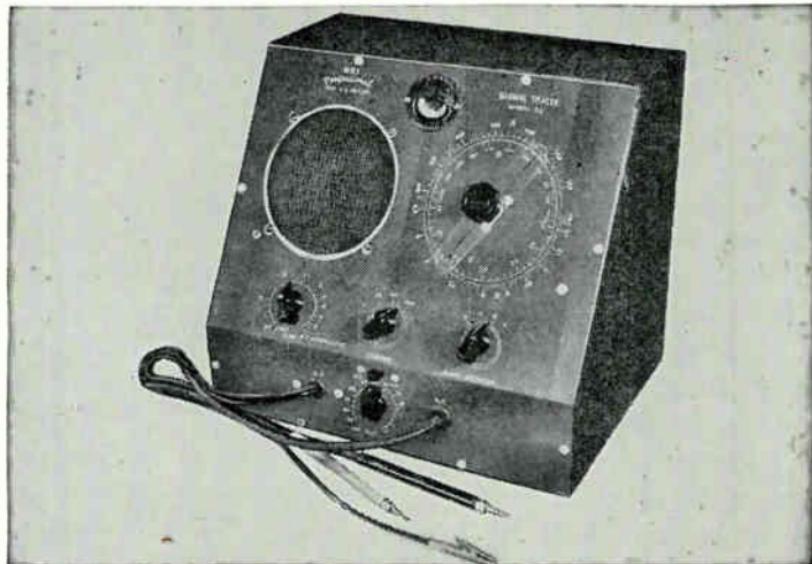
In this example, start with the hot probe on the control grid of the 12SA7 tube. Tune the signal tracer to the frequency of the incoming signal, and retune the set, if necessary, to give maximum indication on the signal tracer. If the signal is picked up at the grid of the 12SA7 tube, the input circuits 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  $C_8$  is short-circuited, that the primary of i.f. transformer  $T_2$  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  $T_2$  or in its trimmers  $C_6$  and  $C_7$ .

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  $T_3$  or condenser  $C_8$ .



A signal tracer, such as this NRI Professional Model 33, speeds up the trouble localization in a dead receiver whenever you encounter an unusual defect. However, if you have no tracer, the other methods described will be reasonably speedy.

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  $T_3$ , or a short in  $C_9$ . 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  $C_{16}$  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  $C_4$ , an open in  $R_7$ , 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  $C_{18}$ .

► 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

#### 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 peened (bent-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.

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

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 bypass 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.

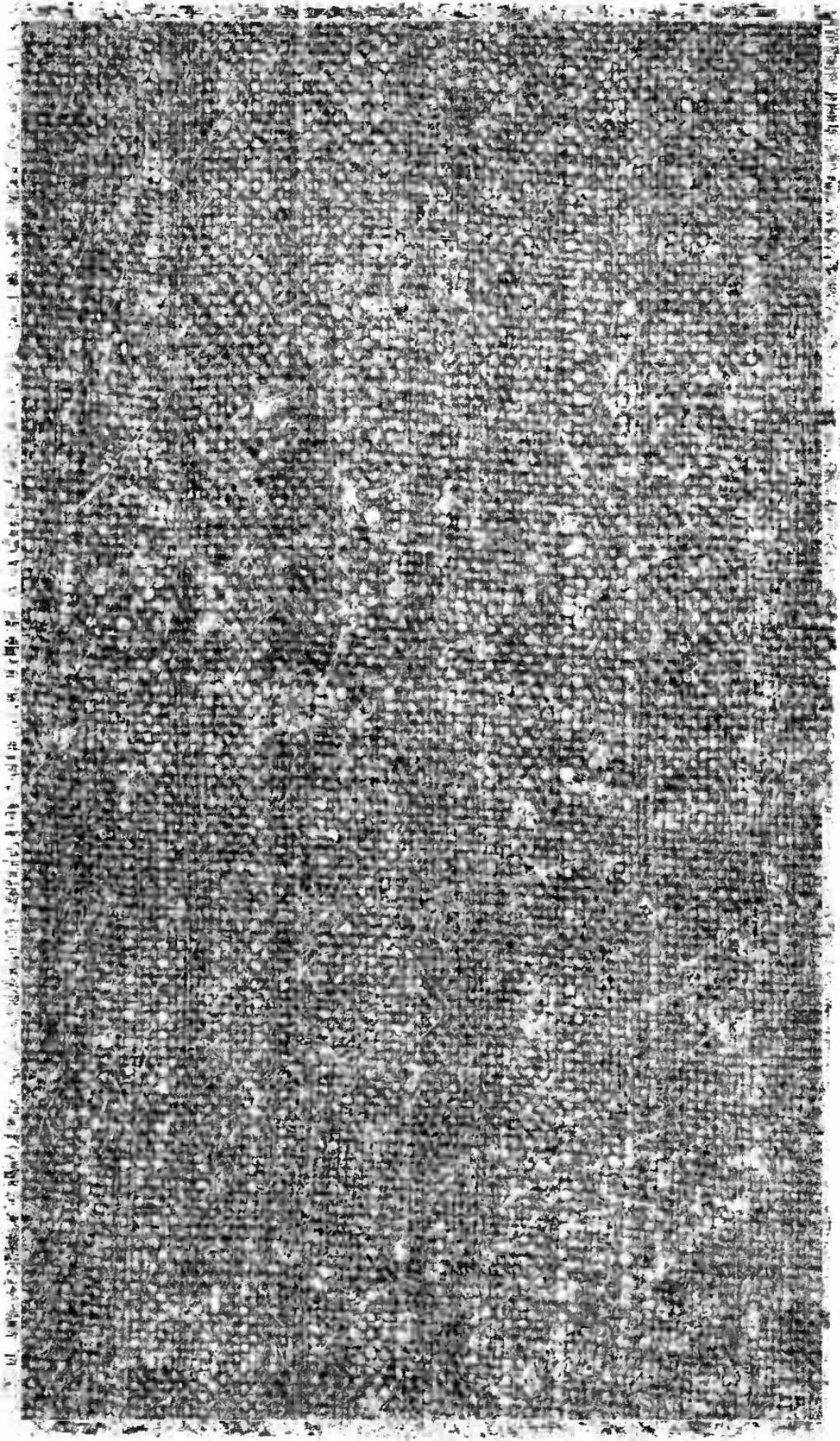
► Unfortunately, short circuits cannot be readily introduced into supply circuits, as resistors or other parts may be damaged. However, you will get experience with these cases when you begin to service radio receivers.

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## DEFECTS COMMONLY CAUSING A DEAD RECEIVER

<i>Cause</i>	<i>How to Test</i>	<i>Usual Location</i>
Burned out tube filament	Ohmmeter or tube tester	Any stage
Loss of emission in tube	Tube tester or substitute good tube	Any stage
Open resistor	Ohmmeter	Screen and plate circuits
Shorted by-pass* condenser	Ohmmeter	Any screen or plate circuit
Broken connection	Ohmmeter or visual inspection	Any stage
Tube not firmly in socket	Push down on tube	Any stage
Top cap connector off tube	Visual inspection	Any section
Top cap shorting to tube shield	Visual inspection and wiggle grid lead	Any section
Shorted electrolytic condenser	Ohmmeter	Power supply
Open electrolytic condenser	Shunt suspect with another condenser	Input filter in power supply
Open field coil	Hold screwdriver to field to note magnetic pull	Loudspeaker (power supply)
Open line cord	Ohmmeter	Power supply
Burned out a.f. transformer primary	Ohmmeter	Audio section
Loudspeaker* unplugged	Visual inspection	Audio section
Open coupling condensers	Shunt suspect with another condenser	Audio section
Open voice coil	Visual inspection or ohmmeter	Loudspeaker (audio section)
Phono-radio switch	Turn switch to other position	a.f. section
Open r.f., i.f., or oscillator coil	Ohmmeter	r.f. section (usually a plate winding)
Tuning condensers shorted	Scraping sound when tuning	r.f. section



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

NATIONAL RADIO INSTITUTE WASHINGTON D.C.

No. 22 How To Fix a Receiver  
That Hums

RADIO SERVICING METHODS



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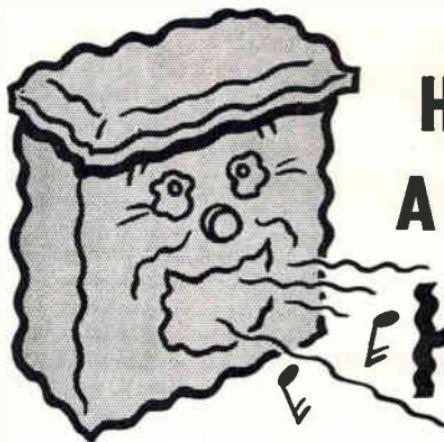
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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**

FM10M250

1950 Edition

Printed in U.S.A.



# HOW TO FIX A Receiver That HUMS

**H**UM 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 (auto 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 at 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  $C_1$  and  $C_2$  are electrolytic condensers, connected with the polarities indicated.

Condenser  $C_1$  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  $C_1$  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  $C_2$ . 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 electrodes. If  $C_2$  opens, the hum will become very strong.

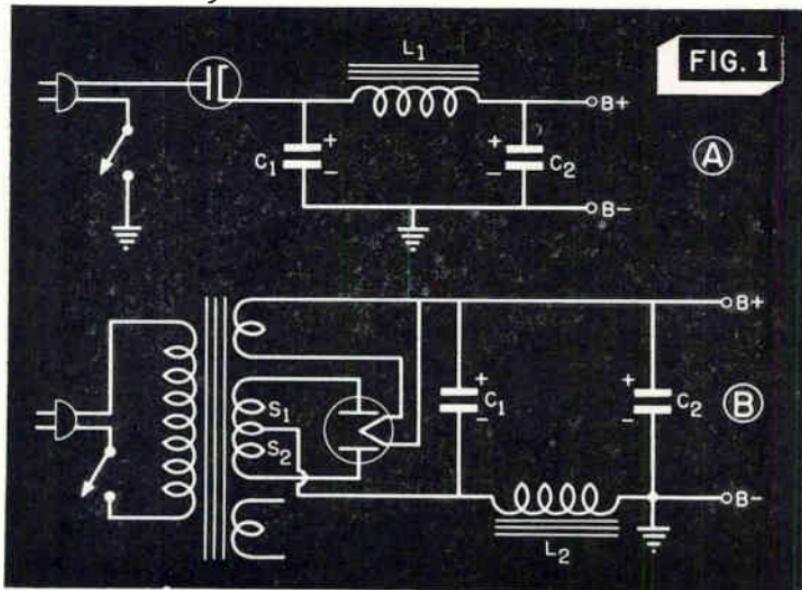
Leakage in condenser  $C_2$  (or leakage in any condenser or circuit in parallel with  $C_2$  at some point farther on in the receiver) will cause excessive d.c. current to flow through the choke. This will reduce the inductance of the choke coil, making it less effective as a filter component, and so causing greater hum. If  $C_2$  shorts altogether, the set will become dead.

► Condenser  $C_1$  and  $C_2$  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  $C_1$  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

FIG. 1



the design of the filter. In a full-wave circuit like that shown in Fig. 1B, the filter is designed to remove the 120-cycle ripple that is normal for full-wave rectification. If anything happens to windings  $S_1$  or  $S_2$  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  $R_1$ , which is by-passed by  $C_1$ . (As you know, any voltage existing between the cathode and ground is also between the grid and the cathode, so the voltage across  $R_1$  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  $R_1$ . 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  $R_1$ . The exact amount across  $R_1$  will depend on whether a complete short or just leakage exists between *B* and *D*.

Whether this a.c. voltage across  $R_1$  causes hum depends on the capacity of  $C_1$ . If this by-pass condenser has a high capacity, it may prevent any hum. However,

\*This depends on the power-line frequency. If the power line is rated at 25 cycles, then full-wave rectification would produce a 50-cycle ripple.

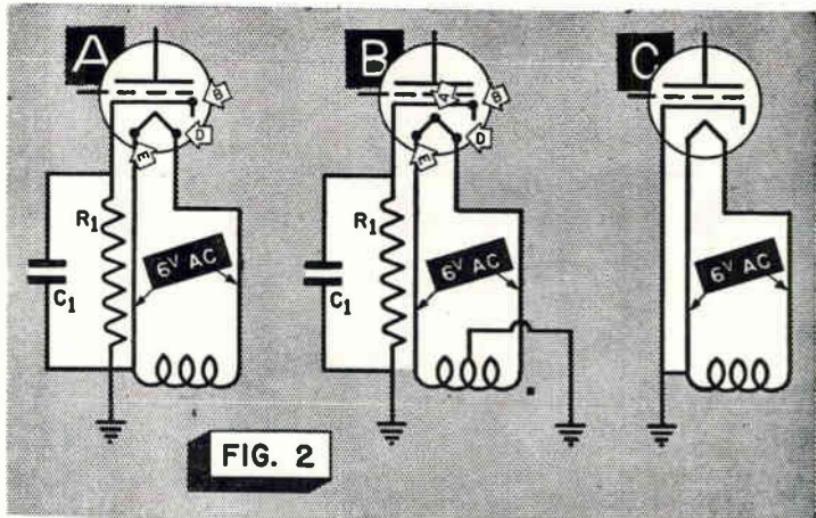


FIG. 2

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  $R_1$  will be amplified sufficiently to cause hum.

On the other hand, if a short or a low resistance develops between  $B$  and  $E$ , there will be no hum because  $R_1$  and the filament will not be in parallel, so there will be no a.c. voltage across  $R_1$ . (However, the low-resistance path between  $B$  and ground will be in parallel with  $R_1$ ; 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

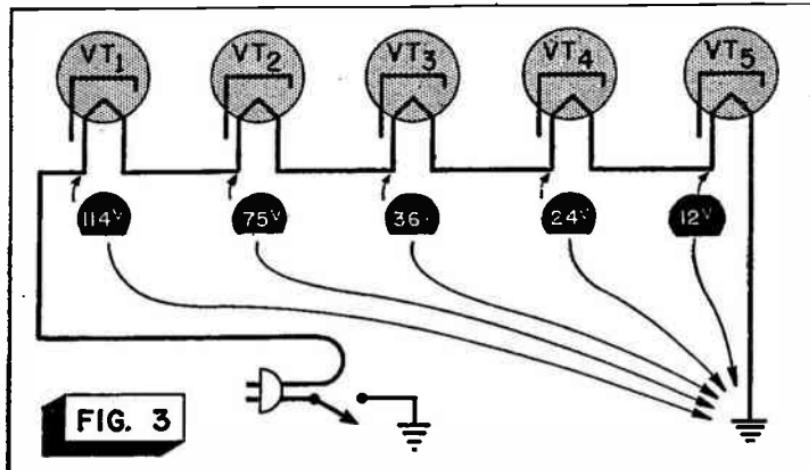


FIG. 3

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 VT<sub>5</sub> toward VT<sub>1</sub>). To compensate somewhat for this, set manufacturers arrange the tube filaments so that the *least* filament-to-ground voltage is applied to the tube that is most 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 troublesome tube, and so on.

Almost always, therefore, tube VT<sub>5</sub> is the first audio tube. Tube VT<sub>4</sub> may be the first detector-oscillator, VT<sub>3</sub> may be the i.f. tube, VT<sub>2</sub> the output tube, and VT<sub>1</sub> the rectifier tube. This odd order of connecting the tube filaments tends to minimize the possibility of hum.

Even though tube VT<sub>2</sub> is the power output tube, this arrangement of filaments results in such a high 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.)

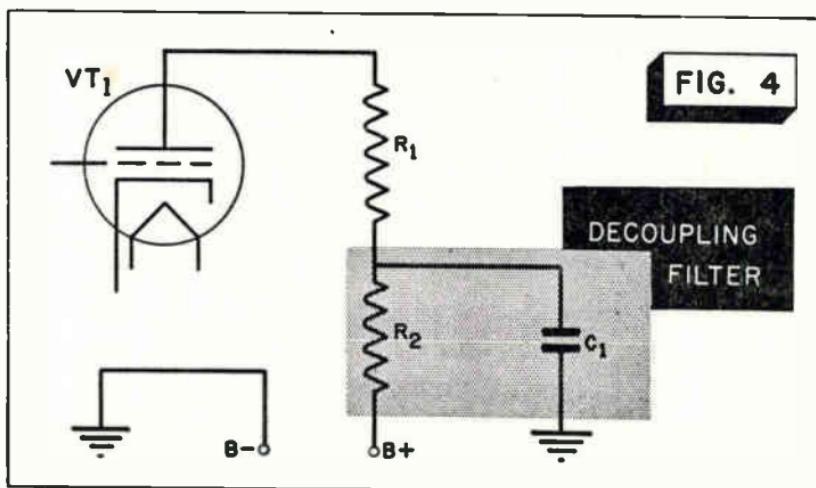
### MISCELLANEOUS CAUSES OF HUM

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  $VT_1$ .

**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.

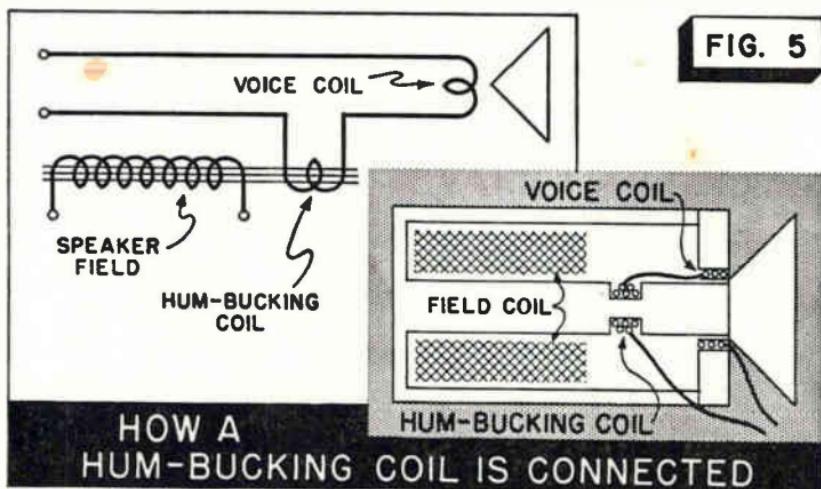
Sometimes a replacement choke or power transformer does not have the complete shielding of the original part. This may allow strong hum fields to escape from the part if it is a power transformer or choke, or to get into the part if it is an audio transformer. In such cases, it is best to get a more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



## MODULATION HUM

HEARD ONLY WHEN A STATION IS  
TUNED IN. ORIGINATES IN AN R.F.  
STAGE



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.

## STEADY HUM

HEARD WHETHER OR NOT A STATION  
IS TUNED IN. ORIGINATES IN POWER  
SUPPLY OR IN AN A.F. STAGE

### BASIC TESTING

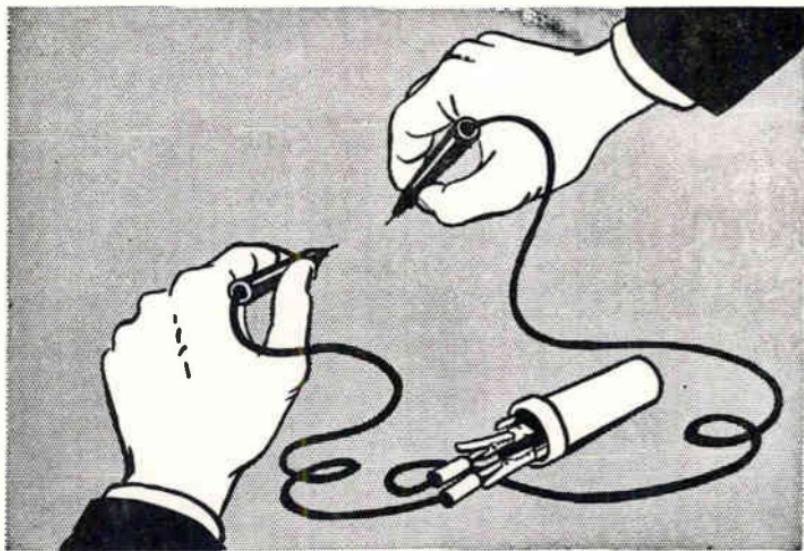
As we said, 90% of hum complaints (plain hum—not modulation hum) are caused by defective filter condensers or by cathode-to-heater leakage in an audio tube. Therefore, it is logical to check these suspects first, before making any further localization tests.

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 prods 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  $C_1$  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  $C_1$  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-

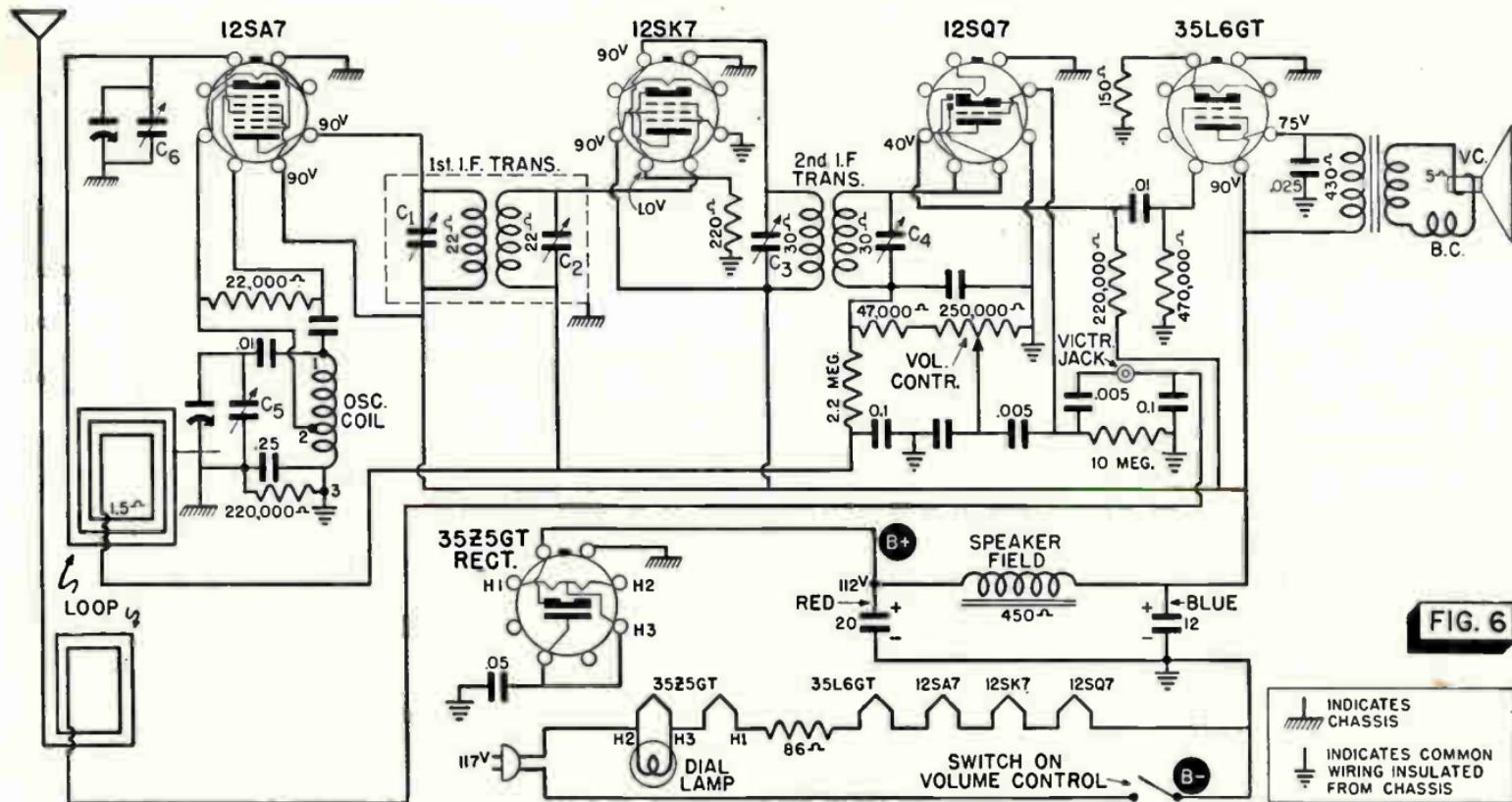


FIG. 6

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.

► 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.

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.

► 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-

cillator 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



When steady hum is the complaint, you can use signal blocking or signal tracing, but not signal injection. For modulation hum, you can use signal tracing or signal injection, but not signal blocking.



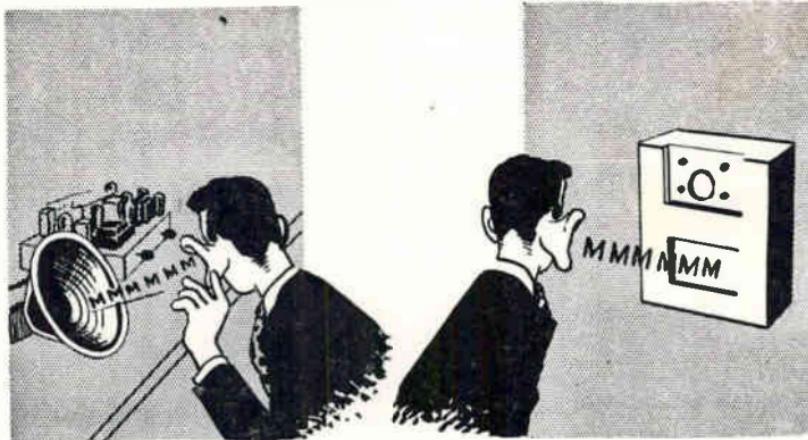
is shorted, remove the shorting lead (or condenser), and short across the 470,000-ohm 35L6 grid resistor. If hum is heard, it is originating in the 35L6 stage.

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. If



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.

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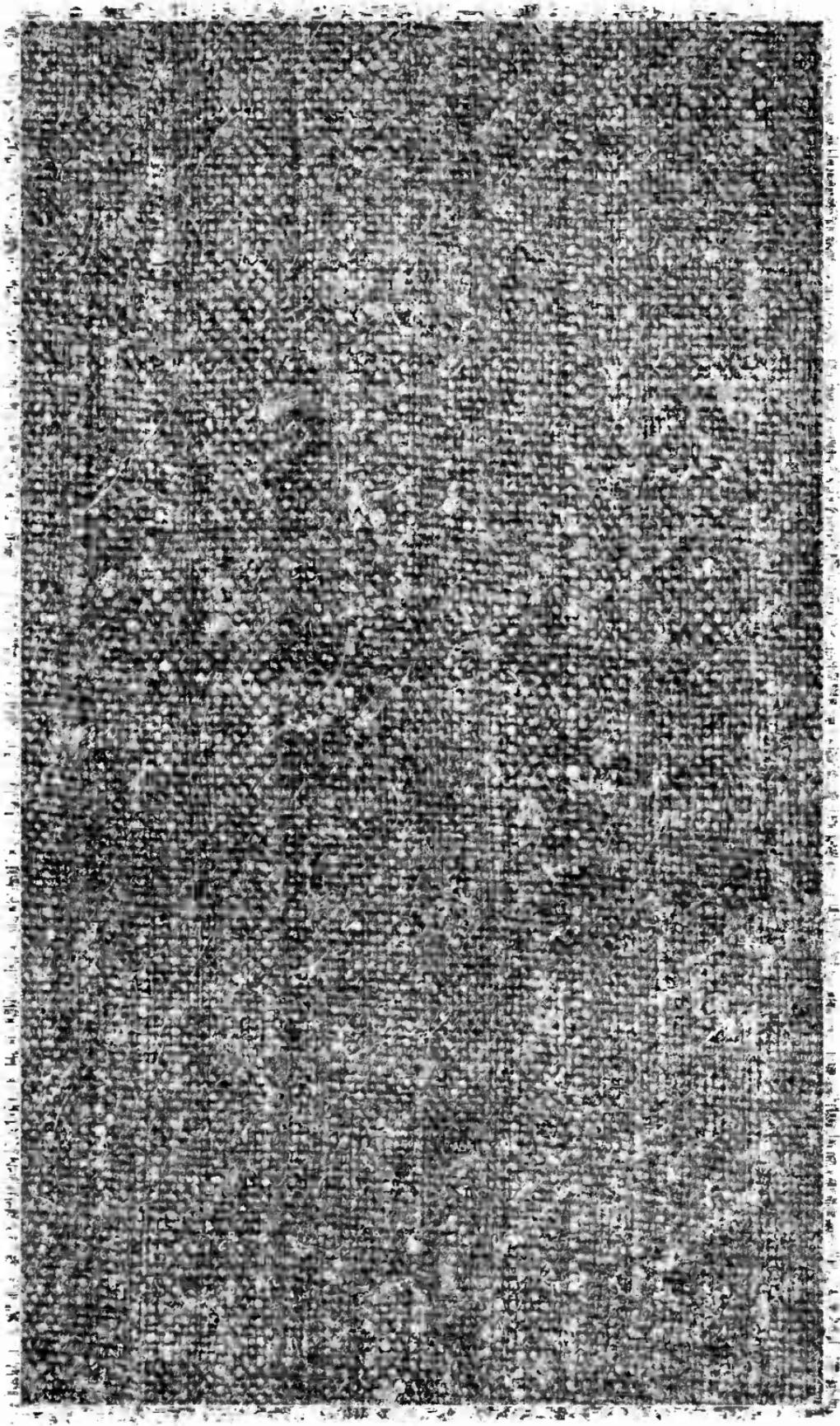
## **COMMON CAUSES OF HUM**

### **SEVERE**

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

### **ANNOYING**

Open or high p.f. input filter condenser	Shunt with a good condenser	Power supply
Half of rectifier tube defective	Test tube	Power supply
Power cord near audio tube grid	Visual examination	Audio section
Hum-bucking coil reversed	Reverse connections	Speaker



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

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 23 How To Fix a Receiver That  
Squeals and Motorboats  
**RADIO SERVICING METHODS**



# NRI TRAINING

# Pays... " " "

Dear Mr. Smith:

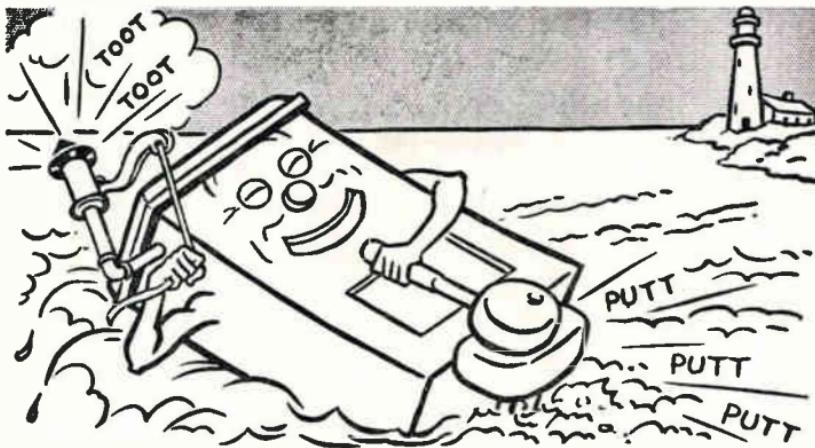
Before I enrolled with you I thought radio was a subject that required a college education to understand. But I did enroll, even though I thought it was a gamble. Soon I discovered that with your method of teaching not only did I begin to know radio, but I was making side money. I am now operating a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

P.J.P., New Jersey



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



## How To Fix a Receiver That Squeals and Motorboats

**O**SCILLATION 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-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:

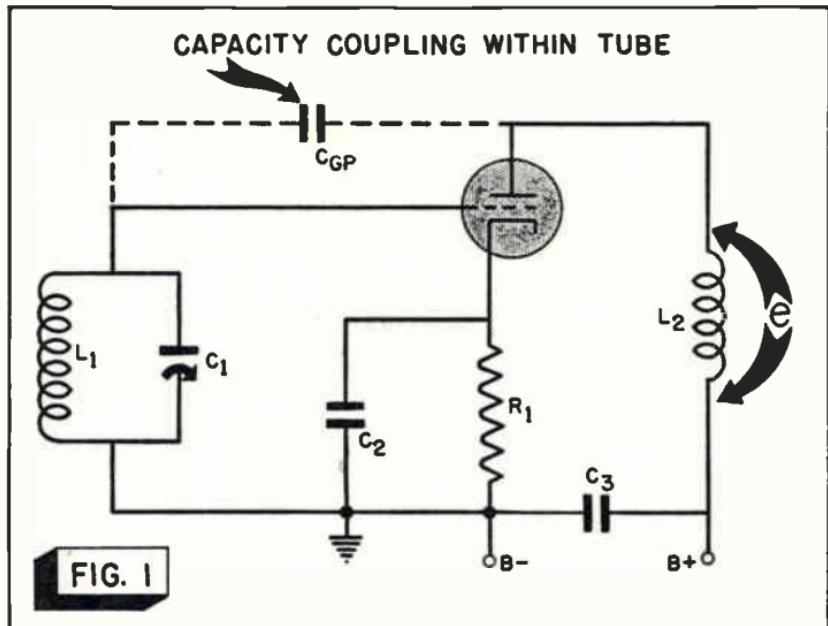
1. A *feedback path* must exist that will allow energy to get out of some circuit and get back into another one in an undesired manner.

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.

► Fig. 1 shows an example of capacitive coupling. When a signal is passing through this stage, there will be a signal voltage  $e$  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  $C_{GP}$ , then the voltage  $e$  will be applied, through  $C_{GP}$  and  $C_s$ , 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  $L_1-C_1$  depends on the Q of the resonant circuit and on the reactance of the capacity  $C_{GP}$ .

► If the capacity  $C_{GP}$  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.

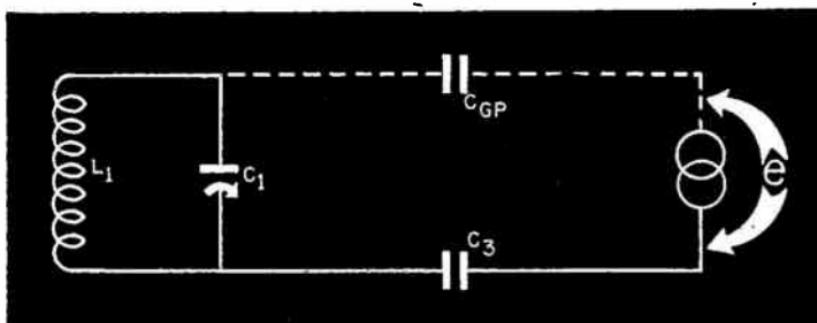
Energy can get back just as well if the magnetic field of the plate load coil ( $L_2$ ) happens to link with the grid coil ( $L_1$ ). Therefore, as Fig. 3 shows, these coils are shielded from each other, or are kept separated, and are so placed that their fields have as little inter-action as possible.

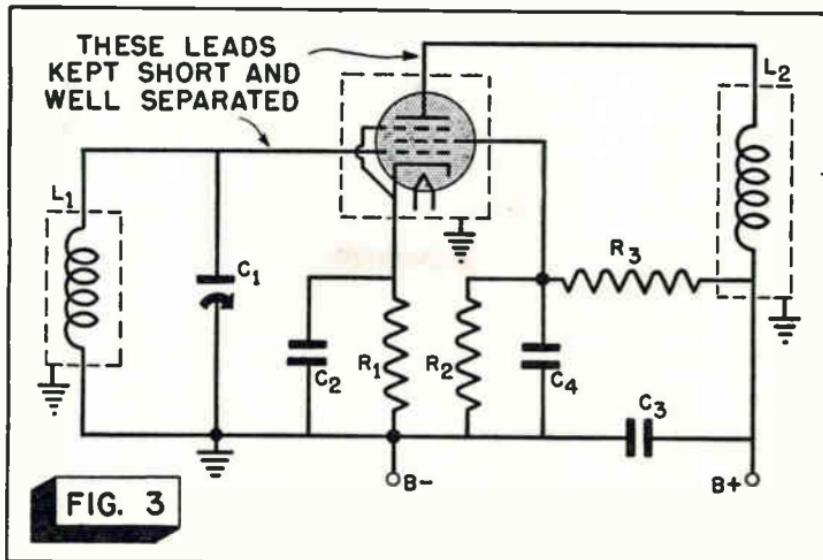
Even the tube is shielded to minimize stray coupling between the grid and plate circuits. (Incidentally, schematic diagrams may not indicate tube and coil shields, but these shields are normally used, whether shown or not.)

## 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 con-

**FIG. 2.** This circuit shows why feedback occurs when grid-to-plate capacity exists in the amplifier shown in Fig. 1. The amplified signal voltage,  $e$ , developed across the plate load in Fig. 1 is here represented by the symbol for an a.c. generator. As you can see, the grid-to-plate capacity  $C_{GP}$  completes a circuit from this voltage source to the tuned circuit. Therefore, part of the voltage  $e$  will appear across the tuned circuit—in other words, part of the output voltage of the amplifier will be fed back to the amplifier input.





denser  $C_4$  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  $R_2$ ) or a lack of bias (caused by a shorted  $C_2$ ) may cause the stage to be unstable. Finally, an amplifying tube with a higher-than-normal  $g_m$  may cause trouble because it develops a higher-than-normal load signal voltage. These last two possibilities—improper voltages or a high  $g_m$  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  $C_2$ . 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  $C_2$  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  $VT_2$ , 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  $C_5$  is the r.f. by-pass for the  $B+$  circuit of the two stages. If it opens, the r.f. components of the

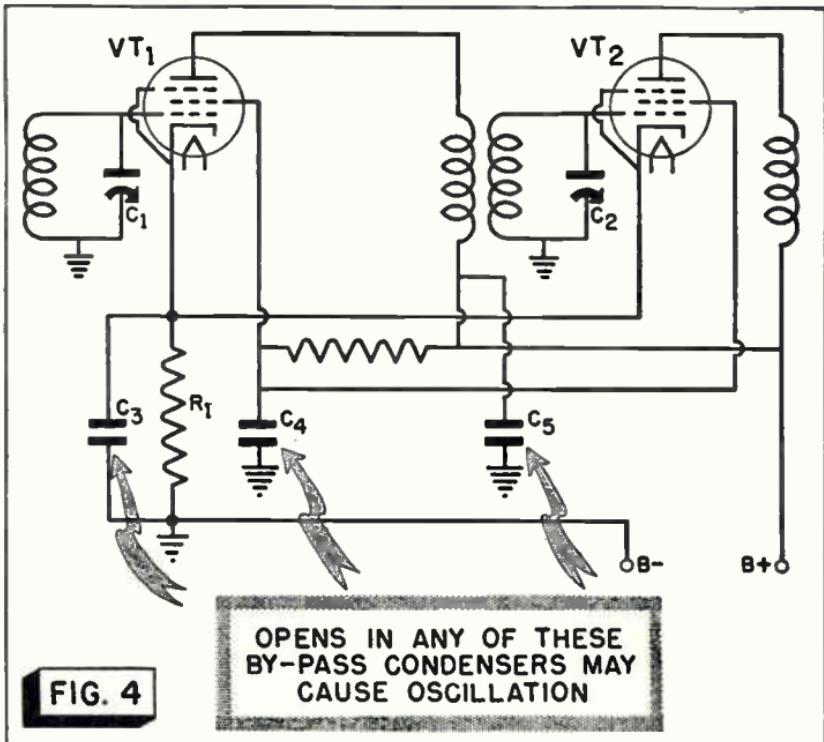
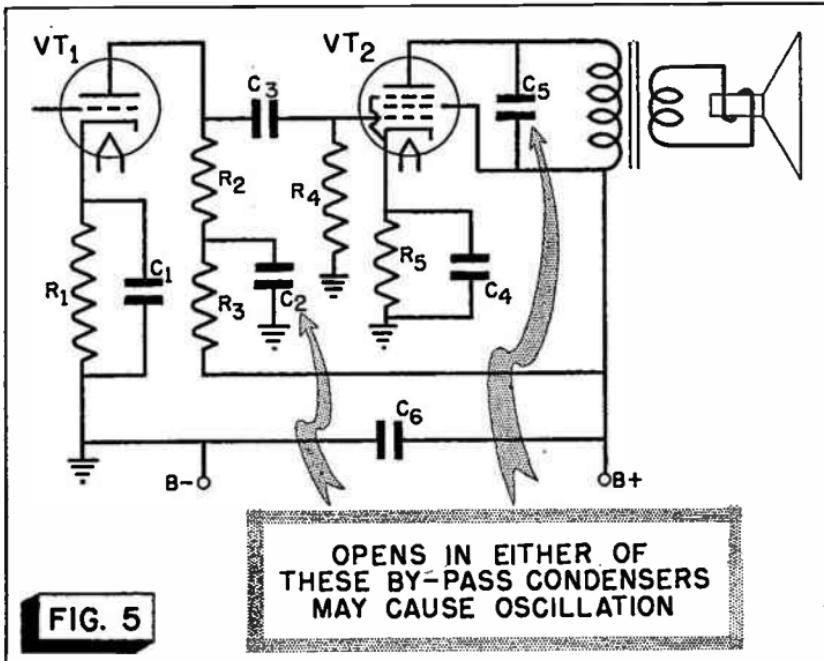


plate currents can get into the power supply leads and be coupled to other circuits in the right phase to cause oscillation. Although  $C_5$  is in parallel with the output filter condenser, the filter condenser cannot assume the function of  $C_5$  because electrolytics have higher power factors than 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  $C_4$  or  $C_5$  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  $C_5$  opens, there is some possibility that oscillation will develop in the audio amplifier. This bypass 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  $VT_2$  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  $C_4$  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  $VT_2$  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  $C_3$  back into the grid circuit of  $VT_2$ , 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  $R_8$  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  $R_8$ , rather than to be applied to the signal circuits of  $VT_1$ . An open in  $C_2$  can, therefore, permit both motorboating and hum.

The filter condensers are another possible cause 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.

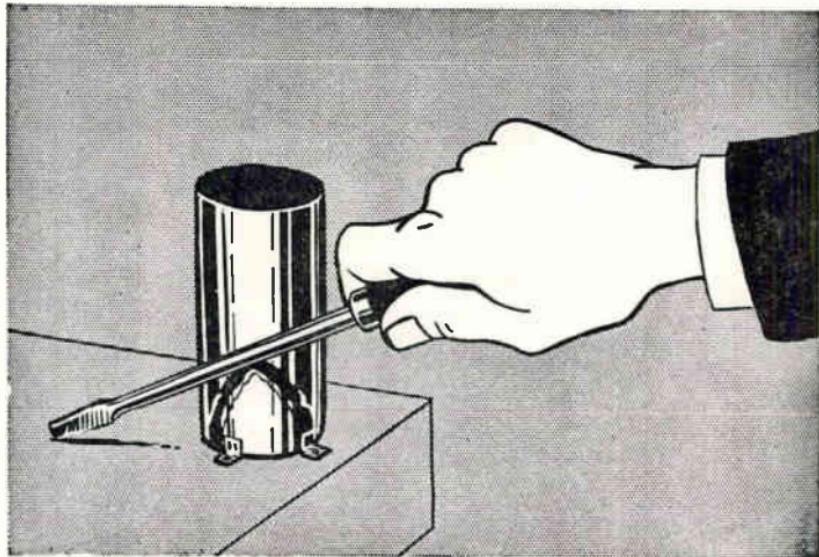
A quick glance over the receiver while looking for surface defects will show you whether tube shields are missing or not, because you can see where shielding bases or shielding clamps are installed on the chassis. Naturally, if you see a base or clamp with no shield over the corresponding tube, you know 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

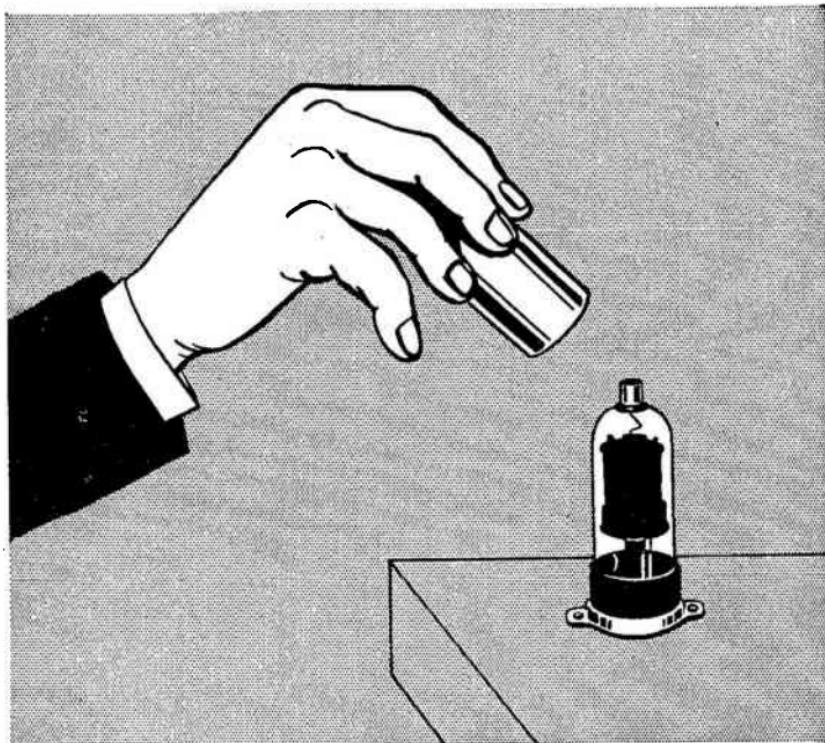


**How to check for a poor contact between shield and chassis.** If grounding the shield to the chassis with a screwdriver this way affects the operation of the set in any manner, the connection between the shield and the chassis is poor.

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, re-aligning 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 this 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 a 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.

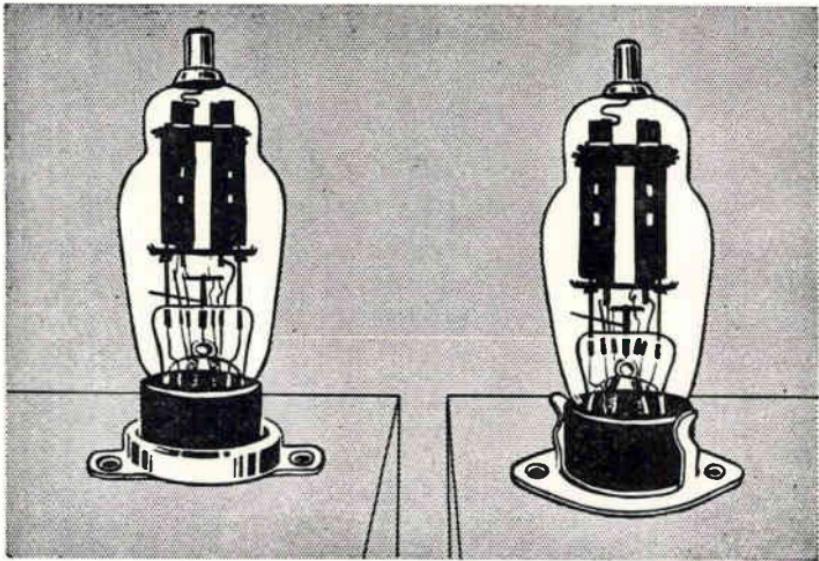
If the oscillation or squealing is audible only when stations are tuned in, but it occurs on *all* stations, the probable location of the difficulty is in the i.f. stages.

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



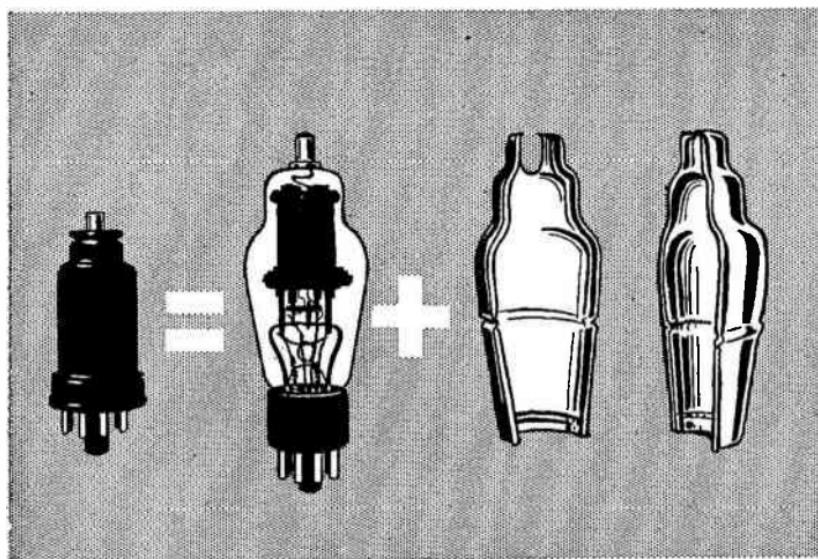
Look for indications of missing tube shields when you inspect a set that is oscillating. If a shield was used originally, the shield base, through which contact is made between the shield and the chassis, will still be in place around the tube socket. The illustration above shows two types of shield bases. Other kinds are also used.

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.

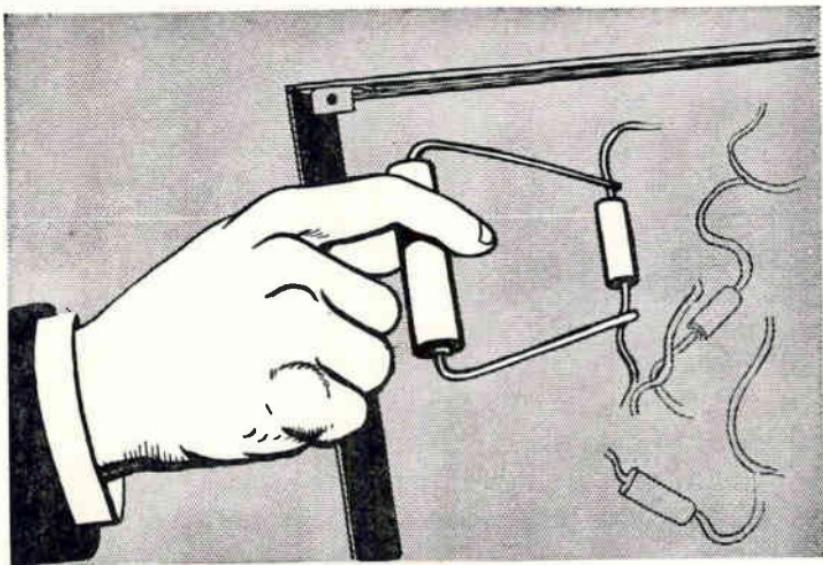
If the oscillation stops when the first audio tube is out of its socket, re-insert this tube, and pull out the second detector if it is a separate tube. If the second detector is in the same tube envelope as the first audio tube, then pull out the last i.f. tube instead. Continue moving in this manner 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



When you connect a test condenser across one already in a circuit, hold it with your thumb and forefinger like this. Never grasp the test condenser with your whole hand while making tests; you may introduce stray voltages, provide a leakage path, or even get a shock.

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.

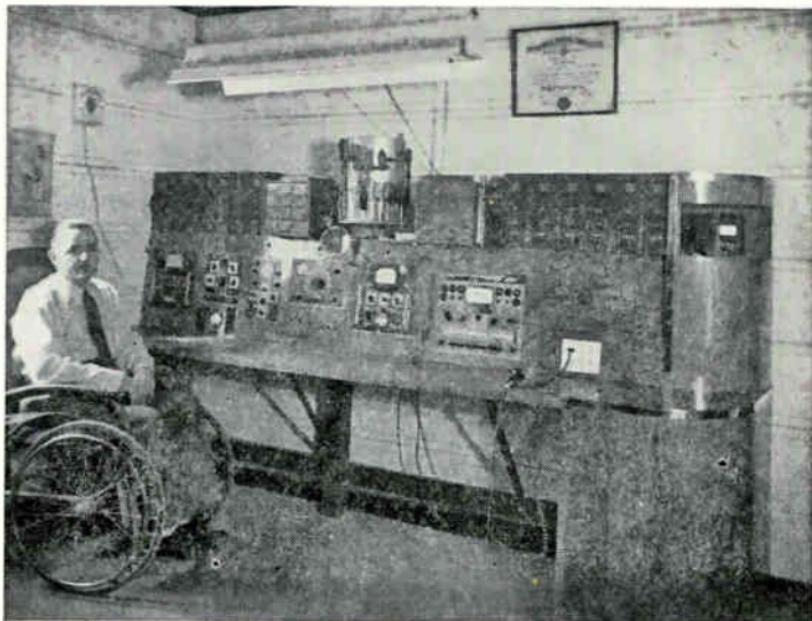
When you are sure that you are hearing the oscillation, move the s.g. back toward the output. In other words, move the hot lead from the antenna terminal to the grid circuit of the first detector. If you still hear the squeal, change the signal generator setting to the i.f. frequency, and move the hot 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 wheel chair, 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.

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## 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 condensers.

2. *Oscillation audible whether or not a station is tuned in, but affected by position of volume control.*

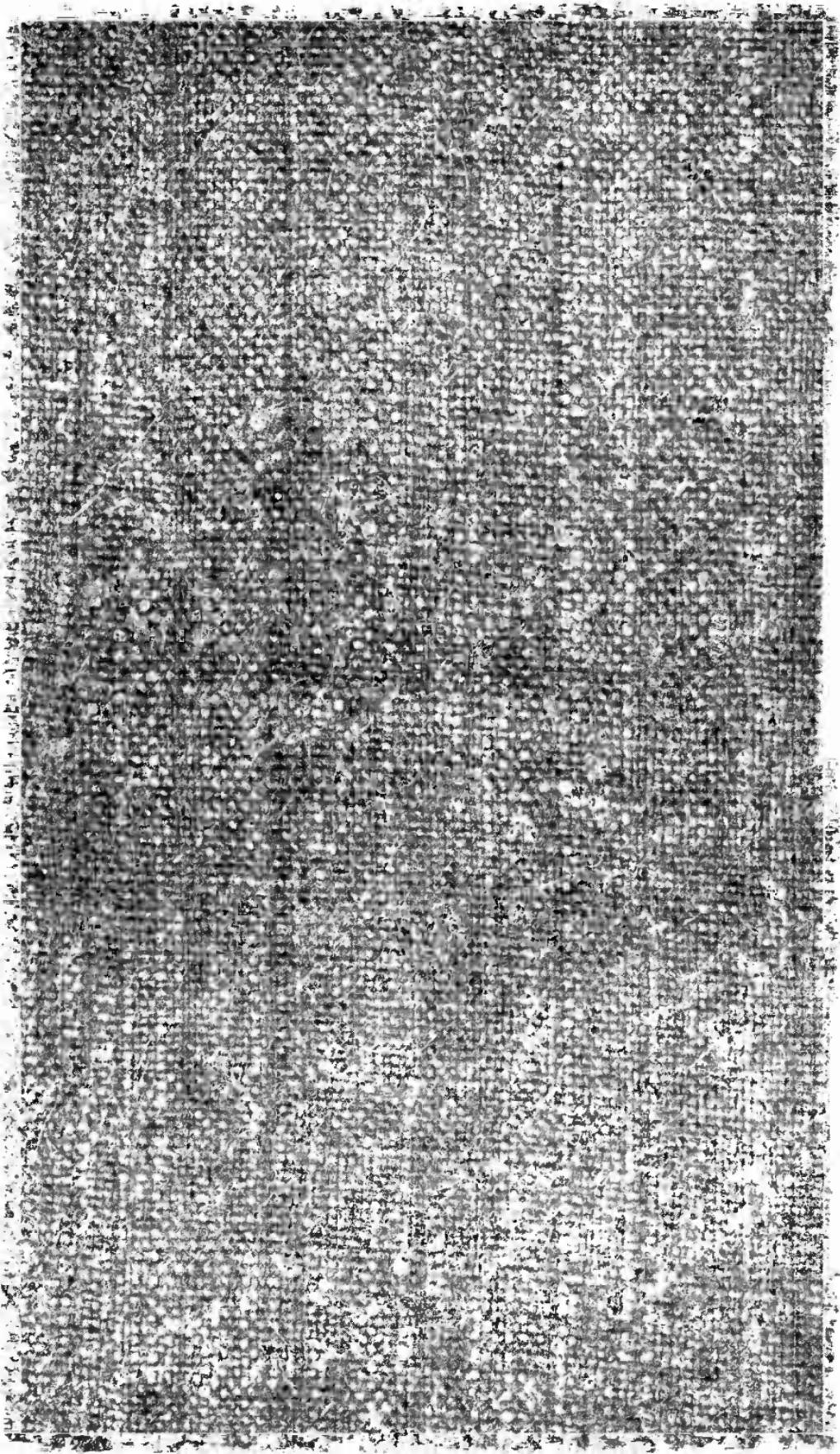
The defect may be in the i.f. stages, in the second detector, or in the first a.f. amplifier. Possibilities: open filter or by-pass condensers; shielding missing or making poor contact; alignment off; excessive screen grid voltage; leads improperly placed.

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.



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

NATIONAL RADIO INSTITUTE, WASHINGTON D.C.

No. 24

How To Fix a Noisy  
Receiver

RADIO SERVICING METHODS



# NRI TRAINING

# Payoff..

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



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**



# HOW TO FIX A NOISY RECEIVER

**W**E 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.

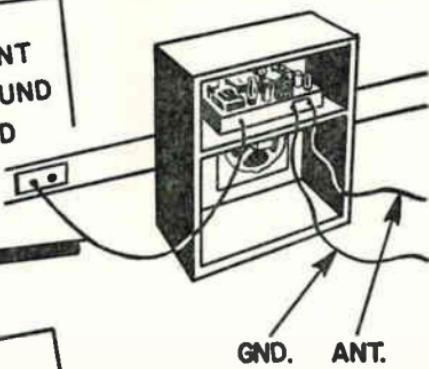
**Disconnect the Ground Lead.** If the noise level remains the same when the ground lead is disconnected, the receiver is at fault, or the noise signal is coming in over the power line. However, if the noise *decreases*, you may have a poor ground. If it *increases*, the noise signal is probably coming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

FIG. 1

## HOW TO LOCALIZE NOISE TO A RECEIVER

1. CONFIRM THE COMPLAINT  
WITH ANTENNA AND GROUND  
CONNECTED TO SET AND  
SET PLUGGED INTO  
POWER LINE



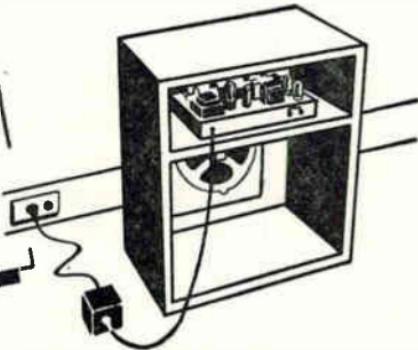
2. DISCONNECT AND REMOVE  
ANTENNA, SHORT ANTENNA  
AND GROUND POSTS ON SET



3. DISCONNECT AND  
REMOVE GROUND



4. PLUG FILTER INTO  
WALL OUTLET, PLUG  
POWER CORD INTO  
FILTER



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.

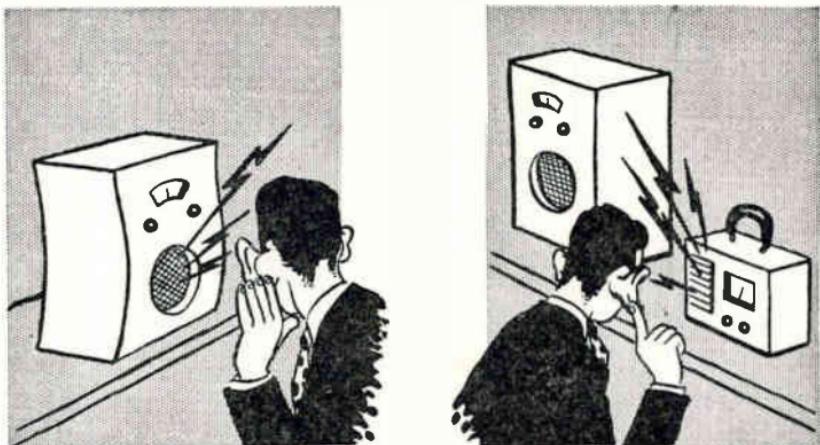
**Using a Test Receiver.** Sometimes these tests will not be conclusive. If you are not sure whether the receiver is defective or whether the noise is of external origin, you can try another receiver in the same location as the suspected one. A small three-way portable receiver is excellent for this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



**To learn whether the installation is responsible for noise, compare the performance of the customer's set with that of your test receiver in the customer's home. Use the same antenna and power outlet for both sets.**

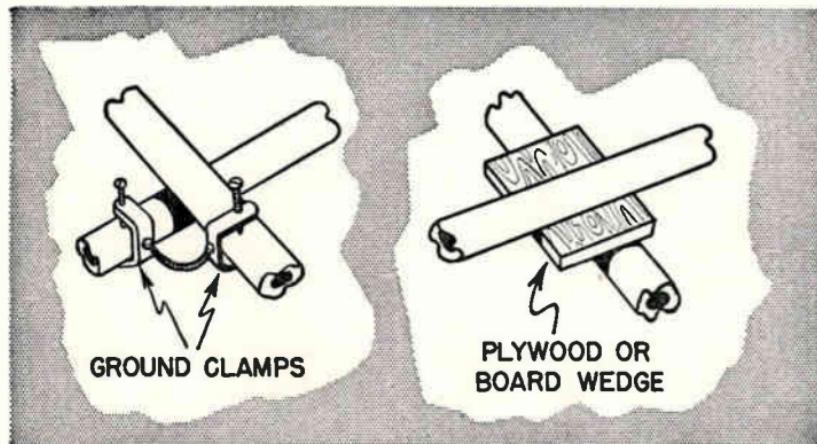
atmospherics, but they do pick up interference from automobile ignition systems and other man-made sources.)

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.



To prevent interference caused by ground pipes that make variable contact with each other, either bond them electrically (left) or wedge them apart permanently (right).

► 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 wave form. 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

sharply, and another noise pulse will be created. A steady noise will be heard if the intermittent open recurs rapidly.

Notice—an open must be *intermittent* to cause noise. A permanent open circuit will result in a dead receiver or in improper operation, depending on the circuit in which the open exists.

*Noise is also caused by a poor connection where no connection is desired.* A partial short circuit is an example. Suppose that the support of a screen grid becomes loose, allowing the screen to move when the tube is jarred. A sound wave from the loudspeaker may cause the chassis and the tube to vibrate. If the screen grid touches the suppressor grid, the B supply will be shorted; a noise pulse will be set up because the plate current will at once drop to zero. Another mechanical shock may break the connection between the screen and suppressor grids, setting up another noise signal as the contact is opened.

### SPECIFIC DEFECTS THAT CAUSE NOISE

Now that you know how a noise signal is generated, let's learn which radio parts cause the complaint. As we discuss each part, we shall describe the tests to use on it, and tell you how to cure the trouble. Hence, when you have localized the trouble to a stage (by methods we will describe later), you should follow the suggestions given for each part.

**Variable Resistors.** Volume and tone controls are the most frequent cause of noise. They come in two types, wire-wound and carbon, and, with use, both types develop poor contacts between the resistor elements and the sliding contact.

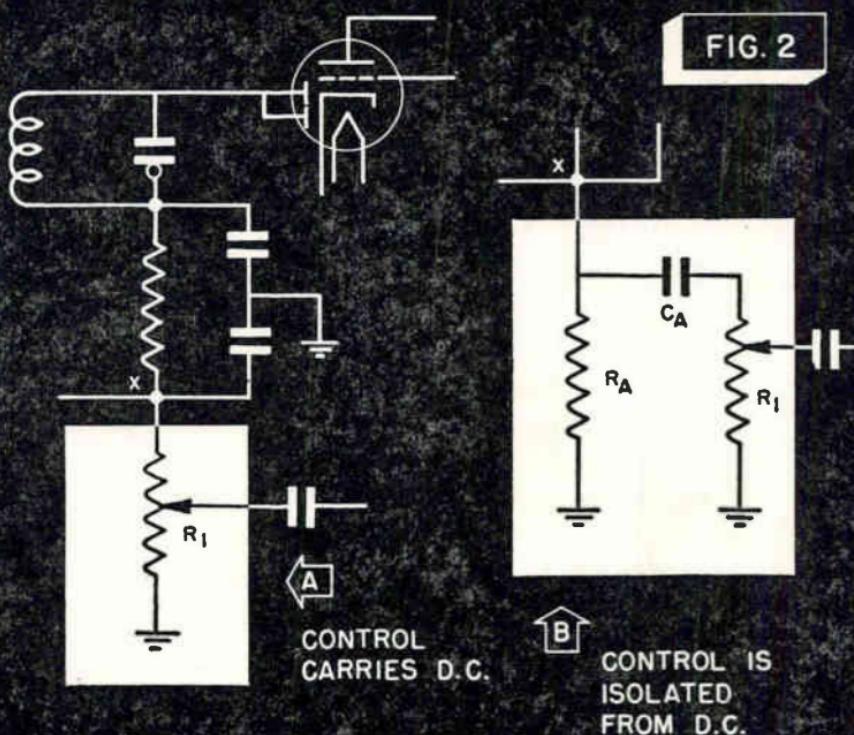
If you hear noise when you adjust a volume or tone control, you can be sure the control is defective. A very bad control will cause noise whether the control is adjusted or not, but the noise will be worse as the control arm is moved.

Once a control goes bad, the best thing to do is to replace it. Any repair you might make would be temporary at best—and would probably take longer than installing a new control.

► 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 resistance of the original volume control as possible within 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 Candohm type (a wire-wound resistor enclosed in a metal can) riveted to the chassis, you can test it by

FIG. 2



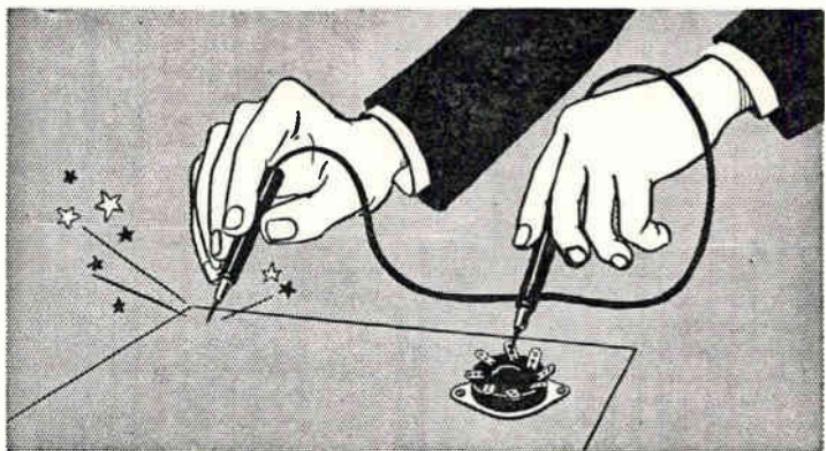
springing out the resistor unit enough to subject it to a mechanical strain. (Insert a screwdriver blade between the resistor can and the chassis, and twist it to cause this strain.) If this causes a sudden appearance or disappearance of the noise, the unit is defective. A defective wire-wound resistor 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.

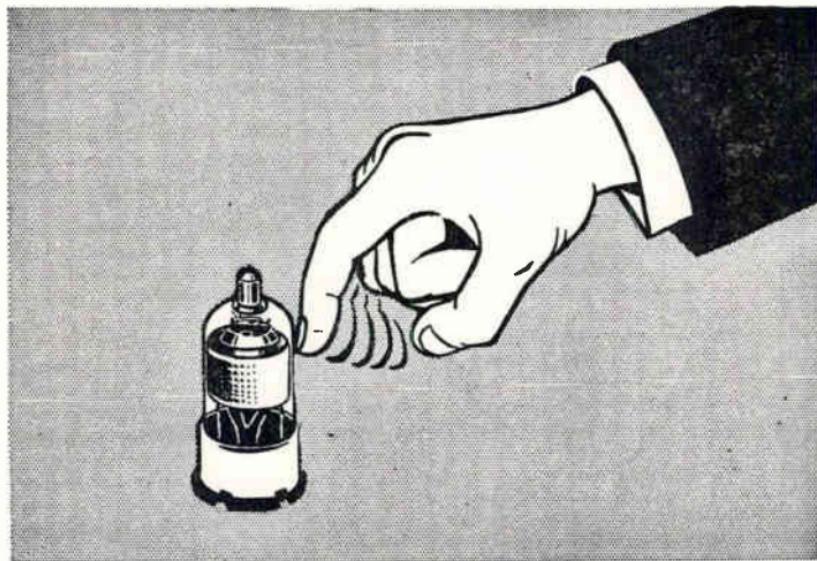


**Use a test lead equipped with prods to short from a tube plate socket to the chassis. It's easier than getting a screwdriver into the restricted space. (For simplicity, we have shown no parts or wires connected to the socket in this illustration.)**

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.

► As a "kill or cure" procedure on an a.c.-operated receiver using a power transformer, you can short-circuit momentarily from the plate socket terminal to B—with a screwdriver or test lead. This will draw a high current through the primary winding of the suspected transformer. If the transformer winding is weakened, it will usually open permanently, thus indicating that the trouble is here. (A winding in good condition will not be harmed by this test as long as the short circuit is momentary.) It is possible that the ends of the wire at the weak spot may be welded together by the high current. This will clear up the noise; however, take this only as an indication that the transformer is defective.



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.

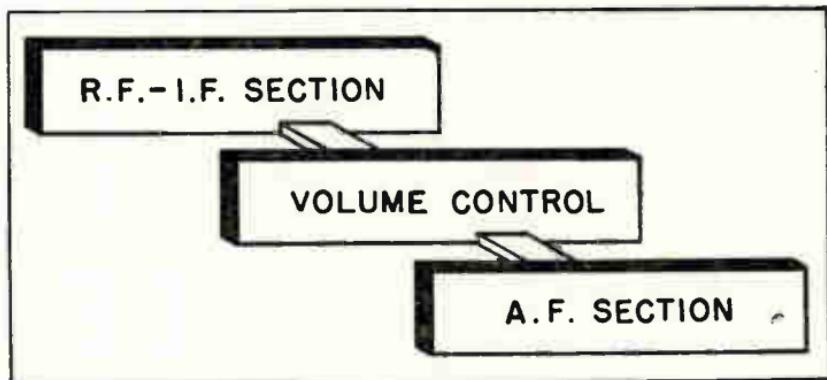
► A poor contact can also exist at a bias cell. These bias cells are held in small holders that depend on spring tension for contact. Sometimes it is necessary to clean the cell or to strengthen the contact.

► 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



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. 3 let's assume first that the noise is in the a.f. amplifier. In this case, you can pull out tube  $VT_8$ . If the noise stops, but continues when this tube is in the socket and the volume control

17

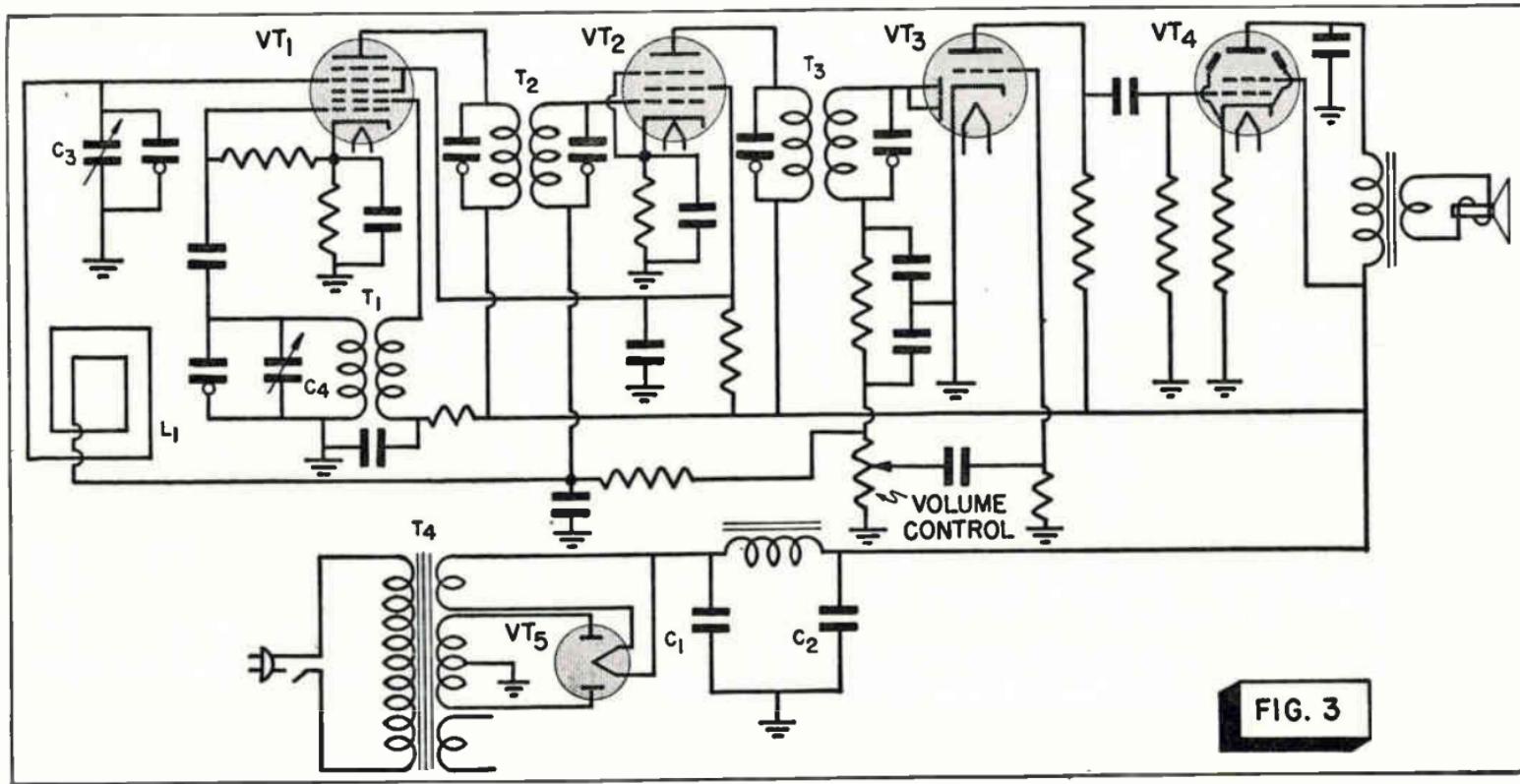


FIG. 3

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  $VT_3$  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  $VT_2$ . If the noise continues with this tube removed, it must be originating in the diode detector stage; tube  $VT_3$  and the volume control are the most likely suspects.

If the noise stops when  $VT_2$  is removed, replace this tube and pull out  $VT_1$ . If the noise continues, it is probably originating in the  $VT_2$  stage. I.F. transformer  $T_8$  and the tube are the most likely source of trouble here.

Of course, if the noise ceases when  $VT_1$  is pulled out, it must be originating in that circuit. I.F. transformer  $T_2$ , the tube, the oscillator transformer  $T_1$ , the loop antenna  $L_1$ , or either of the tuning condensers ( $C_3$  and  $C_4$ ) could be at fault. Examine each carefully.

To determine whether the noise is in  $T_2$ , leave  $VT_1$  out of the socket, and connect a voltmeter between the plate terminal of the  $VT_1$  socket and the chassis. The voltmeter current will then be drawn through the primary of  $T_2$ . If the noise occurs now, but does not with the voltmeter disconnected, the primary of  $T_2$  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

### BENCH HINTS

Many record changers will not work properly if the motor board is not level. Check levelness with a carpenter's or machinist's level resting on the motor board (not on the turntable). If you find the board is not level, slip small cardboard or wood wedges under the cabinet.

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  $VT_4$ .) 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  $VT_4$  is blocked, move back to the grid of  $VT_3$ . If the noise now continues, it is originating in  $VT_3$  or in the coupling between  $VT_3$  and  $VT_4$ .

You can move through the r.f.-i.f. section of the receiver in a similar manner. Blocking the grid of  $VT_2$ , will eliminate any noise originating nearer the antenna, so, if the noise continues, it is arising in the  $VT_2$  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  $VT_1$  and the chassis. If the noise stops, it is originating in the  $L_1-C_3$  circuit. However, if the noise continues, it may be originating either in the plate circuit of  $VT_1$  or in the oscillator circuit. The oscillator circuit can be eliminated by temporarily short-circuiting condenser  $C_4$  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.

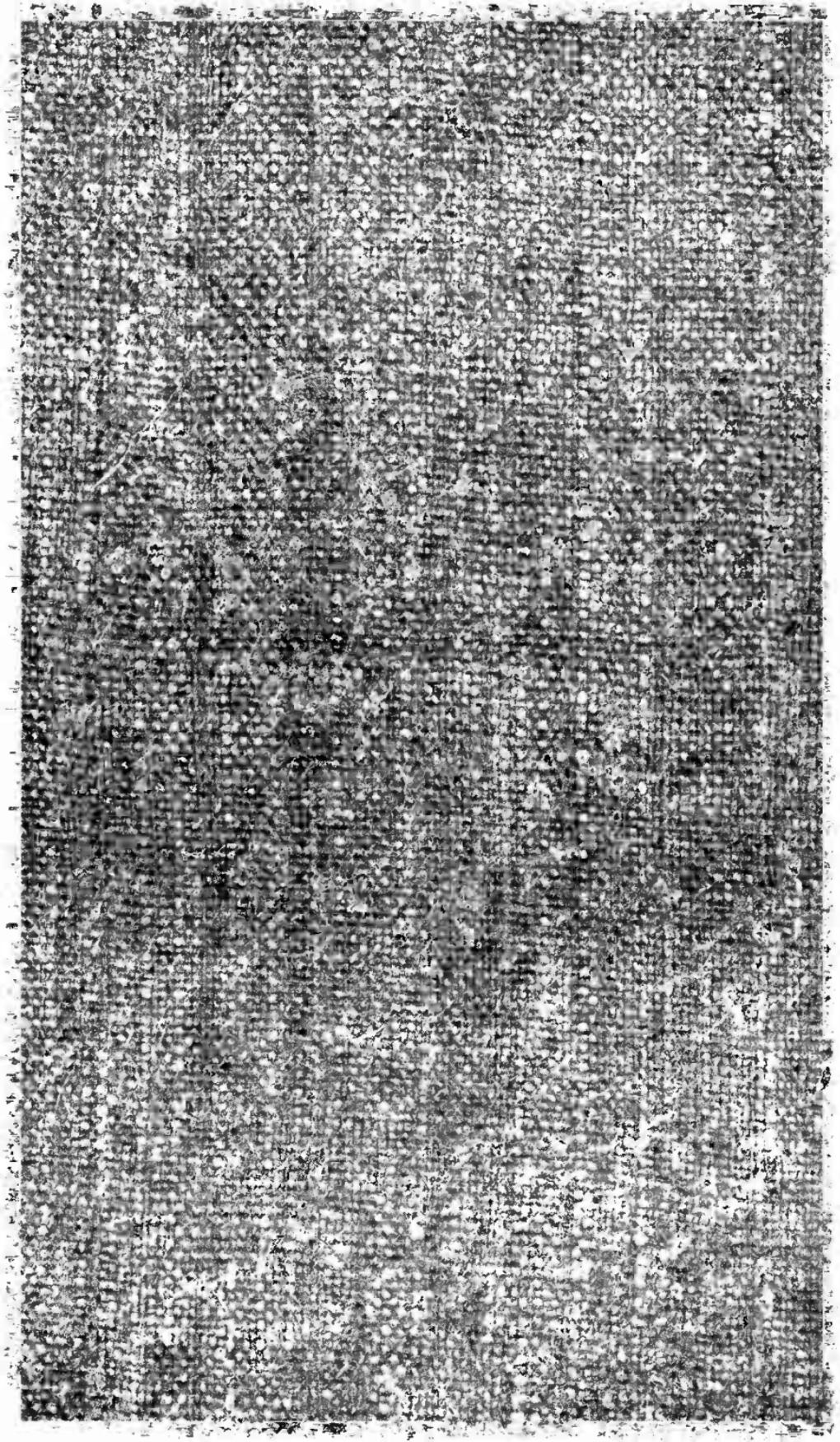
Try to make a poor connection that will cause noise when the receiver is jarred. Hold your soldering iron tip on the plate socket terminal of one tube, and grasp the lead going to this terminal with your pliers. When the solder melts, remove the iron, and wiggle the lead while the solder hardens. This 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.

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## **COMMON CAUSES OF NOISE**

<b>Type of Noise</b>	<b>When Noticed</b>	<b>Parts to Check</b>
Scratching	Tuning set	Condenser gang
Scratching	Adjusting volume or tone control	Control adjusted
Crashing	Changing wave band	Wave band switch
Steady or intermittent rushing	Between stations and on weak stations	Antenna, antenna coil, mixer tube
Steady crackling	Always	I.F. or a.f. transformer primary
Intermittent crackling	If chassis is jarred	Tube or connection



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

**NATIONAL RADIO INSTITUTE WASHINGTON, D.C.**

No. 25 How To Fix a Receiver  
That Distorts

RADIO SERVICING METHODS



# NRI TRAINING PAYS...

Dear Mr. Smith:

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

J.O.B., Canada



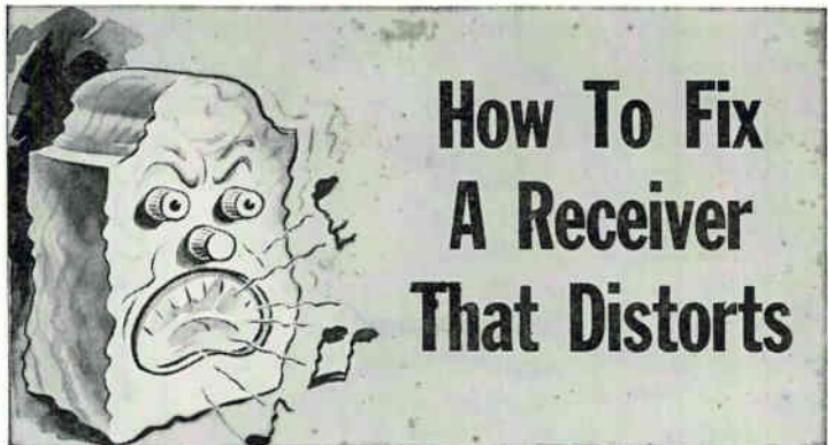
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FMIOMI149

1950 Edition

Printed in U.S.A.



## How To Fix A Receiver That Distorts

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

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

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

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

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

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

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

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

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

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

## COMMON CAUSES OF DISTORTION

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

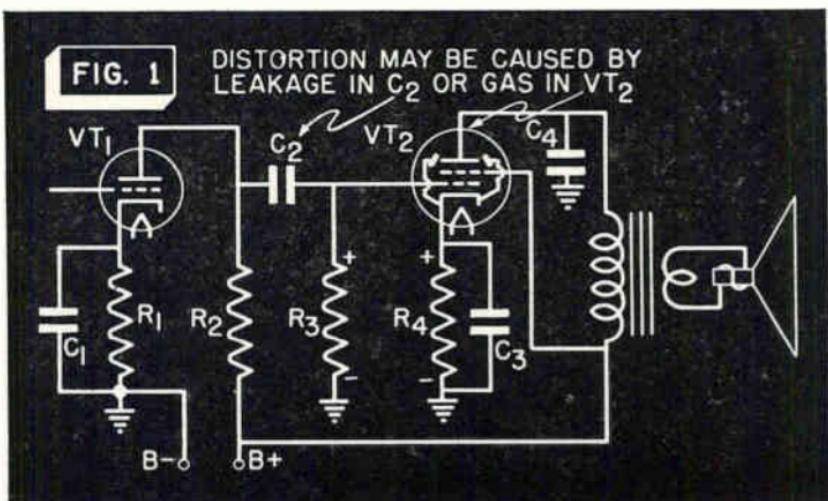
ble defects that can occur in each class of part have been combined in one section. For example, all loudspeaker troubles are in a single grouping, even though some of these troubles occur much more frequently than others.

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

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

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

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



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

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

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

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

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

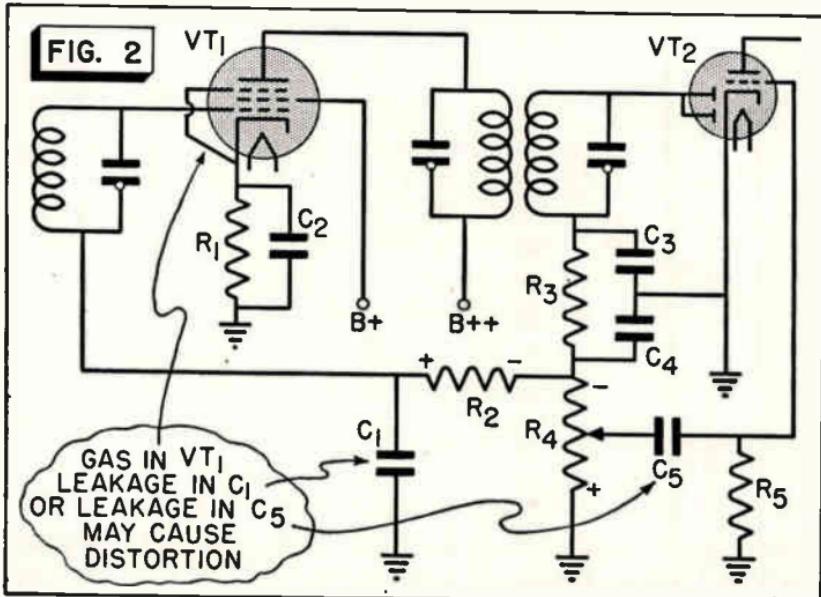
**Overloading.** Two kinds of "overloading" may be noticed. One occurs only on one or two powerful local stations; this is a true case of overloading, in that the powerful signal forces a tube to operate beyond the straight portion of its characteristic. Another kind is the result of improper operating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

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

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

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

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



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

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

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

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

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

. For example, in Fig. 1, resistor  $R_4$  (the bias resistor for  $VT_2$ ) may open. The leakage resistance of condenser  $C_8$  will then complete the plate circuit, but this leakage

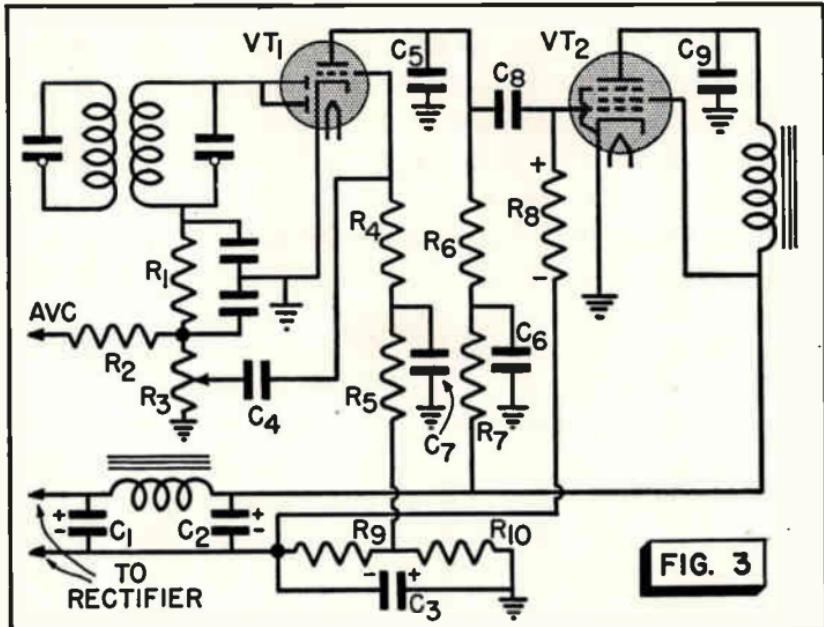


FIG. 3

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

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

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

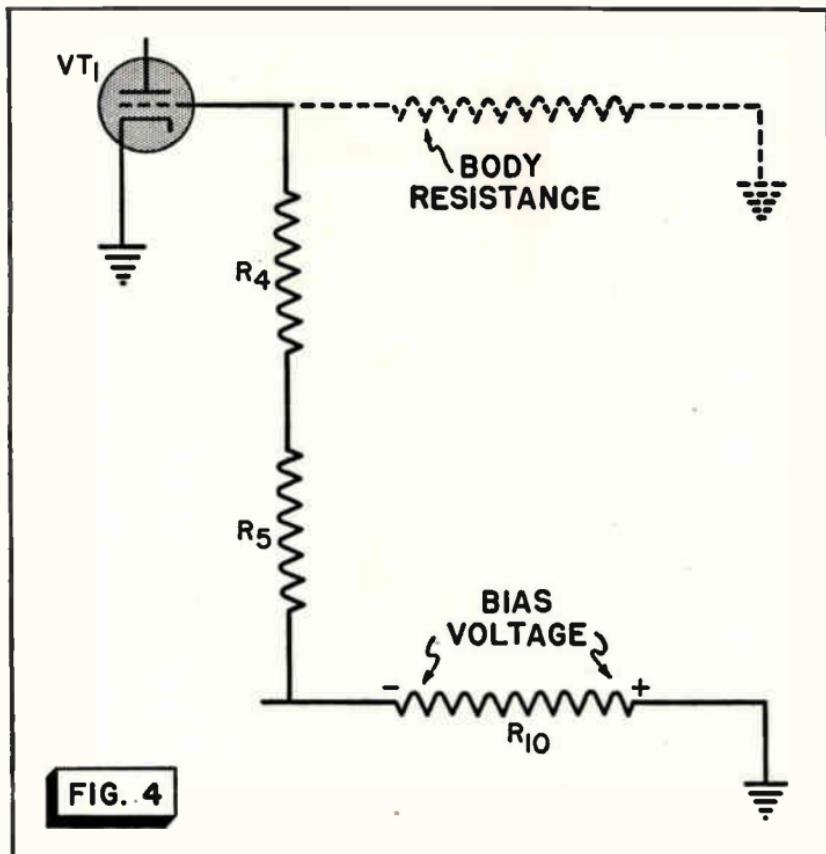
For example, suppose that a slight leakage develops in coupling condenser  $C_8$ , or tube  $VT_2$  becomes slightly gassy. Either defect will cause the voltage across  $R_8$  to assume the polarity shown and thus cause the current of  $VT_2$  to increase. The operation of  $VT_2$  will not be much affected,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

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

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

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

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



**FIG. 4**

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

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

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

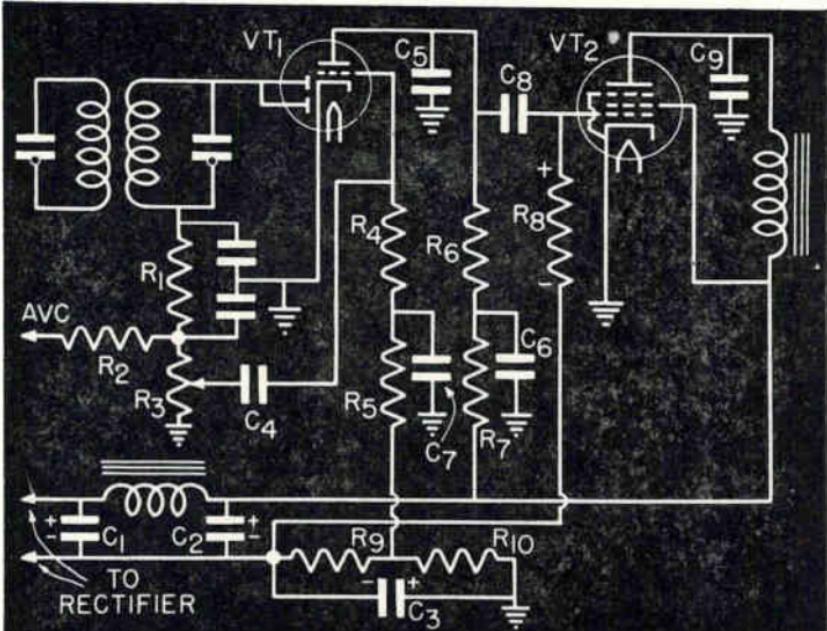
amplifier opens, the grid will then be floating free. It will trap some electrons from the electron stream, thus building up a negative charge on itself. Usually this charge will build up to such a value that the plate current will be sharply reduced, or even cut off altogether. Once in a while, however,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

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

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

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

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



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

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

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

In receivers where  $VT_1$  cannot be pulled from the

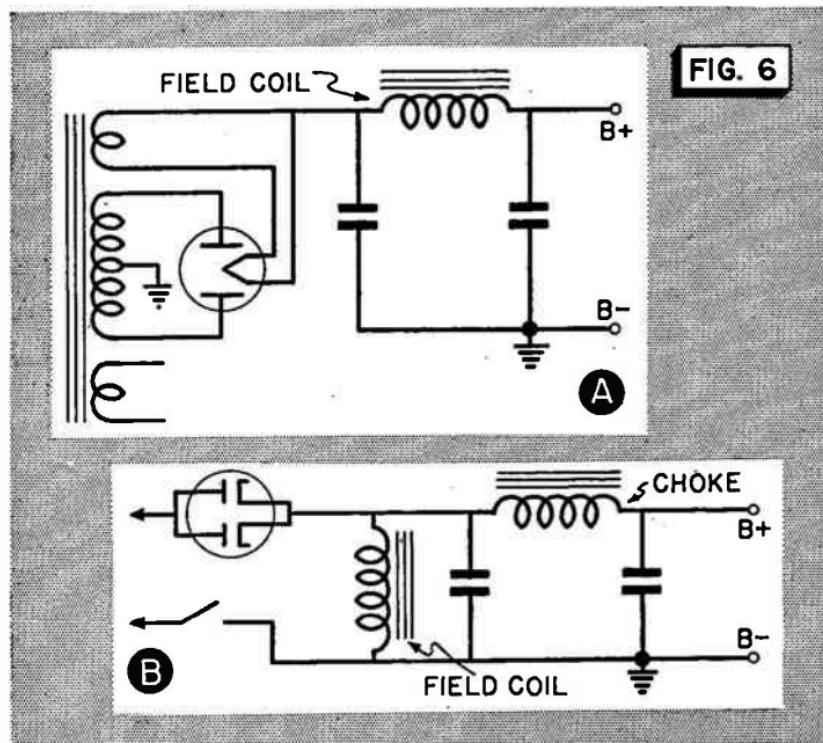
socket, it may be fairly simple to unsolder its cathode or plate lead and make the same check across the resistors. If this is difficult, disconnect the condensers and check them with an ohmmeter.

## LOUDSPEAKER TROUBLES

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

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

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



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

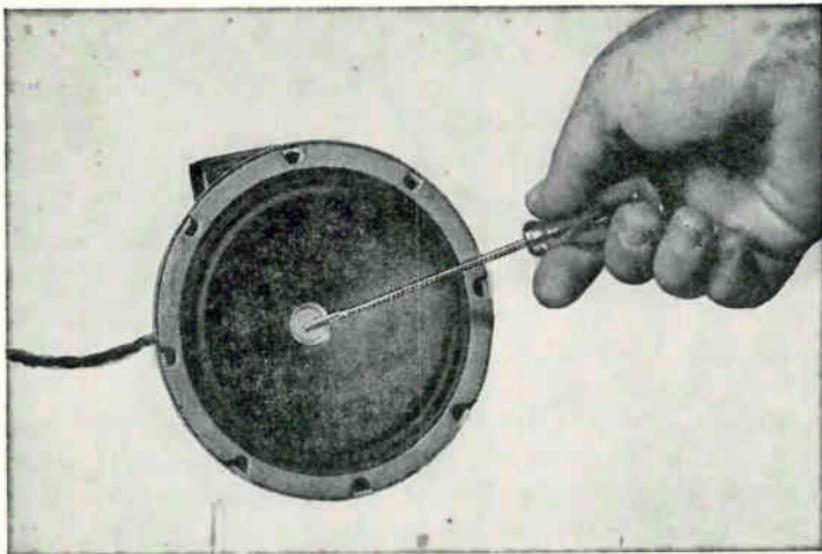
► The permanent magnets of p.m. speakers and magnetic speakers may weaken, reducing the field strength and causing distortion. This trouble usually develops gradually, however, so the distortion may go unnoticed for some time.

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

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

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

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



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

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

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

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

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

## HOW TO LOCALIZE DISTORTION

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

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

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

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

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

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

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

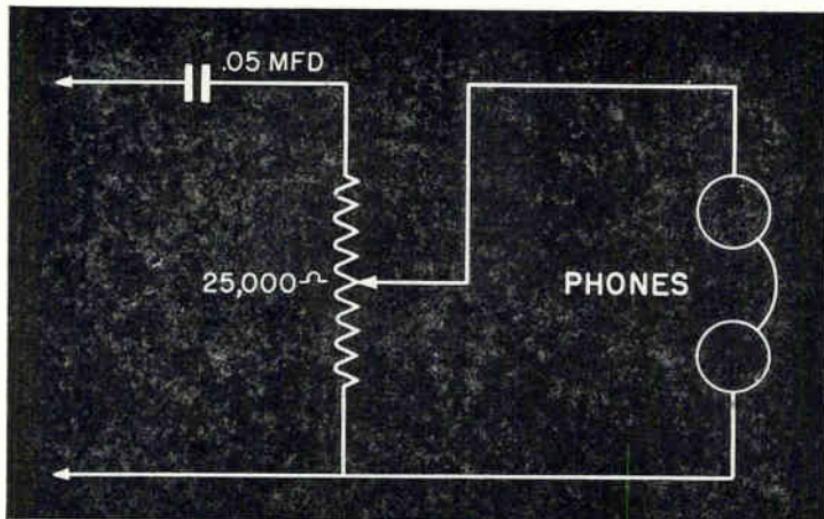
For tracing in the audio end of the set, many servicemen make a simple, homemade listening device like that shown in Fig. 7. In this device, the blocking condenser prevents short-circuiting the B supply when the device is used in the plate circuit, and the volume control is used to adjust the sound in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

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

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

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

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



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

### NRI PRACTICAL TRAINING PLAN

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

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

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

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

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

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

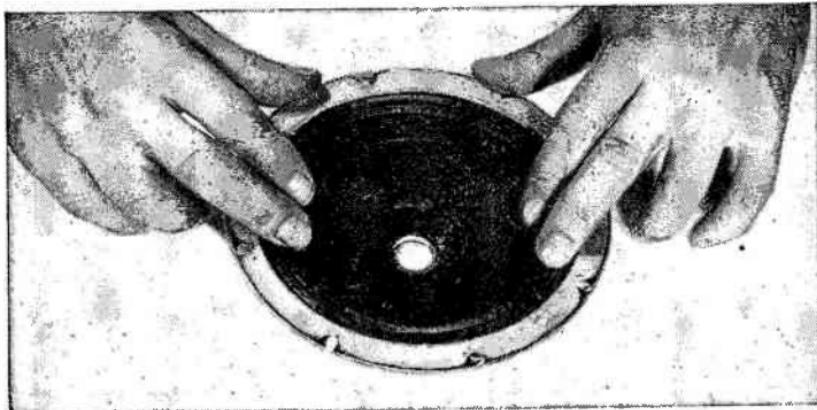
Tune in a program, and note how distorted the reproduction sounds. Measure the voltage across the test resistor, and notice how much higher it is than normal. Remove the test resistor, and replace it with the original bias resistor and the by-pass condenser. Be sure the electrolytic by-pass condenser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

**Shorted Bias By-Pass Condenser.** Make this test with caution; it is possible to damage the power tube. In your receiver, locate the condenser corresponding to  $C_3$  in Fig. 1. Short this condenser with a piece of wire by connecting the cathode of  $VT_2$  to the chassis. Tune in a program and note the distortion. A voltmeter connected across  $R_4$  will show no bias voltage, because of the short. Cautiously feel  $VT_2$  with your hand, and notice how hot the excess plate current has made it. Turn off the set and remove the short across  $C_5$ .

**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 learn how the distortion sounds. Test for the field strength with a screwdriver, and compare it with that obtained when the field is reconnected.

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

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



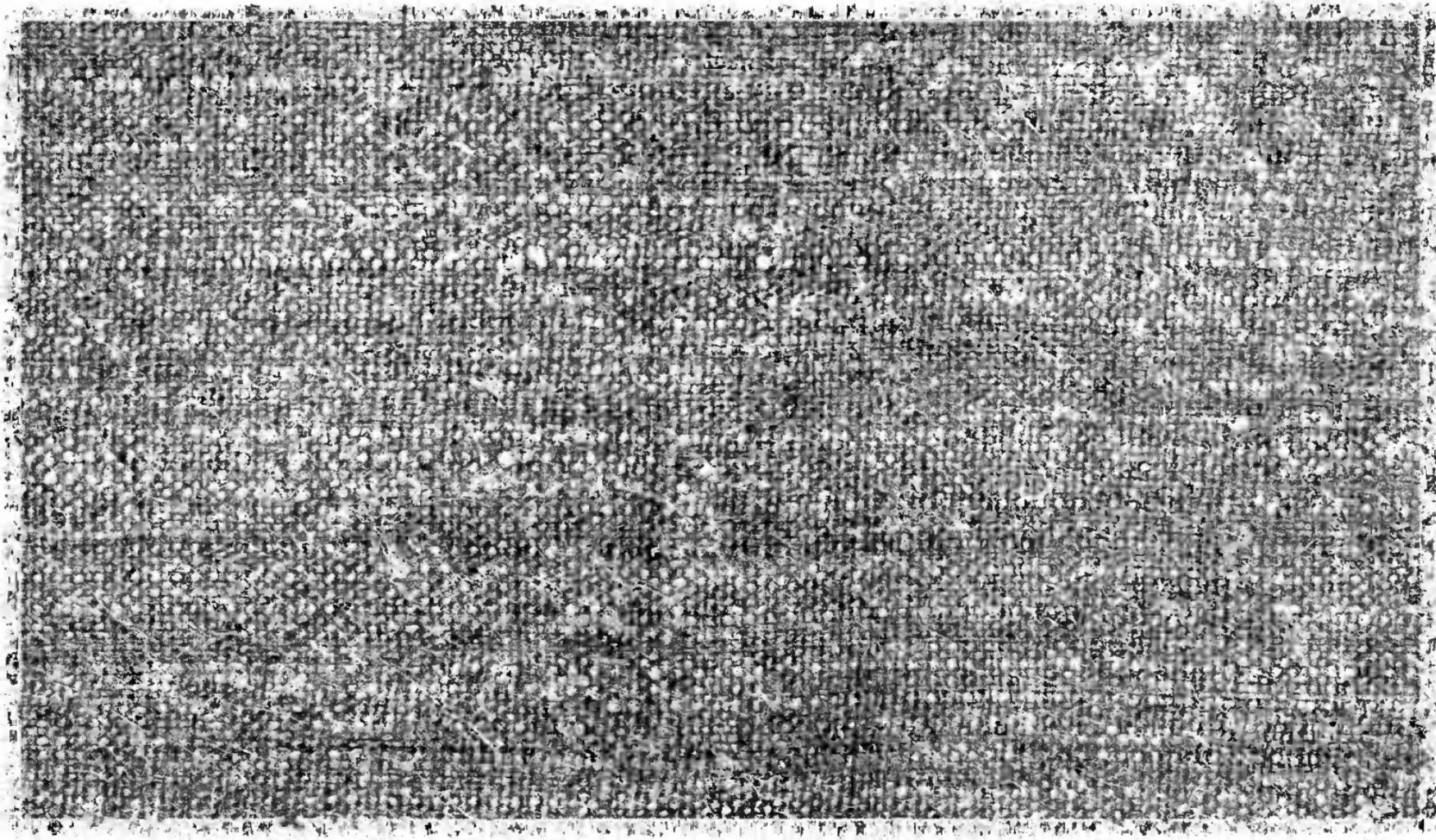
**Push on a speaker cone with your hands placed like this to hear the grating noise produced by an off-center voice coil.**

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

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

NATIONAL RADIO INSTITUTE, WASHINGTON, D. C.

No. 26      How To Align Simple  
One-Band Receivers

RADIO SERVICING METHODS



# NRI TRAINING

# *Pays...*

Dear Mr. Smith:

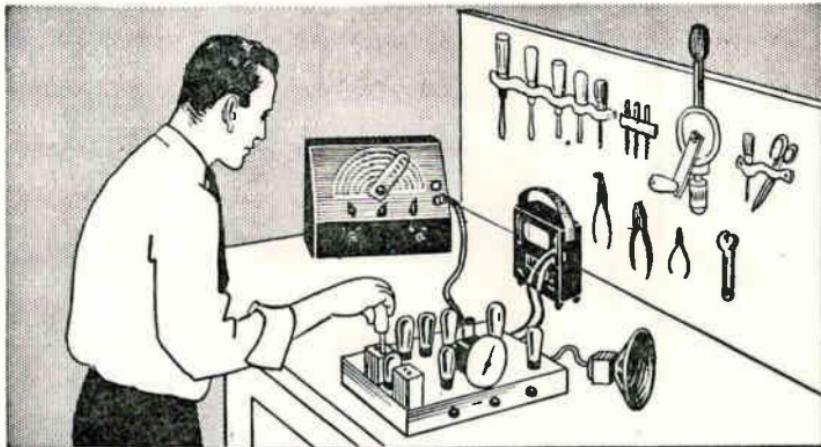
I commenced to repair radios three months after starting the Course. By the time I graduated I had made a net profit of \$567 from spare time work. I am still in spare time work, making something every week and at times turning down jobs because I get too many to handle. You will never know how glad 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



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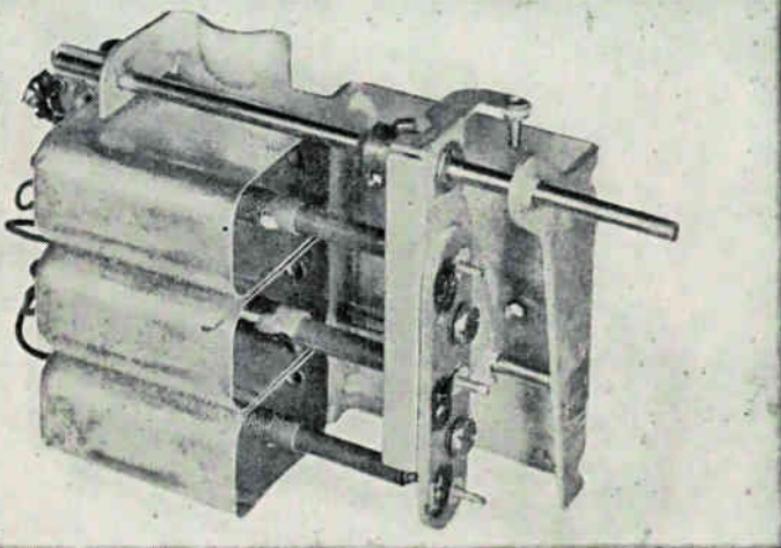


## How To Align Simple One-Band Receivers

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



**FIG. 1.** Each coil in this permeability tuning unit can be aligned by turning the small screw that secures the core to the tuning mechanism. This changes the position of the core with respect to the tuning bar and so changes the inductance of the coil with respect to the others.

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 adjusters 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 super-heterodynes, 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.

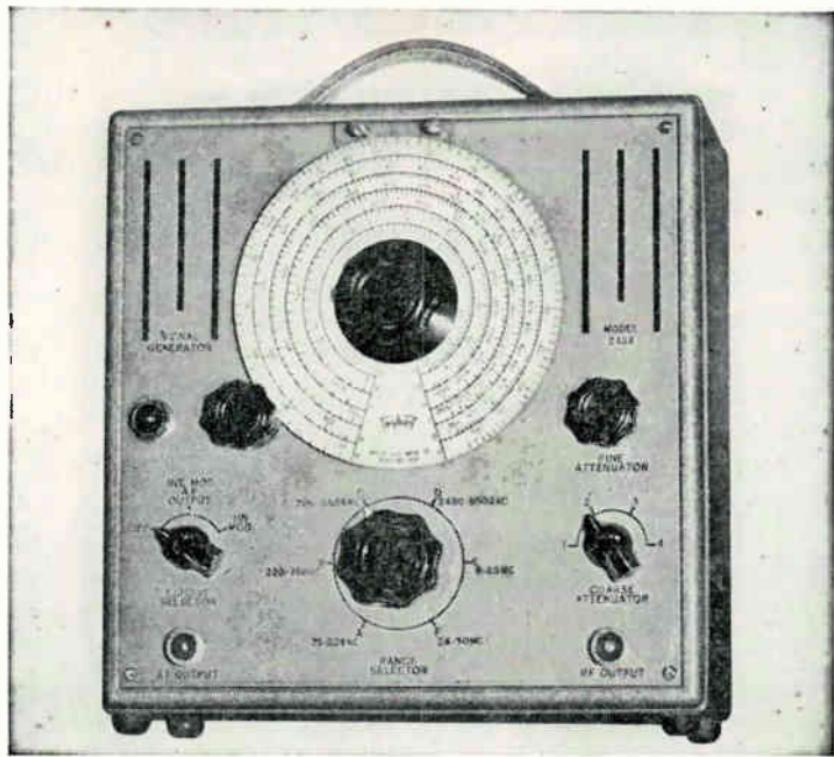
Now let's see what equipment you will need to align a set.

## 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



Courtesy Triplett Electrical Instrument Co.

**FIG. 2.** An a.c.-operated signal generator of this general type is the kind most servicemen choose. When a.c. is not available, then battery-operated types are used.

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 s.g. is fed into the set. This is generally called the "hot" lead of the s.g.

**Output Indicator.** The output indicator may be the tuning eye of the radio, or it may be 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.

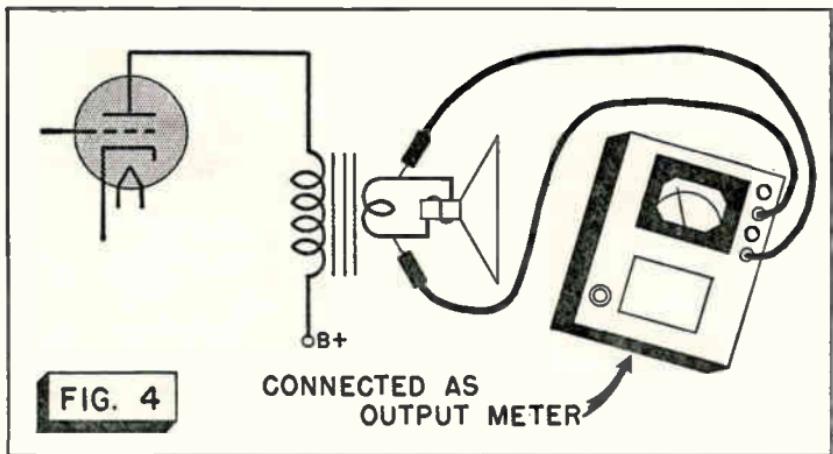
**Manufacturer's Instructions.** You should have the manufacturer's alignment instructions whenever possible. They will speed up the job by telling you exactly what to do for that particular set and by showing you the positions of the trimmers.

## 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.

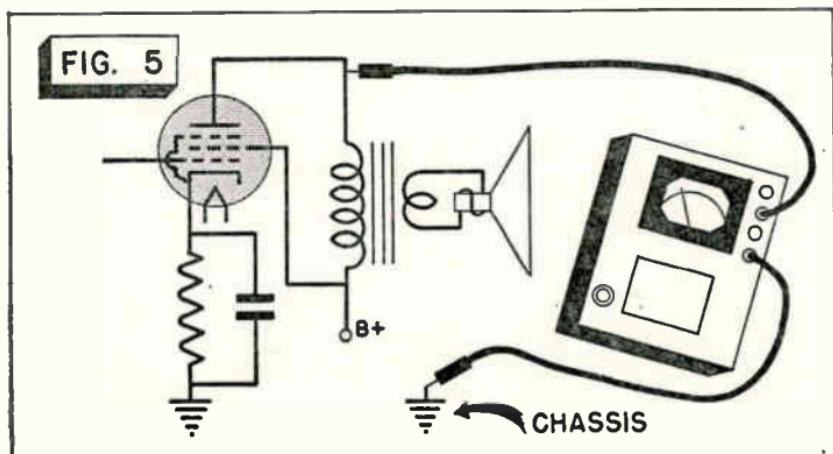
An output indicator is used to indicate when the adjustment being performed has reached the point of maximum output. If the set uses a tuning indicator, such as a meter or magic eye, it is not necessary to use anything else as an output indicator. Proper alignment will be indicated when maximum closure 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



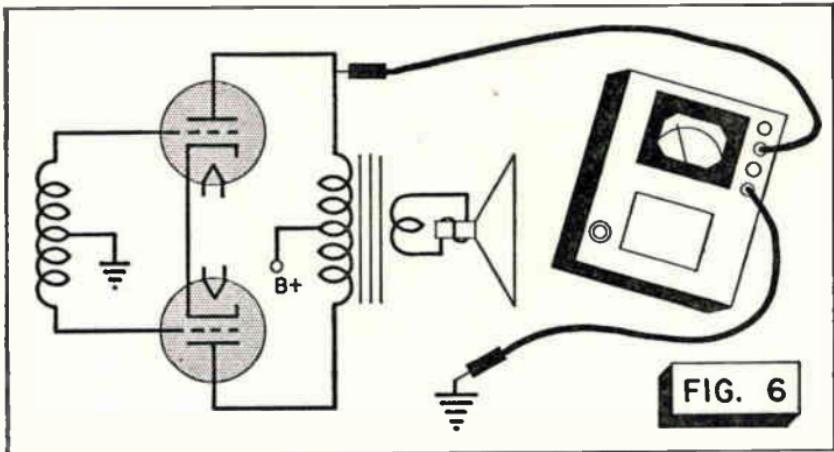


FIG. 6

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.

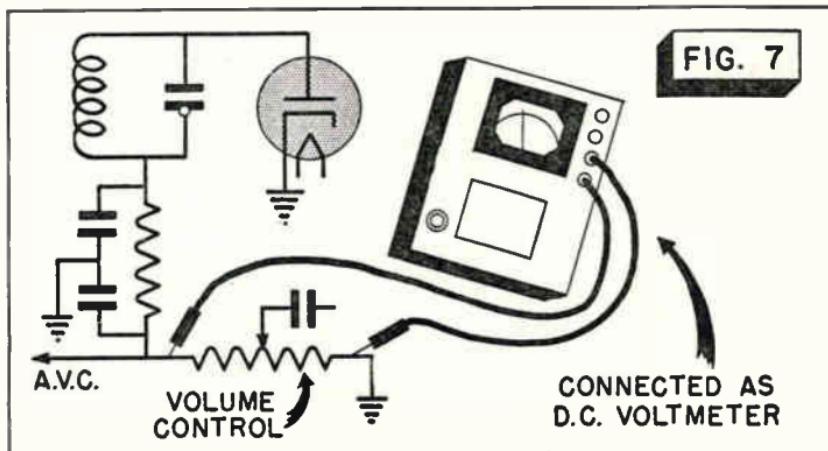


FIG. 7

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.

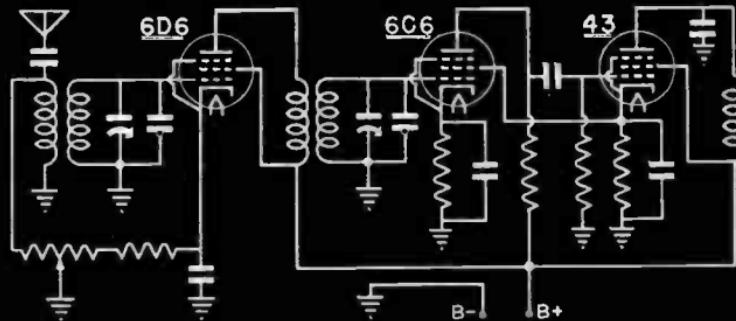
### T.R.F. ALIGNMENT

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



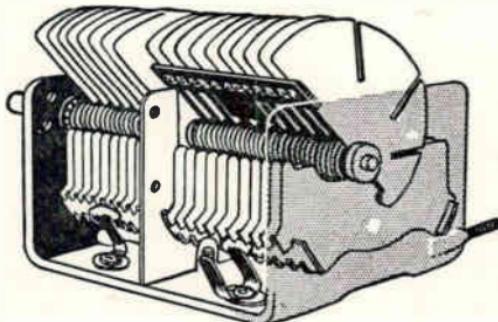
**FIG. 8. A typical midget t.r.f. set of simple design.**

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.



**FIG. 9.** This illustrates the split rotor used in the tuning condensers of both old and modern sets. For clarity, the end bracket of the condenser has been shown in phantom.

To make this possible, not only do these sets have trimmers that are used to make the initial adjustments, but also the last plate on each rotor section is split or segmented, so you can bend a section of the rotor plate in or out at various points over the tuning range (see Fig. 9). This makes it possible to align the circuit at several frequencies over the band.

To align this kind of receiver, first adjust the trimmers for maximum output with the s.g. tuned to 1400 kc. Then, rotate the tuning condenser gang until only the first split rotor segment meshes completely with the stator section. Retune the signal generator to give maximum output at this receiver dial indication. Now bend the first segment (the meshed segment) on the rotor of each condenser section in or out until the output indicator shows maximum voltage. Turn the tuning knob again until the second rotor segments are completely meshed, retune the signal generator for this new setting, and repeat the adjustment for the second segments on each of the condenser sections. When all the split segments have been adjusted in this manner for maximum output, retune the receiver to 1400 kc., and readjust the trimmers to compensate for any effect caused by bending the rotor plates.

**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 such instructions, the NRI Consultation Service will be glad to help you.

► When you are to align a t.r.f. receiver, be sure that first you give it a thorough overhauling, 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 adjusters.

**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



You should strive to keep your own shop as neat as this one. It pays, as the success of this NRI graduate proves.

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.

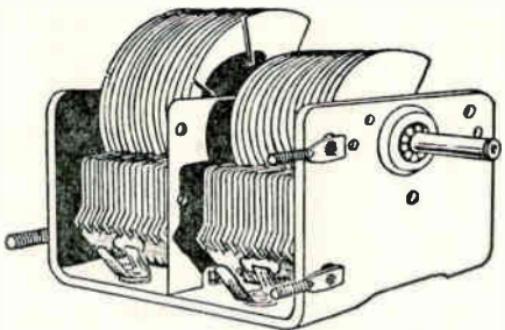
As you have learned from your Course, producing proper tracking is somewhat of a problem in a superheterodyne. The reason is that the resonant frequency of the oscillator must stay a fixed number of kilocycles above that of the preselector at all points on the dial. Therefore, as the tuning knob is rotated, 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,



This picture shows the difference between the oscillator and pre-selector sections of one type of tuning condenser. The oscillator, which operates at the higher frequency, is tuned by the smaller section.

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, 262, 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 cans, 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 padder adjustment and the dial change.)

► If you make any change in the padder 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.

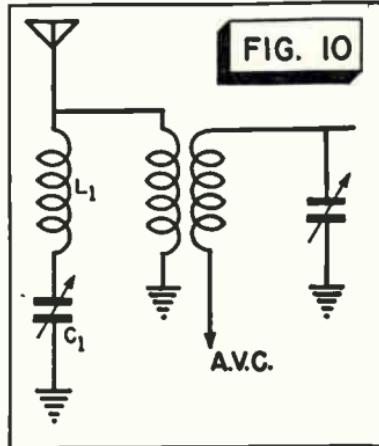
Notice that this alignment procedure is not a matter of making one definite adjustment, but is rather a back-and-forth process. One adjustment affects the other, so you have to make slight changes in both to get the best possible setting of the trimmers.

## **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.

FIG. 10



► 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 padder 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 padder 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  $C_1$  in Fig. 10. This trimmer and the coil  $L_1$  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

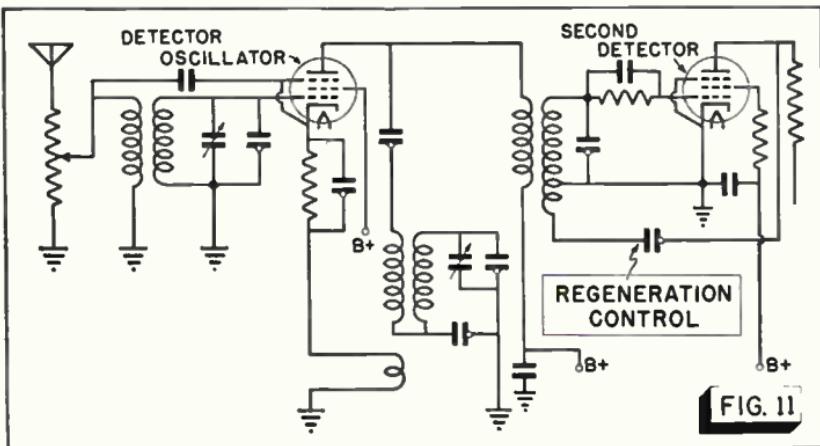


FIG. 11

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.

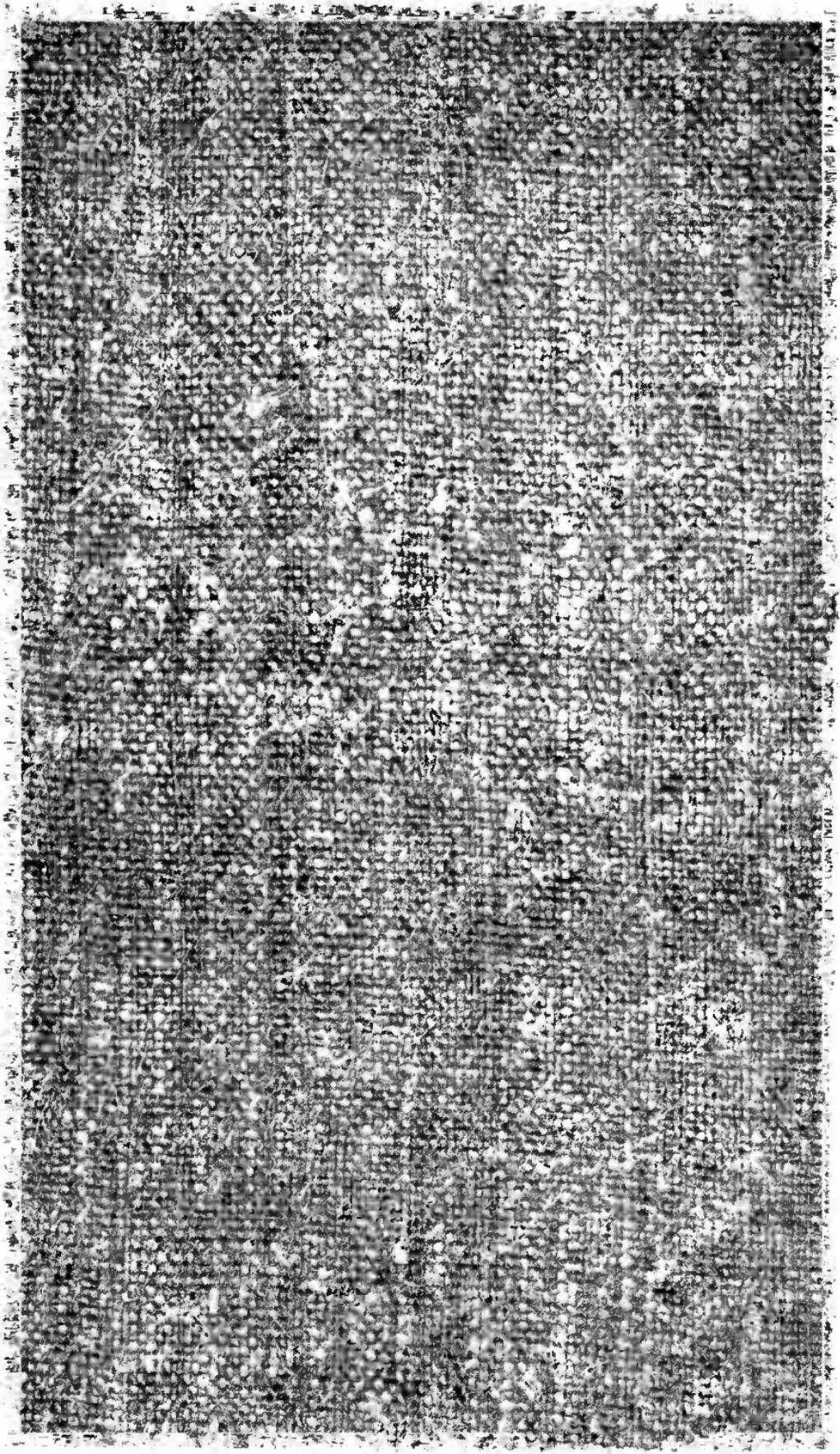
**Regenerative Superhet.** Fig. 11 shows the superheterodyne part of a widely used midget receiver circuit. Receivers using this circuit are unique in that they have no i.f. amplifier tube. The output of the first detector feeds into an i.f. transformer. The output of this transformer feeds directly 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 preselector 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 counter-clockwise (thus reducing the feedback) until the os-

cillation 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.

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No. 27 How To Align All-Wave  
Superheterodynes

RADIO SERVICING METHODS



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1950 Edition

Printed in U.S.A.



## How To Align All-Wave Superheterodynes

**B**ASICALLY, 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.

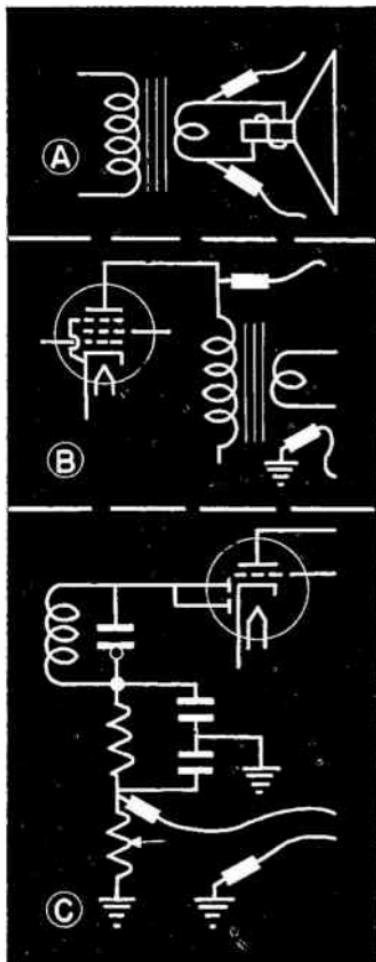
If you do not find one of these tubes in the radio, it will be necessary to identify the stage from its connections. The plate of the first detector tube is connected to the primary of the input i.f. transformer, which is usually rather easy to identify, and the grid of this tube is generally connected 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

**Three ways of connecting a multimeter to a set for use as an output indicator:** A, across the speaker voice coil; B, from the plate of the output tube to the chassis; C, across the diode load. In the first two methods, connect your multimeter as an output meter; in the third, in which you are measuring the a.v.c. voltage, connect the meter as a d.c. voltmeter, with the plus lead going to ground.



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 of this sort 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 from

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 these 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.

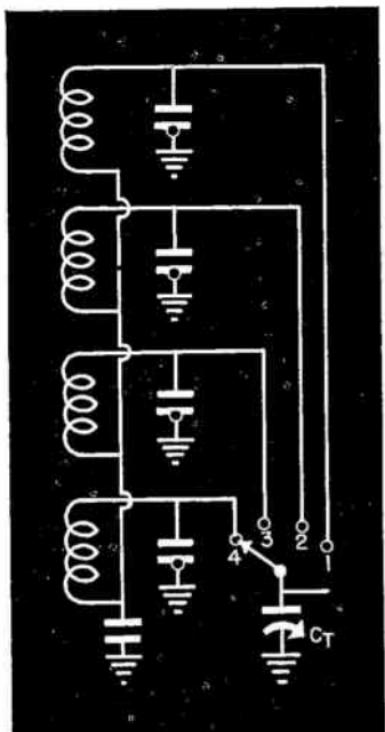
► Another kind of high-fidelity receiver has a third trimmer on each i.f. transformer. This type of set also has a variable-selectivity control switch, but the alignment method used is generally different from the one just discussed. Often the trimmer going to the center set of coils is adjusted first 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 pad-ders. In a set of this sort, the bands can be aligned in

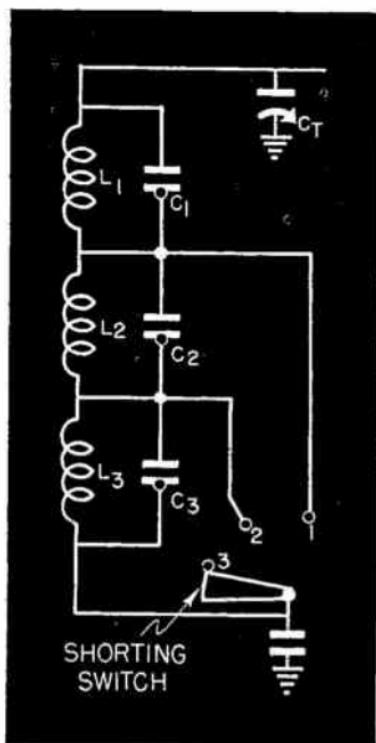
This is the preselector circuit of an all-wave receiver using independent tuned circuits for each band. As you can see, the coil and trimmer of each circuit are separate from those in all the other circuits. You can align the bands of such a receiver in any order you wish.

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 L<sub>2</sub> and L<sub>3</sub> are then shorted, leaving only L<sub>1</sub> to be tuned by condenser C<sub>T</sub>. When the switch is turned to position 2, coil L<sub>3</sub> is shorted; coils L<sub>1</sub> and L<sub>2</sub> are then in series and tuned by C<sub>T</sub>. When the switch is in position 3, all three coils are in series and tuned by C<sub>T</sub>. To align this set, you must turn the switch first to position 1 and adjust trimmer C<sub>1</sub>, then to position 2 and adjust C<sub>2</sub>, and finally to position 3 and adjust C<sub>3</sub>.



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.

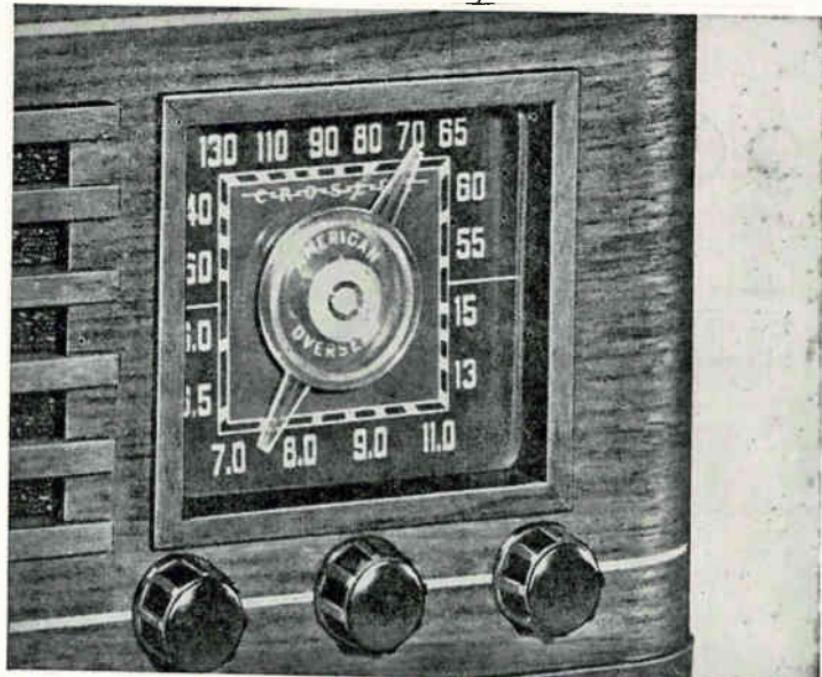
**Dial Pointers.** Before adjusting the preselector and oscillator, make sure that the dial pointer tracks over the dial properly; if it does not, it will be impossible to get the oscillator and preselector to track. The manufacturer's instructions will tell you of any calibration marks to which the 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



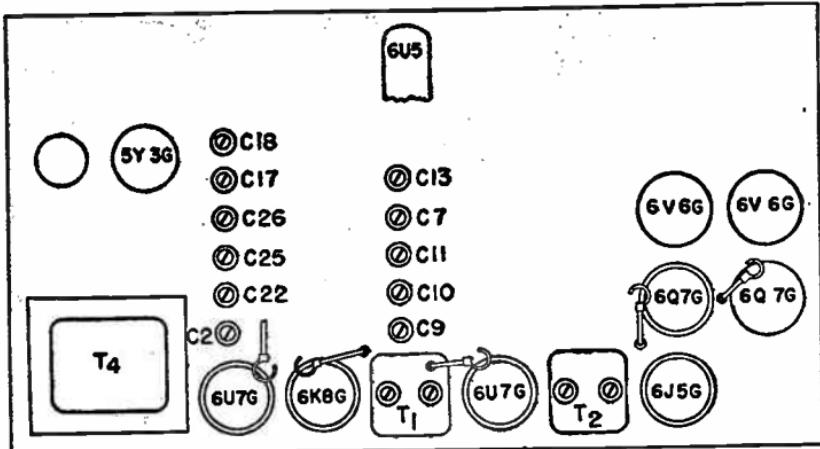
Courtesy Crosley Corp.

FIG. 1. Circular dials of this sort are often used on small 2-band receivers. Larger sets generally use either a slide-rule dial or a large circular dial.

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 s.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-



**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.

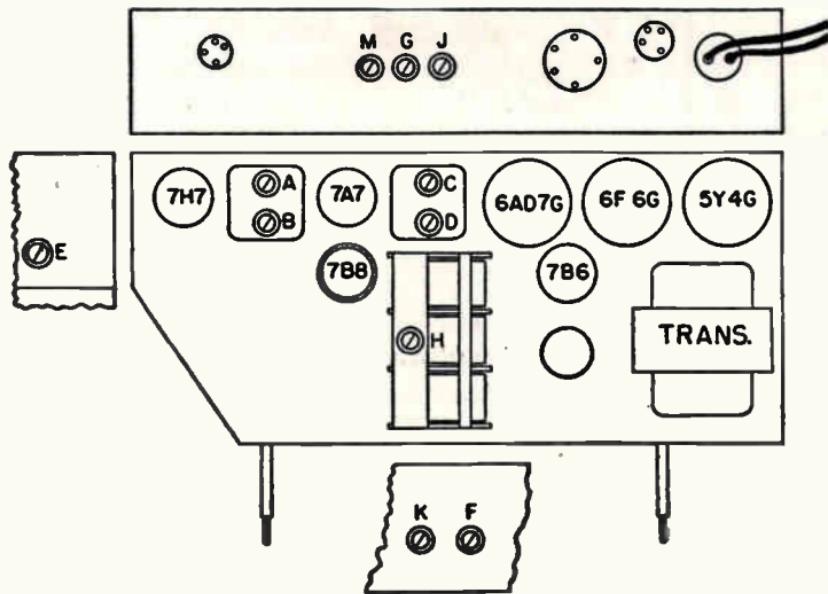
Sometimes just touching the screw with a metal screwdriver will be sufficient to produce a change in the output meter reading if the trimmer is active at the frequency being tuned in. Or, in the case of a book-type trimmer, pressing down on the top plate of the trimmer with an insulated alignment tool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

OPERATION	CONNECT TEST OSCILLATOR TO	DUMMY ANTENNA	INPUT SIGNAL FREQUENCY
1	CONVERTER GRID	$\frac{1}{2}$ MFD.	455 KC.
2	ANT.-GND.	400 OHMS	455 KC.
3	"	"	18 MC.
4	"	"	16 MC.
5	SINGLE TURN LOOP LOOSELY COUPLED TO LOOP ANTENNA	—	1600 KC.
6	" "	—	1400 KC.
7		—	600 KC.

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. 3.** Another example of a trimmer location diagram, plus the alignment information furnished with it.



BAND	SET DIAL AT	ADJUST TRIMMERS	PURPOSE
BROADCAST	600 KC.	A, B, C, D	I. F. ALIGNMENT
S. W.	6.5 MC.	E	ADJUST WAVETRAP FOR MINIMUM
S. W.	18 MC.	F	SET TO SCALE
S. W.	16 MC.	M	ALIGN ANT.
BROADCAST	1600 KC.	K	SET TO SCALE
"	1400 KC.	H, G	ALIGN DET. AND ANT. STAGE
"	600 KC.	J	ROCK GANG AND ADJUST FOR MAX.

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.

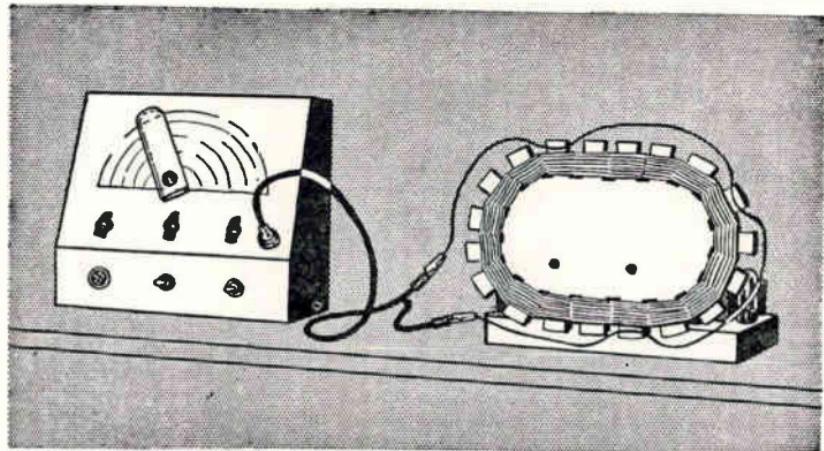
► The other way of identifying trimmers is to trace the various circuits to determine where each trimmer is connected. This is not easy, particularly in sets in which the trimmers are scattered over the chassis. However, in most receivers the trimmers are collected into groups; once you have identified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

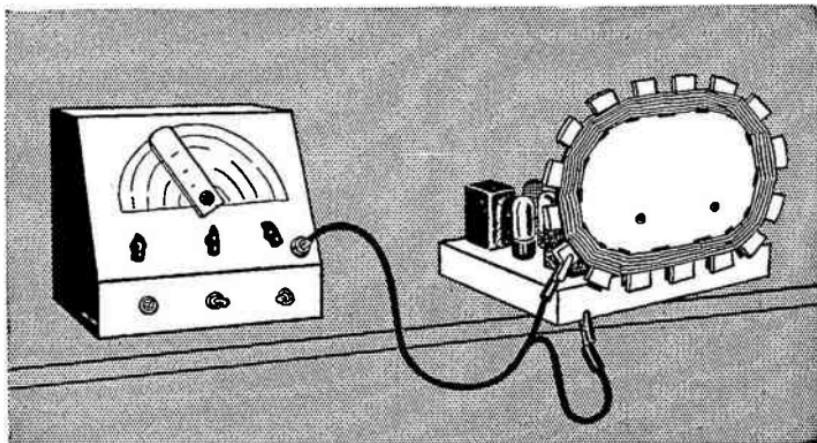


FIG. 5. Clipping the hot s.g. lead to the loop-antenna form is another way to feed a signal into the set. Clip the s.g. ground lead to the set chassis.

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.

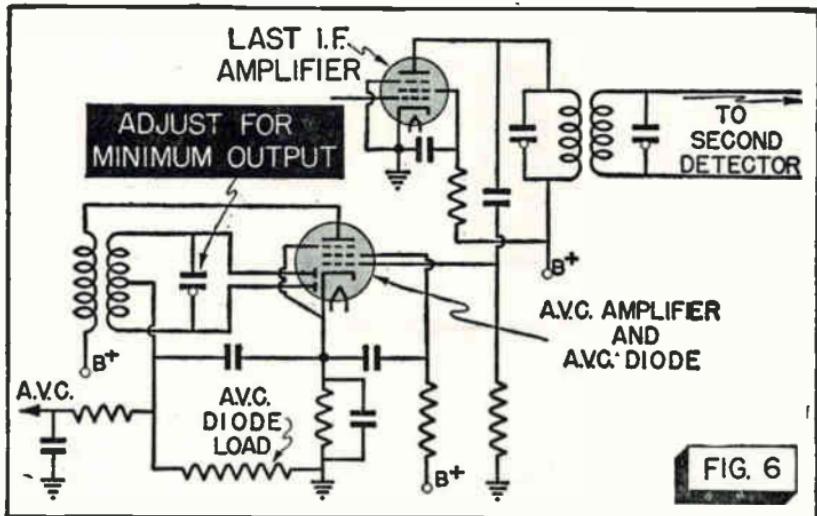
To avoid this difficulty, do not turn the oscillator trimmer very far when you are making a high-frequency adjustment on a short-wave band that is reasonably well aligned. However, if the set has been tampered with, or if you accidentally turn the oscillator trimmer far away from the correct setting, 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



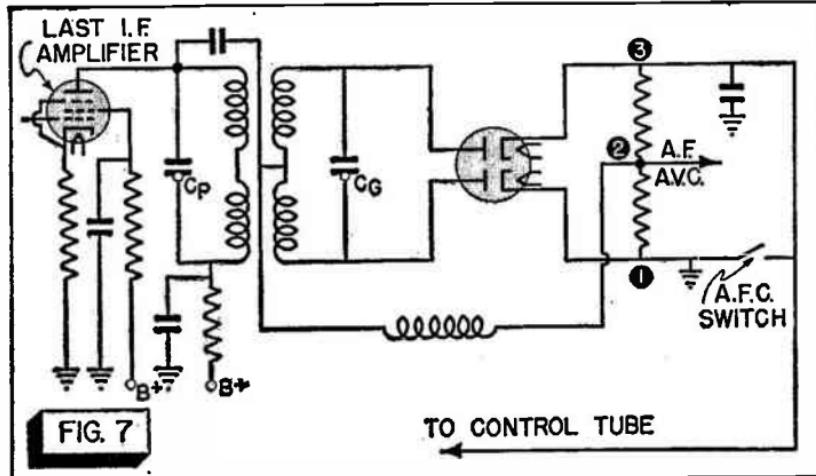
trimmer on this transformer, although occasionally there are two. Since this transformer feeds the a.v.c. network, it is necessary to adjust the trimmer to produce minimum output for the set. (The fact that the set output is minimum means that a maximum a.v.c. voltage has been developed.) Therefore, 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 OFF position to eliminate this feature. Align the set in the usual manner—the i.f. amplifier first (including trimmers  $C_P$  and  $C_G$  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  $C_G$  (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  $C_G$ . (Leave  $C_P$  and the

other i.f. trimmers alone—only  $C_6$  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—once 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 re-align 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.

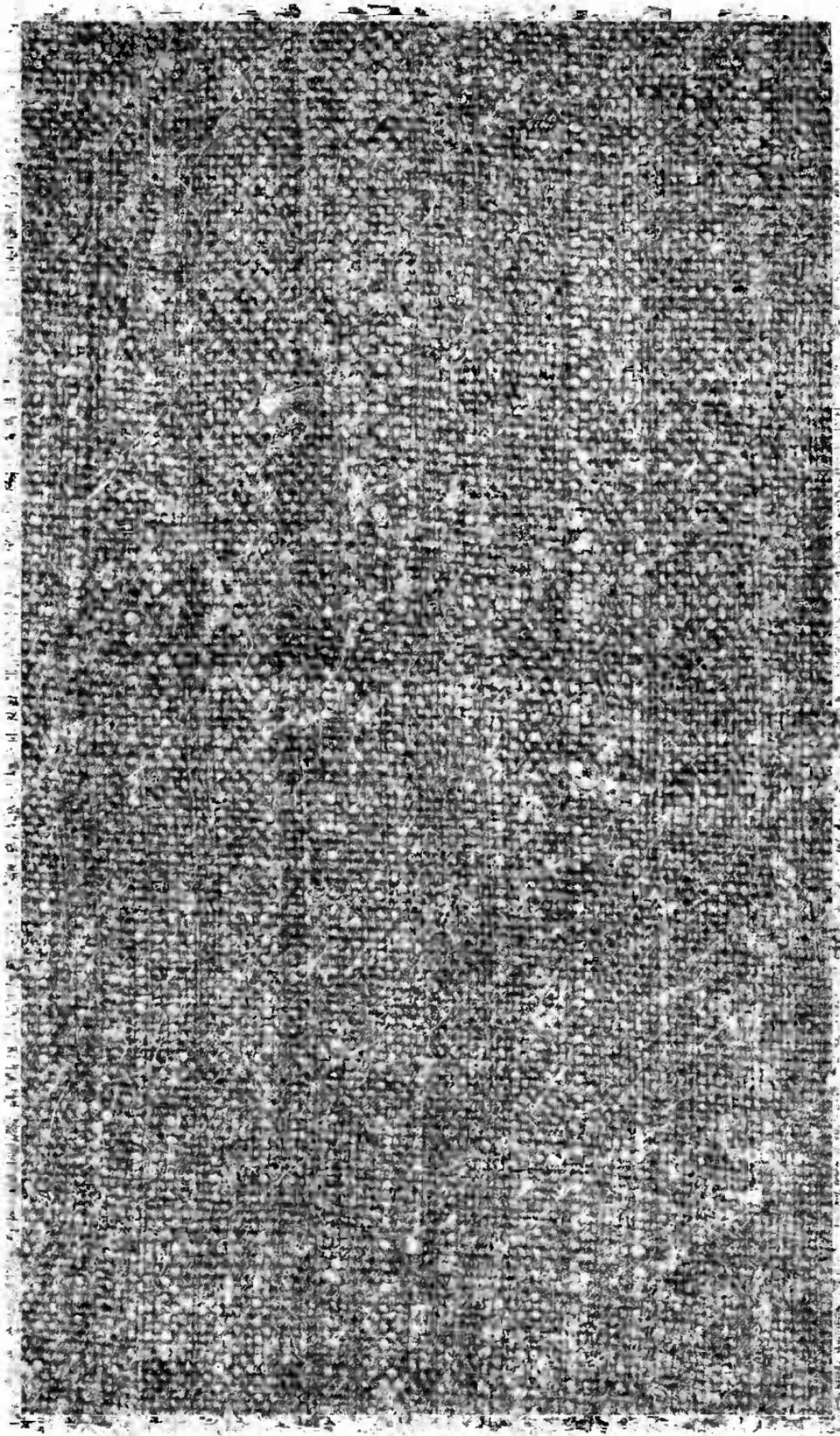
Each time you deliberately misalign a set, be sure you notice the effect your action has on both the sensitivity and selectivity. This is very important—the response of a set is one of the few clues you will have that show that re-alignment is needed.

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

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No. 28

How To Fix a  
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RADIO SERVICING METHODS



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**W**EAK 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.

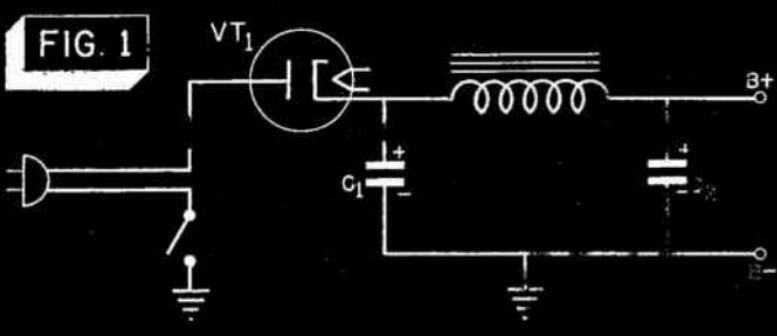
Weak reception exists when stations that have been

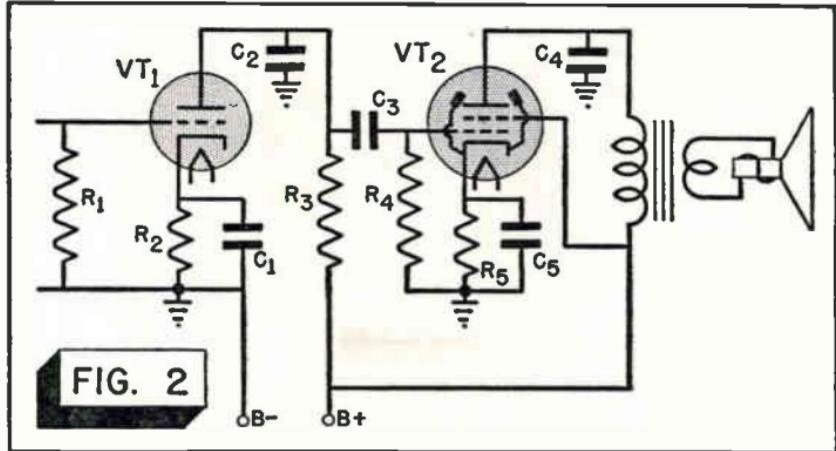
heard normally no longer come in at a satisfactory volume level. The cause may or may not be a defect in the receiver—often the antenna-ground system is to blame. In fact, you should always check the antenna-ground system first when the complaint is weak reception. Look for breaks, short circuits, and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

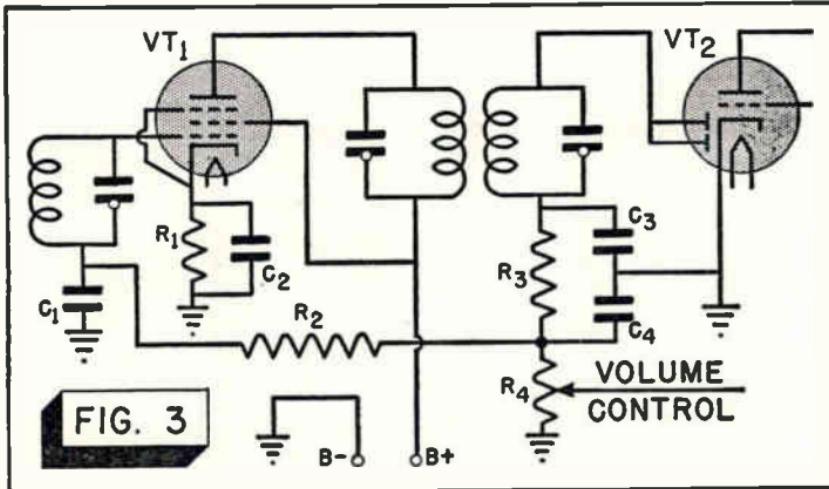


FIG. 3

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  $C_4$  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  $C_1$  in Fig. 3, can also cause weak reception. Normally, the signal applied to the grid of tube  $VT_1$  reaches ground through condenser  $C_1$ —a relatively low-impedance path. If  $C_1$  opens, however, the signal must reach ground through resistors  $R_2$  and  $R_4$ . These form a high-impedance path, over which much of the signal is dropped; consequently, the signal output of tube  $VT_1$  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. Low-

ered 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 voltages. 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

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.

**Touching the top cap of the first audio tube (or the hot end of the volume control, if the first audio tube does not have a top cap) will usually let you locate the defective section in a weak set.**

If the set is a phono-radio combination, try the phonograph. Normal volume on records indicates an r.f.-i.f. section defect, but low volume means an audio or power supply defect.

Watch the tuning indicator (if one is used). A tuning eye that closes on distant signals indicates a normal r.f.-i.f. section, hence an audio defect. On the other hand, little or no response may mean either an r.f.-i.f. defect or trouble in the power supply.

The foregoing tests, and reasoning from the symptoms, should enable you to localize the defective section. If not, proceed with the following stage localizing tests anyway—there is little point in further attempts to locate the defective section.

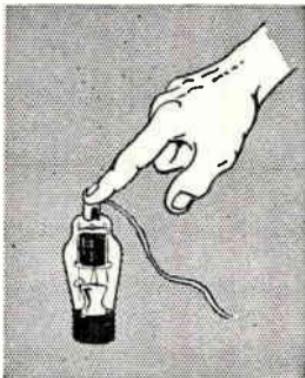
## **LOCATING THE DEFECTIVE STAGE IN THE A.F. SECTION**

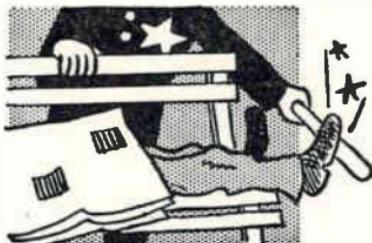
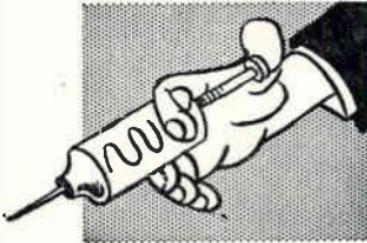
The audio section of most modern radio receivers contains two stages—a first audio stage and either a single-ended or a push-pull output stage. (A phase inverter or some other special tube may also be used.) Since the audio section contains so few stages, there is little need for stage localization tests 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 ( $C_3$  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.





These are the three methods you can use to locate the defective stage when the set is weak—signal tracing, signal injection, and circuit disturbance. Signal tracing is the only method that can be used in all cases; the other two are useful only once in a while.

**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  $C_5$ —or the output tube is oscillating because of an open  $C_4$ . Check the bias from cathode to ground, and check for current through the grid resistor  $R_4$ . If the bias is normal, and there is no current through  $R_4$ , then the trouble must be caused by an open condenser  $C_4$ , 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  $VT_2$  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  $VT_1$ . You should hear a click when you touch the positive voltmeter probe to the plate of  $VT_1$ , and another when you remove it. No click and a low voltage reading, indicates trouble in the plate circuit of  $VT_1$ . No click, but a normal voltage reading, indicates an open coupling condenser  $C_3$ .

If you get a normal click, check the  $VT_1$  stage by touching the voltmeter probes between  $B+$  and the control grid of  $VT_1$ . Weak clicks usually indicate a defective  $VT_1$  or a short-circuited grid circuit.

► An open in either  $C_1$  or  $C_5$  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.

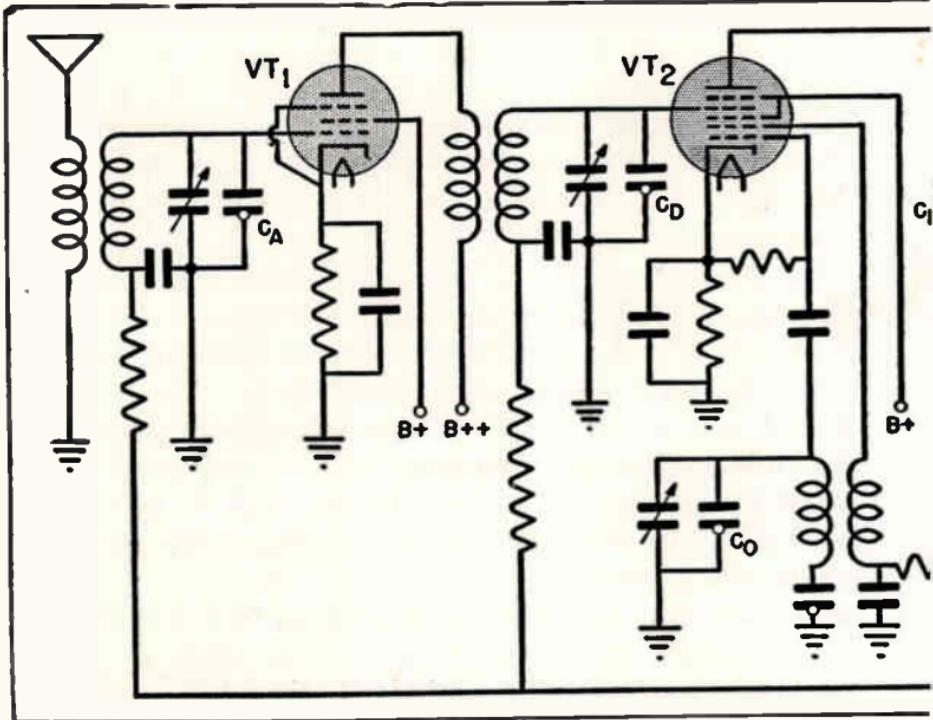
► Signal injection could also be used to locate the defective stage, except that there is practically no source of audio voltage readily available to the average serviceman. However, the circuit disturbance test just described will usually work. Its greatest drawback lies in the fact that you must judge 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



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 one 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  $VT_3$  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

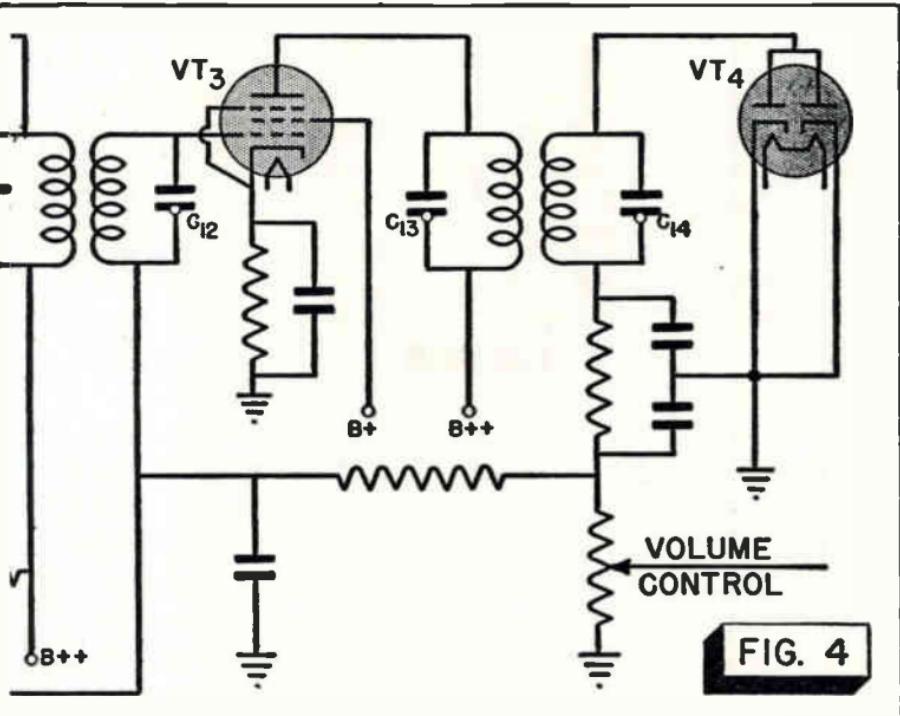


FIG. 4

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  $VT_3$  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  $VT_3$  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  $VT_2$  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. by-pass condenser. Rarely, you may find an open by-pass 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 s.g. attenuator for maximum output. Clip the ground lead of the s.g. to the chassis.

Tune the s.g. to the i.f. amplifier frequency, and touch the hot probe to the plate socket terminal of  $VT_3$ . You should hear the modulating tone of the s.g. in the loud-

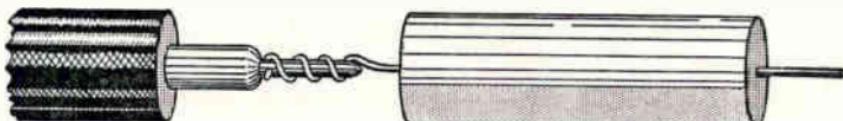


FIG. 5. To put a condenser in series with the hot lead of your s.g., wrap one lead of the condenser around the probe as shown. Use the other lead of the condenser as your probe.

speaker, 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  $VT_3$  or in the circuits of the second detector  $VT_4$ . (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 s.g. probe to the control grid of  $VT_3$ . 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  $VT_3$  stage. Try adjusting trimmers  $C_{13}$  and  $C_{14}$  to see if the alignment is off or if there is broad tuning, indicating low Q.

► If the output is satisfactory, peak trimmers  $C_{13}$  and  $C_{14}$  (that is, adjust them for maximum output with the hot s.g. probe touching the control grid terminal of  $VT_3$ ). Next, move the hot s.g. probe to the control grid of  $VT_2$ . (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  $VT_3$ , both in sound and in the meter reading. If you do not, the defect is in the detector-mixer portions of the  $VT_2$  stage. Adjust i.f. trimmers  $C_{11}$  and  $C_{12}$  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 s.g. to its r.f. range, and tune it carefully to the receiver dial setting. Touch the hot probe of the s.g. to the plate of  $VT_1$ . If you don't hear the signal, adjust the oscillator high-frequency trimmer  $C_0$  until you do. Next, adjust trimmer  $C_D$  for maximum output. If  $VT_2$  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  $VT_2$ . If you find a loss in output, the defect is between the plate of  $VT_1$  and the control grid of  $VT_2$ .

If this test is satisfactory, move the s.g. hot probe to the antenna post, and adjust trimmer condenser  $C_A$  for maximum output. There should be a marked increase in the output meter reading. If there is none, the defect is in the  $VT_1$  stage.

► Notice that we have done nothing to check the oscillator part of the  $VT_2$  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

TABLE 1

<i>Gain between points</i>	<i>Tracer tuned to</i>	<i>Approximate gain</i>
1 and 2	600 kc.	2.5
2 and 3	600 kc.	1 (A) or 7(B)
3 and 4	455 kc.	70
4 and 5	455 kc.	0.7
5 and 6	455 kc.	60(A) or 125 (B)
6 and 7	455 kc.	0.7
7 and 8	400 cycles	30
8 and 9	400 cycles	15

(A) with a.v.c. voltage applied.  
 (B) with the a.v.c. voltage shorted out.

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

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.

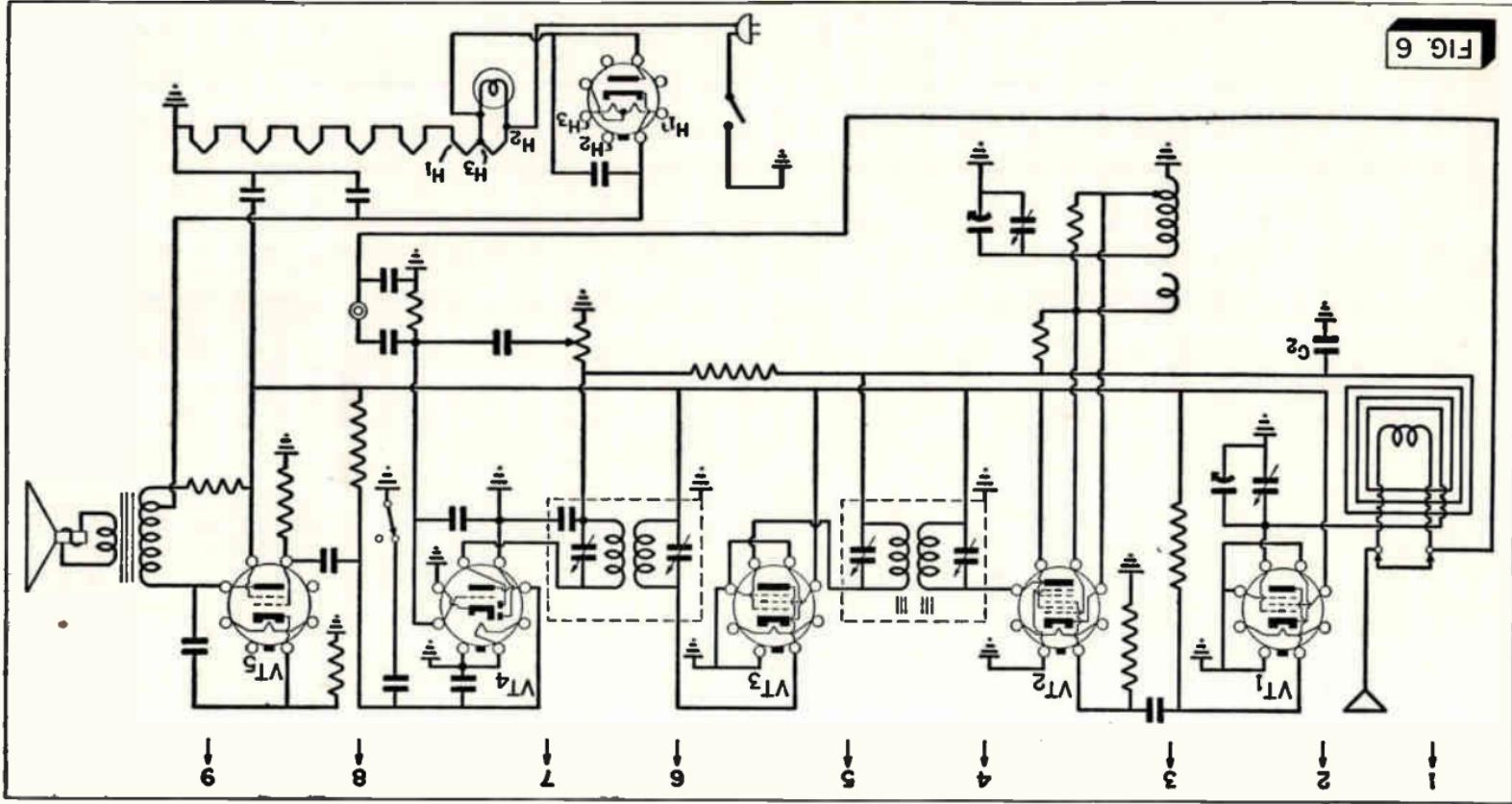
► The gain of the r.f. and i.f. stages depends on the a.v.c. voltage. Hence, most manufacturers recommend that the a.v.c. voltage be killed—in this case by shorting a.v.c. condenser  $C_2$ . Grounding the a.v.c. lead this way permits the set to operate with a maximum and fixed sensitivity. Notice that 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  $C_2$ .

► 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 s.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  $VT_1$ . 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  $VT_1$ . (Thus, if the first reading was 3, and the second reading is 8, the gain is  $8 \div 3$ , or  $2\frac{2}{3}$ .) 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  $VT_1$ . The ratio between the new attenuator reading and the last one should be about 7 when the a.v.c. is not working.

FIG. 6



Next, tune the signal tracer to 455 kc., the frequency of the i.f. amplifier, and touch its hot lead to the plate of  $VT_2$ . Adjust the attenuator until the tuning eye of the signal tracer closes. The attenuator setting ratio should show a gain of about 70.

Next, touch the hot probe to the control grid of  $VT_3$ , 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  $VT_3$ , 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 s.g. output until the signal tracer eye closes at some convenient attenuator setting), and the second reading may be 2500. The gain is  $2500 \div 20$ , 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  $VT_4$  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  $VT_4$ , and adjust the attenuator; the gain should be about 30. Finally, touch the hot probe to the plate of  $VT_5$ , 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**  
**AVERAGE GAIN DATA**

SECTION	GAIN	
	MIN	MAX
<b>R.F.</b>		
Antenna to 1st grid	2	10
Antenna to 1st grid, auto sets	10	50
R.F. amplifier, supers, broadcast	10	40
R.F. amplifier, t.r.f., broadcast	40	100
R.F. amplifier, supers, short wave	5	25
<b>MIXER</b>		
Converter grid to 1st i.f. grid (single i.f. stage)	30	60
Converter grid to 1st i.f. grid (2-stage i.f.)	5	30
<b>I.F. AMPLIFIER</b>		
I.F. stage (single stage)	40	180
I.F. stage (2-stage i.f., per stage)	5	30
<b>DETECTOR</b>		
Biased detector, 57, 6J7, 6C6, etc. (depends on % modulation)	5	40
Grid leak detector, square law	5	50
Diode detector (a loss—depends upon % modulation)	.2	.5
<b>AUDIO AMPLIFIER</b>		
Triode (low gain)	5	14
Triode (high gain)	22	50
Pentode	50	150
<b>POWER OUTPUT</b>		
Triode	2	3
Pentode and beam	6	20

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 tunes 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.

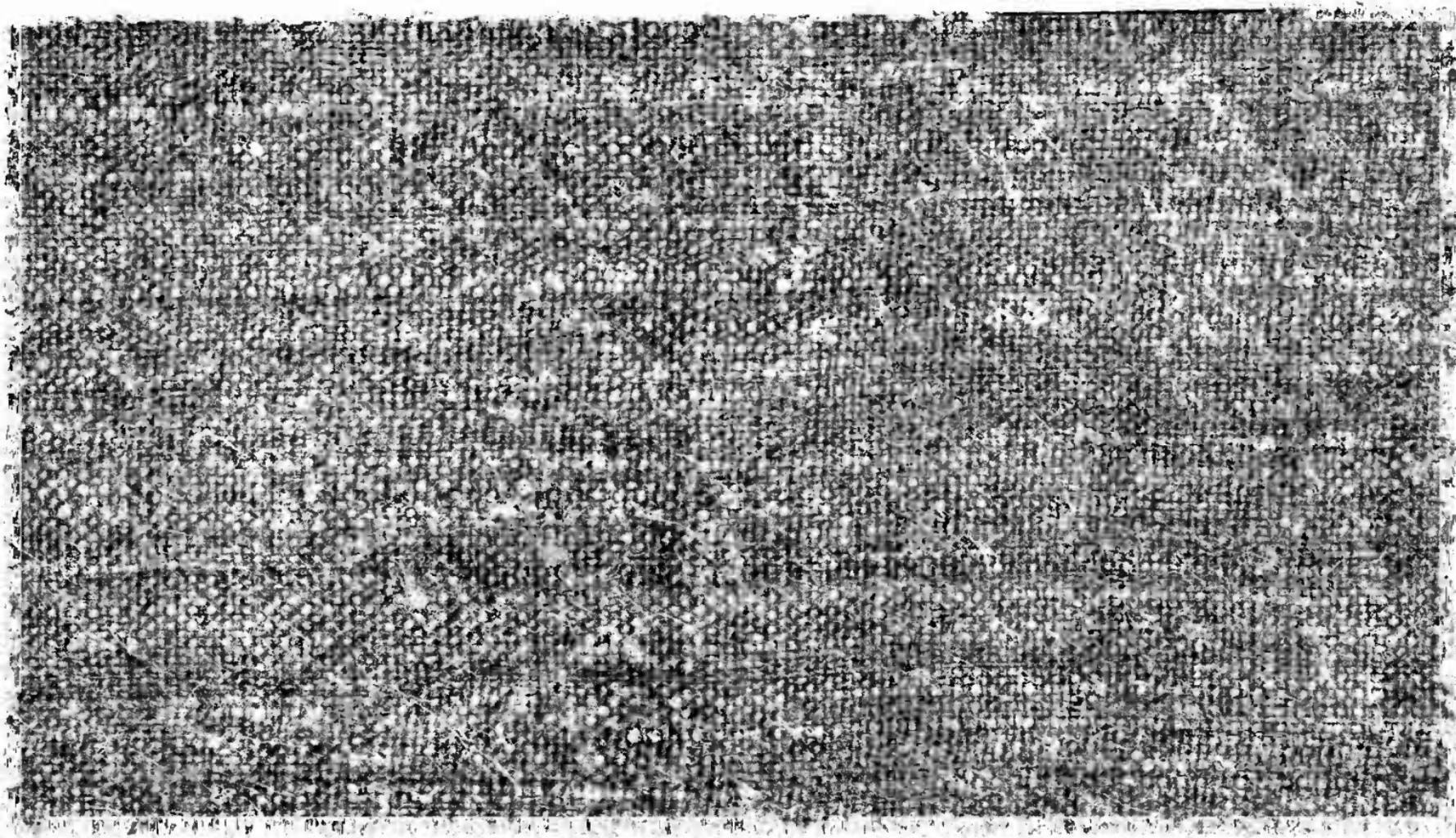
**Weak Stage Localization.** Simulate the effect of a low emission tube in each stage, one at a time. (You can do this readily only in an a.c. set.) To lower the emission of a tube, place a resistor in series with its filament. This will reduce the voltage across the filament, thus lowering the cathode 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.

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

NATIONAL RADIO INSTITUTE WASHINGTON, D. C.

No. 29 How To Fix an Intermittent  
Receiver

RADIO SERVICING METHODS



# NRI TRAINING

# Paid... ...for

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



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FM12M150

1950 Edition

Printed in U.S.A.



## HOW TO FIX AN INTERMITTENT RECEIVER

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 intermittents—THE SAME GENERAL DEFECTS THAT CAUSE PERMANENT COMPLAINTS ALSO CAUSE THE CORRESPONDING INTERMITTENT COMPLAINTS. Armed with this fact, and with modern service techniques, you can expect to have far less trouble with intermittents than did the "old timers."

Before we study the procedures for locating the causes

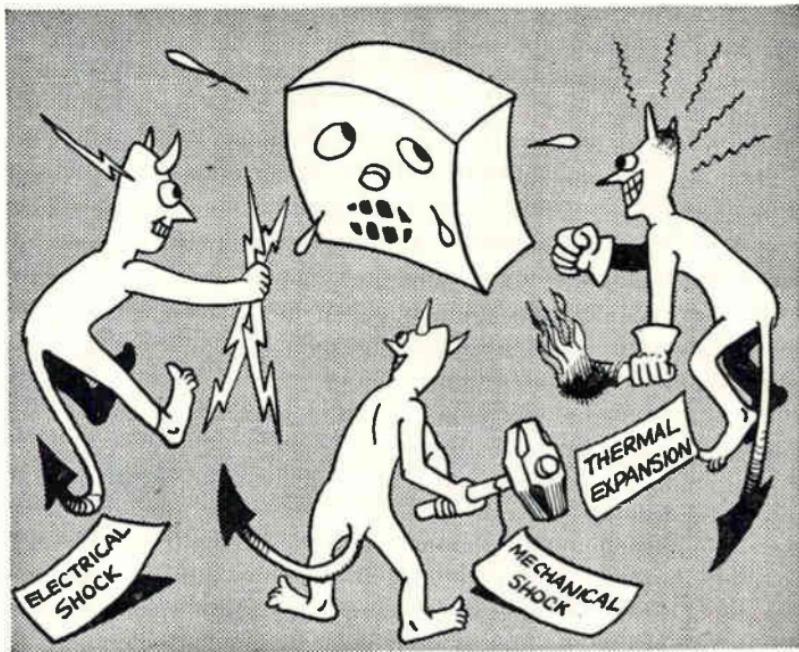
of intermittent complaints, let's see why they occur.

**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.



A receiver may become intermittent because of electrical shock, mechanical shock, or thermal expansion. The first two can cause intermittent operation only if some defect is already present in the set, but thermal expansion may produce it even if no defect exists.

## 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 opens 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.

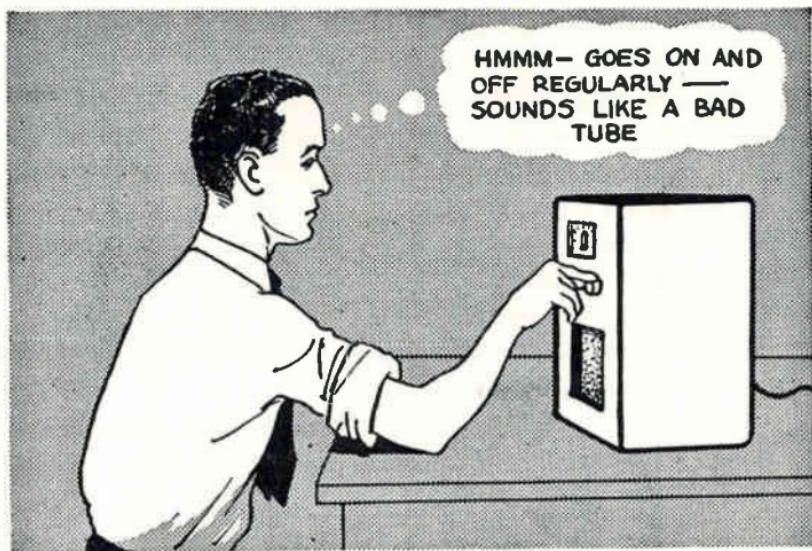
► Intermittent defects in other kinds of condensers are very rare.

**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 shorted 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.



If the set starts and stops with great regularity, a broken tube filament is probably to blame. Occasionally such operation may be caused by some other defect, however. A table later in this RSM Booklet gives a listing of other parts that may cause regular on-and-off operation.

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 coil 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.

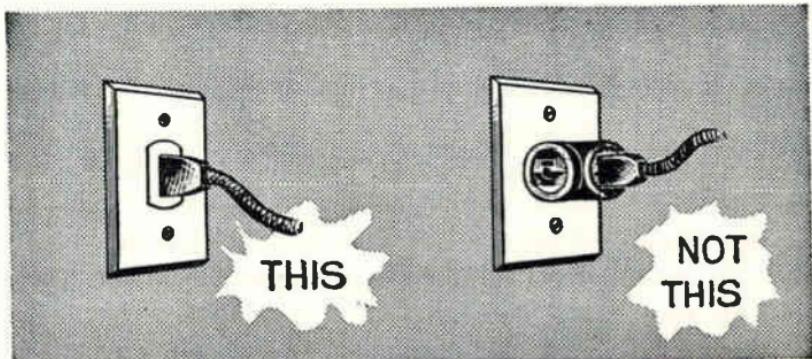
**Tuning Condensers.** A tuning condenser may be intermittently defective if a variable high-resistance connection develops in series with the rotor and stator plates. Usually this is caused by wiper spring contacts that are dirty or have lost tension. Many older receivers made the connection to the 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.

**Whenever 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.**





Intermittent operation is not always the fault of the receiver. Noise may be fed into a set by a refrigerator, an oil burner, a diathermy machine, a neon sign, etc. Intermittent fading on medium-distant stations often occurs around sunrise and sunset.



## 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.

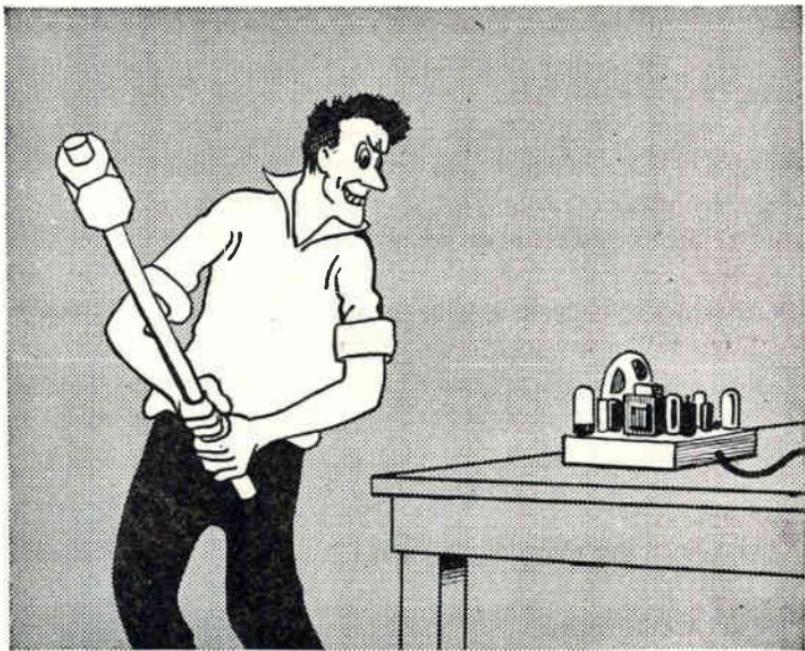
From what we have said, you can see that some judgment is needed to determine whether the set is at fault. Sometimes the only real test is to take the receiver to the shop and try operating it there. Naturally, if it continues to operate improperly in another location, the receiver must be defective.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



In spite of the name, this is NOT what we mean by "brute force" localization! Radio parts are fairly delicate—don't strike or pull them hard enough to injure good ones.

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 tubes, 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.

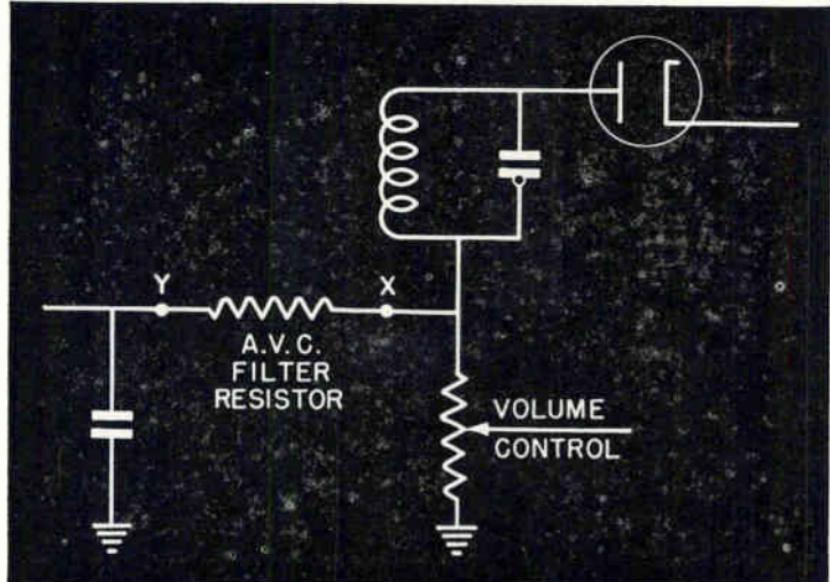
## LOCALIZING THE TROUBLE IN A RECEIVER THAT IS INTERMITTENTLY DEAD OR WEAK

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.

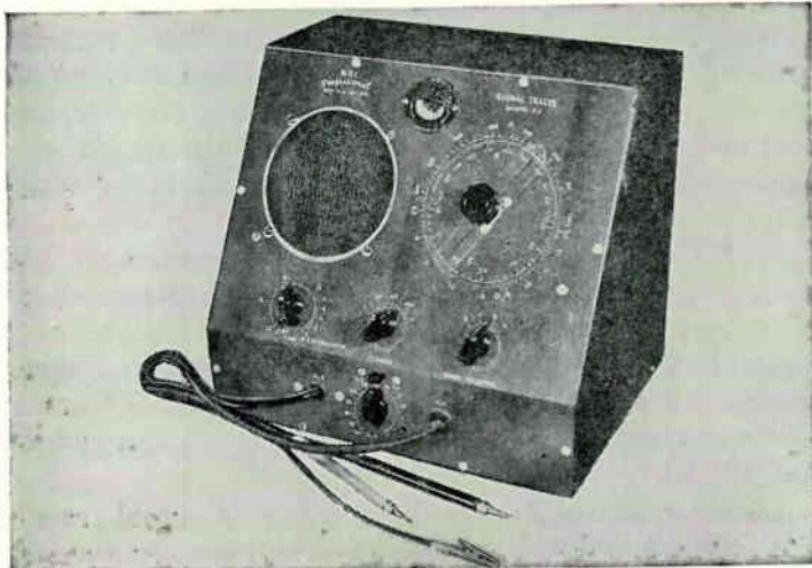
**Using a Signal Tracer.** If you have a signal tracer, the problem is not so difficult. You can connect the sig-

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 be-

A signal tracer like this NRI Professional Model 33 is an excellent instrument for servicing intermittently defective radios. However, since a signal tracer is such a generally useful test instrument, you may prefer not to tie it up in servicing an intermittent set unless the intermittent operation occurs fairly often.



fore 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 1 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 1

Complaint	Most Probable Cause
Hum	Cathode-to-heater leakage, leaky electrolytic filter condenser.
Distortion	Gassy tube, leaky coupling condenser, short in voltage-supply circuit.
Noise	Tube with loose elements, poor connection, open in i.f. transformer primary.
Oscillation	Loose shield, changes in tube characteristics, open electrolytic condenser.

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 severe trouble in the audio 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**

Time	Probable Cause
0-3 minutes	Defective connection.
3-5 minutes	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.
3-5 minutes	(A.C.-D.C. receivers.) Series filament resistors and heavy duty bias resistors that sag and touch the chassis.
Over 5 minutes	Defective power transformers and large resistors.

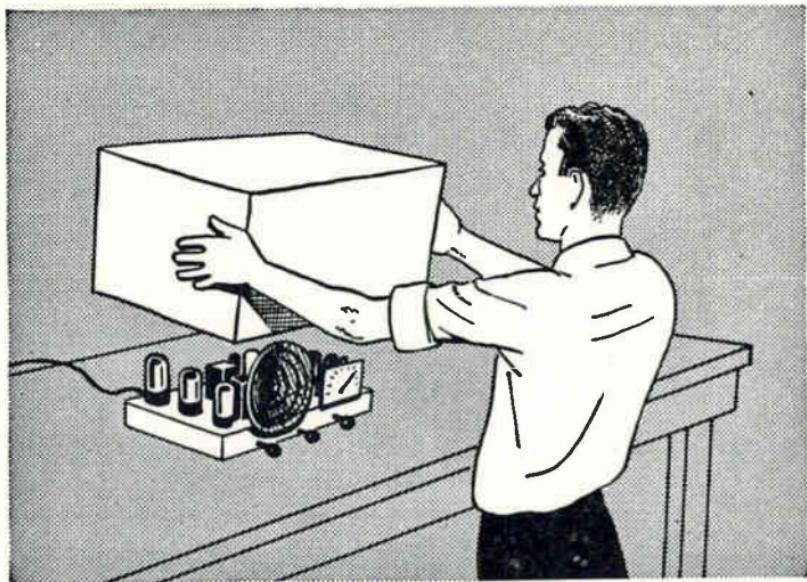
### NRI PRACTICAL TRAINING PLAN

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.

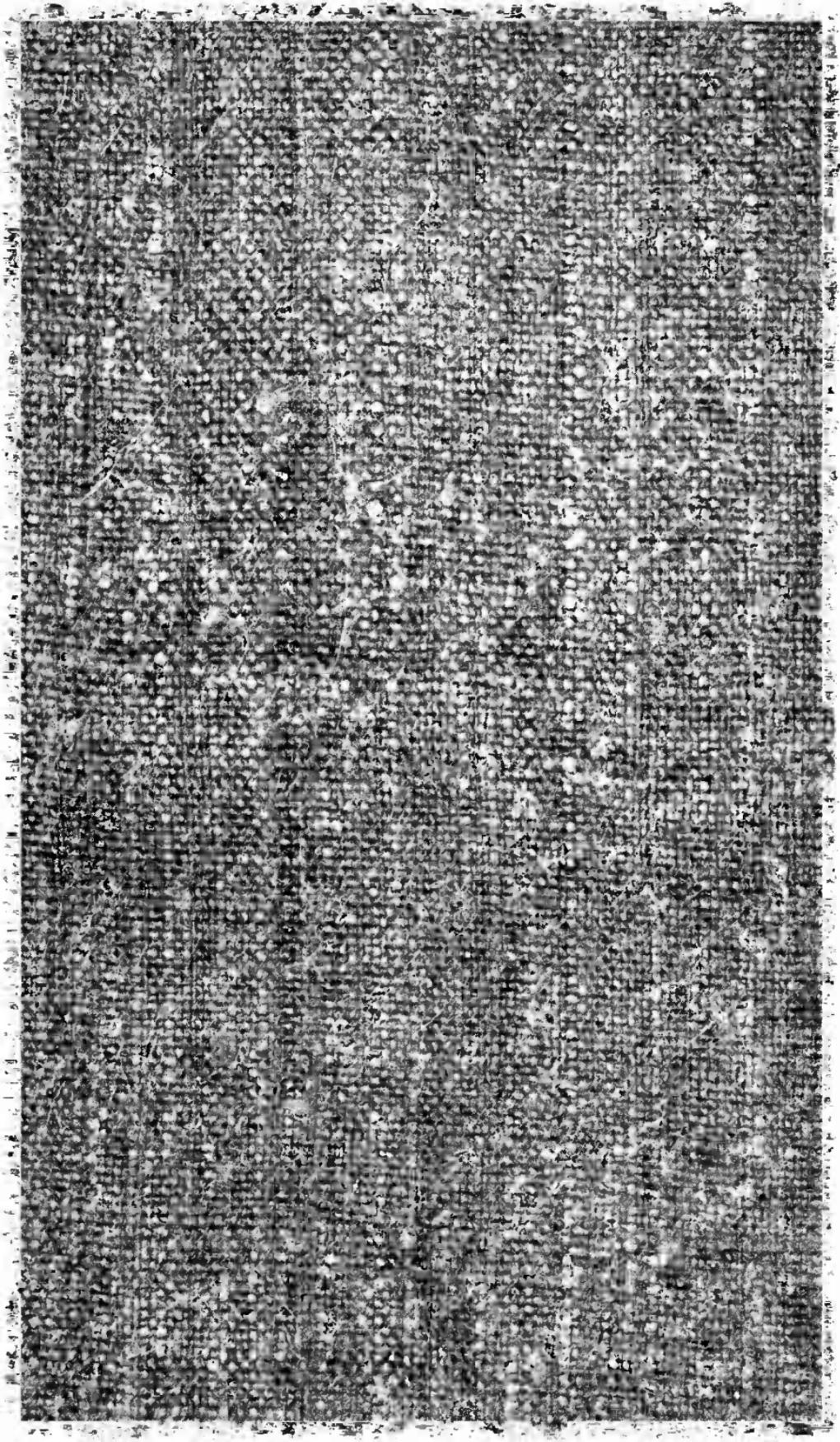
**Looking Ahead.** With this RSM No. 29 you have reached another milestone; this is the last of the series dealing with servicing for particular complaints. You will next receive RSM Booklets on servicing particular *types of receivers*, such as a.c.-d.c., auto, etc. Then you will finish the RSM series 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.

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

NATIONAL RADIO INSTITUTE WASHINGTON, D.C.

No. 30 How To Service A.C.-D.C.  
Receivers  
**RADIO SERVICING METHODS**



# NRI TRAINING

# *Pays . . .*

Dear Mr. Smith:

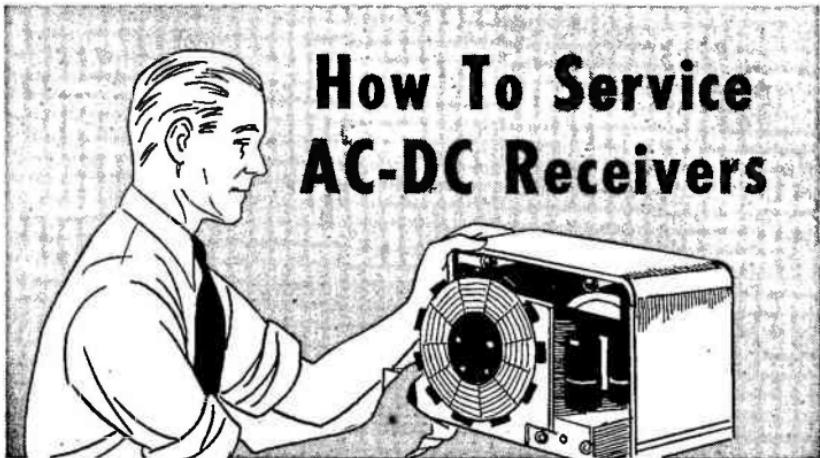
After having spent several years in spare-time radio work, I am in business for myself 100% now. I also have service contracts with several radio and appliance dealers who do not maintain service departments of their own. I make as much in one week as I used to in a month of nights.

R.F.K., Missouri



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WASHINGTON, D. C.**



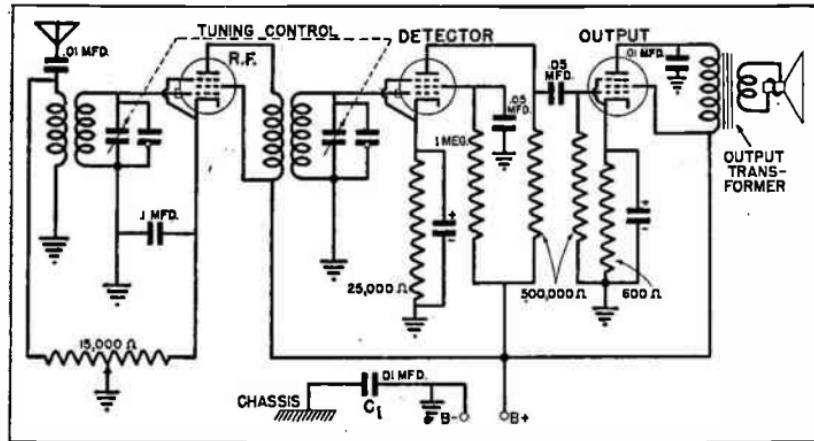
# How To Service AC-DC Receivers

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.



**FIG. 1.** Two tuned circuits are used in this typical a.c.-d.c. tuned radio-frequency (t.r.f.) receiver. To align such a receiver, simply tune in a station near the high-frequency end of the band, then adjust the trimmer condensers (mounted on the gang tuning condenser) for maximum output. The r.f. amplifier tube is usually a super-control pentode such as the 78, 6D6, 6K7, 12K7, or 12SK7. A sharp cut-off pentode is used as a detector; typical tubes are the 6C6, 77, 6J7, 12J7, or 12SJ7. The power output tube may be a 38 or 43 pentode, or a 25L6, 35L6, or 50L6 beam power tube. Some of these receivers use a magnetic speaker, connected directly in the plate circuit of the power tube, instead of the dynamic speaker and output transformer combination shown here. Notice that the volume is controlled by simultaneously varying the antenna input voltage and the C bias on the r.f. tube.

A typical circuit has one r.f. amplifier stage, a detector stage of the C bias type, and an audio output stage, as shown in Fig. 1. The antenna usually consists of about 20 feet of flexible insulated wire which comes wound on a fiber card and is connected to the receiver input circuit through a small paper or mica condenser. This "hank" of wire should be unwound, and dropped out a window, tacked around a window, or placed under a rug. Satisfactory reception can often be obtained simply by connecting this hank to a ground.

These t.r.f. receivers are intended only for local station reception. They have little selectivity, and consequently should not be used on long antennas—also, they will overload and distort on local-station signals if the volume control is advanced too far. Also, the tone quality is not of the best. Remember these limitations so you won't waste time trying to make these sets perform like larger receivers.

**A.C.-D.C. Superheterodynes.** The a.c.-d.c. superheterodyne is also essentially a simple receiver. The most common kind uses 5 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

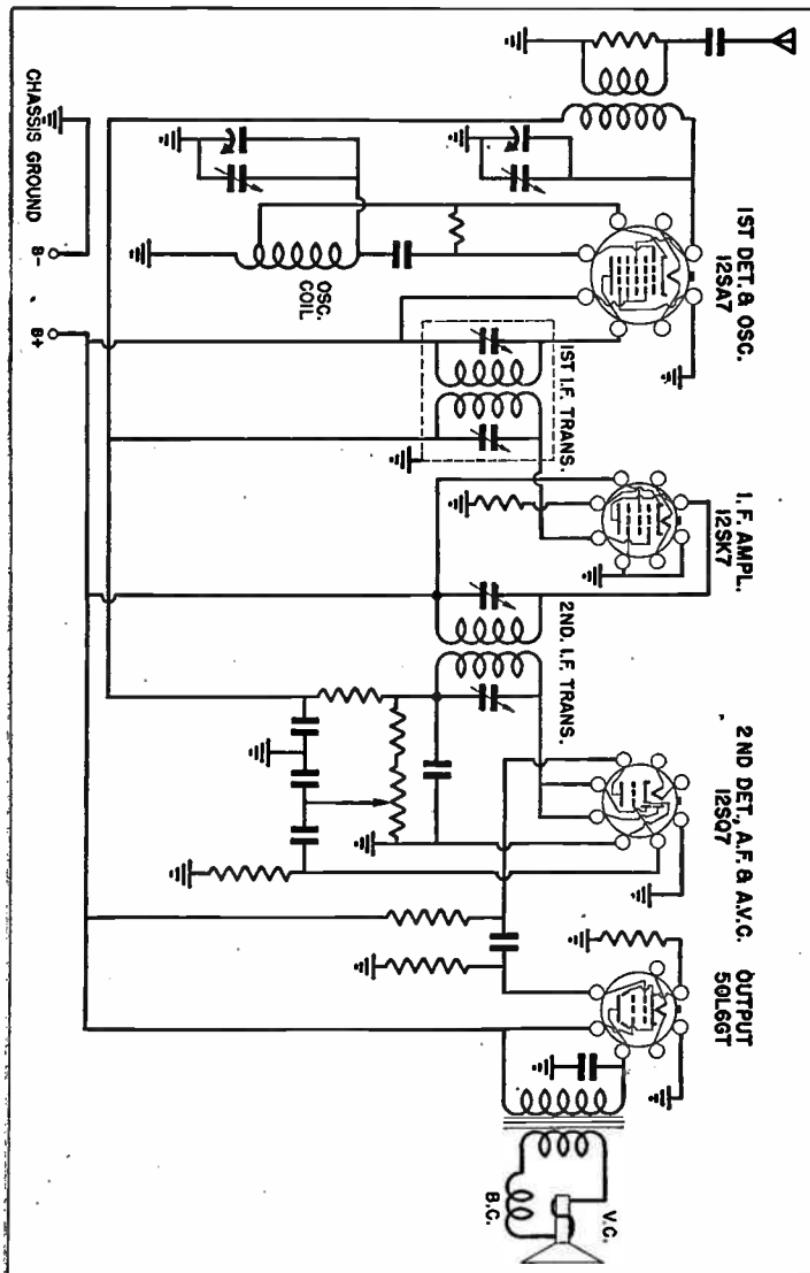


FIG. 2. The tubes used in a set of this kind depend on the age of the set. In the following, the tubes used in earlier sets are given first. The first detector-oscillator is a 6A7, 6A8, 12A8, or 12SA7. The i.f. amplifier is a super-control pentode such as the 78, 6D6, 6K7, 12K7, or 12SK7. The second 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, 25L6, 35L6, or 50L6 tube.

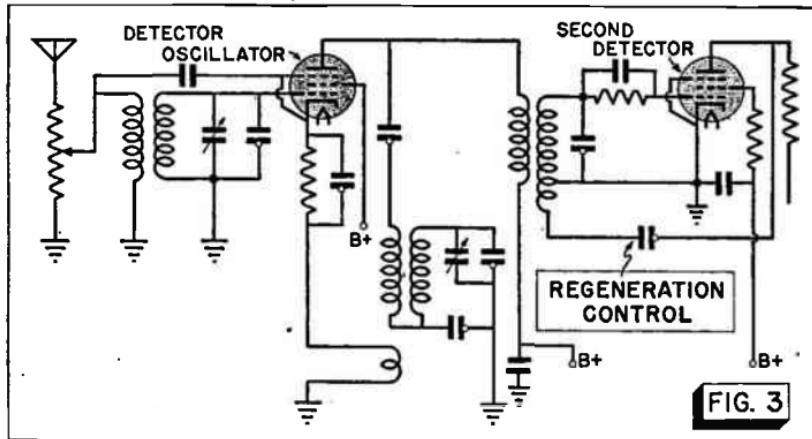


FIG. 3

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.

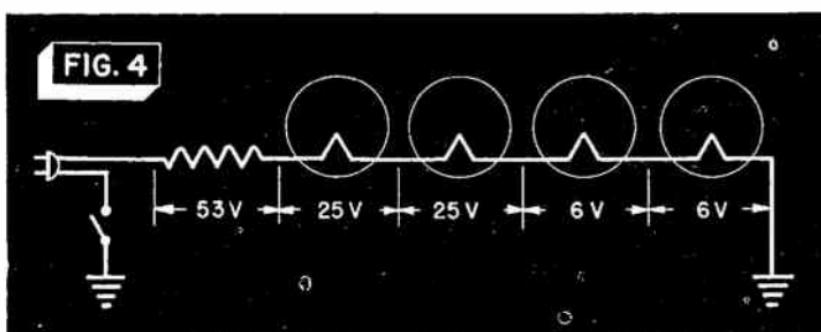
As you know, the resistance of any resistor is equal to the voltage drop across it divided by the current flowing through it. To figure out the proper resistance for a replacement series resistor, first add up the filament voltage drops and subtract their total from 115 volts. The difference is the voltage 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 176 ohms. Actually, a resistor between 170 and 180 ohms would be entirely satisfactory as a replacement.

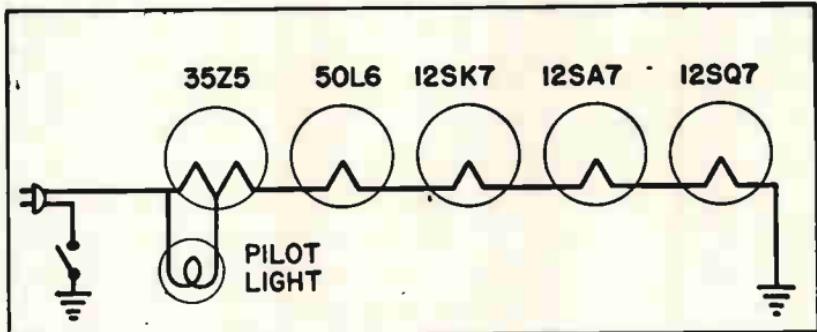
If the series resistance is a power resistor mounted on the set, its wattage must be figured carefully. This is done by multiplying the voltage by the current. The resistor in Fig. 4 dissipates about 16 watts, which means a resistor rated at about 25 watts should be used.

You do not need to figure the wattage rating of Cordohms; 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. 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 15 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 occurs when the tubes are first turned on.

curs when the set is switched on when the tubes are cold. The shunting resistor carries a current equal to the difference between .3 ampere and the current rating of the pilot lamp. The resistance can be found by dividing 4.25 volts by this current value.

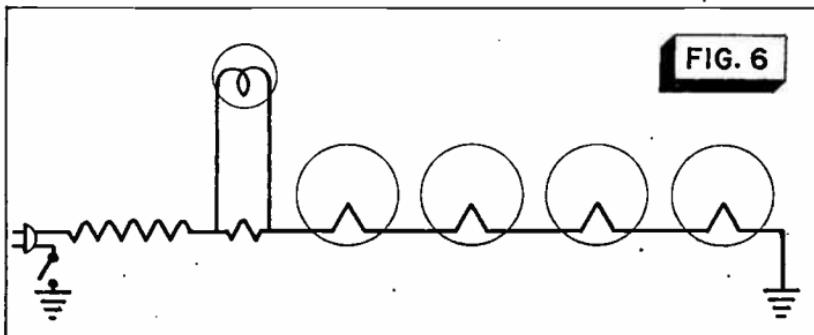
When you replace a pilot lamp, use a 6.3-volt bulb having the same current rating as the original. The current rating is not marked on these bulbs, but it is shown by the color of the glass bead that supports the filament. In the 6.3-volt bulbs, a brown bead indicates a .15-ampere bulb, a white bead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

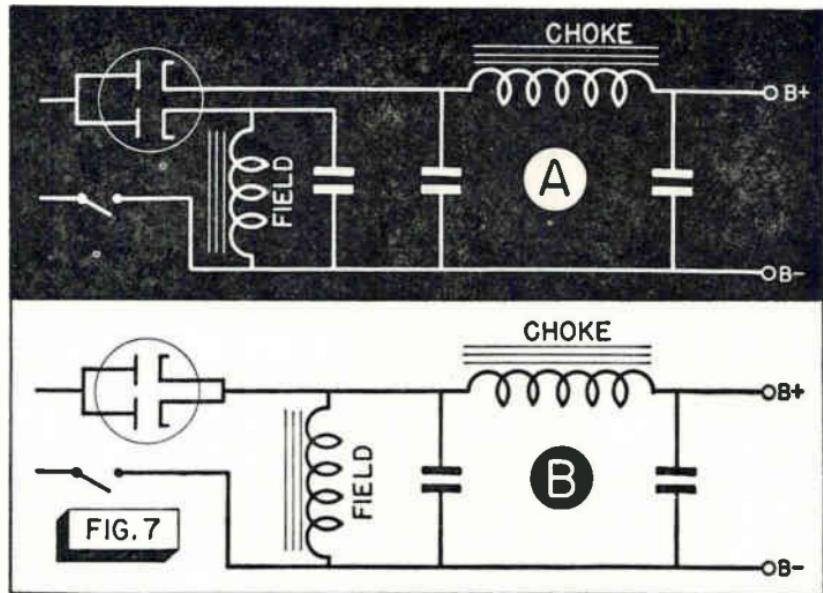
► If the pilot lamp burns out as soon as it is installed, the wrong lamp has been used, or a circuit defect exists. The shunt resistor may be burned out, in which case the pilot lamp is called upon to carry too much current. However, if the shunt resistor is normal, and the pilot lamp is used only in 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



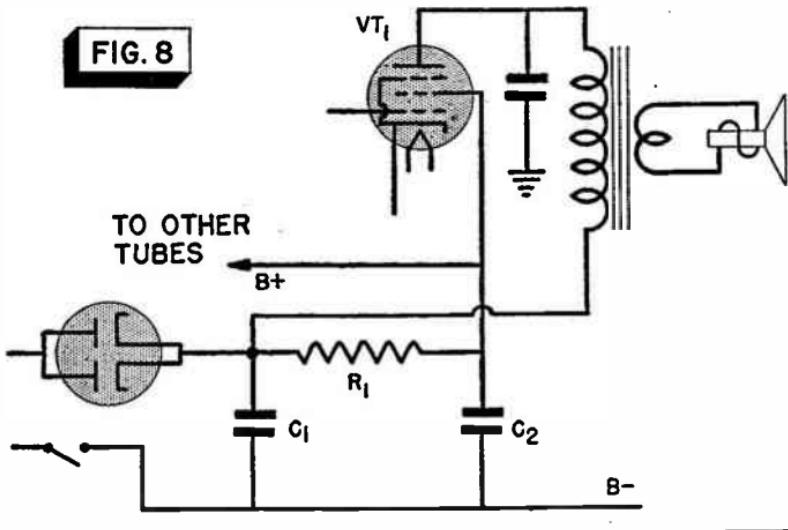


tube is operated directly from the power line. The rectifier output is filtered in the usual manner, and then is used as the plate and screen-grid supply.

Some early a.c.-d.c. sets used magnetic speakers, and many modern ones use p.m. dynamics. 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.

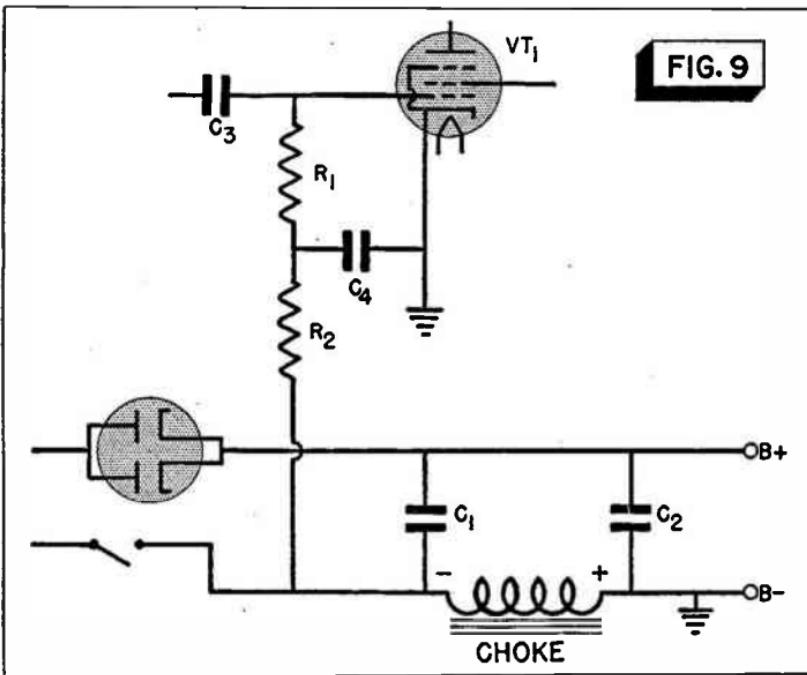
More commonly, the speaker field is connected directly across the output of the rectifier. Some early sets use the circuit shown in Fig. 7A, in which one cathode is connected to supply the B voltage, and the other is used to supply the speaker field. The field coil in this case is usually about 2500 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 capac-

**FIG. 8**

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  $C_2$  to provide sufficient fil-

**FIG. 9**

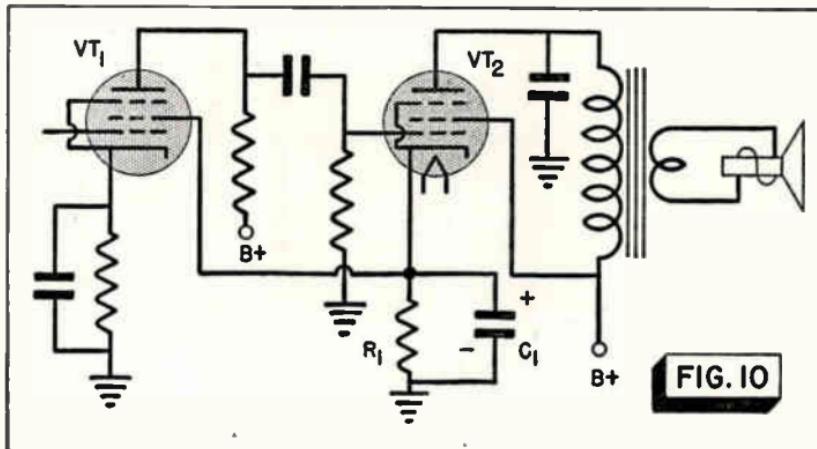


FIG. 10

tering. 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  $R_1$  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  $B+$ .)

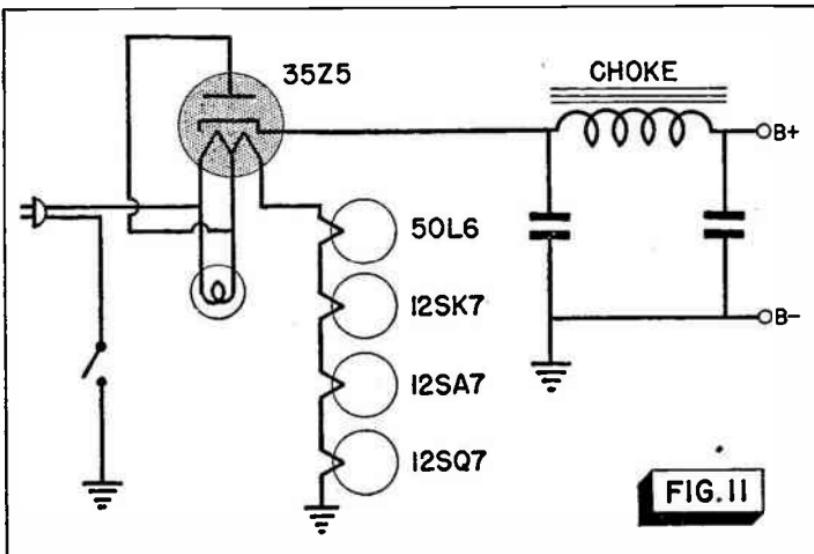


FIG. II

► 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 brilliancy 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 house 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.

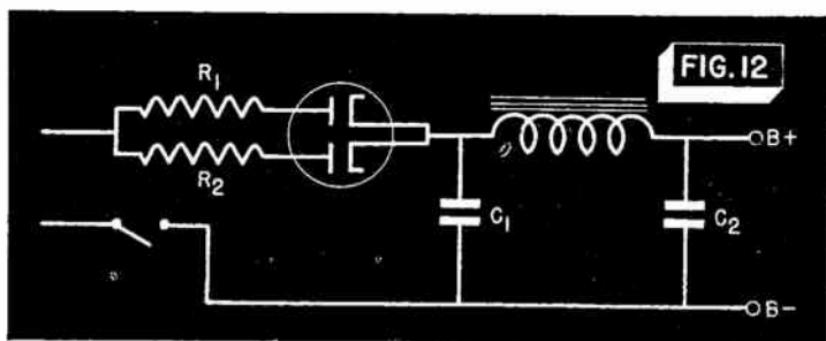
On a set of this kind, if you find the pilot lamp is burned out, replace it. If the replacement burns out, either there is a short circuit across the B supply, or the tapped section of the rectifier filament is open. If the lamp burns normally, then the original was probably burned out by one of these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

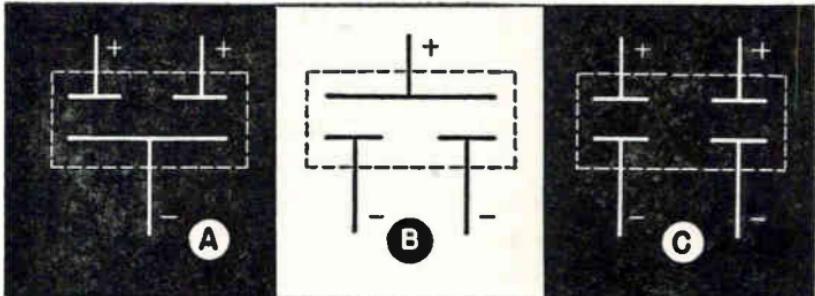
**Output Filter Condenser.** Any value between 16 and 40 mfd., rated at 150 volts or higher.

**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.



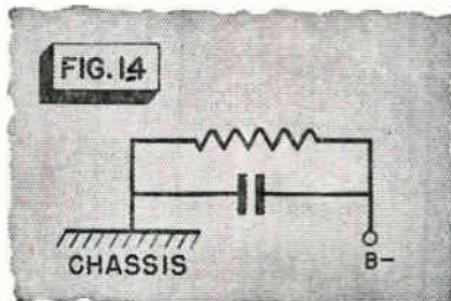
**FIG. 13.** The dotted lines represent the condenser cases. In the types shown at *A* and *B*, the two condensers are tied together inside the case so that a "common" lead is obtained. You can replace these with exact duplicates, or else you can use the general replacement type, shown at *C*, by connecting 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  $C_1$ . (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

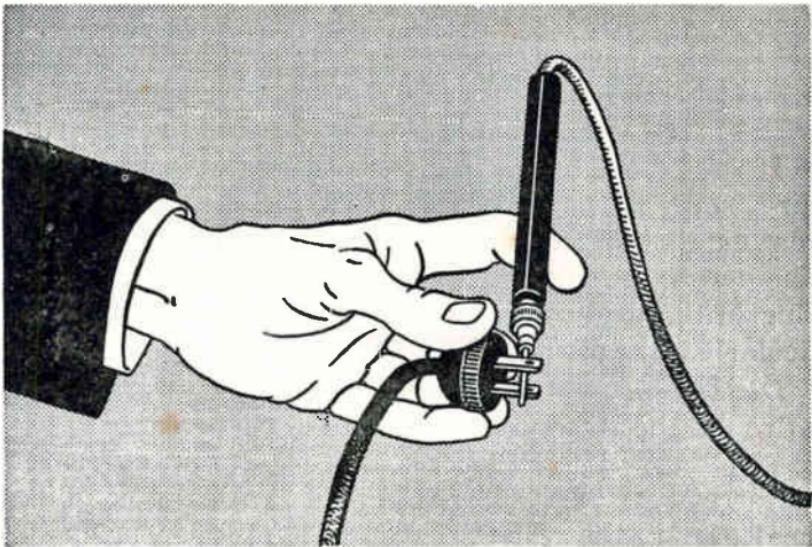
Now that you know the main features of a.c.-d.c. sets, let's see how to service them.

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-

denser before it has time 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, an 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 hank 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

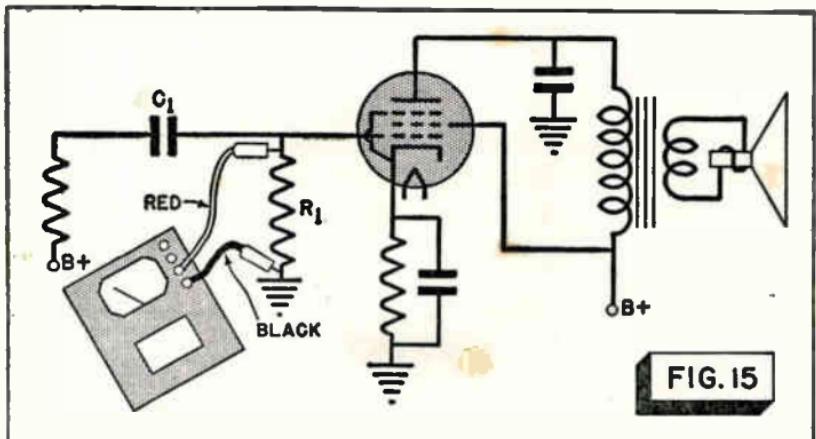


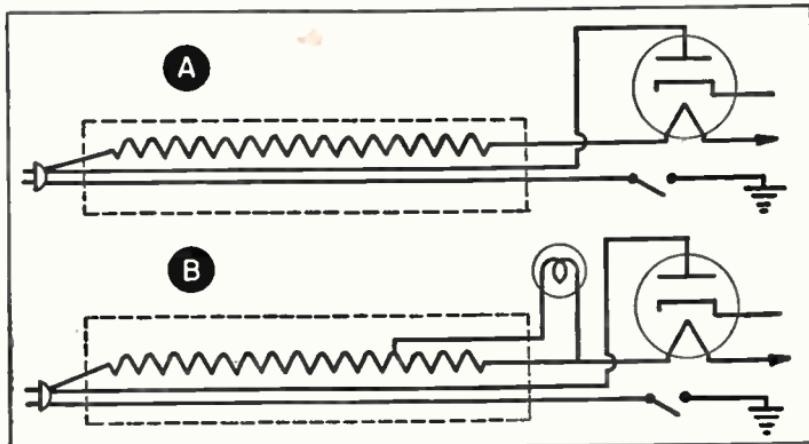
FIG. 15

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.



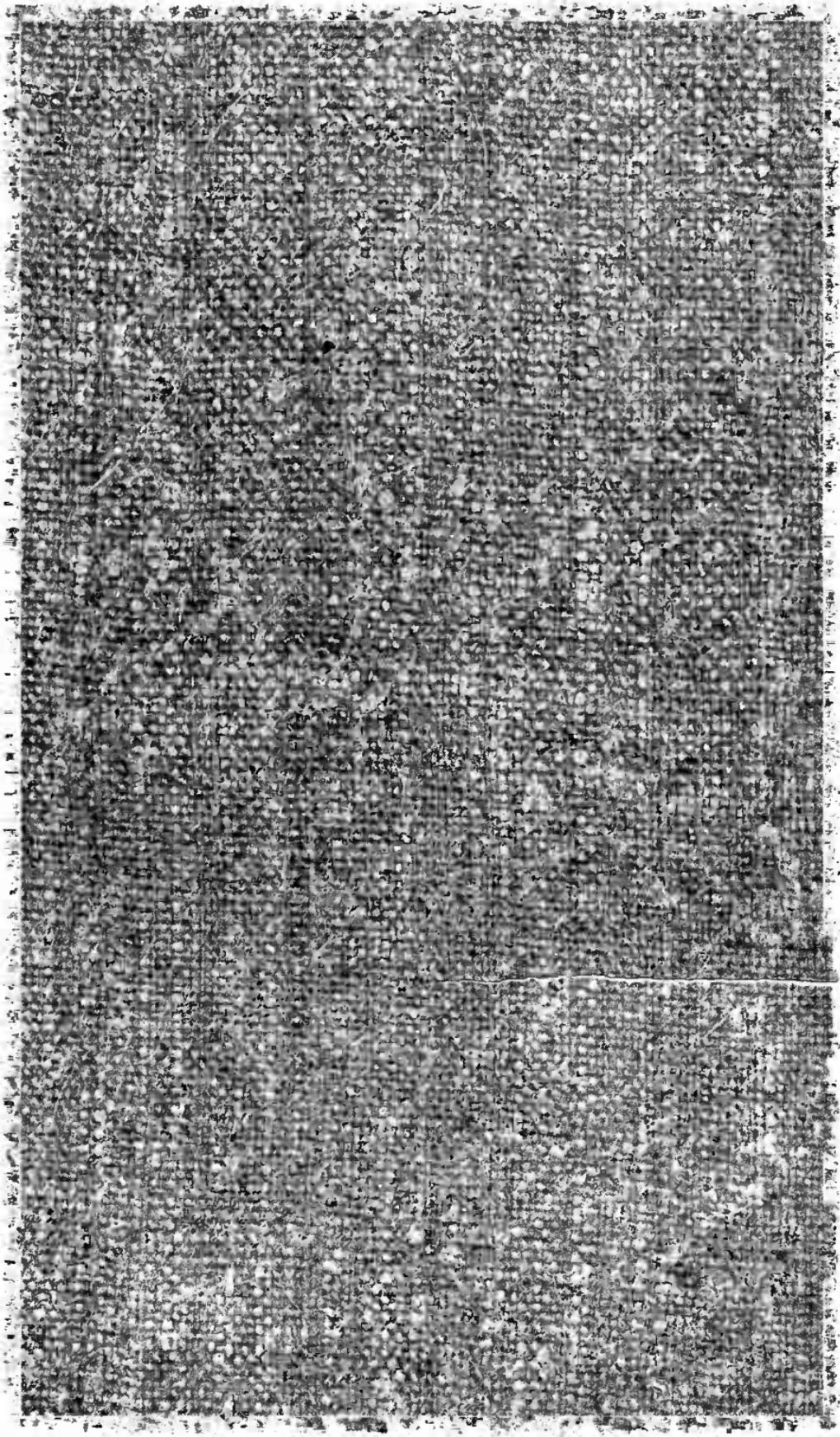
Two styles of Cordohms are shown here. The standard is at A, and one tapped for a pilot lamp is shown at B. Occasionally, you will have to replace a Cordohm. If you have no information as to the resistance value, calculate it as you would a series filament resistor. As you know, the Cordohm was developed 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.

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

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

No. 31 How To Service Three-Way  
Portable and Battery Receivers  
**RADIO SERVICING METHODS**



# NRI TRAINING PAYS...

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



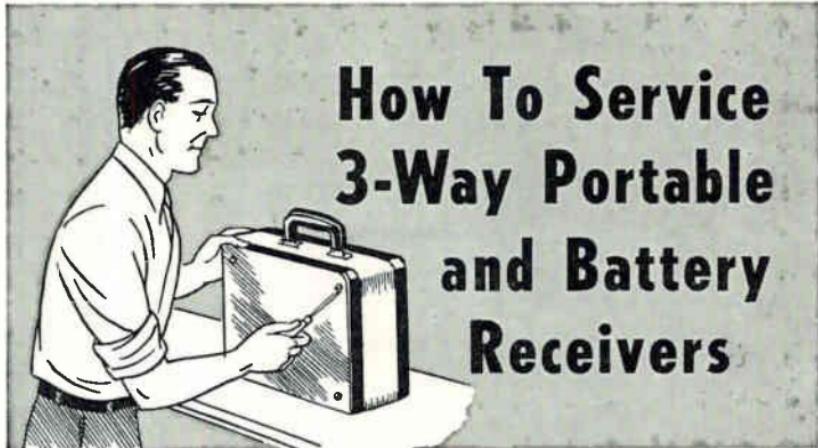
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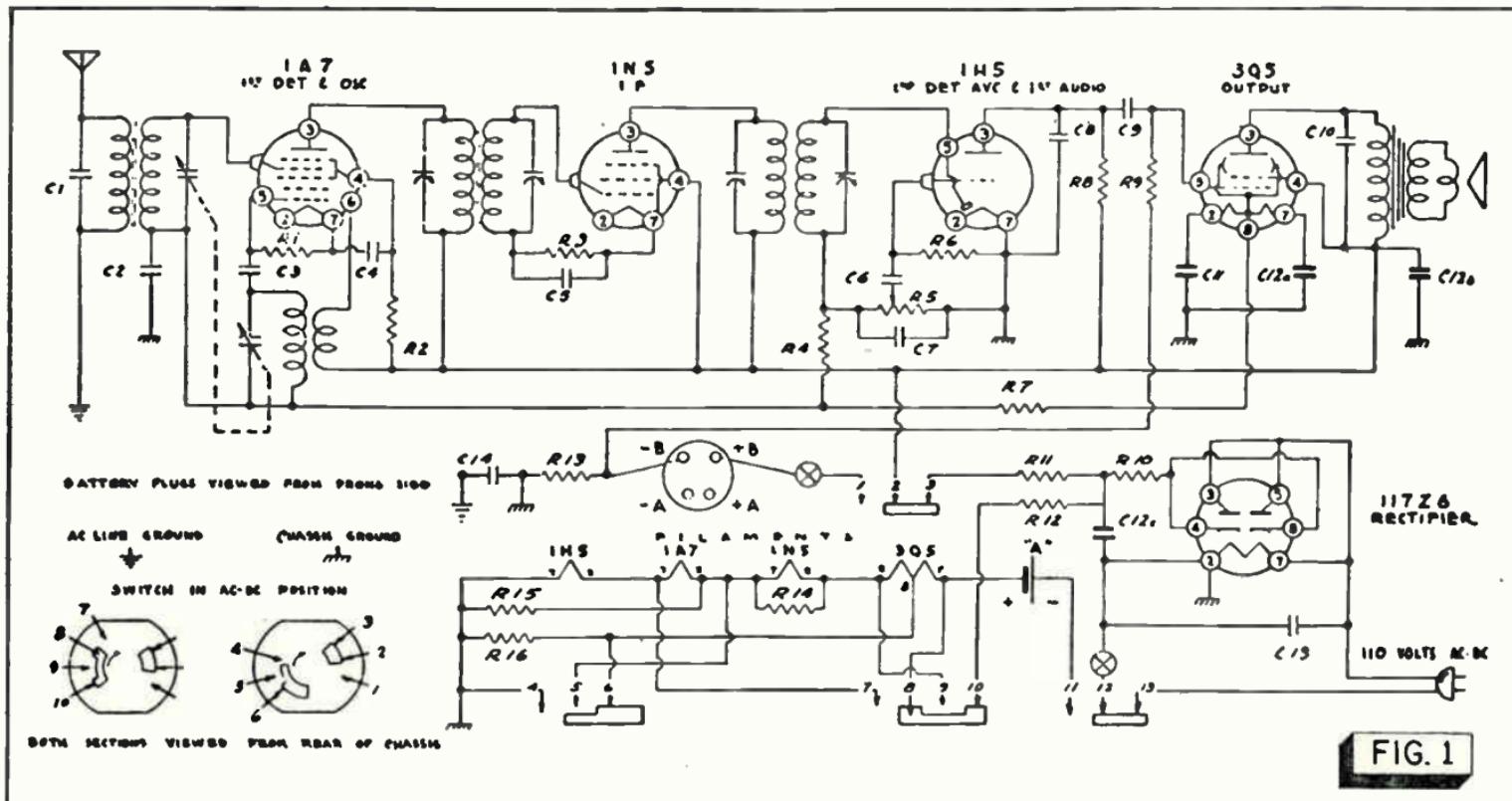
## How To Service 3-Way Portable and Battery Receivers

THERE are a great many battery and portable sets both in cities and in the country, so it is well worth your while to learn how to service them. That is what this RSM Booklet is going to show you. In it, we will follow our usual procedure of describing the technical differences between these receivers and those you have studied previously. Then, we will show you how to locate the defects that are particularly apt to occur in portable and battery receivers.

Of course, any radio that can be carried is portable. However, this name is most usually applied to a type of set known as the three-way portable. This type of receiver is not only light in weight, it can be operated anywhere, because it is designed to obtain its operating voltages from any 110-volt a.c. or d.c. power line, or from self-contained batteries.

You are already familiar with the a.c.-d.c. receiver. Obviously, B batteries could be substituted for the B supply, and 6-volt tube filaments could be put in parallel and operated from a 6-volt storage battery. However, you certainly couldn't class a set using a large storage battery as a portable set. For this reason, tube manufacturers brought out first the 2-volt series of tubes and more recently, a series of 1.4-volt filament tubes requiring very low current drain for filament supply. This has made possible the modern, relatively lightweight portable receiver.

Let's examine the circuits of some typical three-way portable receivers.



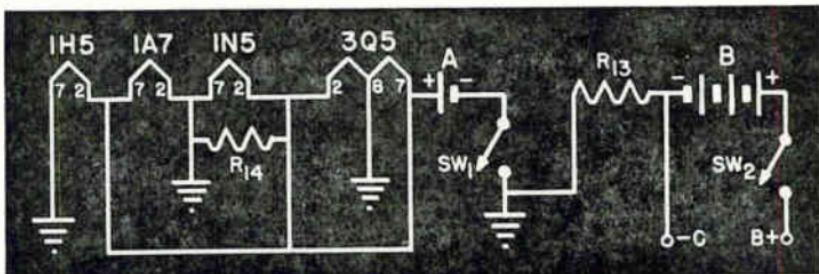
## A TYPICAL THREE-WAY PORTABLE SET

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  $1\frac{1}{2}$ -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  $1\frac{1}{2}$ -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 SW<sub>1</sub> and SW<sub>2</sub> 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  $R_{13}$ , 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.

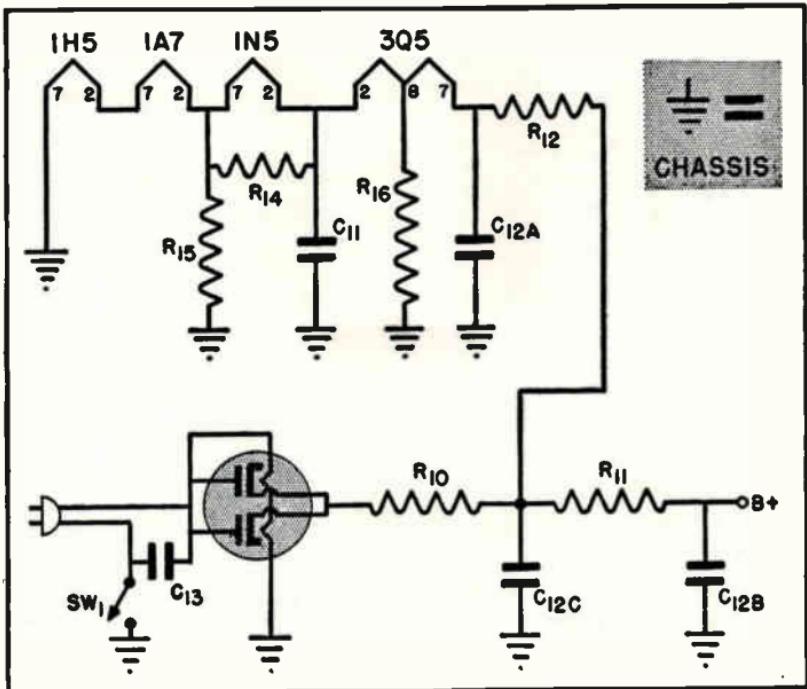
**Power-Line Operation.** Fig. 3 shows a simplified sketch of the connections for power-line operation. Now the tube filaments are in series. (The rectifier tube has a 117-volt filament, which is connected directly across the a.c. power line.) Resistor  $R_{12}$  drops the B-supply voltage to about 7.5 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  $R_{12}$  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  $R_{15}$  is in parallel with the filaments of the 1H5 and 1A7 tubes,  $R_{14}$  is in parallel with the filament of the 1N5, and  $R_{16}$  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 the 1A7 if  $R_{15}$  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,  $R_{15}$  is included in the circuit as a shunt resistor; if its value is properly chosen,  $R_{15}$  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  $R_{16}$  shunts half of the plate current of the 3Q5 past all the filaments.

The resistances of  $R_{14}$ ,  $R_{15}$ , and  $R_{16}$  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

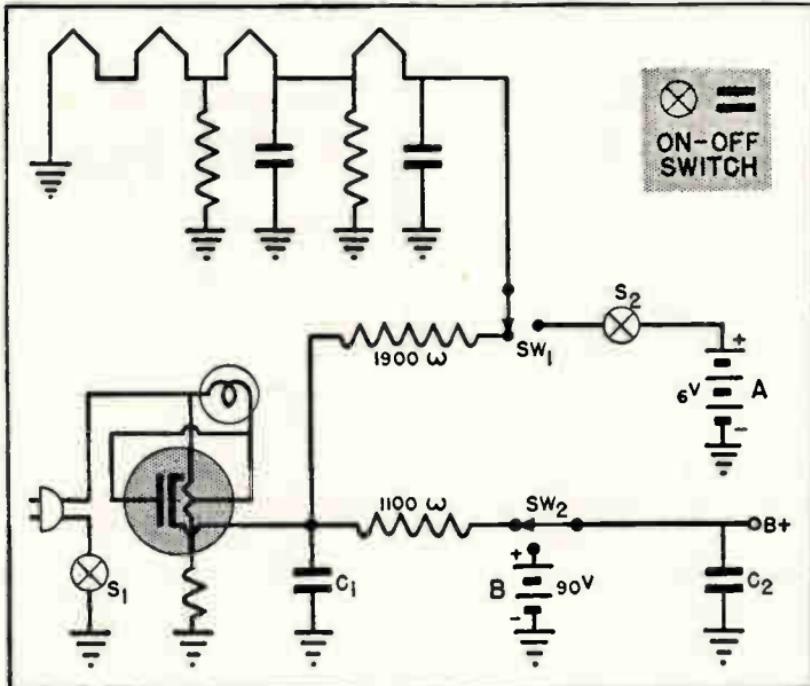


**FIG. 3.** This sketch shows the "power line" version of the filament circuit of Fig. 1. The series filaments are supplied with power through  $R_{12}$  from the B supply.

bias for the 3Q5 tube. As you can see from Fig. 1, the 3Q5 grid is connected to ground through  $R_9$  and  $R_{13}$ . (There is no voltage across  $R_{13}$  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 IN5 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



**FIG. 4.** Because the filaments stay in series, a much simpler change-over switch can be used in this circuit. Some sets of this type do not even use switches; the batteries are connected at all times. You can see this circuit by imagining that all three terminals of  $SW_1$  are connected together to complete the A circuit, and all three terminals of  $SW_2$  are connected together to complete the B circuit.

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 fila-

ment is used, so that its filament can be connected directly across the power line.

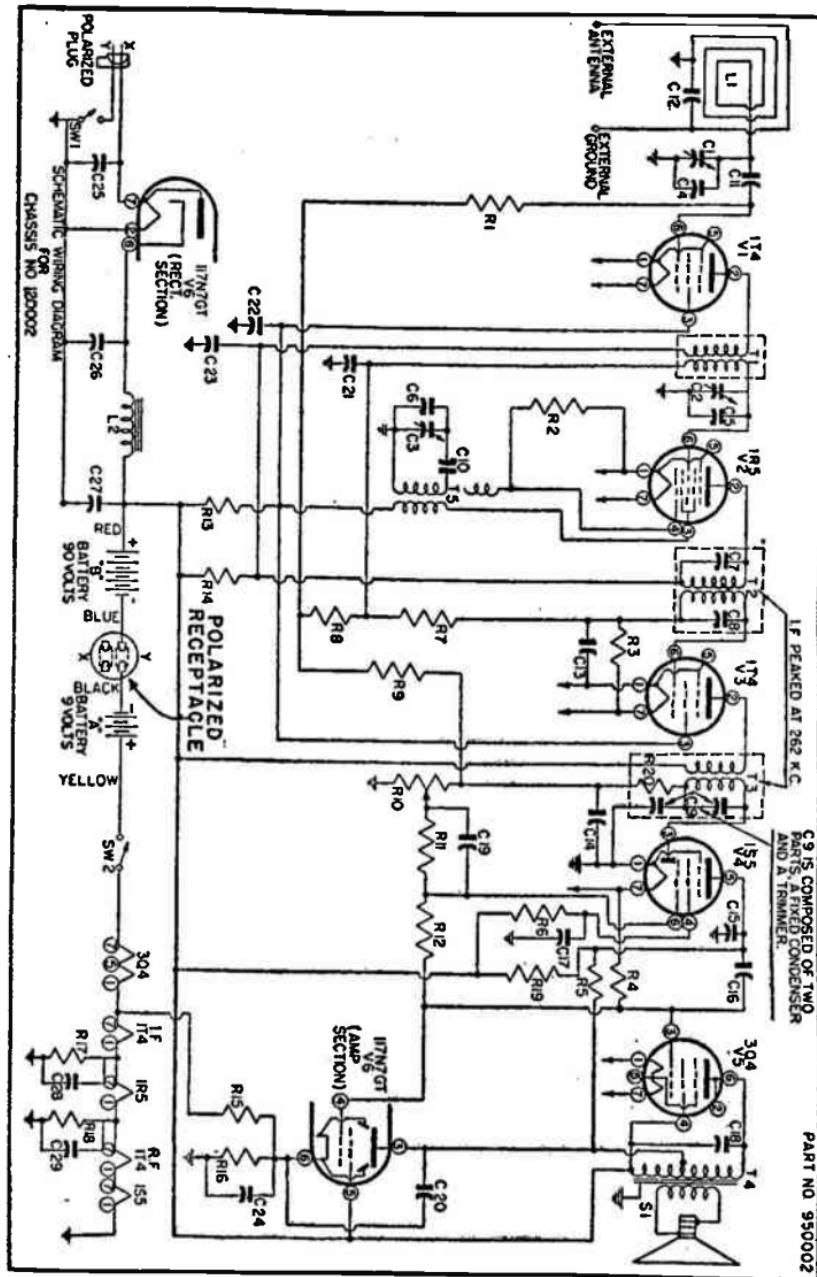
► Fig. 5 shows another important type of three-way portable. This set is unique in two ways—it uses two power-output tubes and has an unusual method of changing from battery to power-line operation.

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  $SW_2$  and through the filaments of the 3Q4, 1T4, 1R5, 1T4, and 1S5 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  $R_{15}$ , in parallel with the 117N7 bias resistor  $R_{16}$ . 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.

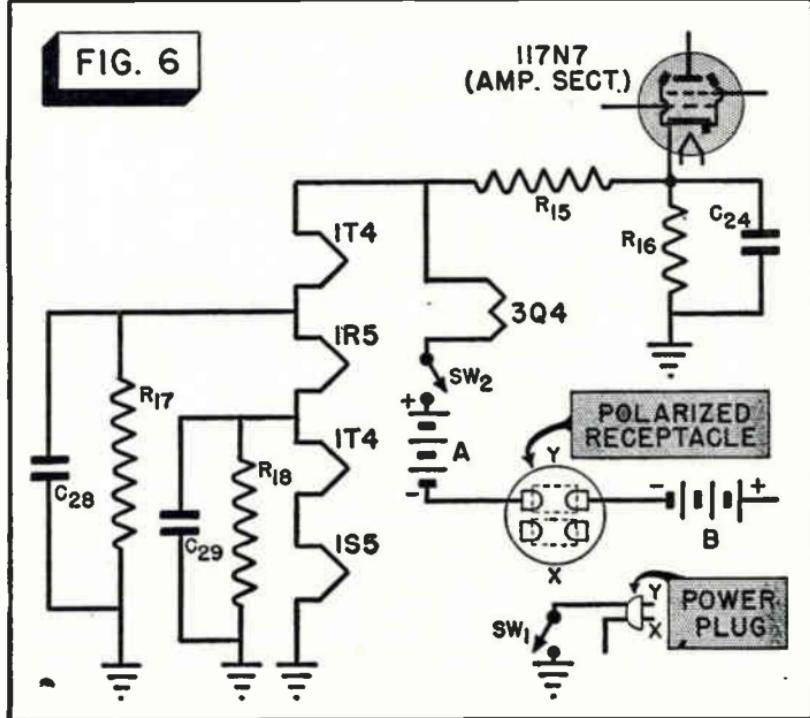
In Fig. 6, condensers  $C_{24}$ ,  $C_{28}$ , and  $C_{29}$  by-pass the a.c. components of the plate currents, and  $R_{15}$  reduces the current flow through the filaments to the desired value. Resistors  $R_{17}$  and  $R_{18}$  are filament shunt resistors.

Going back to Fig. 5, we see that resistor  $R_4$  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 1T4, 1R5, and 1T4 tubes. Since  $R_4$  connects to terminal 7 of the 1S5 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  $R_{12}$  is connected so as to feed energy from the grid of the output tube back to the grid circuit of the 1S5 tube. Since the 1S5 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

FIG. 6



such a set works, imagine that we connect together all three terminals of switch  $SW_1$  in Fig. 4, and do the same for the terminals of  $SW_2$ . 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

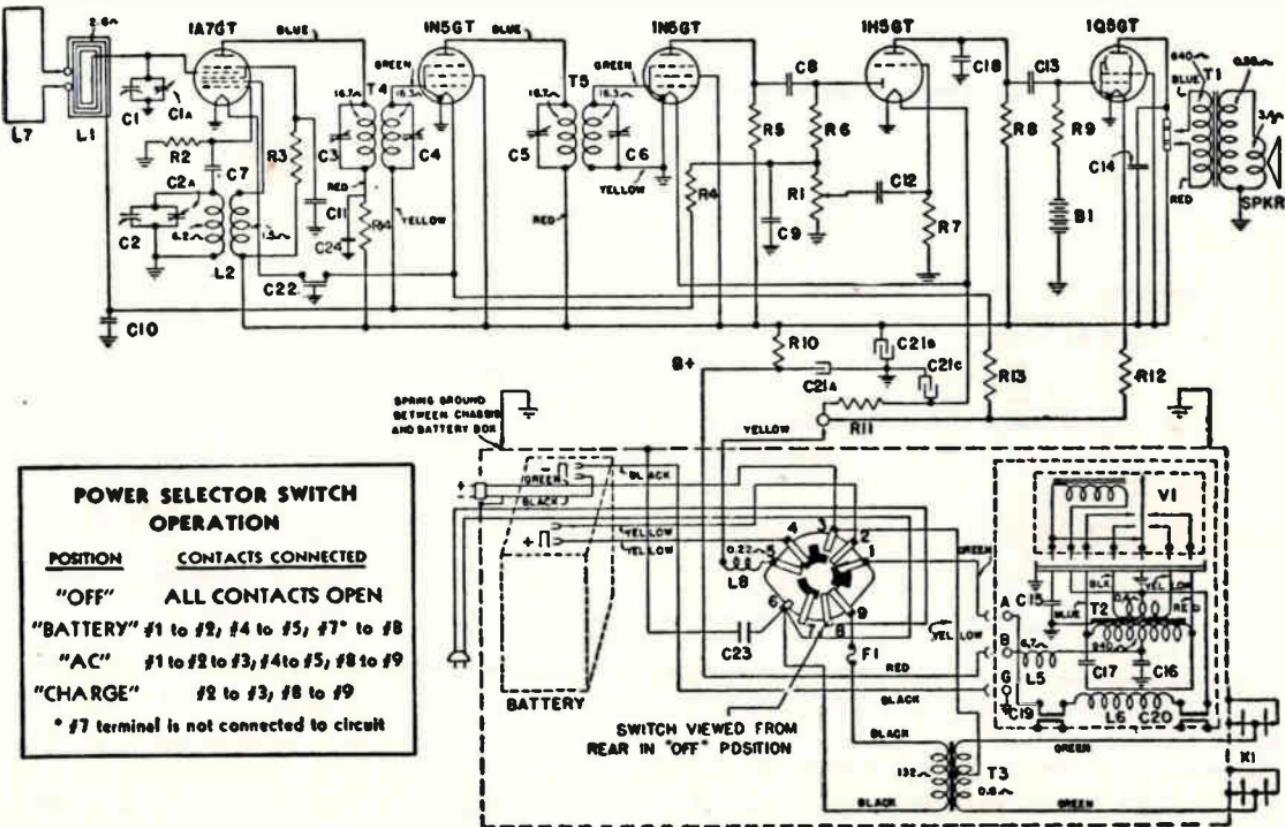
The development of low-filament-drain tubes has led to the production of one portable using a special 2-volt lightweight storage-battery cell. A diagram of this set is shown in Fig. 7.

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

**FIG. 7.** This circuit is shown only to acquaint you with the general features of this type of portable. The set uses a special 2-volt vibrator  $V_1$ , of the synchronous type, as a means of getting the B supply. Notice the special shielding needed around the power supply to keep down vibrator hash. The state of charge of the 2-volt cell is indicated by a built-in hydrometer feature.



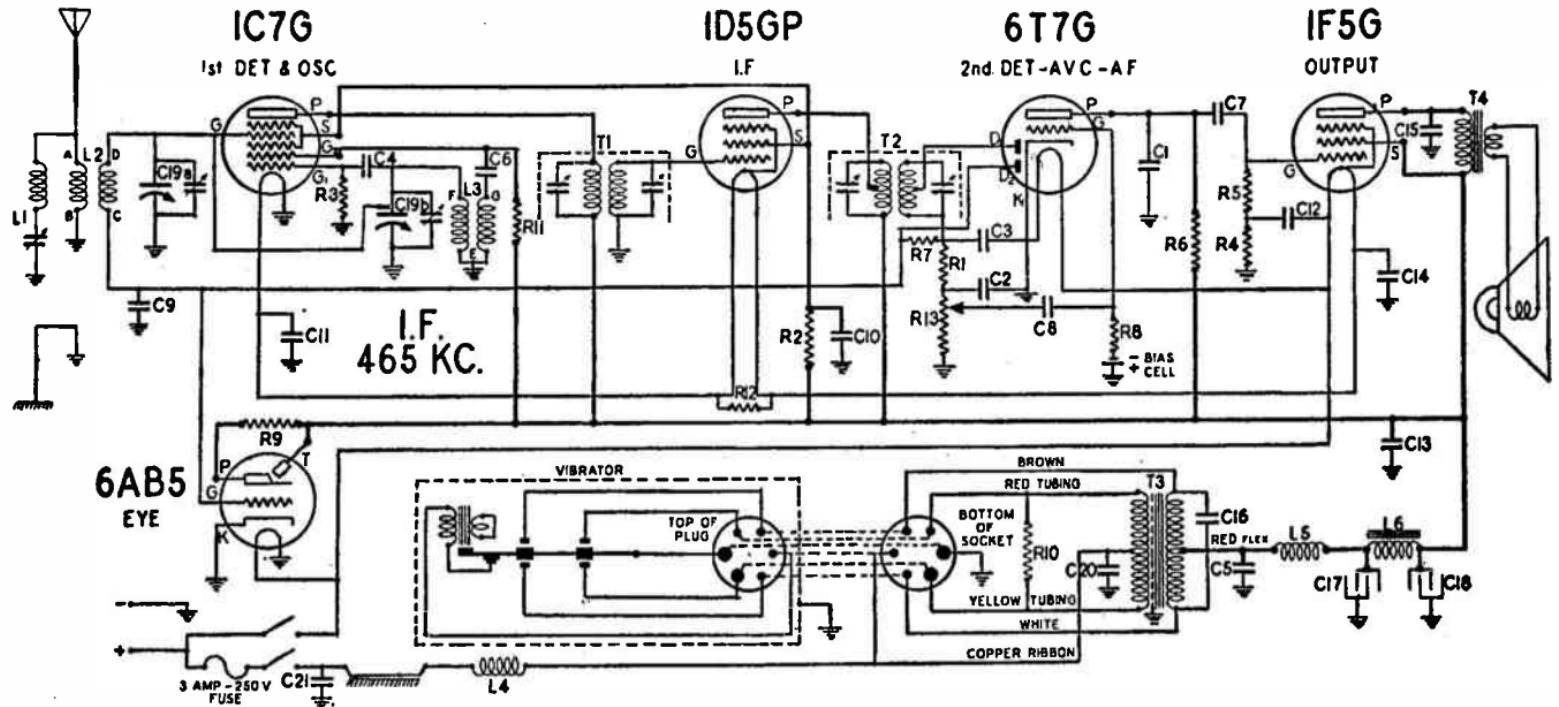


FIG. 8. This type of radio is designed for operation in regions where there are no power lines. This model gives efficient operation from a 6-volt storage battery. Every effort is made to reduce battery drain; for example, some of the tubes are 2-volt types with their filaments in series. (Some of these sets use 6-volt tubes throughout.)

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.

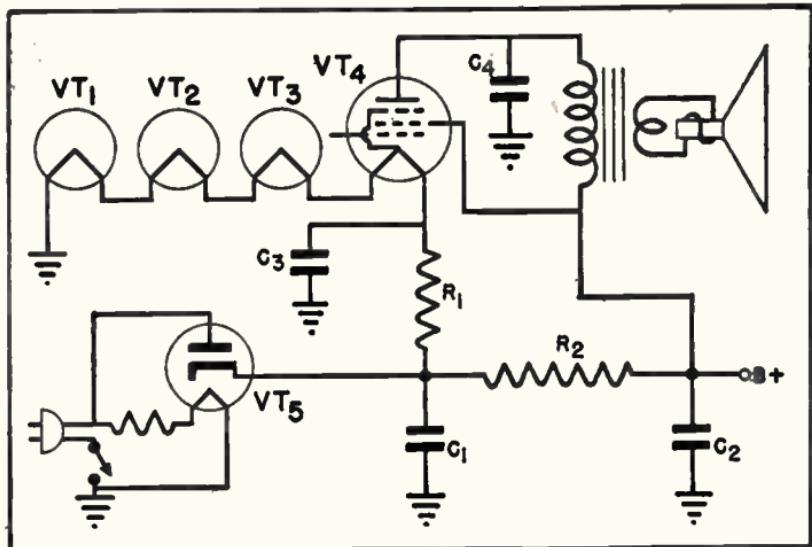
When the trouble occurs on *both* power-line and battery operation, use the usual methods of localization. Usually it is simplest to operate from the a.c. power line and treat the receiver as you would an a.c.-d.c. set. Remember—you cannot pull tubes out of these sets in your localization procedures.

► 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  $C_3$  is a high-capacity electrolytic condenser. If you pull out a tube, this condenser will charge up through  $R_1$  to the full 90-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



**FIG. 9.** This is the filament connection for power-line operation of one type of portable. (Battery circuit is not shown.) The filament supply filter condenser  $C_3$  is a high-capacity electrolytic; typical values range from 50 to 200 mfd. If a tube filament burns out, there will be little voltage drop across  $R_1$ , so  $C_3$  can charge up to the full B voltage. Always be sure  $C_3$  is discharged (short its terminals with a test lead or screwdriver, with the set turned off) before replacing burned-out tubes.

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 4 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.

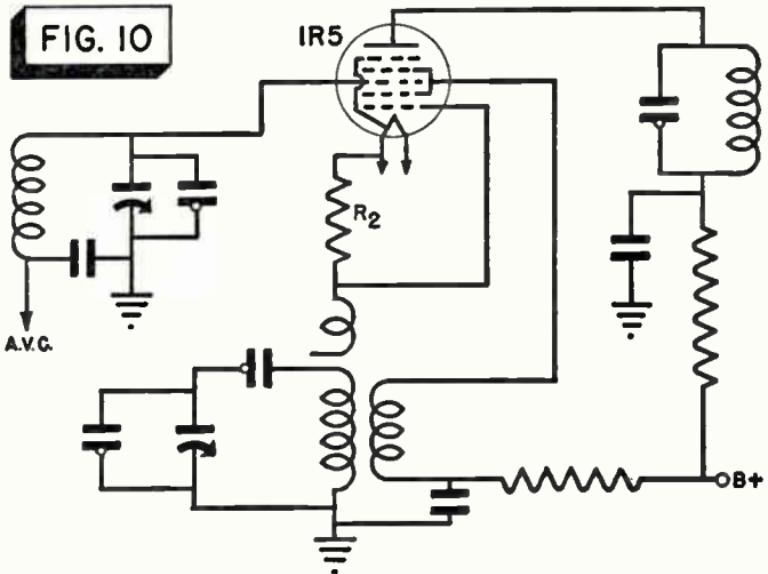
If it is not, first check the operating voltages, particularly the filament voltage. Low filament voltage is the most common cause of oscillator failure, when battery operation is normal. Check the line voltage, since low line voltage will reduce all the filament voltages. (Frequently you will find that 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  $C_3$  may be somewhat leaky. Also, the B-supply voltage may be somewhat below normal because of a defect in condenser  $C_1$ , leakage in  $C_2$ , 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,

FIG. 10



BURGESS	RAY-O-VAC	GENERAL	NAT'L CARBON	USALITE	ADVANCE	BRIGHT STAR	WINCHESTER	BOND
"A" BATTERIES								
4F	P94A	4F1	742	634	247	462	4816	4826
6F	P968	6F1	743	637	147	660	4814	4824
BF	P98A	BF1	741	635	147	860	4819	4829
8FL	P98L	8CFL	745	645	547	865	4813	
F4L				643				
4FL	P94L	3L1		642		465		
F4PI	P694A	4F4		639		646		
2F	P24A	2F1						
2F4	P698A	8F4	718	638	817	866	4817	4827
2F4L	P698L	8CF4	747	646		868	4815	4825
F4PIX				636	2476			4823
G3	EM83	3H3	746	683		361	4918	4928
G5	P85A	5H5	687			561		
FX	9							
"B" BATTERIES								
M30	P5530		482	640	284	30-33	6210	6220
B30	P5303	V30B	762	624	267	30-03	6218	3017
A30	430P	V30A		621	237	30-55		
A30M				622		30-50		
Z30	P7R30	V30AA	738	620				
A60	BB60P							
W30PI	P3A30	V30AAA	733					
W20PI		20AAAAG						
W34		34AAAAG						
W40	3440P							

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  $R_2$  in Fig. 10 by 10% to 20%. (Watch 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.

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.

## 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.

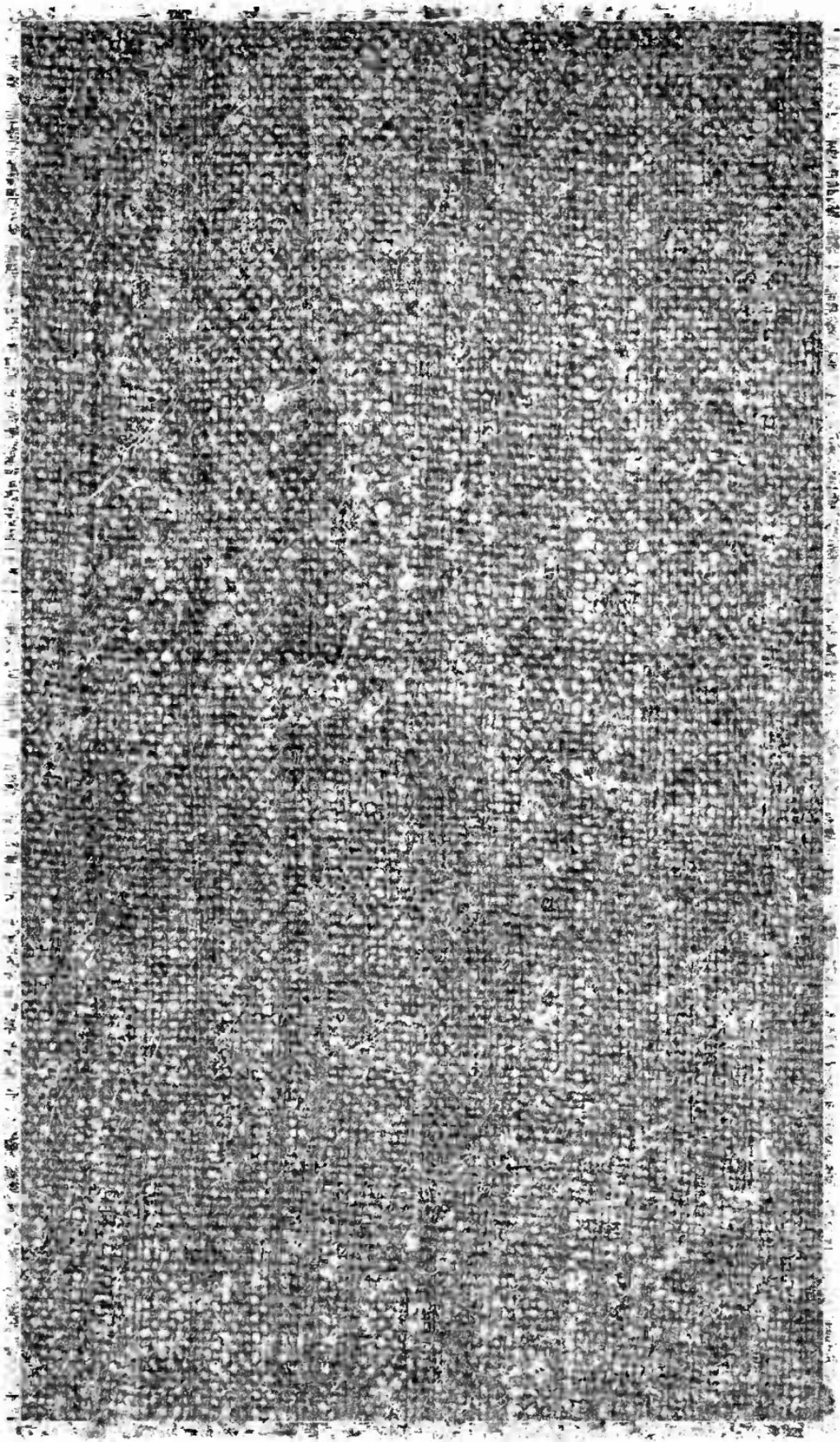
**Noise.** Noise on battery operation and not on power-line operation may indicate defective batteries, but probably indicates loose connections to some battery. Check over the battery connections carefully, and go over the switch that changes the operation from the battery to the power line.

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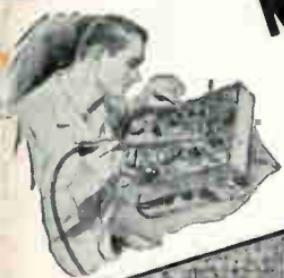
# How to Make Extra Money **FIXING RADIOS**

NATIONAL RADIO INSTITUTE, WASHINGTON D.C.

No. 32

How To Service  
Auto Receivers

RADIO SERVICING METHODS



# NRI TRAINING

# Pays . . .

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



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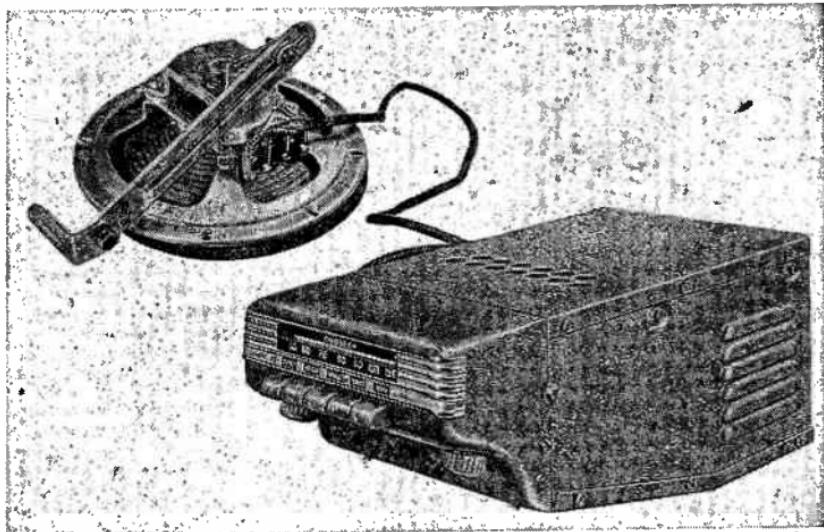
## HOW TO SERVICE AUTO RECEIVERS

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



Courtesy Crosley Corporation

This set, which has a separate speaker, is representative of one of the two main types of auto radios. Its speaker is usually mounted behind a grille in the dash, and the set itself is mounted under the dash. In the other type, the speaker is a part of the set; the whole unit is mounted in or under the dash.

taken to eliminate interference have failed of their purpose. One of the first steps, therefore, in servicing an auto set is to make sure that it is the set and not the installation that is to blame.

If the set itself is defective, you will find that most complaints are caused by the same defects that produce similar complaints in home receivers. However, the electrical and mechanical differences between auto and home sets do create some defects in the former that are not found in the latter. Let's see just what these differences are.

**Electrical Differences.** The chief electrical difference, of course, between an auto radio and a home set is in their power supplies. The auto set must get its operating voltages from a 6-volt battery rather than from a power line. To get the high voltage step-up needed, an auto set usually contains a vibrator that interrupts the flow of d.c. current into the set many times a second, thereby producing sharp voltage pulses. The a.c. components of these pulses can be stepped up by a transformer. Police cars and other special installations sometimes use small motor-generator sets instead, but

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.

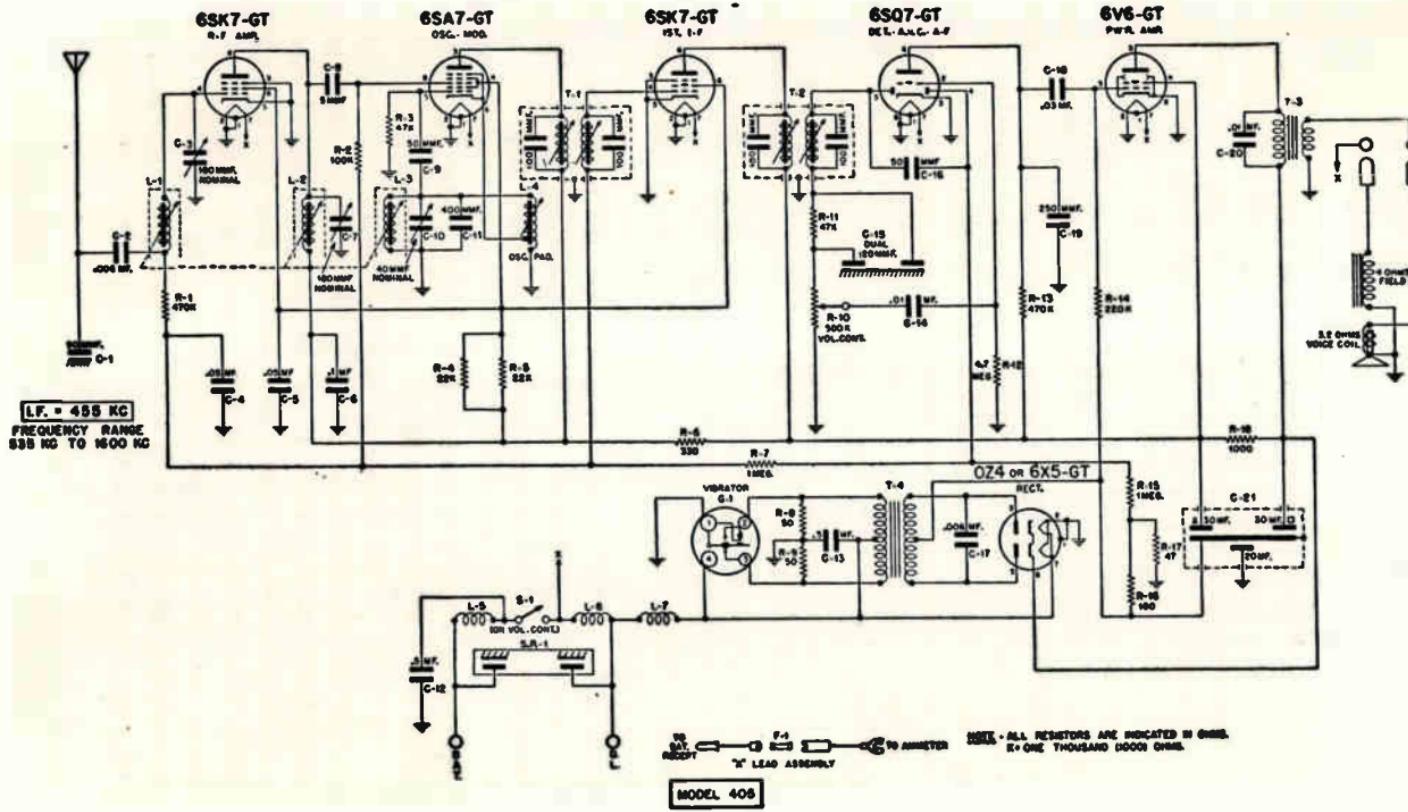


FIG. 1. This is the manufacturer's circuit diagram of a typical small auto radio, the Motorola 405. Notice that it uses permanent ability tuning in the r.f.-i.f. section.

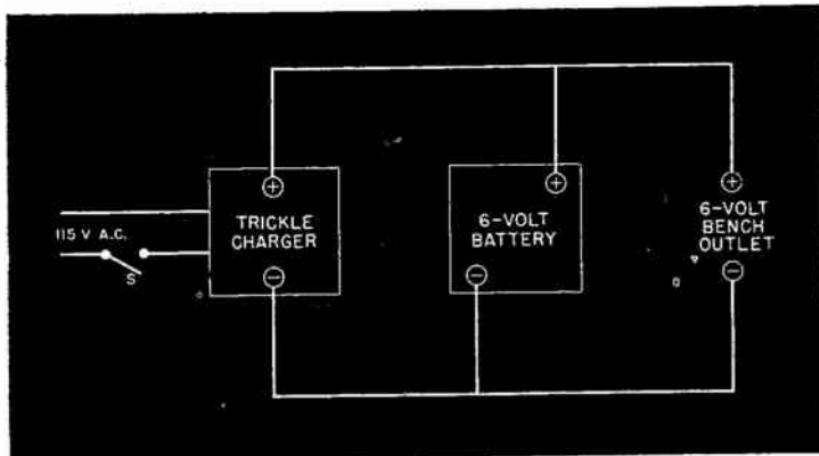
## EQUIPMENT NEEDED FOR AUTO SET SERVICING

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. 2.** To prevent excessive voltage drops in the wiring, be sure to use No. 10 wire for all low-voltage connections in this power supply. Leave it connected to the power line, with the power switch on, except when the battery is fully charged.

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 lead-in. (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.

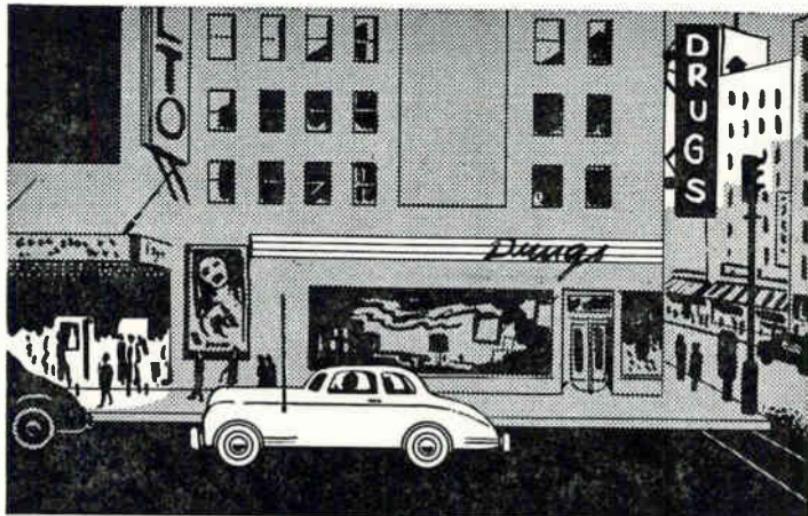
If you hear no noise, start the engine and allow it to idle. If you hear noise now, it is caused by the car ignition system, and the set can be considered to be all right. If you do not hear noise, speed the engine up somewhat; some ignition difficulties do not occur until the engine is moving at fairly 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.**

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

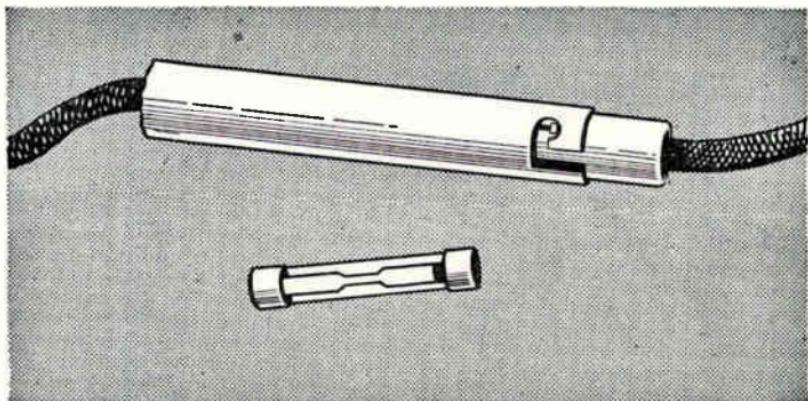
As we have already said, the antenna of a car set is so short that very little signal is supplied to the input of the receiver. When this small signal is further reduced because the car comes near some natural shield, such as a steel bridge, it is only normal that the volume of the receiver should decrease. 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



A typical fuse and fuse retainer, shown approximately full size, of the sort used in the hot A lead of many car radios. In use, the fuse is inside the retainer. When an auto set is dead, find this retainer, open it, and examine the fuse, before making any other tests; a blown fuse is one of the most common causes of a dead set.

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.

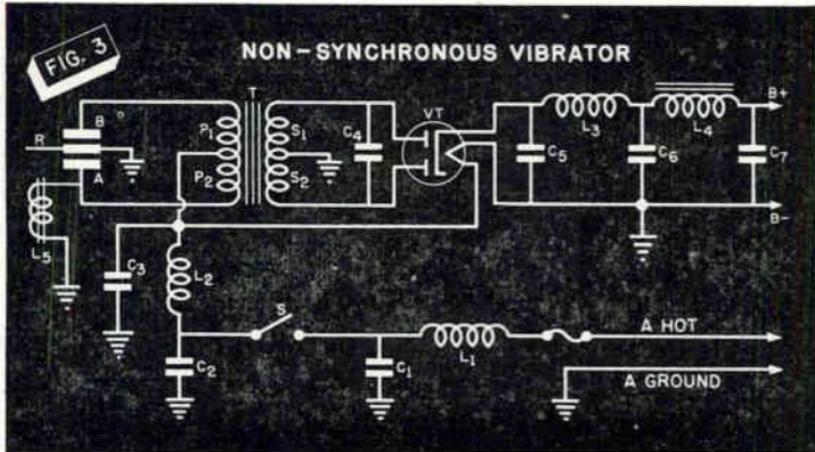
If testing the tubes does not point out the cause of the complaint, you will be forced to remove the set from the car and take it to your bench for testing. It may be difficult for you to remove the set alone—you may need a helper to hold the set while you loosen the holding bolts. (Some sets are hung 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 electromag-



net; 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  $L_1$ ,  $L_2$ ,  $P_2$ , and  $L_5$  (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  $P_2$  and also shorts  $L_5$ , causing it to release the reed. The reed then flies back, striking contact B, and completing a circuit through  $P_1$ . Then coil  $L_5$  again attracts the reed, repeating the cycle.

The pulsing current flowing first through  $P_2$  and then through  $P_1$  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  $C_4$  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  $C_5-L_3-C_6-L_4-C_7$  is used in the power supply.

► The synchronous vibrator power supply, shown in

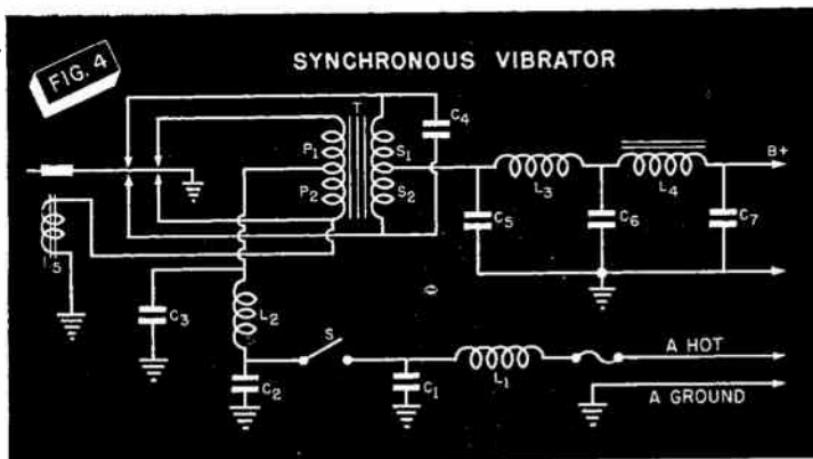


Fig. 4, uses a mechanical system to rectify the secondary voltage of the transformer, thereby making it unnecessary to have a rectifier tube in the set. It is not as popular as the non-synchronous vibrator already described, chiefly because it is more complex, and therefore more prone to failure.

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  $C_6$  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 ( $C_4$  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 B supply 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 downscale, 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 loctal 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

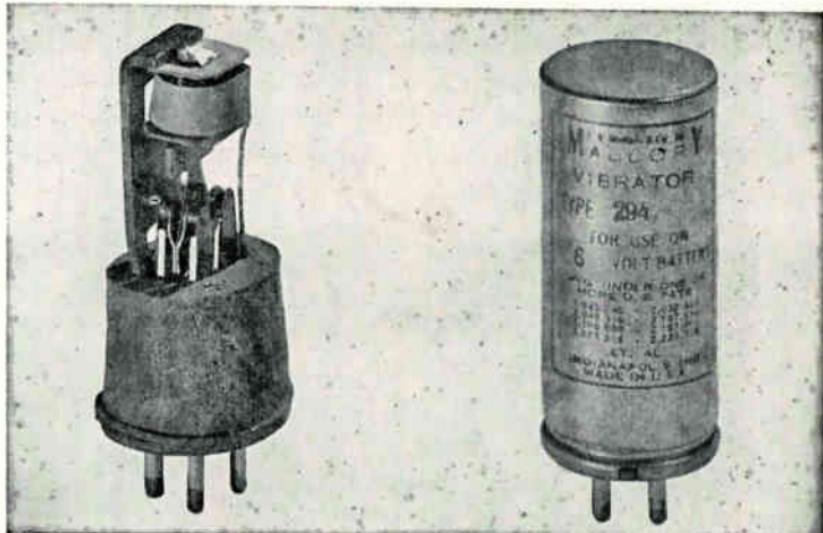
If the set is dead, listen for the vibrator hum. If no sounds at all come from the speaker, and you cannot hear any sound directly from the vibrator, the vibrator is defective or is not getting power. (Look for a blown fuse, or a break in the A lead.) On the other hand, if the vibrator buzzes, but no 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



Courtesy P. R. Mallory and Co., Inc.

Internal and external views of one popular kind of non-synchronous vibrator. Notice that four sets of contacts are used, instead of the two indicated for the non-synchronous vibrator in Fig. 3. Electrically, however, this vibrator and that shown in Fig. 3 are identical, for the pairs of contacts on each side of the vibrating reed are connected in parallel. This arrangement permits the contacts to carry fairly heavy currents without burning or pitting.

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 car 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

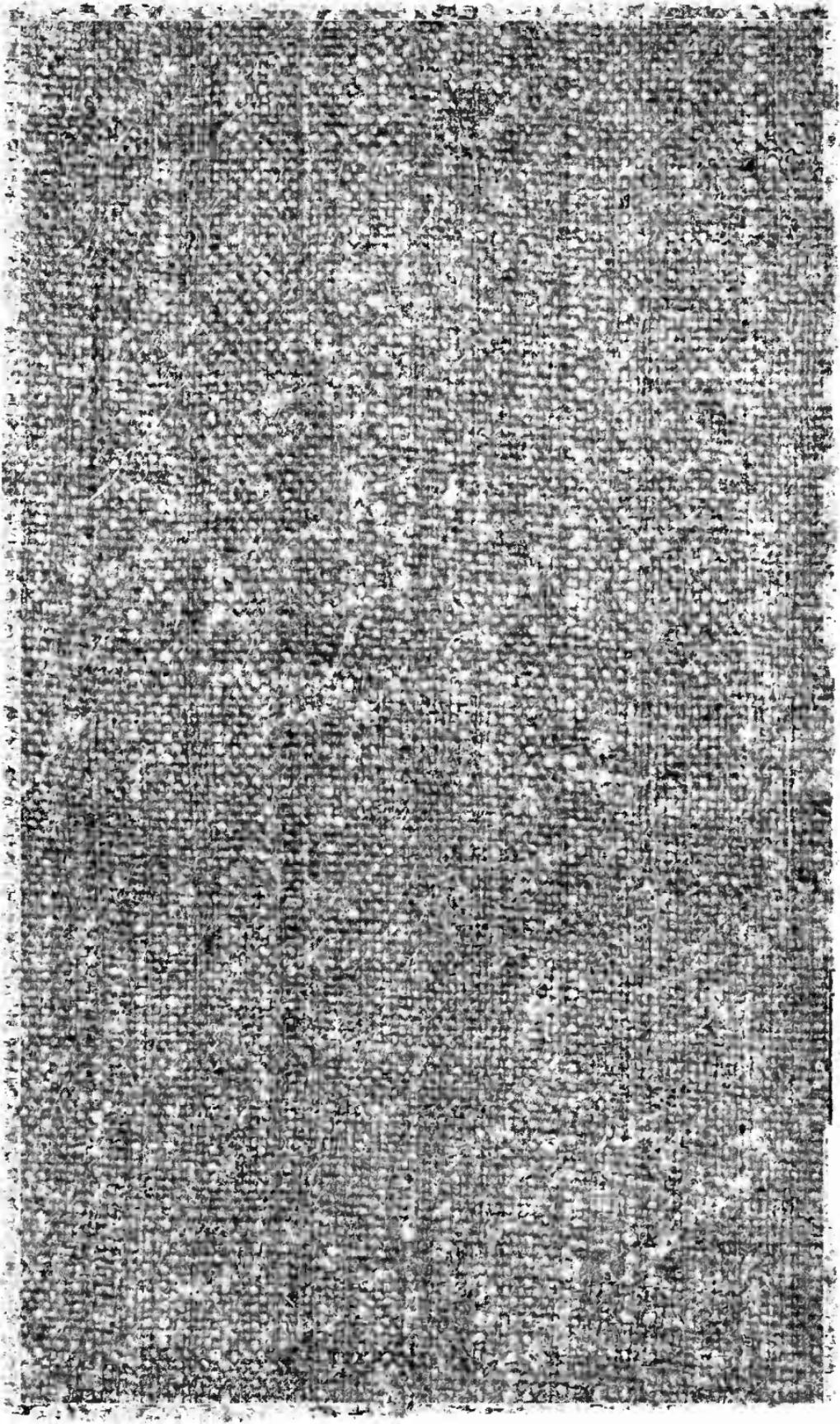
An auto set is more prone to oscillation than is a home receiver, because it is far more sensitive. Some very slight defects may cause trouble. Look for loose shield-

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.

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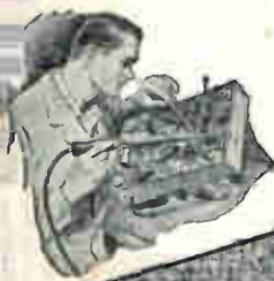
(REGISTERED U.S. PATENT OFFICE)



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

NATIONAL RADIO INSTITUTE, WASHINGTON D.C.

No. 33 Recognizing Complaints Not  
Caused by Receiver Defects  
**RADIO SERVICING METHODS**



# NRI TRAINING

# Pay A . . .

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



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FM10M250

1950 Edition

Printed in U.S.A.



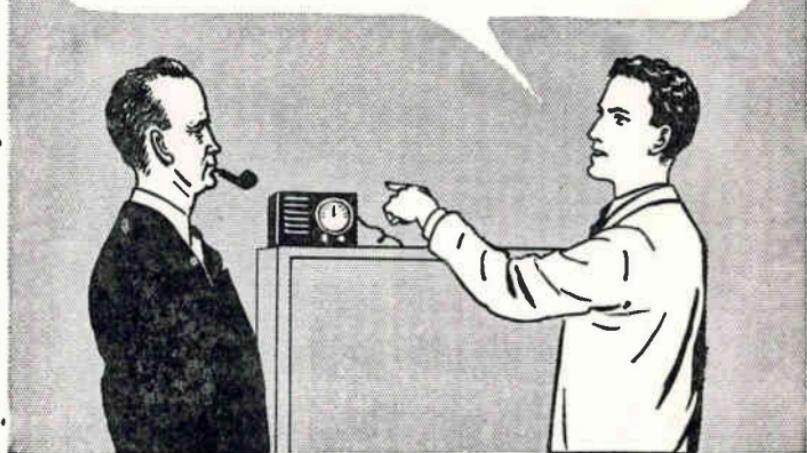
## Recognizing Complaints Not Caused by Receiver Defects

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

THESE SMALL SETS ARE DESIGNED FOR LOCAL RECEPTION. THEY DON'T HAVE ENOUGH TUBES TO PULL IN DISTANT STATIONS.



When you find that a customer's complaint is that his little a.c.-d.c. set doesn't have the performance of a large console receiver, remember to be diplomatic. Don't insult his set—he bought it, and he may resent your remarks as a slur on his judgment. Point out the limitations of his set in such a way that he will not take offense. For example, you might use the words of the serviceman in the illustration above when your customer complains that he can't get a distant station. DON'T say, "You can't expect a cheap set like this one to be any good."

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.

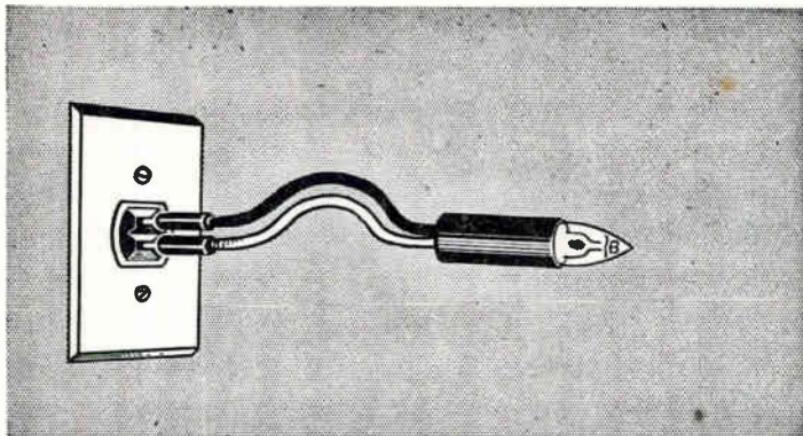
When a customer complains that one or more short-wave bands are dead, check carefully to see whether other bands are alive. If they are, and the noise level and the fading on these bands appear unusually intense, it is quite probable that ionospheric disturbances are to blame. In this case, just wait 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



When a set is completely dead, always check the wall outlet to make sure it is "hot." A neon test light like this one is a handy device for testing the outlet. If you prefer, you can plug in a lamp or use your voltmeter to make the check. If you find no voltage at the outlet, most likely a fuse is blown in the power line.

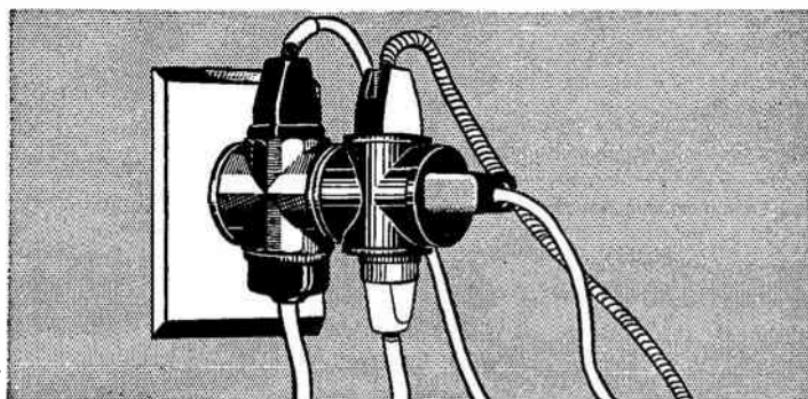
he tries to pick up distant stations under adverse conditions, or with a radio not designed for this reception. In these cases, the customer's complaint of weak reception is not really justified; true, reception is not good, but it is as good as can be reasonably expected. When you get a complaint of 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 day-time, 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 49-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 receiver 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-eye 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.

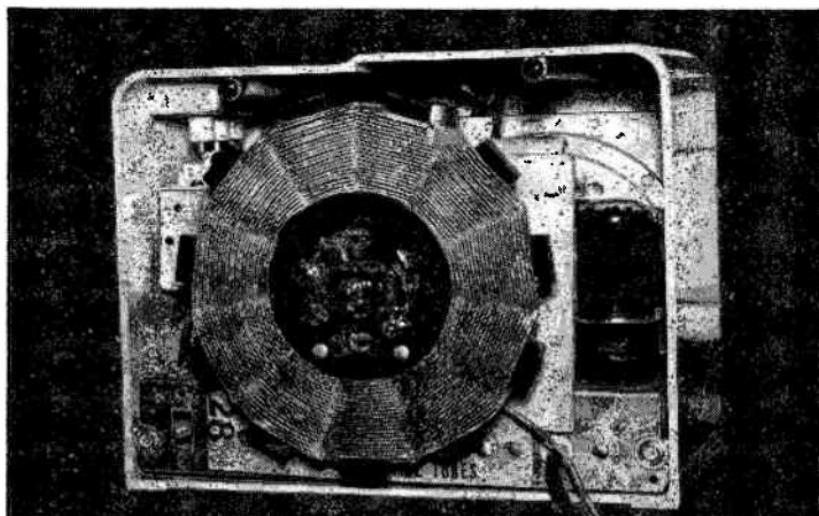
Naturally, if you find every receiver of a particular make and model operates at about the same level, then they must be designed to work that way. But don't make snap judgments after hearing only one or two sets. Remember that radio receivers are production devices—they are allowed rather wide variations 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.**



## FADING 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 at 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.

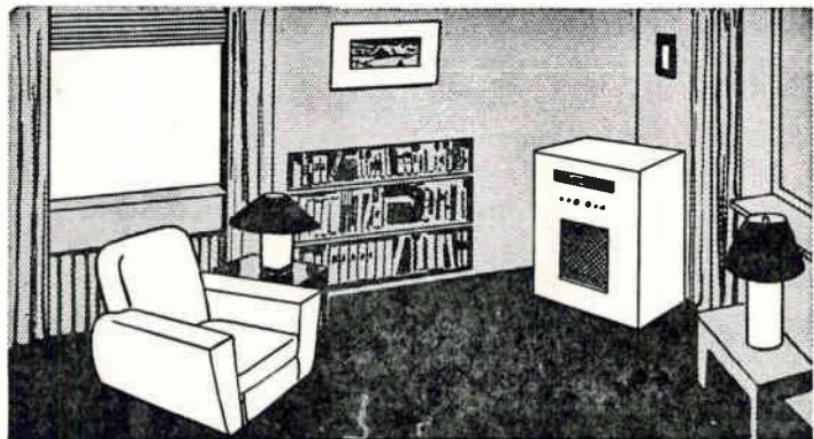
However, sometimes it is hard to tell whether a set is actually intermittent. The prime example is a set that changes radically in its volume when light switches are snapped on or off. This may mean that the set has an intermittent defect, and that the line voltage surges caused by snapping the switches 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 interference. 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 antenna 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 superheterodyne (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 interferences 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 station or long-wave weather station that happens to be on a frequency equal to the i.f. frequency 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 (produced in the receiver) causes the trouble.

The best cure for this difficulty is to shift the i.f. frequency 10 or 15 kilocycles, if this can be done without seriously upsetting the dial calibration. Another possible cure is to use a wave trap in the antenna 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 connecting 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 minimum.

► Another common trouble is

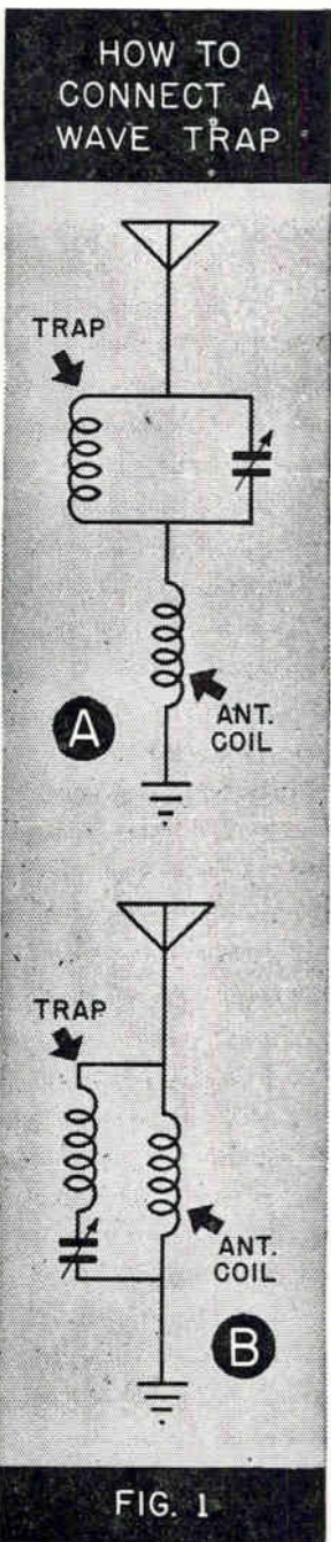


image interference. As you know, in the superheterodyne the desired incoming signal frequency is normally *below* the oscillator frequency by the amount of the i.f. frequency. However, if there is a strong station at a frequency *above* the oscillator frequency by the amount of the i.f., it may be able 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.)

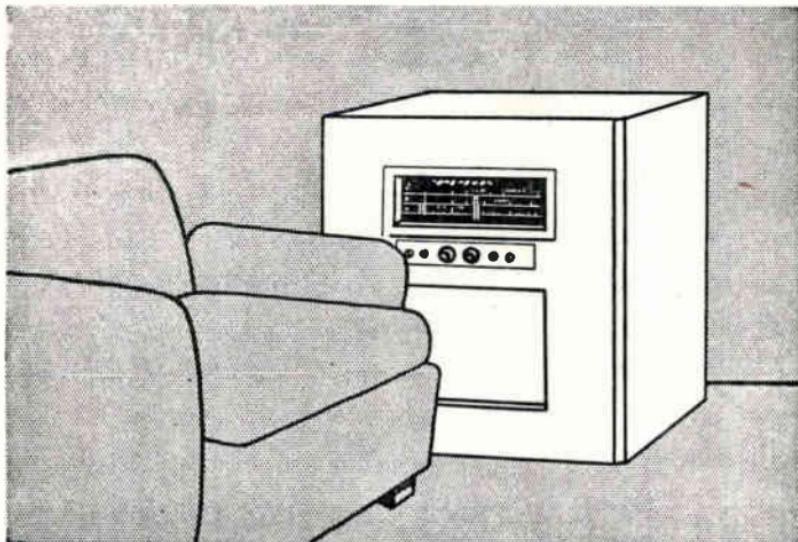
Image interference normally occurs only when you are very close to a powerful local station, or when the preselector of the receiver is not of the best quality. Sometimes it is caused by too long an antenna, because the loading reflected into the resonant circuit broadens the preselector response.

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



If the customer complains that the tone of his receiver is not clear, make sure the set is not placed so that a large chair or other piece of overstuffed furniture is close to it and directly in the path of the sound waves produced by the loudspeaker. The chair will tend to absorb high frequencies, creating a muffled sound.

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

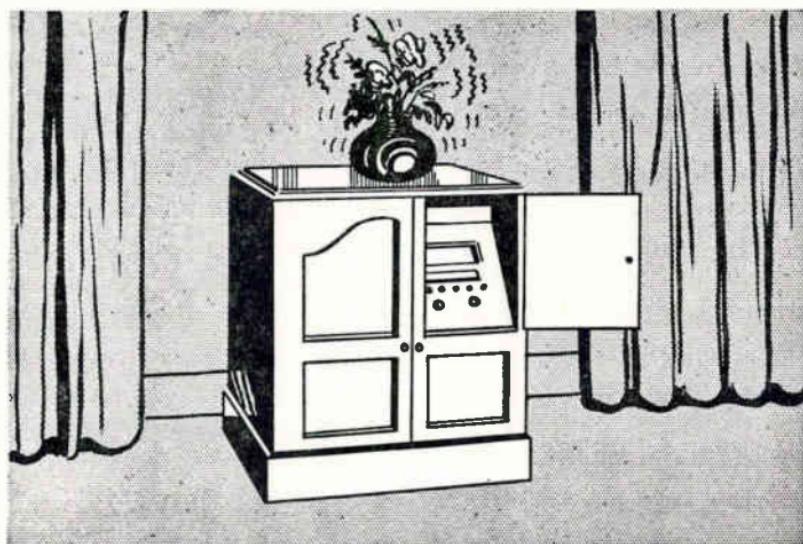
image interference if some desired station is at the same point on the dial as the repeat point of the high-frequency station. If no station comes in at the repeat points, just explain to the customer why this is so, but do nothing about it.

## 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,

A complaint that the receiver makes a rattling or buzzing sound usually means that the speaker cone is unglued. However, sometimes such a noise occurs because a vase or some other object that has been placed on top of the radio is set into vibration by the speaker. Loose hardware on the set, such as an escutcheon plate or a door handle, may also buzz or rattle for the same reason.



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.

ers, particularly in the summer time. F.M. receivers are not troubled by atmospheric conditions, because limiter circuits, or discriminator circuits having limiter functions, cut out the noise before it reaches the speaker. This is an inherent design feature that cannot be built into a.m. receivers.

Sometimes a customer who has just purchased a receiver having short-wave bands does not realize that various forms of noise are heard on these bands that are not noticeable on the broadcast band. For instance, ignition interference from passing cars may be quite severe on certain short-wave bands. This is, of course, a random interference, since it will occur only when cars of certain types are passing.

About the only thing that you can do to minimize interference caused by car ignitions is to erect a noise-reducing antenna system as far away from the street as possible. Even this is not a cure-all, for some of this interference is very severe.

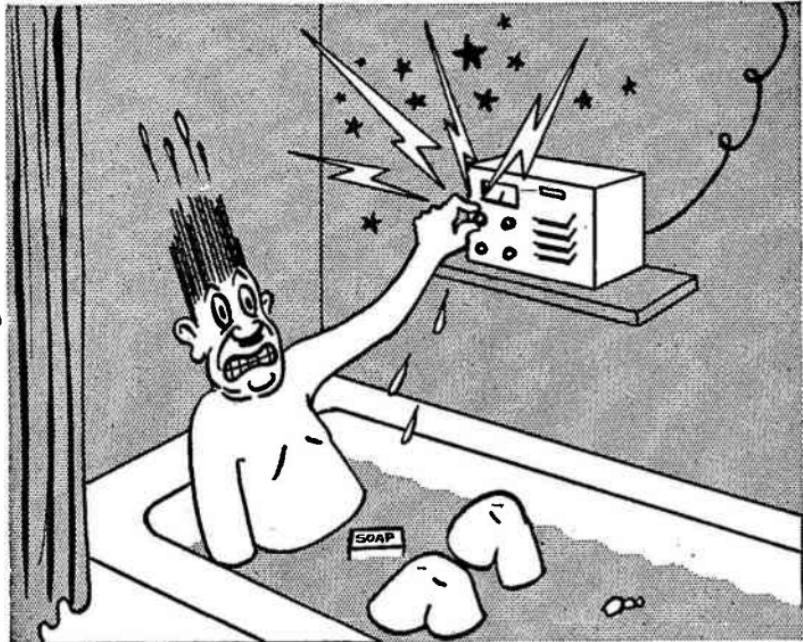
## MISCELLANEOUS COMPLAINTS

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.

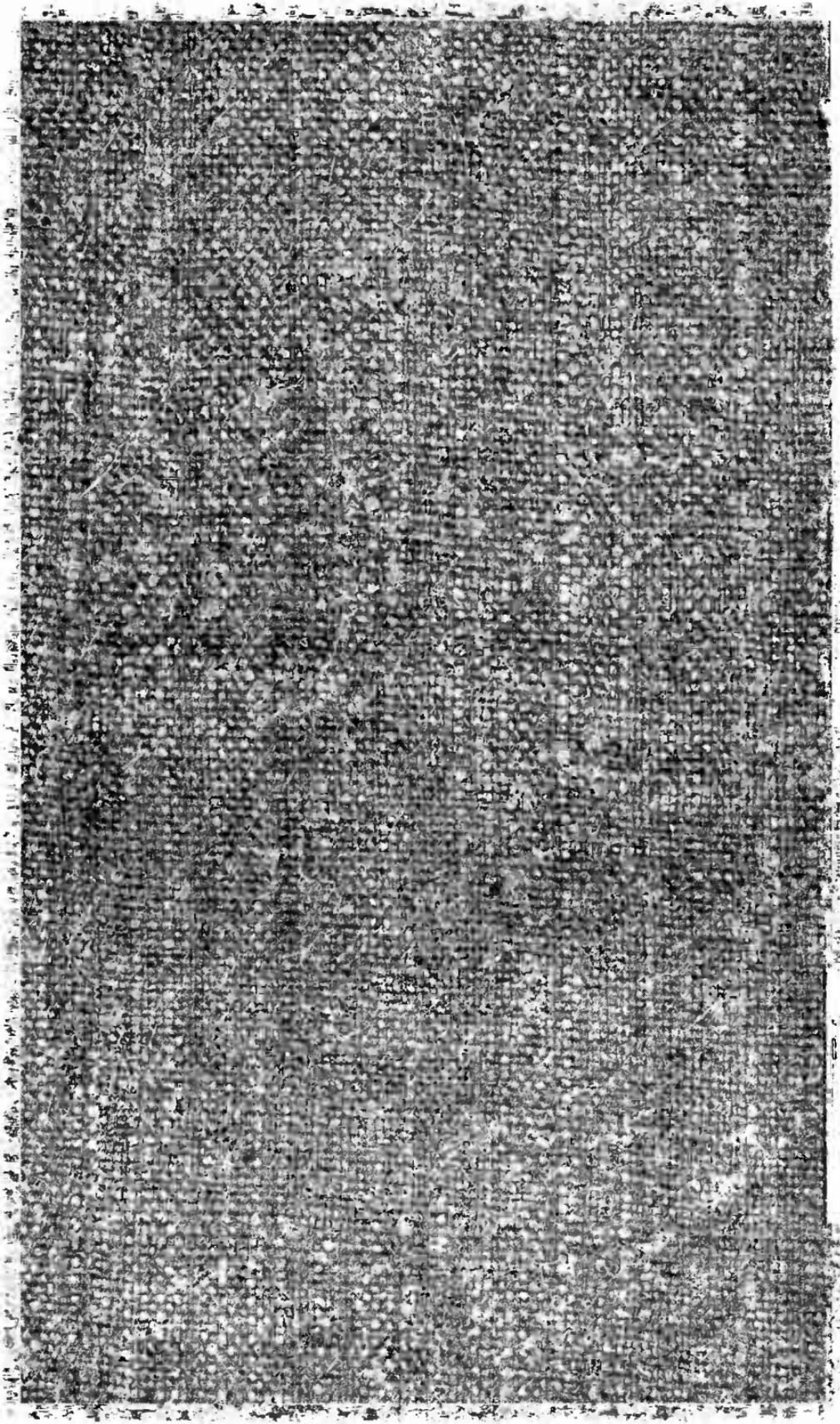
► When an owner finds that a power cord of the Cord-ohm type, or a transformer, or the speaker field of his set becomes hot, he is apt to get excited about it—particularly if he makes the discovery when the receiver happens to be in need of repair. Of course, you can assure him that it is normal for 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.

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

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NATIONAL RADIO INSTITUTE, WASHINGTON D.C.

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No. 34

How To Service  
F.M. Receivers

RADIO SERVICING METHODS



# 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



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WASHINGTON, D. C.**

FM10M1149

1950 Edition

Printed in U.S.A.



## How To Service F. M. Receivers

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 ionospheric 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

a.m. set. You will have to modify your service procedures only when you service the r.f.-i.f. section of an f.m. receiver. We will show you how to do so in the first part of this Booklet, then show you how to align and install f.m. sets.

## 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. 2.

Switch  $SW_1$  directs the output of the first detector tube into the proper i.f. transformer  $T_1$  or  $T_2$ . This signal is amplified by the tube  $VT_2$ . From  $VT_2$  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  $VT_2$  is the low-frequency transformer  $T_4$  and its condenser. On the other hand, transformer  $T_3$  and its trimmer form the plate load when the 10-megacycle f.m. signal is present, because the condenser across transformer  $T_4$  acts as a by-pass around that transformer at this frequency.

For the same reasons, the signal path again divides at the output of  $VT_3$ . A 456-kilocycle a.m. signal passes through  $T_6$  to the a.m. detector tube  $VT_6$ . The output of

this tube is fed (through a switch) to the audio amplifier. On the other hand, a 10-mc. signal passes through  $T_5$  to tube  $VT_4$ , which is the limiter. From the limiter, the signal goes into discriminator  $VT_5$ . The audio output of the discriminator is then fed to the audio amplifier.

The switch  $SW_2$  opens the cathode circuit of the limiter tube  $VT_4$  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-

STAGES OF  
A TYPICAL F.M.  
SUPERHETERODYNE

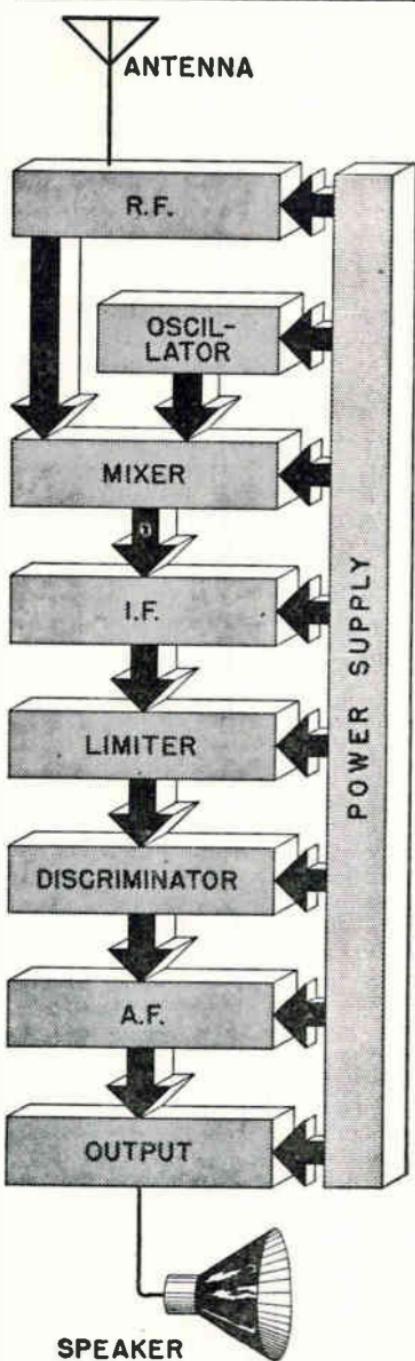


FIG. 1. This diagram shows the stages used in a typical f.m. superheterodyne. Although only one is shown here, there are usually at least two i.f. stages. Some sets do not have an r.f. stage.

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.

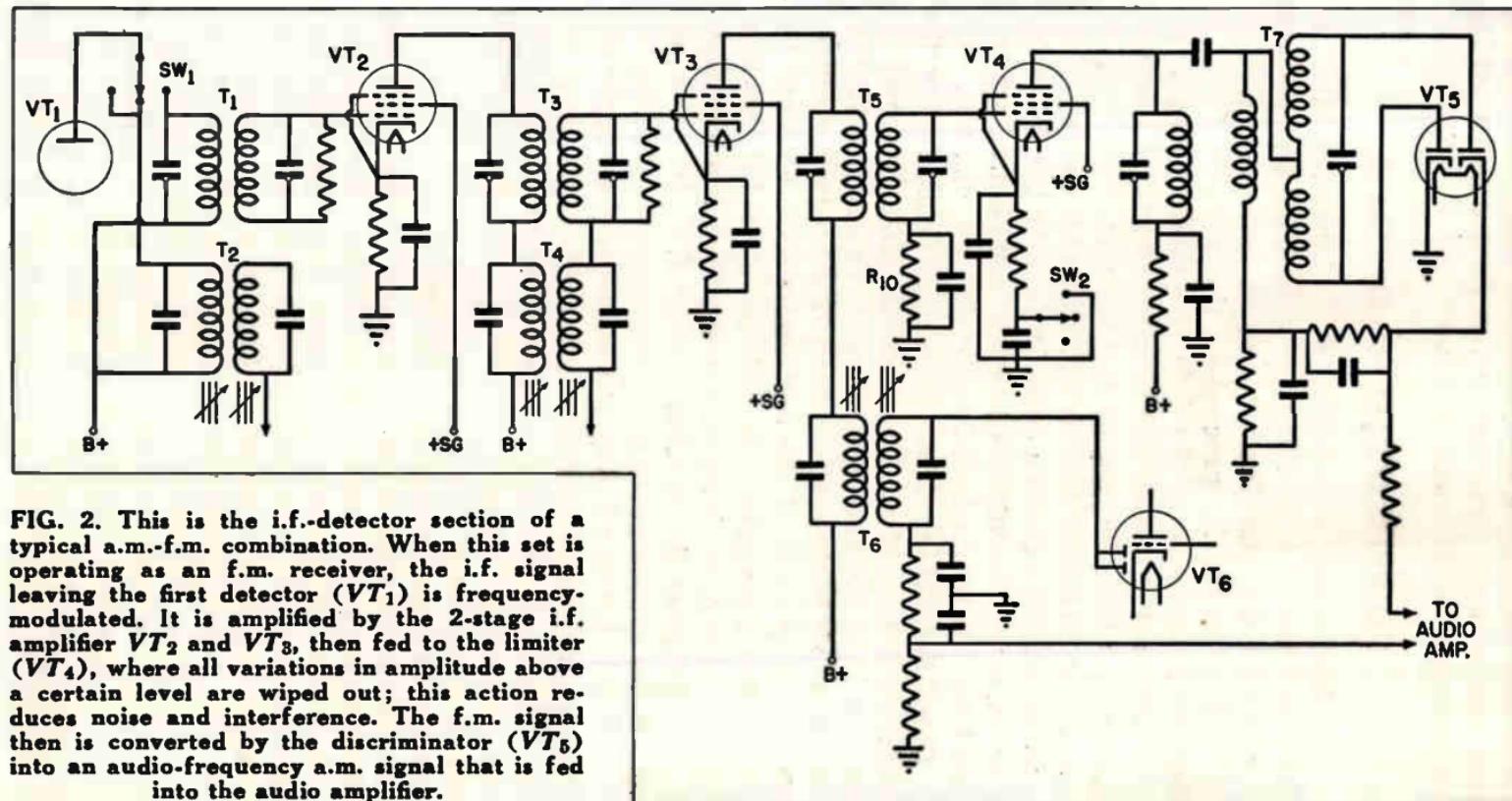
► How you service the r.f.-i.f. portion of the f.m. receiver will depend greatly upon whether the set is a combination, and if so, upon whether the trouble occurs on a.m. reception as well as on f.m.

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  $VT_4$  or  $VT_5$  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  $T_3$  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, in



**FIG. 2.** This is the i.f.-detector section of a typical a.m.-f.m. combination. When this set is operating as an f.m. receiver, the i.f. signal leaving the first detector (*VT<sub>1</sub>*) is frequency-modulated. It is amplified by the 2-stage i.f. amplifier *VT<sub>2</sub>* and *VT<sub>3</sub>*, then fed to the limiter (*VT<sub>4</sub>*), where all variations in amplitude above a certain level are wiped out; this action reduces noise and interference. The f.m. signal then is converted by the discriminator (*VT<sub>5</sub>*) into an audio-frequency a.m. signal that is fed into the audio amplifier.

*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-

FRONT

TOP VIEW SHOWING TUBE LOCATION &amp; TRIMMERS

BU46



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This is the layout of the top of the chassis of the Stromberg-Carlson No. 1121 a.m.-f.m. combination. Notice that there are separate antenna, oscillator, and preselector trimmers for each of the two f.m. bands. The i.f. trimmers on this side of the chassis are for the a.m. bands only; the i.f. trimmers for the f.m. bands are under the chassis.

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.

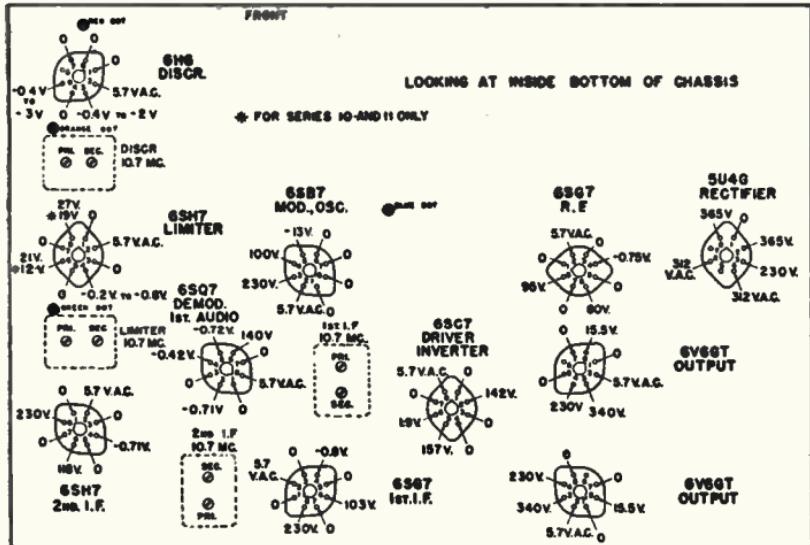
Furthermore, when the discriminator stage is properly aligned, it will tend to produce *minimum output at the resonant frequency*. Therefore, you will get a stronger signal by tuning to one side or the other of the i.f. resting frequency. Thus, if the i.f. frequency is 10.7 megacycles, you may find that 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.



This is the bottom layout of the chassis shown on page 7. Notice that the alignment adjustments for the f.m. discriminator, limiter, and i.f. stages are located on this side.

ity, 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 microammeter 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 connected as a signal strength indicator, move your signal generator back from the limiter through the i.f. amplifier toward the first detector. As you add stages, the output indicator should show that the signal increases greatly.

► When we speak of weak reception, we mean reception 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 antenna 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. receivers—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 alignment—particularly of the discriminator—to cause distortion in f.m. receivers.

► When a receiver sounds all right at first, then exhibits 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 frequencies on which f.m. signals are broadcast. The circuits already use extremely tiny amounts of capacity and inductance. 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 counteract each other.

If you ever replace a temperature-compensated condenser, 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 produce 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, turn 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.

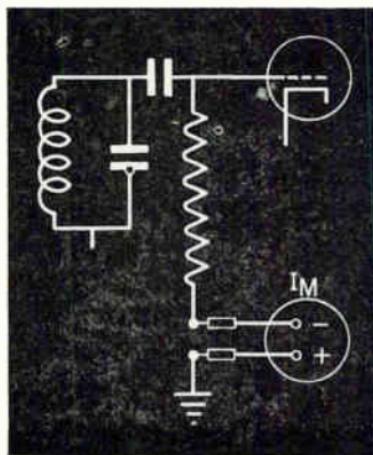
Generally, set manufacturers recommend that the grid current be measured by placing a microammeter with a 0-100 microampere range in series with the limiter grid resistor, as shown in Fig. 3. Note the polarity of the meter connections. Often the set will have a terminal strip arranged for conveniently inserting a microammeter in this manner. With such, unsolder the jumper wire that normally closes the circuit, and connect the meter in its place.

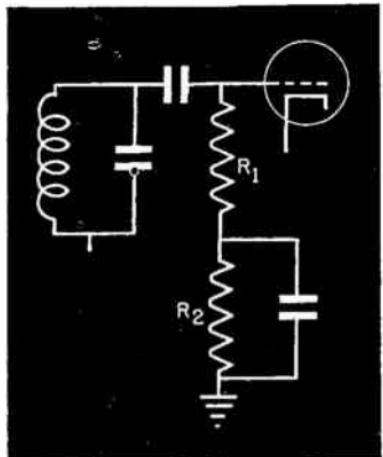
You can also use a high-sensitivity voltmeter when provisions for its use are made. The voltmeter capacity would upset the alignment if it were connected across the grid resistor  $R_1$  in a circuit like Fig. 4. However, here you can connect the voltmeter in parallel with  $R_2$ ; now  $R_1$  acts as 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 .01- to .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 preventing 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  $R_{10}$  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.

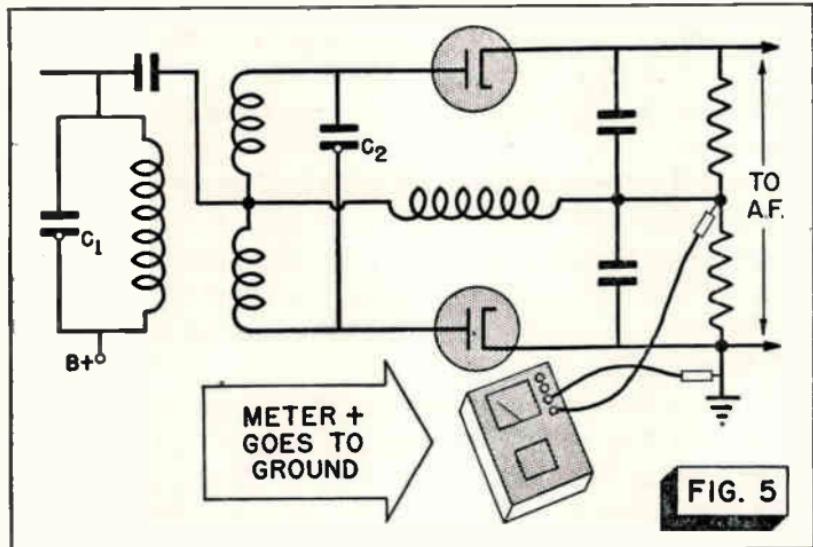
You can leave the output indicator connected to the limiter grid circuit if you have another meter to use as a discriminator indicator. However, if you are going to use the same meter, it is all right to turn the receiver off to make the change in the output indicator connection. (When you disconnect 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 upscale. 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



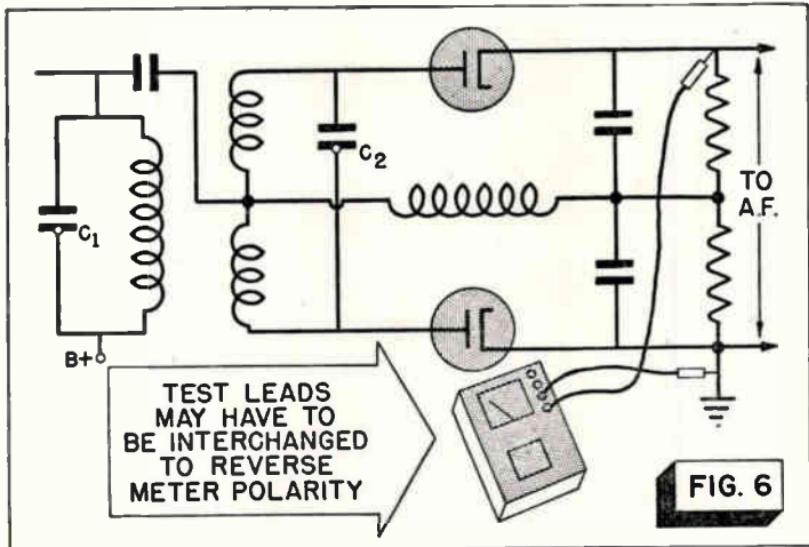
of the receiver. Follow the manufacturer's instructions carefully, because, for maximum results, the proper decoupling resistors should be used between the s.g. and the antenna terminals of the set.

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 align 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.

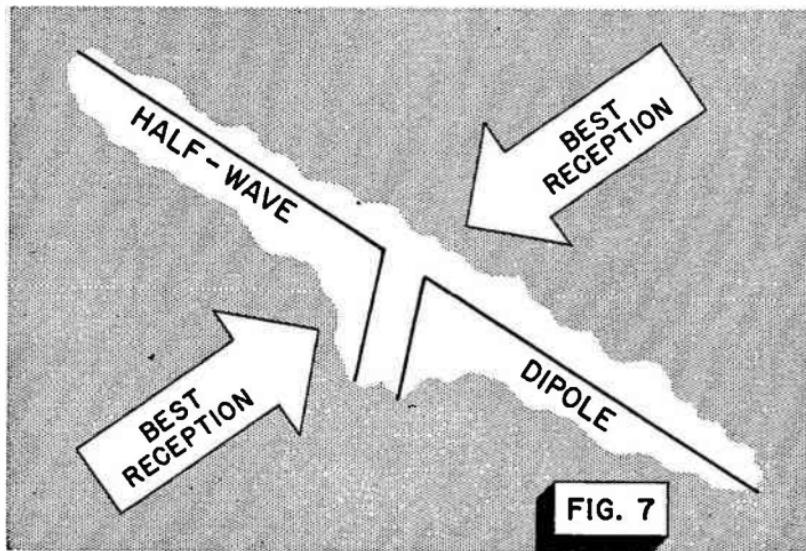


It is impossible to give hard and fast rules that will work in every installation. Always try the receiver first on an ordinary antenna and see how it works. If the reception is entirely satisfactory, fine—no more need be done. However, if there is excessive noise, or if the signal is weak or is interfered 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.

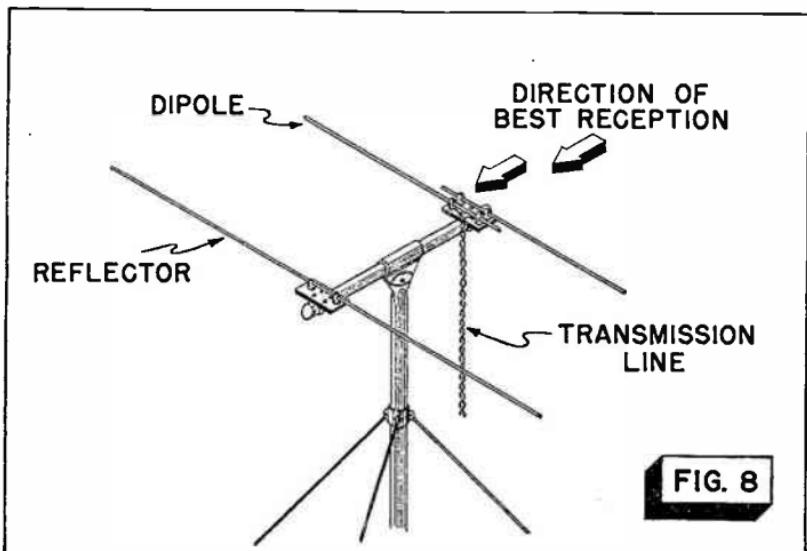
It is standard practice for the f.m. transmitter to radiate a signal having horizontal polarization, so the antenna is mounted in a horizontal plane. It should be mounted securely, as high above grounded objects as is possible.

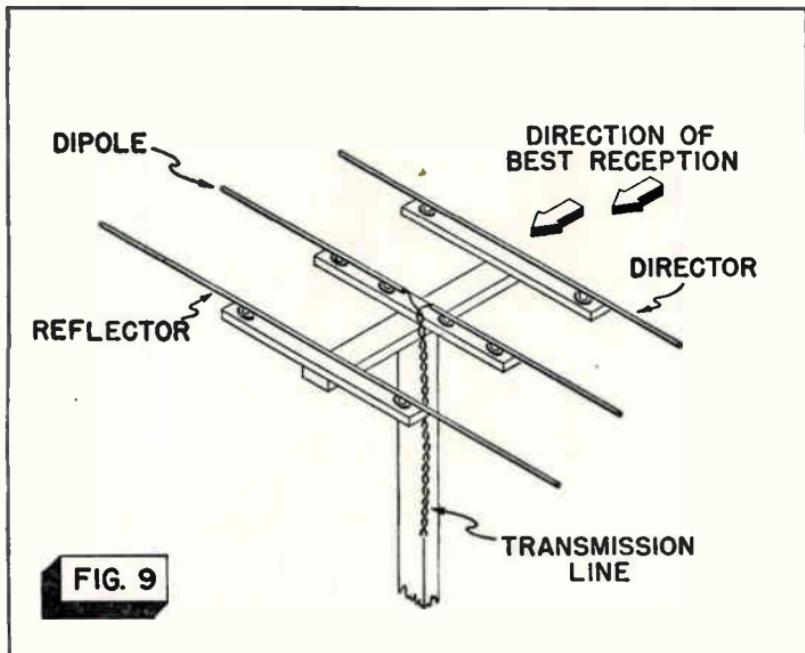
The half-wave dipole receives best from its side, as shown in Fig. 7. Therefore, the antenna must be rotated so that it is broadside to the radiation from the desired station.



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 sta-

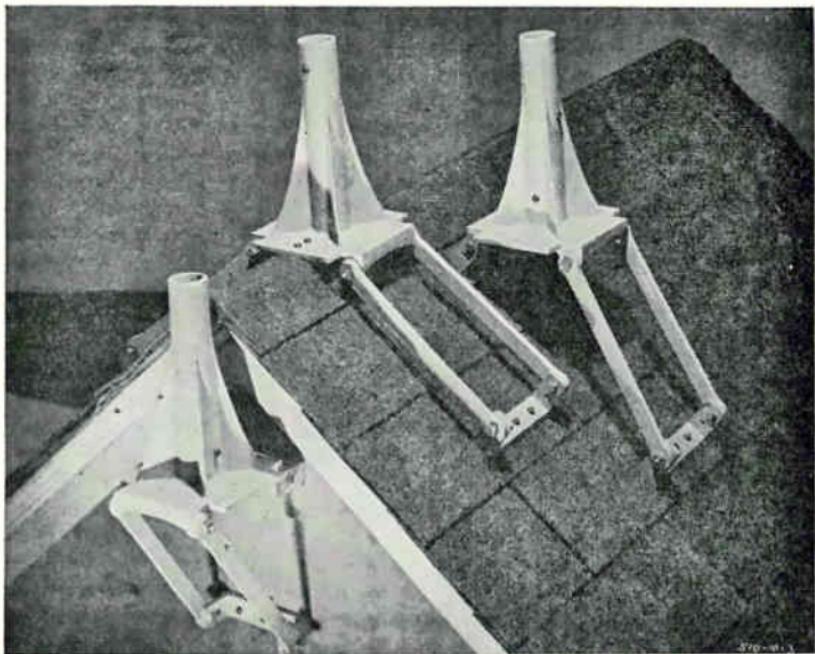




tion that would otherwise come in weakly.

- 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 doublet at the f.m. frequencies is only about  $4\frac{1}{2}$  to  $5\frac{1}{2}$  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



Courtesy Shur-Antenna-Mount, Inc.

**Anchoring the base of an antenna mast is often a problem. Shown above is a commercial device that is excellent for the purpose. As the picture shows, this mount can be secured to the gable peak of a house or to the ridge or side of a roof.**

maximum reception is reached, anchor the antenna in place.

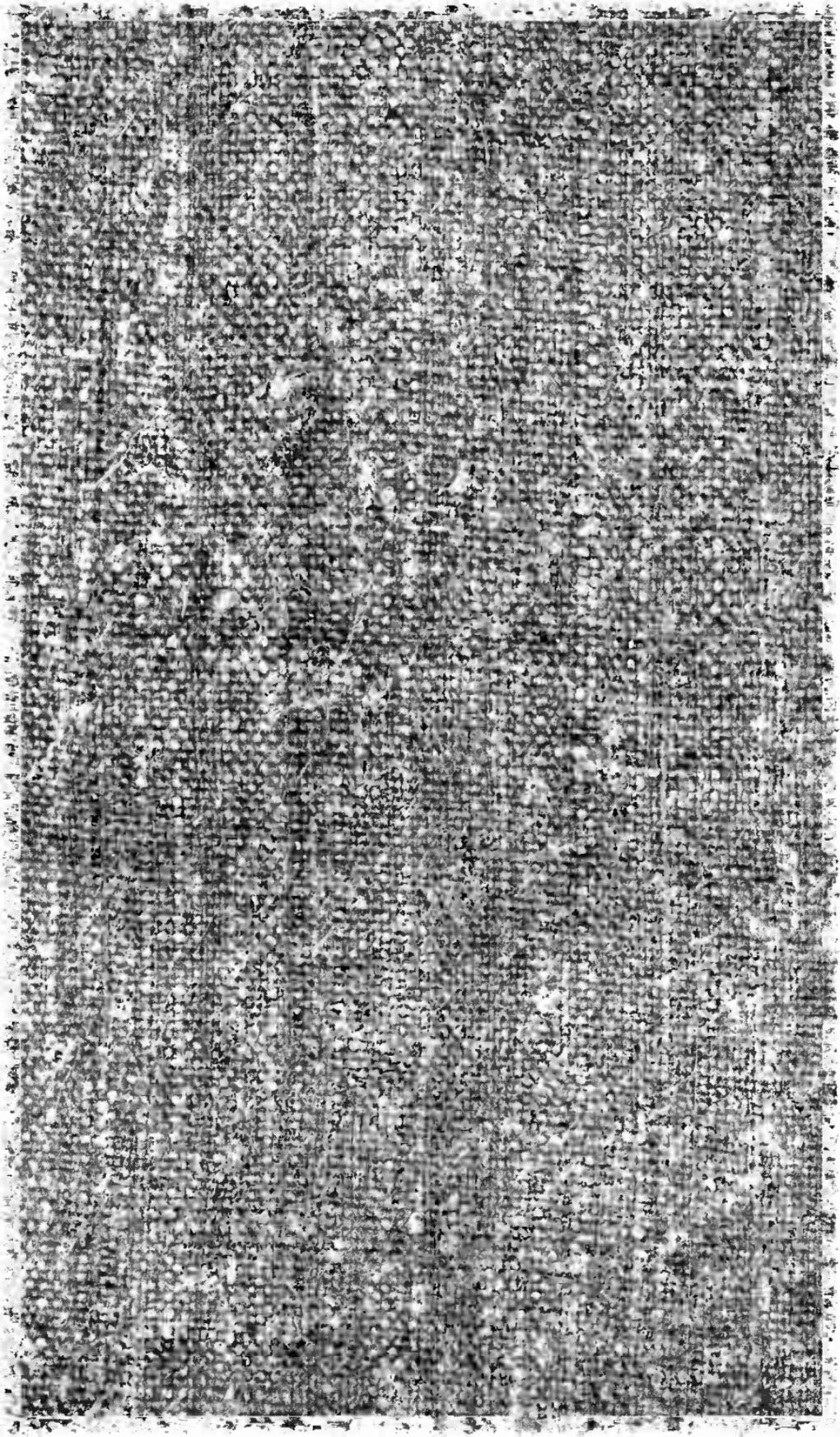
Not much trouble occurs with the antenna itself—it is practically foolproof. However, the transmission line will eventually require servicing and, probably, replacement. All types of transmission lines are used—twisted pair, coaxial cable, and parallel wire. The coaxial line, if properly sealed against 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 weather-proof 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.

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

**NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.**

No. 35 How To Go into Full-Time  
Servicing

**RADIO SERVICING METHODS**



## 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.



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**NATIONAL RADIO INSTITUTE  
WASHINGTON, D. C.**

FM8M849

1949 Edition

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 spare-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—instead, 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 do not need to set up an elaborate shop when you start full-time servicing. Often you can use the location in which you have been doing your part-time work. The basement shop shown here, for example, was being used for part-time work at the time this picture was made. However, it would make an acceptable full-time shop. Some full-time servicemen never have much more equipment nor a much better location than this.

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



This is an example of an extremely well equipped small shop. You will not need as much equipment as this when you start full-time work—nor, in fact, until you have a very good business. A multimeter, a tube tester, and a signal generator are all you need, although it would be a good idea for you to have a signal tracer and a condenser tester also, or at least to plan to get them soon.

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?

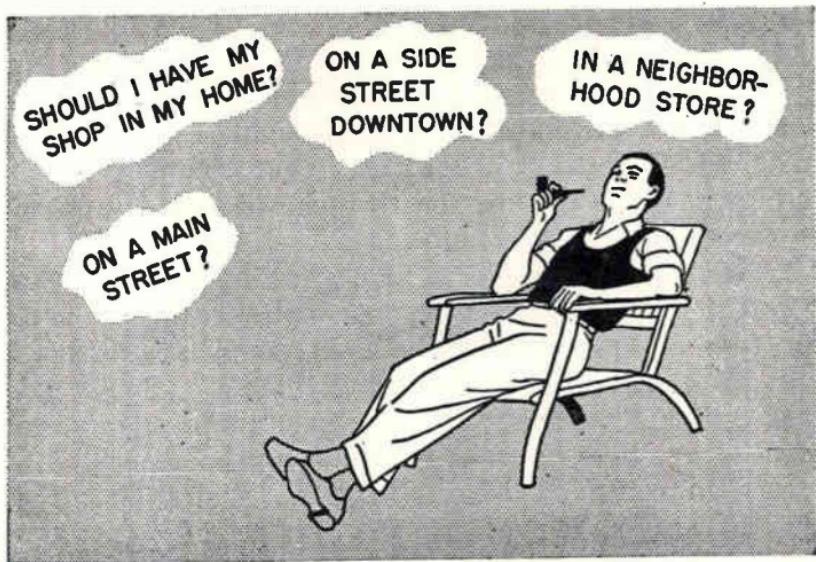
When you can answer an unqualified "Yes" to each of these questions, you are ready to start a full-time servicing business of your own. Now let's see how you can start and run such a business successfully.

## **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,



Selecting the proper location for your shop is an important step. Give the matter real thought, weighing the advantages and disadvantages of each possibility. The information in this Booklet will help you reach the right decision.

you shouldn't expect to get much legal counsel for nothing, but you may be able to get considerable help at reasonable cost. In any event, do not take any important steps involving legal matters without competent legal advice. In such matters, a few dollars spent with a lawyer at the beginning may save you a great many dollars in the end.

Perhaps it seems odd to you that we should speak about laws and regulations at the very beginning of this discussion of running a business, but we do so deliberately. Business today is very much regulated, and any beginning businessman is wise to remember that fact.

## SELECTING YOUR SHOP LOCATION

Selecting the location for your shop is one of your most important first steps. There are many questions involved—should you have it in your home, in a neighborhood store, or in a store in the downtown area? —if you decide on a downtown location, should it be on a main street or on a side street?

The right answer for you depends upon your own circumstances. If the community is small, and the

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, there-

fore, 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

**A corner location in a downtown area is highly desirable if you intend to sell merchandise. If you intend to be solely a serviceman, however, it is seldom worth the high rent.**



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.

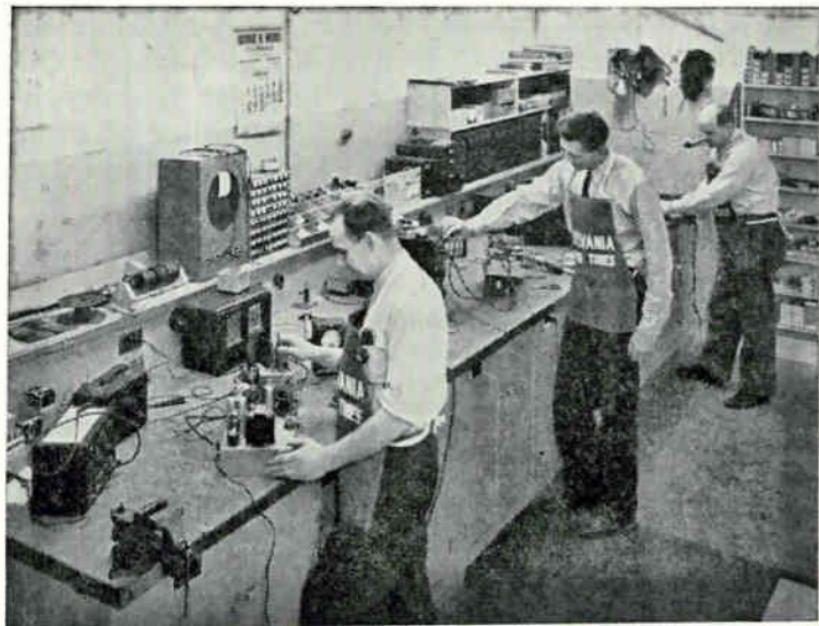
Remember, also, that you'll need to install an antenna for testing sets in your shop. It is better, therefore, to choose a location that is not completely shielded by tall buildings—and you should make sure that an antenna installation will be permitted. If you must use some other building to help support 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 merchandising business needs display space.) This will make it easier for you to make the front of your shop attractive, 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 consideration. Remember, you are not committed to one location for life; if you must start out in a place you don't particularly 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



Courtesy Sylvania Electric Products Inc.

Notice the simple bench used in this large service shop. It is common practice not to bother with an elaborate bench in a "hidden" shop—one the customer never sees. If yours is to be visible, however, by all means make it impressive.

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, however, you'll do well to have your bench and other working equipment up near the front, and your storage equipment, including shelves for finished and unworked-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 work-bench. 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.

Courtesy Sylvania Electric Products Inc.



► 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

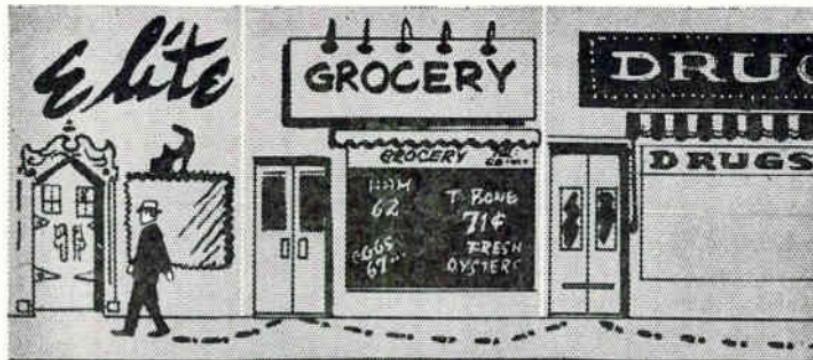


Courtesy Sylvania Electric Products Inc.

**Many servicemen find it a good idea to hire a girl to take care of the front-of-the-shop work—answering the phone, keeping books, waiting on customers, etc.**

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.



When you are considering a location for your shop, you will be wise to interview the merchants near by. Find out as much as you can from them about the credit standing and financial ability of the people in the neighborhood. This is an excellent way of finding out whether your potential customers are able and willing to pay for your services.

## 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.

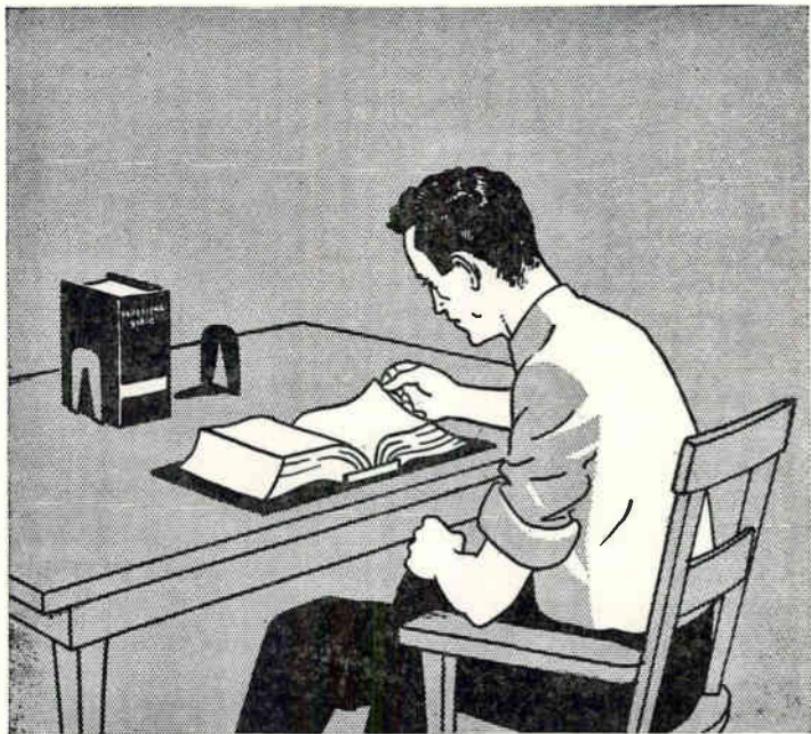
Since advertising is so important to you, you will do well to learn all you can about it. Probably your public library has some books available on the subject. Your newspaper will undoubtedly be glad to help you write ads (but remember, often the space salesman for a newspaper will be interested in selling 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-



**You must keep your technical knowledge fresh to keep pace with the constant advances in radio. Set aside a definite time each week to devote to reviewing your Course and reading professional magazines.**

ginning, 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 apart 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 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 merchandising, 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 spare-time project—in fact, you can probably also hire him

to look over your books once or twice a month for a small fee. If you do have someone set up a system for you, make sure you understand its workings thoroughly. Be sure, also, that the system is not too elaborate for your needs. Ideally, it should be a system that your helper can maintain for you readily.

► The thing we want to impress upon you most about record keeping is that you must be sure you know your financial standing with reasonable accuracy at all times. By this, we mean you must not allow inaccurate or oversimplified records to give you the impression you are making money when actually you are not. Many a serviceman assumes that he is making a profit because he sees a fair volume of business coming into his shop, when actually overhead and other more or less hidden costs are allowing him very little if any profit. Only an accurate and fairly detailed system of records will make it possible for you to avoid such a misconception of your true financial position. Many technically trained men dislike the amount of "paper work" involved in keeping records, but there is no help for it; proper records are essential to every business.

### **LOOKING AHEAD**

What does the future hold for you as a serviceman? That's a question that's hard to answer. Your success depends very largely upon yourself.

One thing, however, is certain. When you graduate from your NRI Course, you will have a thorough technical preparation for a servicing career. The knowledge you have gained from your Course and from these RSM Booklets, and the knowledge that is still to be yours from the future Lessons of your Course, will give you as good a background for servicing as can be secured anywhere. If you work hard on your studies—if you make sure you understand everything the Course has to teach you—and if you then put real thought and energy into creating a servicing career for yourself, you have every chance for success.

Good luck!

**IMPORTANT**

**This is the LAST of the RSM BOOKLETS**

