

**No. 18** How Circuit Diagrams Are  
Used in Servicing

**RADIO SERVICING METHODS**



# NRI TRAINING

*Pay A...*

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



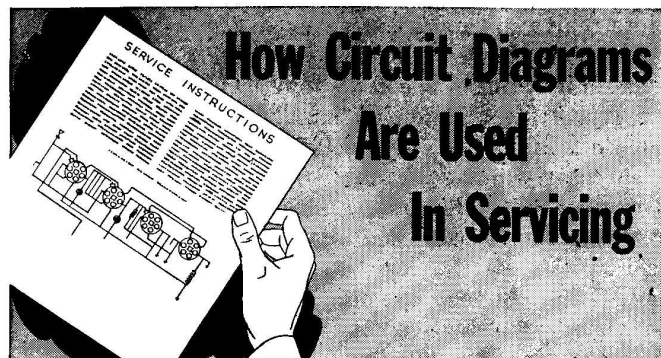
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ONE of the important steps in becoming a professional serviceman is learning to use the servicing aids furnished by set manufacturers. Schematic wiring diagrams, pictorial layouts, tube layouts, alignment information—the professional uses them all, 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

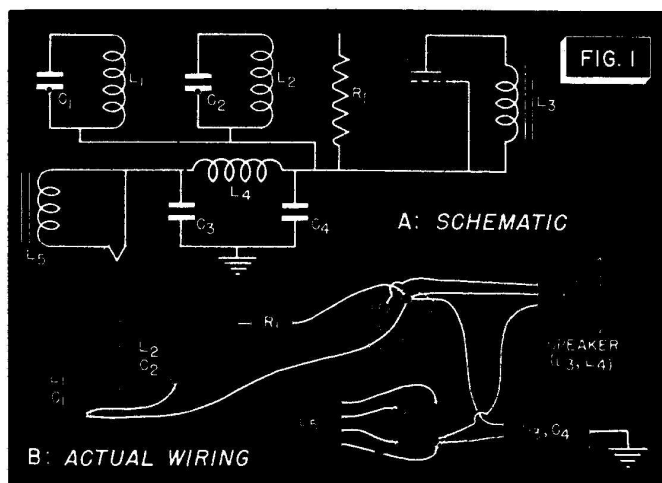
of the receiver, and the tubes used in it, and we will send the circuit diagram to you.

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.

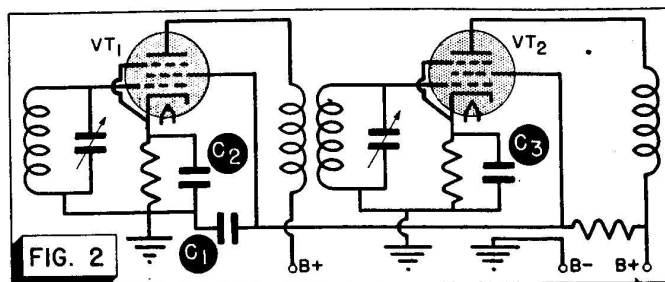
### SCHEMATIC DIAGRAMS

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



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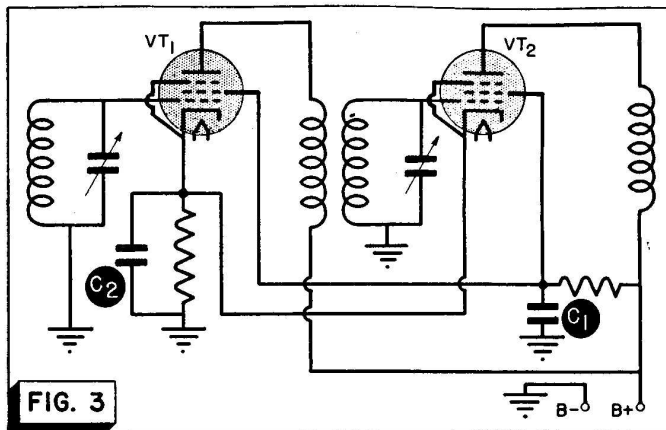


a schematic. See how easy it is to trace from the filament of the rectifier through  $L_4$  (the speaker field coil) to the i.f. transformers  $L_1-C_1$  and  $L_2-C_2$ , to resistor  $R_1$ , and to the output tube screen grid and plate circuit (through  $L_3$ ). But now try to trace the same B supply 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-



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*.

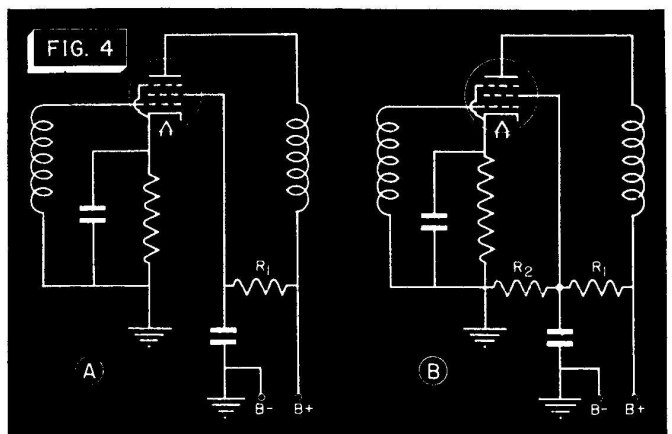
However, all cathode by-pass condensers are not incapable of causing oscillations. If two tubes operating at the same frequency use a common cathode by-pass condenser and bias resistor, as shown in Fig. 3, an open in the condenser  $C_2$  will allow feedback from  $VT_2$  to  $VT_1$  to occur, and, if 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.

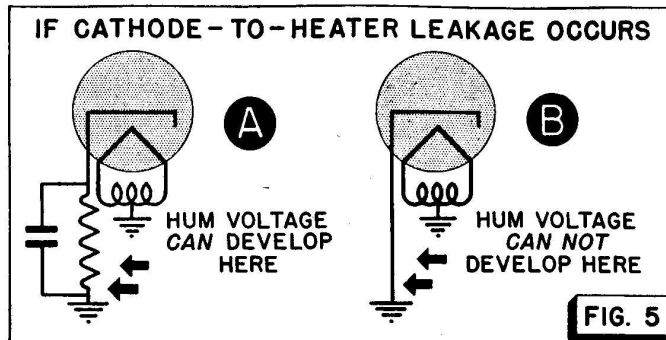
► To carry our example further, suppose that a by-pass condenser is not at fault, and suppose that the screen voltage of a stage is excessive. Again a Radio-trician would look at the diagram to see where the defect

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





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-

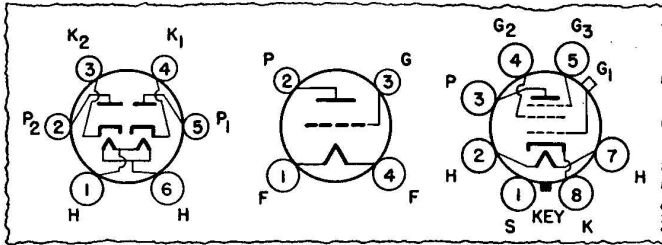


FIG. 6. Tube manufacturers supply diagrams showing connections between the base pins and the elements of each tube type. Bottom views of the tube bases are shown in all cases.

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.

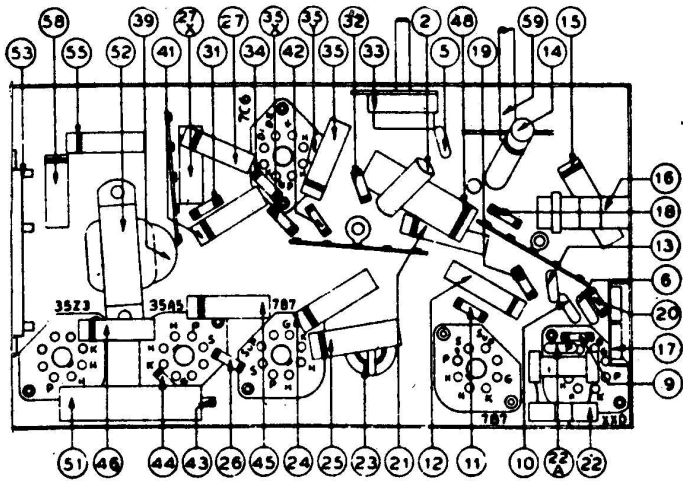
It is not always *necessary* to have all these forms of servicing data; in fact, most of the time a schematic is all you really need, and an experienced man can get along even without this type of diagram. You, too, will learn how to get along on a minimum of service information whenever such information is not available. Of course, it is very convenient to have all this information,

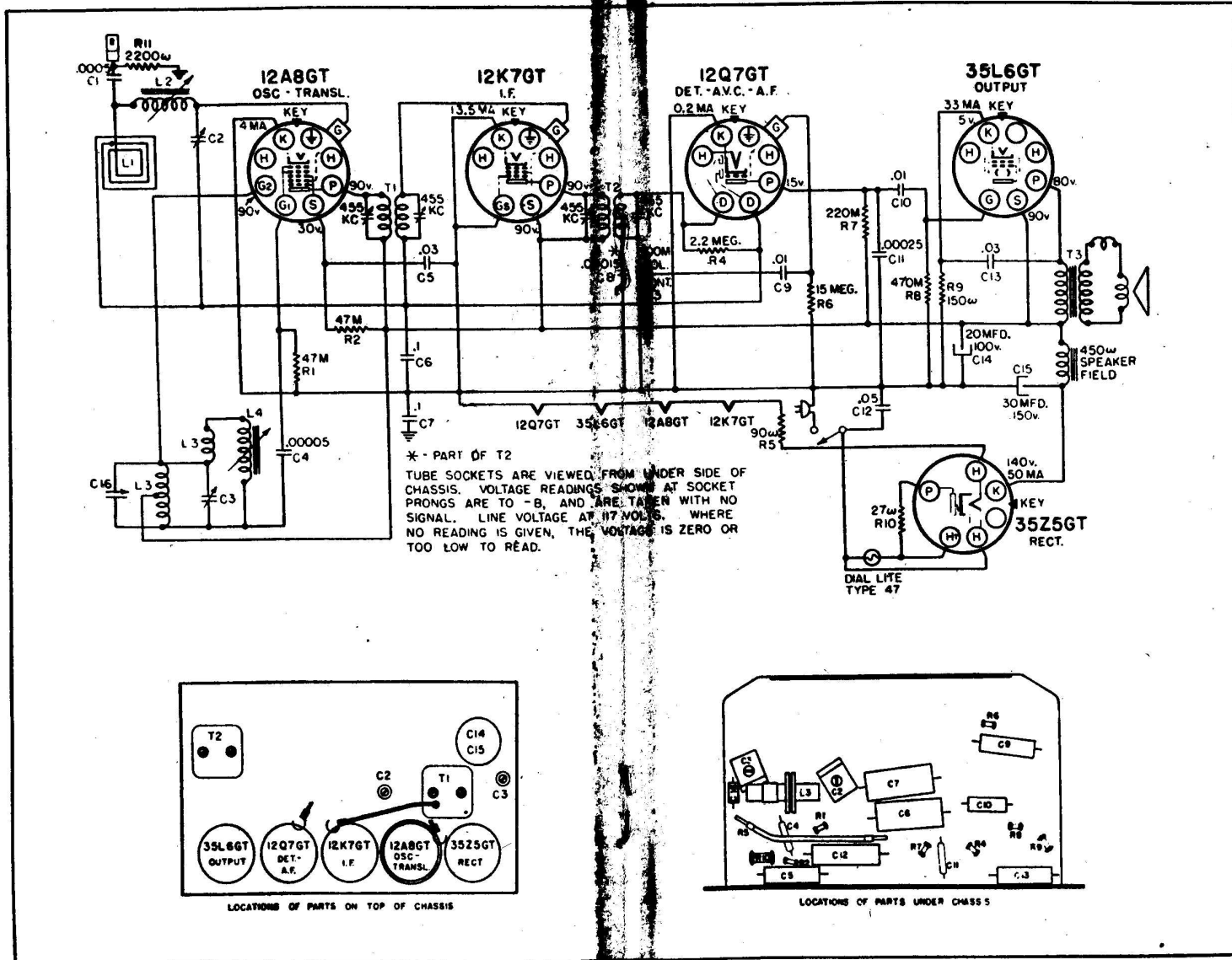
because, to check a receiver, you will have to identify stages so that you can introduce circuit disturbances and trace signals; you will have to locate reference points from which to test; and you will have to locate the suspected parts you wish to test. All these steps are speeded if you have the complete 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 SERVICING 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

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.

TABLE I			
GROUP I RECTIFIERS USED IN AC SETS		GROUP II 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

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

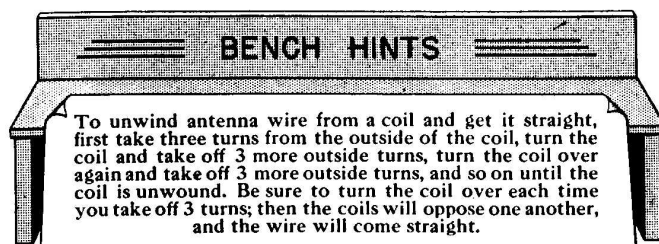
(supplied by various tube manufacturers) should be referred to in order to find the most common functions of a particular tube.

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-



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.

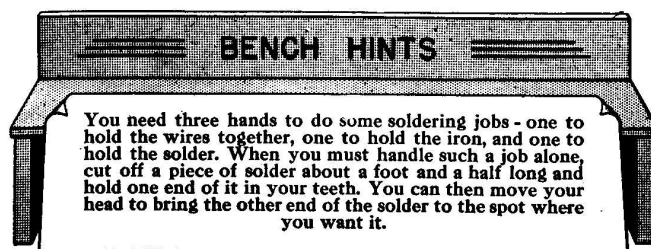
You can identify the second detector at once when you have located the i.f. stage or stages. In most cases, it will contain a diode tube (or a triode connected as a diode), which will be connected through a transformer to the plate of the last i.f. tube.

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



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

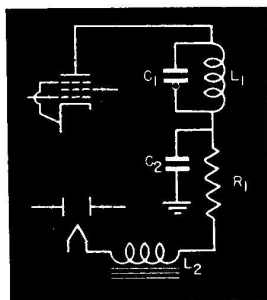


FIG. 8. If this plate circuit opens, then  $L_1$ ,  $R_1$ , or  $L_2$  might be to blame, but not  $C_1$  or  $C_2$ .

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>u</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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