

# FIXING RADIOS

HOW TO REPAIR AND SERVICER RADIOS

**No. 3** Equipment Used by  
Servicemen  
**RADIO SERVICING METHODS**



# NRI TRAINING

*Pay A...*

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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## Equipment Used by Servicemen

**E**QUIPMENT 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 megohms). 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.

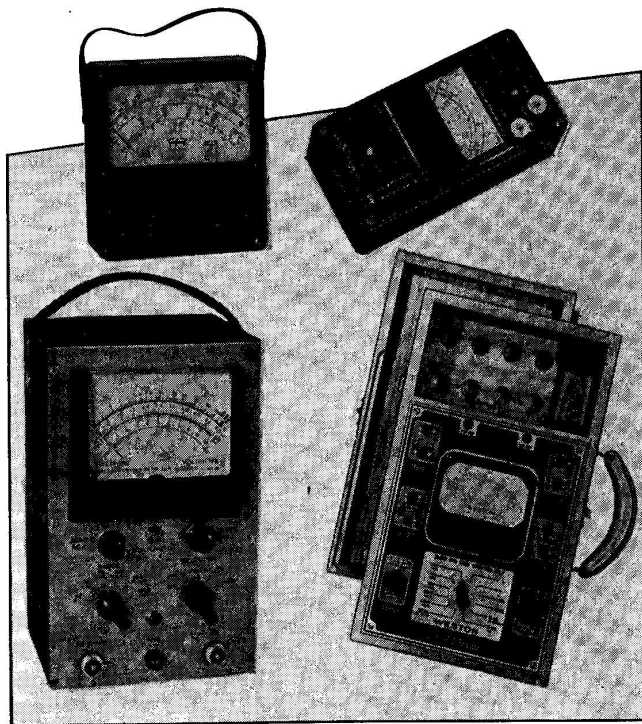
Naturally, you have no trouble reading the values that are marked, but there is not room enough to place the proper numerical value opposite each division on the scale. Thus, you must find out what each division represents before you can read values that fall between the numbers. To do so, count the 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.

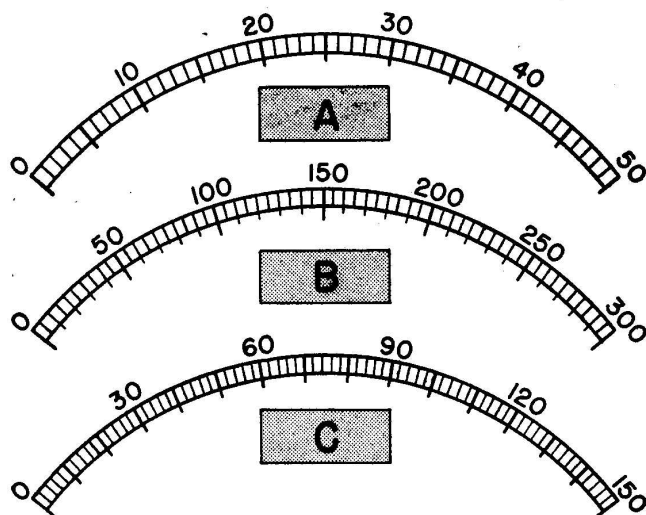


FIG. 2. D.C. voltage and current scales of multimeters frequently use markings like these.

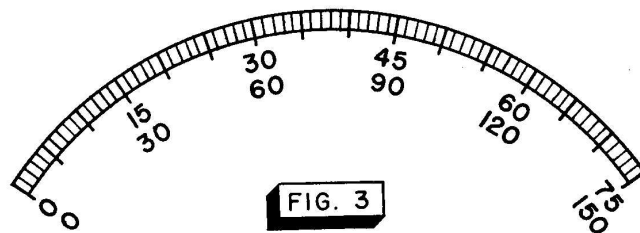
Suppose, for instance, the meter pointer moved to a position halfway between 90 and 92 (the first division to the right of 90 in Fig. 2C). Although there is no division line there, you know the reading must be 91 (since 91 is halfway between 90 and 92).

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





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.

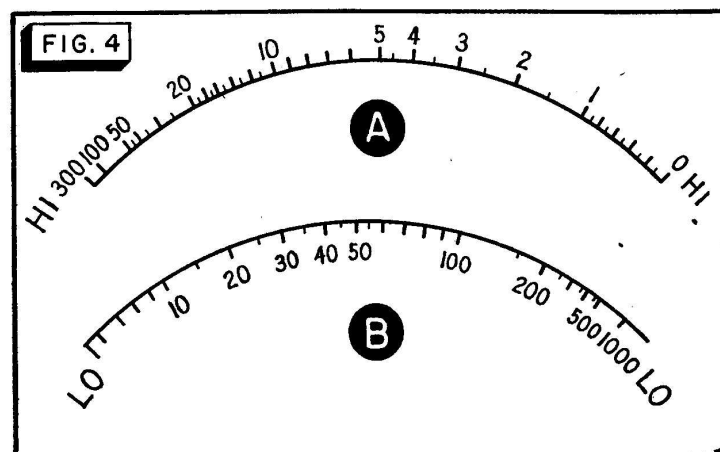
► This is not always true, particularly in the case of ohmmeter scales on which the readings will be crowded or bunched at one end of the scale. This is clearly shown in Fig. 4A; here the readings are spread out on the right half of the scale and are bunched together at the left-hand end. Such a scale 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

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.

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



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.

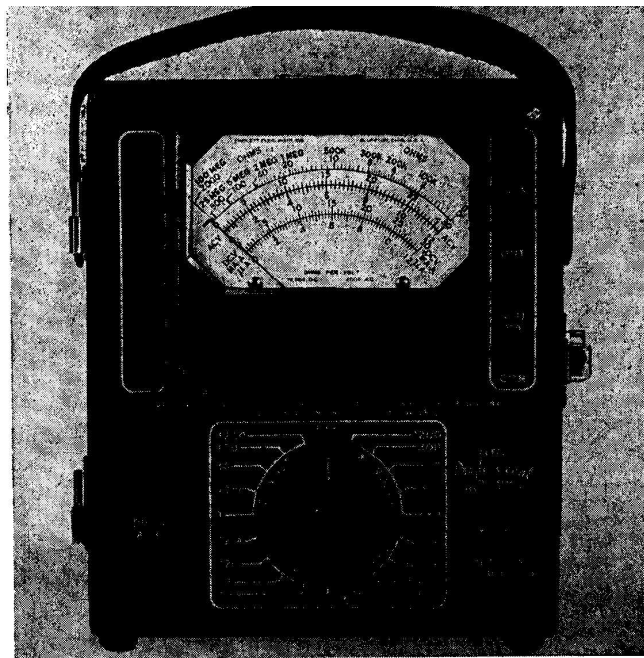
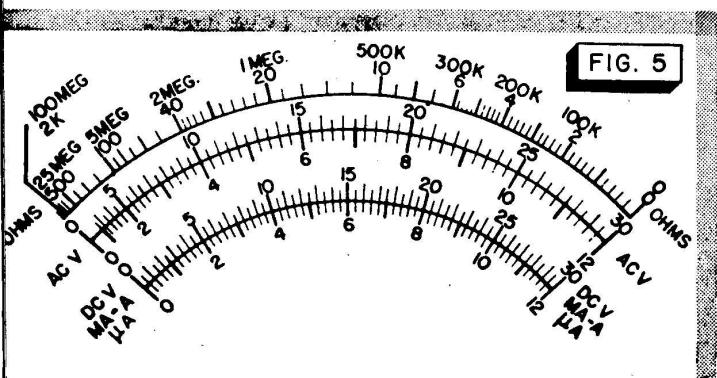
► Once you build the tester for the experiments (or obtain a test instrument) and practice a little, you will find it surprisingly easy to read meter scales. **ALWAYS READ THE SCALE FOR THE PURPOSE AND THE RANGE YOU ARE USING.**

### 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. 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.

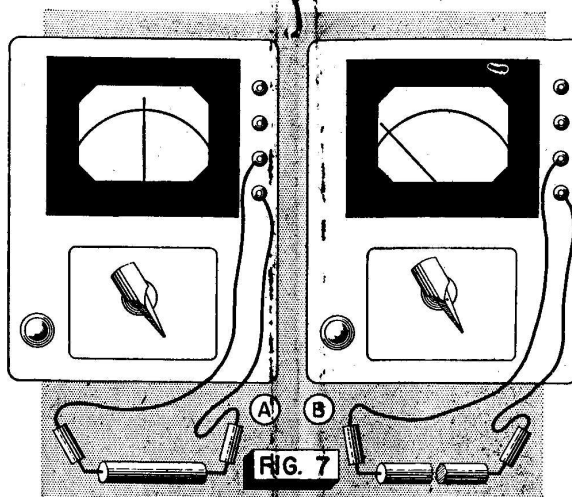
When the ohmmeter probes are placed on the terminals of a defective resistor as in Fig. 7B, no current can flow because the circuit is open (the resistor is broken), and there is no deflection of the meter needle.

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



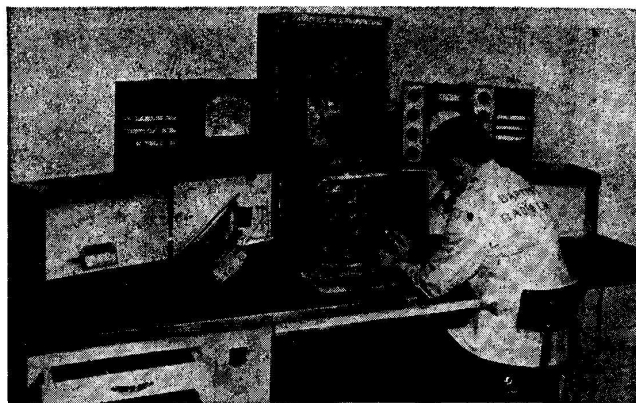
made merely to find out if a complete circuit exists. You don't try to read the meter—you just look to see if the pointer moves. Often, however, you will want to determine the exact resistance of a part or of a whole circuit. For example, you may find continuity through a short-circuited part, but the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



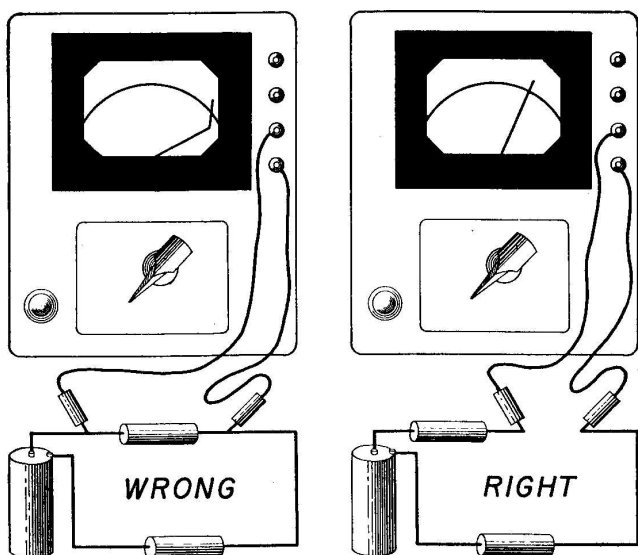


FIG. 8. The wrong and right ways to measure current. You can damage the pointer of a milliammeter, or even burn out its coil, if you connect the meter across some part in the circuit. Even if the meter is not harmed, you will not get a true reading of the circuit current. Always connect a current meter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

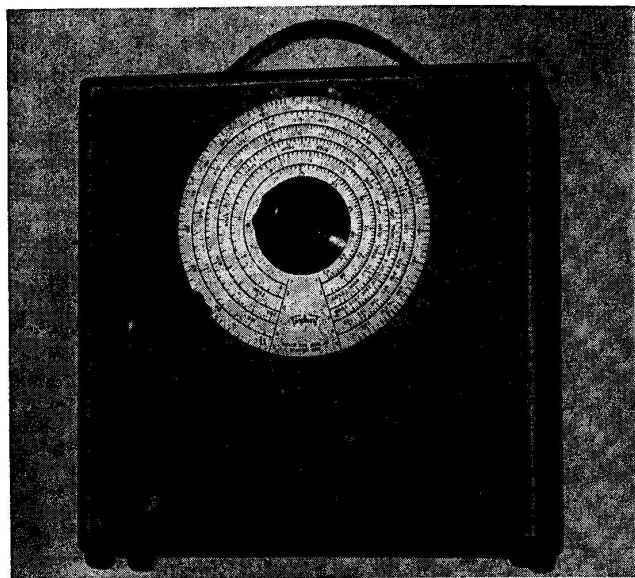
c. Break the circuit so the meter can be placed in series with it. *Never connect a current meter across a radio part or across a voltage source.* (Don't try to measure the "current" of a battery or of a power line.)

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

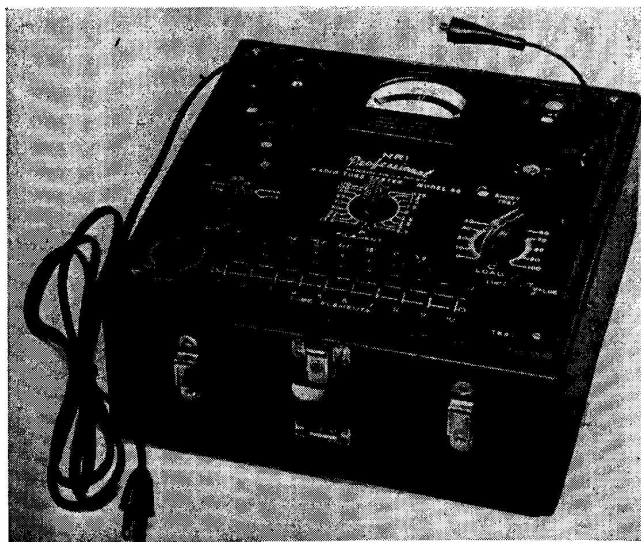
is caused by a defective part that kills the action in some stage. The rest of the stages may be all right, and if you can find the bad stage, the job is almost half done. The signal generator helps in this. Just inject its signal into the various stages one at a time, working back a stage at a time 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.

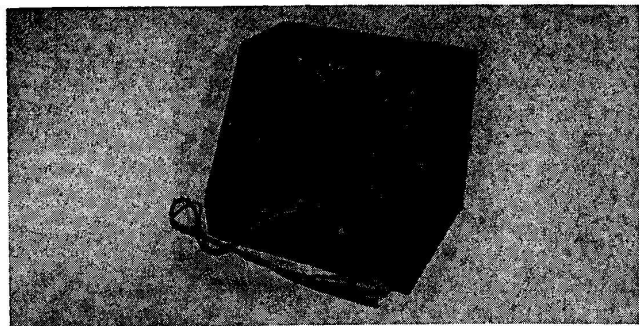
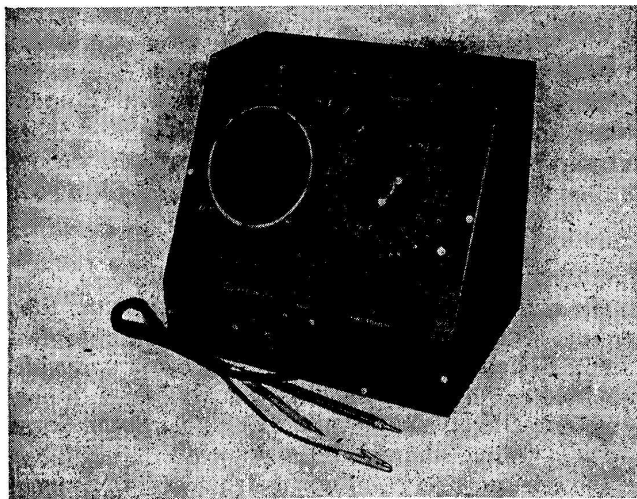
The most important of these instruments is the signal

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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