No. 31 How To Service Three-Way Portable and Battery Receivers

RADIO SERVICING METHODS
Dear Mr. Smith:

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

R.B.R., Kentucky
HERE 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 1½-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 1½-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

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**FIG. 2.** When the change-over switch is thrown to the “Battery” position, the filament circuit in Fig. 1 is as shown below. Notice that one terminal of each filament is grounded, and that the other terminal is connected to A+, so the filaments are in parallel. ON-OFF switches SW₁ and SW₂ are ganged together, and they open both the A and the B circuits when turned off. Opening the A circuit would be sufficient to stop set operation, but the B circuit is also opened to prevent draining the B battery through leakage paths. (The “ground” symbol here represents a connection to the set chassis.)

![Diagram of filament connections for battery operation.](image)
the drop across $R_{18}$, 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 $C_{12c}$ 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
bias for the 3Q5 tube. As you can see from Fig. 1, the 3Q5 grid is connected to ground through $R_g$ 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 1N5 filaments supply the bias for the 3Q5.

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

This receiver will operate from a d.c. power line as well as from a.c., provided the power plug is connected to the power line so that the plate of the rectifier tube is made positive. Otherwise, the rectifier tube will block the passage of current. On a.c. operation, the line polarity is usually unimportant, although sometimes noise...
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 SW₁ are connected together to complete the A circuit, and all three terminals of SW₂ 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 SW₁ and SW₂ are thrown. Switches S₁ and S₂ 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-
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 SW1 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 SW2 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 R15, in parallel with the 117N7 bias resistor R16. 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
the 304 plant, because its circuit is broken at the
front. However, none of this current can flow through
the a.m. and provides the necessary plant current.
If the 1177 and a.m. are connected at the power line
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When power operation is desired, the line is
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reedy across the power line.
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FIG. 6 SHOWS ANOTHER IMPORTANT TYPE OF THREE-WAY
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 of this type of paralleling. Notice the condenser symbols used here.
Reversing Batteries. In some receivers, the battery input signal to this tube, so inverse feedback is obtained. The signal, this feedback is out of phase with the grid from the grid of the output tube to the grid circuit because resistor $R_{5}$ is connected so as to feed energy is obtained on both power-line and battery operation. Inverse feedback, a feature that improves the fidelity of the latter tube. Instant is not used as bias. Resistor $R_{5}$ is connected to terminal 7 of the 12S tube, the drop across the voltage drop across the 114, 116, and 117 tubes. Since the bias for this tube is obtained from the plateau of the power-tube grid resistor. On battery-grid resistor, current can flow through the plate current, and $R_{8}$ reduces the components of the plate current, and $C_{8}$ passes the r.f. component. In Fig. 6, $C_{7}$, $C_{11}, C_{12}$, and $C_{14}$ pass the a.c. component of the plate current. The power plug is not in this receptacle on receptacle—see Fig. 5, we see that resistor $R_{4}$ is the grid resistor. $R_{11}$ and $R_{12}$ are plate load resistors. $C_{2}$ and $C_{3}$ are plate load resistors. $C_{4}$ and $C_{5}$ are plate load resistors.
A Storage-Battery Portable

such as could be carried on with a storage battery. This receiver differs in several ways from other port-

able receivers from the line while the set operates from the battery. In the "a.e. line" and "a. e. line," and

charging when the switch is thrown to the charging position, marked "off," the battery, or "batteries," in the storage battery. The power selector switch has four

positions, and applied to a copper oxide rectifier unit that charges and supplies from the storage battery all the time.

The set operates from the storage battery all the time.

Volts etc.

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the 2-volt cell is indicated by a built-in pyrometer feature. The 2-volt supply to keep down vibrator heat. The state of charge of the B supply. Notice the special shielding needed around the 2-volt vibrator. A picture of this type found in a small generating set is shown in Figure 7. This circuit is shown only to acquaint you with the gen-

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**POWER SELECTOR SWITCH**

- **OFF**
- **COMPLETE BATTERY**
- **AC**

**OPERATION**

- **CONTACTS CLOSED**
- **CONTACTS OPEN**

**POSITION**

- F7 terminal is not connected to circuit.

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**Diagram**

- Components labeled with numbers and connections.
- Various electrical parts such as capacitors (C1, C2), resistors (R1, R2), transformers, and coils (L1, L2).
- Connections marked with symbols and text descriptions.
FIG. 8. This type of radio is designed for operation in regions where there are no power lines. Every effort is made to reduce battery drain; for example, some of the tubes are 3-volt types with their filaments in series. (Some of these sets use 6-volt tubes throughout.)
When you start to service a three-way portable

PRELIMINARY SERVICE PROCEDURES

After operating sets. Several of these are designed primarily for use in

of these receivers is basically like that of a

having at hand a service station and using a

The 6-volt storage battery is
drawn as low as possible. The 4-volt

Many of the larger consoles receivers, particularly

now, 1.4-volt tubes are generally used.

Battery is only 16 pounds. Thus, it is portable.

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are designed to provide a detector signal, a detector

or an electrically supply detector. If the detector occurs only

2-volt, and 2-volt batteries were used in these sets; from 6-volt storage batteries, and use a d-c power

Batteries sets are of several major types. In one all

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POWER COMES FROM A, B, and C batteries. In the past, power comes from A, B, and C batteries. In

However, in appearance to receivers the three-way

operate from d-c, power lines—the power line must be

operate from d-c, power lines—the power line must be

in the detector and battery operation, the

occurs on both power-line and battery operation, the

determine just how the Faulty operation occurs. It is

Now, let's see how to service these receivers. We'll

because they are strictly intended in their power output,

since the troubles that occur in this set on battery opera-

since the troubles that occur in this set on battery opera-

there working in your attention to the three-way portable,

exceed, of course, sets, which you have already studied, except for these sets, which you have already studied, except for the

and selectivity. The tone quality may not be remarkable,

not unlike the same as those that occur in all other

but it will be at least acceptable in the better sets.

Since battery sets are designed primarily for use in

Regarding commutators, they are usually both sensitive

The receiver battery while the antenna is being tuned.

and using a

having at hand a service station and using a

when you start to service a three-way portable.

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operate from d-c, power lines—the power line must be

in the detector and battery operation, the

occurs on both power-line and battery operation, the
power tube-operated receiver. If you do this, be sure the 
the batteries can be removed and the set used as a 
except that of the storage-battery set described earlier, 
may not want battery operation any longer. In all cases 
and at the space allotted to them. Sometimes these 
sets must unusually be exact duplicates, physically and 
- The replacement batteries used in three-way portable 

It's in doubt

These tubes are good or not. Check them in a tube checker
high; so don't depend on observation to tell you whether
As in modern battery tubes, the very low power necc
Don't be alarmed if you cannot observe any fluctua
When the effect just described may occur:
condenser of the Hartley string are discharged—other
more than the filter capacitor. Another factor here is the
/put the tube back, the high current
When you pull the tube back, this condenser will charge up
through R, to the full 90-volt output of the b. supply.
When you pull it back in for example, in Fig. 6, can-
in a three-way portable, you might burn the tube out
As a matter of fact, it is dangerous to pull out tubes
localization procedures.
member—you cannot pull tubes out of these sets in your
and treat the receiver as you would an ac-dc set. Re-
usual is simplest to operate to operate the ac power line
W hen the trouble occurs on ac-dc power-line operation, 
W hen there is trouble on power-line operation, it
on battery operation, the trouble is in the batteries or
SET DEFECTIVE ONLY ON

Dead Receiver. Check to see if the receiver is defective on its batteries, but is defective when you try to power-line operation.

Now let's see what to do about specific receiver defects. First, see what is the trouble. For example, allow the electrolyte to leak out and dam the battery case; for the zinc cases of the cells may be hausted batteries, for the zinc cases of the cells may be destroyed. Incidentally, it is always advisable to remove electrolyte before replacing battery cases or positioning so that they cannot short to each other. Replacements can be easily put in, and be sure the leads of the battery cables are clearly marked so that in the future.

Before replacing burned-out tubes, the terminals with a test lead or scovolmeter, with the set turned on, there will be little voltage drop across Rs, so C4 can change tipical values range from 50 to 200 mfd. If the lamp blinks, Pic. 9. This is the lamp connection for power-line operation.
For more current data on the state of the heat.

PLATE VOLTAGE MAY BE INCREASED SHARPLY BY APPUING
low, and is found to be above below normal, the
but not in the customer’s home. If the heat voltage is
the trouble when a receiver works all night in your shop
quality you will find that low heat voltage is the cause of
heat will reduce all the heat content of
operation is normal. Check the heat voltage, since
heat the heat content. Low heat content voltage is the
If it is not, first check the operating voltage, partition-
put no reading on very little reading shows that it is not
voltage of the oscillator section of this tube. A reading of 10
the oscillator probe should be placed on grid terminal
resistance the oscillator should be 0 reading, and the heat-
volts across the oscillator grid resistor, A high-
what is the oscillator is working by measuring the d.c.
receiver in Fig. 3. As you know, you can readily deter-
which shows the oscillator-first detector section of the
receiver is falling below a grid of the oscillator stage to function.
receiving the proper heat content voltage.

Oscillator Failure. A rather common defect of these
receiving the proper heat content voltage is preventing these tubes from
that a defect in the switching system used to switch over
must be good. However, there is always the possibility
since the sets plays on batteries, the 1.4 volt tubes
operation.

Plate Voltage. An open in the plate circuit will kill all
plate voltage. An open in the plate circuit will kill all
If a heat cord resistor is used (the rectifier tube is
more wear than does that of the standard rectifier.
portable is connected to and disconnected from the
in the power cord near the power cord plug. Usually a
Should you find that the filament voltage to be normal on this tube, and it still does not function, try another tube.

If the filament voltage is below normal, and the drop across the 1.4-volt tube is low, check their filament. If they get their voltage from the plate circuit, normally no other circuit will have dropped to zero. If they do not get their voltage from the plate circuit, check their plate supply and plate current. If the plate current appears normal, but the voltage across the 1.4-volt tube remains low, check their supply voltage. Any of these conditions may reduce the filament voltage. Any of these conditions may have decreased in the rectifier tube. If there are filament shorting re-dection in condenser C, there may be somewhat below normal because of a condenser C may be somewhat leaky. Also, the D-supply resistance may have increased slightly, or this resistance may have increased slightly. Then is provided by a certain resistor such as R1 in Fig. 9, then the drop in the filament voltage is below normal, and the drop across the 1.4-volt tube drops below 1.8 volts. It will still critical in this respect, and some tubes will fail. However, the oscillograph-first-detector tube is some seconds. Indications, this tube filament testing indicates that the average voltage at which they will work. They were below their output tube. Below-normal plate current will naturally reduce the voltage that drops across the 1.4-volt tube. Also, if you have a weak output tube, they will not get their voltage from the plate circuit.
be so severely loaded that the voltage drops considerably.

At certain times of the day, particularly in the early

Intermittent Reception. If the set is intermittently

If so, the trouble may be the result of line-voltage

Intermittent operation occurs at definite times in the day.

tion of the power supply. Check to determine if the in-

- battery operation, then the trouble must be in some part
- dead on power-line operation, this plays normally on
- tube-top caps or measuring voltages.

If any of the above suggestions do not lead at once to the

tube on the circuit distribution steps made by touching

For a dead set, you can use signal interchange source of trouble, proceed to the usual localizaton tests.

Whenever the resistance has increased

Without the substitution of the specific battery, the substitution of the specific battery that has been noted will allow for a more reliable

battery should be used in the better

Regardless of the way the original tests in a tube-checker.

also publish lists of the batteries used in the better

manufacturers and particularly with those of another battery

Choose a satisfactory replacement battery when an exact dupli-

- a tube is not available.
If the trouble occurs only on a.c. power-line-op.

Improperly centered voltage coils and loosened cones.

Check also for a bypass output tube, particularly if the tone is turned down somewhat.

Mains

This trouble occurs only on a.c.-power-line-op.

If the proper repair or replacement.

This recognizes these forms of distortion and can make

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Battery to the power line.

Check over the battery connections carefully, and do not
plug battery interconnections loose connections to some battery.

Note: No current on battery operation and not on power.

If the operation may indicate defective batteries, but
appropriately, replace the batteries.

Re-check after the set has recharged. If any have dropped
between the two and the tubes and number of the tubes
number of the set and the types and model name, you will
have listed the power line by the tubes.

Generally give the right replacement by ordering duplicates of
the original. The factory manual for the receiver will
indicate the right replacements by ordering duplicates of
If you find it necessary to replace the batteries, you

is placed on them.

Dead set. If the set works O.K. from the power line
set will operate from its batteries.

For this section, we will assume that the receiver

Battery Operation Only

Set defective on