How to Make Extra Money

FIXING RADIOS

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

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

RADIO SERVICING METHODS
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
There are a great many battery and portable sets both in cities and in the country, so it is well worth your while to learn how to service them. That is what this RSM Booklet is going to show you. In it, we will follow our usual procedure of describing the technical differences between these receivers and those you have studied previously. Then, we will show you how to locate the defects that are particularly apt to occur in portable and battery receivers.

Of course, any radio that can be carried is portable. However, this name is most usually applied to a type of set known as the three-way portable. This type of receiver is not only light in weight, it can be operated anywhere, because it is designed to obtain its operating voltages from any 110-volt a.c. or d.c. power line, or from self-contained batteries.

You are already familiar with the a.c.-d.c. receiver. Obviously, B batteries could be substituted for the B supply, and 6-volt tube filaments could be put in parallel and operated from a 6-volt storage battery. However, you certainly couldn't class a set using a large storage battery as a portable set. For this reason, tube manufacturers brought out first the 2-volt series of tubes and more recently, a series of 1.4-volt filament tubes requiring very low current drain for filament supply. This has made possible the modern, relatively lightweight portable receiver.

Let's examine the circuits of some typical three-way portable receivers.
A TYPICAL THREE-WAY PORTABLE SET

Fig. 1 shows a diagram of a typical three-way portable receiver. This set is designed so that for battery operation, the tube filaments are connected in parallel to a single 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

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.)
the drop across $R_{12}$, 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 $R_9$ and $R_{18}$. (There is no voltage across $R_{18}$ 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 $SW_1$ are connected together to complete the A circuit, and all three terminals of $SW_2$ are connected together to complete the B circuit.

and hum can be cut down somewhat by reversing the line plug in the wall outlet.

THREE-WAY PORTABLE VARIATIONS

Fig. 4 shows a somewhat different filament arrangement for a three-way portable. Here, the tube filaments remain in series at all times. On power-line operation, they are supplied by the B supply; on battery operation, they are supplied by a small 6-volt dry-cell battery. To change from battery to power-line operation, the ganged switches $SW_1$ and $SW_2$ are thrown. Switches $S_1$ and $S_2$ are the on-off switches, and they are ganged with the volume-control shaft.

Incidentally, some sets use a 35- or 50-volt rectifier tube, plus a series filament resistance, as shown in Fig. 4. More generally, however, a tube with a 117-volt fila-
ment is used, so that its filament can be connected directly across the power line.

Fig. 5 shows another important type of three-way portable. This set is unique in two ways—it uses two power-output tubes and has an unusual method of changing from battery to power-line operation.

Notice that the control grids of the 3Q4 and the 117N7 power amplifier tubes are in parallel, and their plates are connected to the same output transformer (the 117N7 is connected to a tap on the transformer for a better impedance match). Therefore, either can be the output tube; the power supply used determines which one operates.

Fig. 6 gives more details of the filament circuit, and of the method of changing from battery to power-line operation. On the back of the receiver chassis, there is a polarized receptacle—one into which the receiver power plug will fit, but only in one way, because the receptacle openings are a different size, and the plug prongs are specially shaped.

When battery operation is desired, the line plug is inserted into the receptacle. When properly placed, the plug prong marked Y connects B—and A—through the on-off switch 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 R₁₁₃, in parallel with the 117N7 bias resistor R₁₁₆. 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 364 amplifier, because its circuit is broken at the
point. However, none of this circuit can flow through
the amplifier and provides the necessary amplification
to the 364 amplifier section passing through these
points. Therefore, a portion of the 364 amplifier
connected through R43 in parallel with the 1177 bias
resistor R56 is now in a wall outlet. The amplifier of the 1177 now is Energized
withdrawing from this receptacle (thus disconnecting the
desired plug) when power line operation is desired, the plug is

The 1177 plug receptacle is not energized,
and of course, these plugs operate from the A supply, and
1177, and 120 volt. Therefore, on battery operation all
SW's and through the amplifier section of the 364 A, 1177, and 120 volt. When the
swtiches to the set chassis (the other side
of the plug's X, does not, as of now, connect to anything in this re-
ceptacle, by turning the amplifier circuit in Fig. 6, you
connected to the battery plug. This operation
will fit, but only in one way, because the re-
ceptacle openings are a different size, and the plug
power plug will fit only in one way, because the re-
ceptacle is connected to a tap on the transformer for
the 1177, and their
Notice that the control grids of the types of three-way
meant is used, so that the plug can be connected to-

one of the plugs are specially shaped.
The condenser symbols have a straight arrow drawn through them.

Denote "coupled plate" symbols has an arrowhead, and that the common.

Denote "A" current's examination will show that the transformer con.

Symbols shown here to represent 's by-pass and filter con.

Some manufacturers have adopted the special "curved line" of this type of potentiometer. Notice the condenser symbols used here.

Operation greatly improves the output power and the tone qualities.

The use of a different power output tube for power-tube
In some receivers, the battery is connected in the circuit at all times. To see how
inverters
Inverters
Input signal to this tube, so inverse feedback is obtained.
Grid of the 155 tube. Since the 155 tube is connected to the grid of the
output tube back to the grid of theircuit.
Because resistor $R_{15}$ is connected so as to feed energy
is obtained on both power-line and battery operation,
that improves the fidelity.

The latter tube filament is not used as bias.

$R_{15}$ is connected to terminal 7 of the 155 tube, the drop across
voltage drop across the 174, 175, and 176 tubes. Since
the bias for this tube is obtained from the filament-
power tube grid resistor. On battery operation of the
receiver, the power plug is not in this receptacle on

Resistors $R_{15}$ and $R_{16}$ are filament stabilization resistors.

In Fig. 6, condensers $C_{20}$ and $C_{21}$ by-pass the $A_{1}$
receptacle—the power plug is not in this receptacle on
This receiver differs in several ways from other post-
battery.

charges from the line while the set operates from the
battery. In this case the position of the switch is bypassed
through the storage battery. The power selector switch has
four positions, marked "off", "batteries", "ac", and "line". The
storage battery supplies a.c. power to the transformer
and is stepped down by a transformer. The a.c. supply is then
applied to the receiver, battery and storage cell.

However, when the set is connected to a.c. power
The set operates from the storage battery all the time.

Voltage

A storage-battery type, which furnishes the necessary B-supply
operates a diode from the storage battery cell. The cell also
receives direct current from the 2-volt storage cell. The two are
connected in parallel, and operate from the power source.

The plate diodes are connected in series, and act

A Storage-Battery

such as could be carried on the storage battery.

A storage-battery type operates when the battery rather than a storage
batteries. Dry batteries can be discharged by a current through the plate
that forms an electrolyte. Then, as the positive plate is reduced, the negative
polarization of the battery, rather than a decrease.


diode from the receiver, and a small resistor cut

Therefore the set will not operate from the power line when the
batteries have begun to run down. Therefore, the set will not operate from
the plate diode. The storage battery will be a little higher than the
batteries. When the power source is bypassed to a line, the

for the terminals of SW1. Now, when the power line is
the same as with SW1 in the "off" position and do the same
three terminals of SW2. Now, when the power line is
such a set works, imagine that we connect together all
FIG. 7. This circuit is shown only to acquaint you with the general features of this type of portable. The set uses a special 2-volt vibrator V1 of the synchronous type, as a means of getting the B supply. Notice the special shielding needed around the power supply to keep down vibrator hash. The state of charge of the 2-volt cell is indicated by a built-in hydrometer feature.
FIG. 8. This type of radio is designed for operation in regions where there are no power lines. This model gives efficient operation from a 6-volt storage battery. Every effort is made to reduce battery drain; for example, some of the tubes are 3-volt types with their filaments in series. (Some of these sets use 6-volt tubes throughout.)
Preliminary Service Procedures

Two types of batteries are used in the marine environment. The first type is the dry battery, which is used in portable equipment. The second type is the lead-acid battery, which is used in fixed installations.

Before you start to service the three-way portable battery,

Battery Sets

Battery is only 16 pounds. Thus, it is portable. However, it appears to be in good condition and is operating properly, so there is no need to replace it.
power-line-operated receiver. If you do this, be sure the batteries can be removed and the set used as a desk set or the storage-battery set described earlier, except that the storage-battery set described earlier, may not want battery operation any longer. In all cases and if the space allotted to them. Sometimes these sets must usually be exact duplicates, physically and electrically, of the original to provide the proper voltages. The very low power needed in modern battery tubes, the very low power needed by these tubes means that there will be little visible effect. If there is no power in use, the effect just described may occur.

condensers of the filament string are discharged—other condensers of the filament string are charged. This condenser effect will charge up the filament. When you pull out the tubes, the filament will charge up through the 90-volt supply, and when you put the tubes back in the filament will charge up through the 90-volt supply. When you pull out a tube, this condenser will charge up the filament. When you put it back in, the filament charger back up. A tube, therefore, be careful when you replace a burned-out tube.

In mind, in doubt, do not check them in a light, do not depend on observation to tell you whether or not there is power. By these tubes means that there will be little visible effect if there is no power in use. The effect just described may occur.

The replacement batteries used in these-way portable receivers are good or not. Check them in a light, do not depend on observation to tell you whether or not there is power. By these tubes means that there will be little visible effect if there is no power in use. The very low power needed by these tubes means that there will be little visible effect if there is no power in use. The effect just described may occur.

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In a tube tester, be on the lookout for a broken lead.

Dead Receiver. Check to see if the rectifier tube is
power-line-operated.

In this section, we will assume that the receiver op-
erates on its batteries, but is defective when you try
- set defective only on

Now let's see what to do about a defective receiver.

Before replacing burned-out tubes, it is important with a feed lead or speaker wire, with the set turned
up to the full B voltage. Always be sure C is disconnected (short
the supply voltage range from 60 to 200 volts). If a tube is blown.

PIC. 9. This is the filament connection for power-line operation.

[Diagram of electronic circuit]
in the power cord near the power cord plug. Usually a portable is connected to and disconnected from the power line rather often, so its power cord gets much more wear than does that of the standard receiver. If a line cord is used, the power cord gets much more wear than does the standard receiver.

If the rectifier tube lights, check the second rectifier voltage of the power supply. Check the B supply first. If the 1.4-volt tubes have their filaments in series with the cathode of the power supply, be sure this tube is getting some plate voltage. An open in its plate circuit will kill all operation.

Since the set plays on batteries, the 1.4-volt tubes must be good. However, there is always the possibility that a fault in the switching system used to switch over to power-line operation is preventing these tubes from receiving the proper filament voltage.

If the rectifier tube lights but there is no B voltage, the rectifier diode is probably shorted. Check the filament voltages at the filament terminal of this tube. If the filament voltage is present, the filament is probably okay. If the filament voltage is not present, the filament is probably open. Check the filament voltage at the filament terminal of the 1.4-volt tube. If the filament voltage is present, the filament is probably okay. If the filament voltage is not present, the filament is probably open.

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If the rectifier tube does not light, the rectifier has probably failed. Check the filament voltages at the filament terminal of this tube. If the filament voltage is present, the filament is probably okay. If the filament voltage is not present, the filament is probably open. Check the filament voltage at the filament terminal of the 1.4-volt tube. If the filament voltage is present, the filament is probably okay. If the filament voltage is not present, the filament is probably open.

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should you find the filament voltage to be normal, another tube.

voltaic

Any of the conditions will reduce the filament

voltage. Any of these conditions may be increased in

the rectifier tube. If there are filament shunting re-

sistors, one or more of these may have decreased in

defect in condenser C, leakage in C, or low emission

condenser C may be somewhat below normal because of a

tubes resistance value may have increased slightly, or

is provided by a series resistor such as R in Fig. 9, then

the drop

If the filament voltage is below normal, and the drop

to work if the voltage drops below 1.5 volts.

what critical in this respect, and some tubes will fail

if under such conditions. However, the oscillator-first-detector tube is some-

supposed to operate on any voltage below 1.2 and 1.65

meets. Indicating, this tube filament rating indicates

reduce the voltage drops across the I-A-volt tube into

the grid voltage at which they will work. They are

natural

output tube. Below-normal plate current will naturally

of the power output tube, check to see if you have a weak

across the I-A-volt tube filament is low, check their

If the line voltage appears normal, but the voltage
be so heavily loaded that the voltage drops considerably. At certain times of the day, particularly in the early morning and early evening hours, the electric lines may

It so the trouble may be the result of line-voltage

terminal operation occurs at definite times in the day.

Check to determine if the in-

power supply. If the trouble occurs, then the trouble must be in some part of the power line, dropped out in the terminal operation, but that normally on

Intermittent Reception. If the set is intermittently

Intermittent Reception. If the set is intermittently

tube top caps or measuring voltages. For a dead set, you can use signal lights or a source of trouble to the usual localization tests. If the above suggestions do not lead at once to the above, refer to the valve(s). Upon the return of the resistance has increased,

% by reducing the value of R in Fig. 10 by 10% to 20%. Also, sometimes the oscillator can be made more reliable. Regardless of the way the original parts in a tube checker,

Case is not available.

When a satisfactory replacement cannot be obtained, from a known maker, from such who you or your parts supplier can

manufacurers, also publish lists of the batteries used in the better

spaced electrolytic and specifically wish those of another battery

Charts like this show which batteries of one manufacturer correlate.
Humm. This trouble occurs only on a-c-powere-line op-

eation. The power repair or replacement will recognize these forms of distortion and can make

improperly centered voice coils and loosened cone

stuck is turned down somewhat.

distortion clears up satisfactorily when the volume con-
trol is turned up too high. This is not a receiver defect if the

volume control is overloaded; it is a receiver defect if the

receiver operates on power-line operation, and there may be dis-

charge in the receiver's voltagess, from the higher d-c. voltagess

for power-line operation.

Check also for a thinny output tube, particularly if the

set is so designed that a different output tube is used

so on the above item is relatively different.

to find the one item that is radically different.

Compare both battery and power-line voltagess

and see usually somewhat higher than those for battery op-

eration in mind that the voltagess on the power-line operation

are somewhat higher than those for battery op-

eration. You will probably find

some unusual condition on the audio amplifier. You will probably find

returning to the audio amplifier. You will probably find

one of the power-line voltagess

while controlling may occur when the audio voltagess rises above

caused by the reverse of the above condition—

A trouble of this sort is intermittent oscillation may be

now, the house.

Another outlet, on a different branch of the electric cir-

a trouble of this sort is intermittent oscillation may be

caused by the reverse of the above condition.

If you don't succeed, there is little you can do except call

the matter to the attention of the power company.
Battery to the power line.  

Check over the battery connections carefully, and if so probably indicates loose connections to some batteries.  

The operation may indicate defective batteries, but battery operation and not on power.  

Noise: None on battery operation.  

Replacing, replace the batteries.  

Secure after the set has cleared out.  

Make a careful check of the battery voltack.  

Particularly when the set plays at first and then gradu-lary, battery operation only also indicates battery trouble.  

Intermittent Reception.  

Use in it.  

The number of the set and the types and number of the tubes generally give battery type numbers of several different manufacturers.  

Your Jonet can also suggest battery manufacturers.  

The right replacement.  

Generally, the right replacement for the receiver will be used.  

The factory manual for the receiver will also get the right replacement by ordering duplicates of the original.  

If you find it is necessary to replace the batteries, you can get the right replacement by ordering duplicates of the original.  

If your set works O.K., from the power line.  

Dead set.  

If the set does not play normally on the power line, but does not play.  

For this section, we will assume that the receiver is played on the power line.  

Battery Operation Only  

Set defective on