Using Your Ohmmeter

How to use a volt-ohmmeter, a tube handbook, and intelligence to service a set

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RADIO experimenters are frequently asked to repair broadcast receivers for the neighbors. Often, for diplomatic reasons, it is unwise to refuse (for example, when your antenna is tied to the asker's chimney). And servicing broadcast receivers can help make one's hobby self-supporting. Most experimenters say, "I'd like to, but I have neither test equipment nor service manuals."

Have you ever watched a skilled serviceman at work? You may have noticed that he used his volt-ohmmeter more than all the rest of his equipment combined. This meter makes an excellent substitute for more elaborate test equipment.

Finding a substitute for service manuals seems a difficult task; but is it? The aim of a serviceman is to detect and replace defective parts, not to rewire the receiver. A complete diagram is seldom required to service it. The vacuum tube is the heart of any piece of radio equipment, so let us examine a good tube manual.

There is page after page of tube characteristics, with application notes for each tube. Socket connections and voltage ratings interest us most.

The end pages of the manual list typical circuit diagrams with suggested parts values. Examine these circuits and those appearing on the circuit pages of each issue of RADIO-ELECTRONICS. A significant fact emerges: *no matter what the circuit, the components associated with a given type of tube are startlingly similar.* Recalling that the serviceman's job is to detect and replace defective parts, the worth of a tube manual as a service tool begins to appear. With it, a volt-ohmmeter, and a small stock of parts, all a.c.-d.c. receivers and over 90% of all others can be speedily serviced.

Finding the trouble

Now the set is on the bench and if you have asked a few questions, you have a fair idea of what is wrong with it before you touch it.

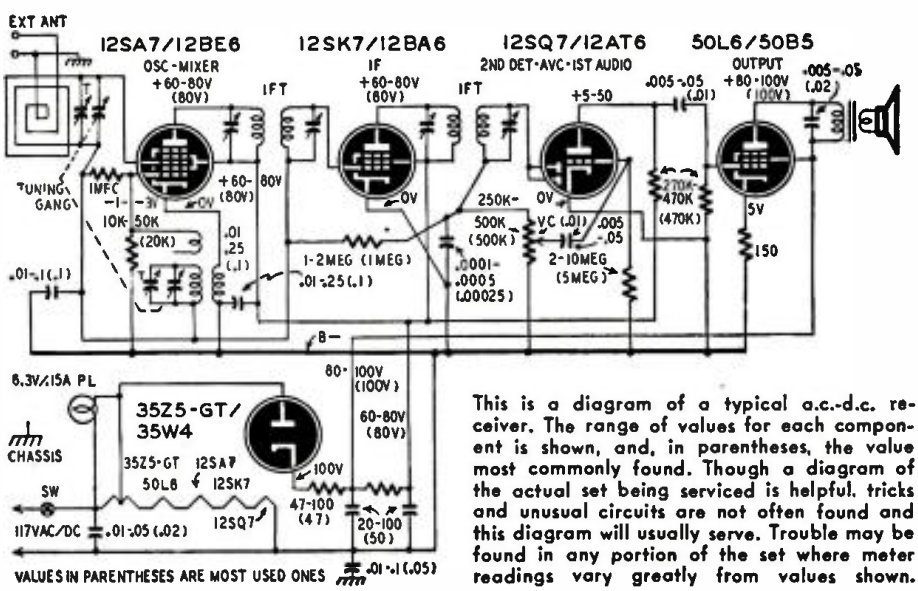
Did it suddenly stop working? Probably a burned-out tube, shorted condenser, or open resistor.

Did the volume get weaker and weaker, the receiver finally failing completely? Probably weak tubes.

Does it play normally for a time, then cut out? Could be almost anything.

Does it have excessive hum or squeals? Probably the electrolytic filter condensers have dried out.

Has anyone else worked on the receiver? More than one baffling bug has been caused by someone's having removed several tubes and replaced them in the wrong sockets.



This is a diagram of a typical a.c.-d.c. receiver. The range of values for each component is shown, and, in parentheses, the value most commonly found. Though a diagram of the actual set being serviced is helpful, tricks and unusual circuits are not often found and this diagram will usually serve. Trouble may be found in any portion of the set where meter readings vary greatly from values shown.

Plug the set into the power line to see if it is actually defective and (assuming it is transformerless) if the tubes light. If not, remove the power plug and, using the tube manual to identify the correct terminals, test each filament in turn for continuity. Replace burned-out tubes *and pilot bulbs.* If all filaments show continuity, test the a.c. switch and cord. If they are good, plug in the set again and, using the 150-volt a.c. scale, put the meter across each filament. The meter will indicate when it is across a filament that may not open until power is applied to it.

Caution: When working on a transformerless set which is connected to the power line, always put it on a piece of insulating material and be very careful about what you touch, because it is very possible to get a shock, even with the switch off.

In most a.c.-d.c. sets, the total of the filament voltages in series equals the line voltage, but in some a resistor, often in the form of a resistance line cord, or resistance tube, dissipates the difference between the two voltages. An open line cord can sometimes be repaired, but it is usually more satisfactory to replace it with a new one. The correct resistance is calculated by means of Ohm's Law: E = IR. The difference between the line voltage and the combined filament voltages equals the required voltage drop and the current is that of a single tube. Assume the line voltage is 120, the filament voltages total 75, and the current is 0.15 amperes. 120 minus 75 equals 45 volts drop, and 45/0.15 equals 300 ohms, the required resistance.

If the tubes light, measure the d.c. voltage and the resistance between rectifier cathode and circuit ground. The voltage should be approximately 100 and the resistance several thousand ohms minimum. Low voltage and normal resistance indicate a defective rectifier. Low voltage and low resistance point to a short circuit. Use the ohmmeter to look for blown filter and bypass condensers. It may be necessary to unsolder one lead of a suspected one before a definite decision about its condition can be made. When the short has been eliminated, measure the d.c. voltage again. Even a momentary short circuit often damages the rectifier permanently.

Proper voltage at the rectifier and none at a tube element which the tube manual shows should have voltage indicates an open resistor or coil or a short-circuit, usually in the form of a blown bypass condenser. An open circuit reduces the voltage at the point it should feed to zero, with little effect on other points. Zero voltage at the plate of the output tube, for instance, and normal voltages at other points, would make the serviceman suspect the primary of the output transformer. In a.c.-d.c. receivers all plate and screen voltages are obtained from a common point, so a short circuit anywhere causes a drastic reduction in all B-voltages.

A tube manual and multimeter are chief tools.

No instruments are required to detect excessive hum. If an 8-μf capacitor temporarily connected in parallel with one of the filter capacitors reduces hum level, the filter capacitors should be replaced.

As the tube manual will tell you, the best test of a tube's worth is how well it works in the piece of equipment concerned. Trying a doubtful tube in another receiver or replacing it with a new one will give all the information required. But there are indirect methods which may be used to obtain an approximate idea of a tube's condition without a tester. Measure the cathode voltage. If it is lower than the rated value, the cathode emission is probably low. Too high a reading may mean a shorted element or that a leaky coupling condenser is applying positive voltage to the control grid.

Touching a finger to the control grid of a good audio tube will produce a hum in the speaker. Touching the control grid of the first audio amplifier will immediately reveal whether a signal can get through the audio section.

The oscillator section of the mixer may be tested by putting the test meter between its control grid and B-minus, with an r.f. choke in series with the meter. If the tube is oscillating, the meter will read a few volts negative and touching the grid will cause the reading to decrease.

Those intermittents

Intermittent troubles take a perverse pleasure in not appearing while the receiver is being worked on. To find them, move and tap components while the receiver is playing until a suspicious part is discovered. Then the only sure test is to replace it and play the receiver for several hours. Loose elements in tubes are often the cause of intermittents; in fact, every part in the receiver is suspect and great patience may be required to locate the guilty one.

Do not use a screwdriver or other metal instrument for moving or tapping parts. There is too much chance for it to slip and cause a short.

When replacing defective parts try to duplicate the electrical characteristics of the original, but, with the exception of tuned-circuit components, a large variation may have little effect on performance. Space permitting, voltage and wattage ratings may always be increased. The capacity of bypass and filter condensers can usually be made larger, often with beneficial results. Resistance values are sometimes more critical, but often may be increased as much as 50% without much effect on performance. A study of the circuits and application notes in the tube manual will quickly acquaint you with the very few components whose values are critical.

Larger receivers

From the serviceman's viewpoint, the big differences between a.c.-d.c. midgets and more elaborate receivers are more tubes and higher voltages. Both mean additional points of possible trouble. More tubes mean more circuits, and higher voltages more dropping and decoupling resistors, with their bypass condensers. A systematic approach will locate the troubles in these receivers quickly. With the filaments in parallel, one tube's burning out does not affect the others. The bad one is easily detected because it is cold. Open resistors, which are relatively common, are quickly located with the ohmmeter (power off), or with the voltmeter (power on).

Personal three-way portables yield to the same treatment as the others. If the receiver works on commercial power, but not on the batteries, the batteries are probably dead. (Batteries should be replaced when their voltage has dropped one-third, measured under load.) If the receiver works on batteries and not on commercial power, the trouble is in the rectifier circuits. And if it works on neither, the trouble is one of those previously discussed.

Alignment methods

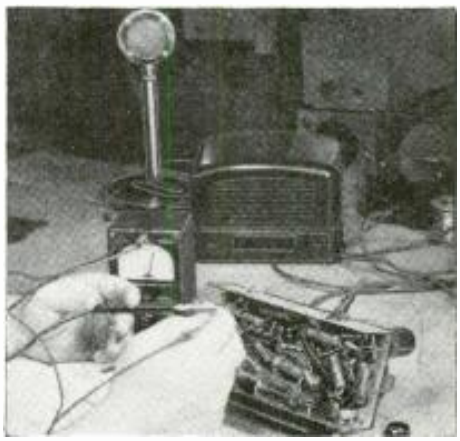
Aligning a receiver without a test oscillator seems a hopeless task; nevertheless it can be done with nothing more than a neutralizing tool and your ear. If the high-frequency oscillator is not disturbed the job is especially simple.

To align the i.f. amplifier tune in a weak signal, and, starting at the second detector, adjust each trimmer in the i.f. transformers for maximum deflection of the tuning indicator. If the receiver does not have a tuning indicator, simply adjust the trimmers for maximum audio output on a weak signal or noise. (This will work only on a receiver which has not been tampered with, and which brings in the stations on their correct dial markings. Even then, there is danger of misaligning instead of aligning.—*Editor*)

The mixer and r.f. stage (if any) trimmers are similarly adjusted, although it is doubtful that one setting will give maximum response over the entire band; so a compromise setting must be chosen to give best results over the most-used part of it. As a general rule these trimmers should be adjusted near the high-frequency end of the dial.

Earlier we put a "hands off" sign on the oscillator trimmers because they determine the accuracy of the dial calibration. However, if the calibration is incorrect it may be corrected if a little care is taken. If the receiver uses specially shaped oscillator condenser plates for tracking, tune in a station near 1450 kc and adjust the oscillator trimmer until the station comes in at the correct point on the dial.

In receivers using both series and parallel trimmers, the parallel trimmer (mounted on the variable condenser) is adjusted near 1450 kc and the series trimmer (padder) near 600 kc. The adjustments interact somewhat so they should be repeated for maximum accuracy. After the oscillator is adjusted readjust the r.f. stage and mixer trimmers.


Be sure set is off when measuring resistance.

Receivers using permeability tuning are set on frequency by adjusting the oscillator padder near 1450 kc and the position of the slug in the oscillator coil near 600 kc. The r.f. and mixer stages are similarly adjusted for maximum output.

This method of correcting frequency calibration assumes that the i.f. is reasonably close to its original frequency, and that the calibration was correct when the set was new, both reasonable assumptions.

The aim of this article is not to belittle adequate test equipment, but to show that successful radio service work can be done with a minimum of it. Undoubtedly, a receiver can be serviced more rapidly with additional equipment, which should be acquired by anyone who intends to service receivers regularly.