TROUBLE SHOOTING SIGNAL TRACING

Most of the troubles that occur in radio are due to open circuits and short circuits, either complete or partial. It is the serviceman's job to locate the cause of trouble in a radio unit and repair the unit in as short a time as possible. This could be done by testing each part individually for open or short circuits, but there are much quicker and better methods of locating defective units. If the stage that is not operating properly in a multi-stage receiver can be found quickly, the defective part may be located by simple resistance and voltage checks. The process of locating the defective stage is known as *signal tracing.*

One widely used method of locating a defective stage in a receiver is that of *signal substitution.* For example, each stage of an audio amplifier may be checked for normal operation by using the signal from an audio generator instead of depending on a receiver signal. If the audio generator is connected to the input of the final amplifier of a two-stage amplifier and a normal signal is heard in the speaker that stage would be considered to be operating correctly. If the audio generator were then connected to the input stage of the amplifier and no signal were heard in the speaker, then the input stage must be defective. Once this is determined, the tube socket terminals should be checked to see that voltages are applied to the tube. If the plate voltage is lacking, the parts in the plate circuit should be checked for open or short circuits. If the plate and other voltages are correct, the input device should be checked for defects.

A second method of signal tracing is to connect the audio generator to the input of the amplifier and to use a separate indicator for tracing the signal. This indicator could be another audio amplifier with speaker, an oscilloscope, or even a sensitive output meter. The indicator should be first connected to the input device of the unit being checked to be sure that a signal is reaching the grid of the first audio tube. If a signal is present, the indicator should then be connected to the plate of the tube or to the output device to see if a signal is present. If no signal is indicated, the component parts of the plate circuit should be checked for defects. If a signal is present, the indicator should be connected to the grid of the next tube and the signal checked. If a signal is present, the indicator should then be connected to the plate of the tube and a check made for signal. If no signal is indicated the voltages and parts in this circuit should be checked. If the plate circuit of the tube is operating in a normal manner, the secondary of the output transformer will probably have an open or shorted output winding and can be checked with an ohmmeter. The point where the signal disappears will indicate the approximate location of the trouble.

It is evident that the path of a signal through an amplifier may be checked by one of several indicating units, such as a similar amplifier, an output meter, an oscilloscope, or the commercial signal tracing units.

One of the simplest ways to determine if an amplifier is operating is to quickly remove and reinsert the first amplifier tube. If the circuits are in operating condition, a loud click will be heard in the speaker. It is caused by the breaking and remaking of the electrical contacts of the first tube. This interruption or noise is amplified by the following tubes, and causes a click in the speaker. If removing the first tube did not produce a click in the speaker, the second tube should be removed and re-inserted. If a click is heard, it means that the first tube is bad, or it has no plate voltage, or the coupling device (condenser or transformer) between the two tubes is defective. This quick check may be made before applying the tests as outlined in this experiment. Indicator units used in signal tracing should be of a type suitable for the circuit under test. The audio amplifier would use such indicators as output meter, speaker, oscilloscope, etc. Amplifiers operating at radio frequency would require a test instrument that would give an indication at radio frequencies. Vacuum tube voltmeters, r-f oscilloscopes, detectors with an audio amplifier, etc., would be satisfactory for this purpose.

Signal tracing in an r-f amplifier is very similar to that in an audio amplifier. The circuits operate in much the same manner except that all signals are at radio frequency.

In signal tracing the unit used as an indicator must be capable of operating at the frequencies used in the amplifier, or it must be capable of accepting the radio frequency signal and converting it to an audio signal. Such an instrument would be a detector, or rectifier, followed by an audio amplifier. With this combination a speaker or output meter could be used to indicate the presence or lack of a signal in the r-f amplifier. The detector could be connected to the various stages of the r-f units so their output can be checked. If a signal were present in the output of the first amplifier tube but missing at the output of the second stage, a defect would be indicated in the second stage. Once the trouble was localized, a volt-ohmmeter could be used to check the parts associated with that particular tube and the exact trouble determined.

Signal tracing in an r-f amplifier can be done by both the "signal substitution" method and the indicator method. In the first method, the detector should be connected to the output terminals of the r-f amplifier and the signal generator successively connected from the output coil to the input circuit. The point where the signal disappeared would indicate the location of the defective stage. In the indicator method the signal generator should be connected to the input of the r-f amplifier and the detector successively connected from the r-f amplifier input terminals to the output terminals. Here again, the point where the signal disappeared would indicate the location of the defective stage.

Other indicators may be used in checking r-f amplifiers. The oscilloscope, if its amplifiers will pass radio frequency, is very good. The scope should be adjusted to show the modulated r-f signal. A vacuum tube voltmeter is an instrument that will read radio frequency and may be used as an r-f output meter.

Hum, oscillation, and noise are common troubles which are sometimes very difficult to locate, because often they may not be determined by the use of voltage, current, or resistance checks. They must sometimes be found by careful recognition of slight differences between sounds from the speaker.

Hum may originate in the power supply, due to defects in the ripple filter. Open filter condensers, or condensers having reduced capacity due to the drying of the electrolyte, are the most common cause of this kind of hum. Shorted or partially shorted filter chokes are another cause.

If the tube filaments are shunted with center-tapped resistors, with the center-tap grounded, an open half of the resistor will cause hum. Very often these resistors are constructed with variable center-taps. In this case hum will result if the resistor is out of adjustment.

Closely associated with this trouble is leakage between the heater and cathode of indirectly heated tubes, which will vary the emission of the cathode at the heater supply frequency.

Magnetic coupling between a power transformer and filter choke (or audio transformer) will also produce hum; however, this is unlikely to occur in well designed commercial radios. It is possible though, where original components are replaced, and their position changed or shields not replaced.

If the laminations of a power transformer become loose, a characteristic buzz, very similar to a hum, will be produced. This buzz may be definitely determined by placing the ear very close to the transformer, and then to the speaker. If the buzz is louder at the transformer loose laminations are the trouble. This buzz is not conveyed through the speaker, but is heard directly from the part itself.

The types of hum already mentioned are steady in character and independent of dial setting. Another type of hum, which occurs only when in tune with a signal, is called modulation hum. It is caused by the modulation of a carrier signal by the a-c power supply frequency. When a-c heater leads are brought into the range of grid leads, or by-passing is inadequate, or line-buffing condensers are open, this trouble may be produced. Cathode to heater tube leakage may also cause this trouble. Very often, by-passing one or both sides of the power line to ground (at its entrance to the chassis) will eliminate modulation hum. Reversing the line plug will sometimes affect this hum, particularly if the grounding of the set is poor.

Oscillation is generally caused by some kind of inter-stage coupling, and may occur in more than one tube circuit. Coupling between the plate circuits of different stages and the screen grid circuits of different stages is the most frequent cause of oscillation. This coupling generally results from open by-pass condensers in the plate or screen grid circuits, or shorted r-f chokes.

High resistance connections between shields and ground may also cause this trouble. Shields should always be carefully replaced in original positions, when replacing coils, tubes, etc. If leads from sentive r-f and i-f circuit parts are placed in different positions from the original, oscillation may result. Manufacturers often place the plate and grid leads in such a relation as will produce certain critical degrees of regeneration. Altering these constants may cause oscillation, or too much regeneration.

Noise is sometimes one of the most difficult troubles to locate. It may occur in any part of a radio—in fact, in almost any connection. Radio noise may be classified as natural atmospheric static, interference from other electrical devices, and noise originating in the set itself. Noises external to the set may usually be determined by shorting the antenna and ground terminals of the set, and noting whether the noise persists. If so, the noise is likely to be coming from the set itself, if not, it is likely to be coming from outside the set. However, this test will depend considerably on how well the set is shielded.

Set noises may be caused by loose connections, broken leads, leaky or arcing condensers, noisy resistors, noisy tubes, dirty or loose switch and socket contacts, rosin joints, corroded or dirty variable condenser wiping contacts, scraping variable condenser plates, noisy audio transformers, loose speaker cones, dragging voice coils, and many other troubles.

A good test to make for noise is a slight jarring of the chassis, and moving of leads, and parts. Thumping of tubes will often disclose a noisy tube. Condensers and resistors must sometimes be disconnected or replaced, as a definite check of their condition. Practical, common sense is necessary to dictate the best procedure to employ under particular conditions. Very often noises are intermittent, making their location very difficult.

The most helpful procedure to follow in trying to determine the cause of hum, oscillation, or noise, is to localize the trouble. The simplest method is either to remove one tube at a time (beginning with output tube), or to short out the input circuit of each tube (beginning with output tube). By this method, a particular circuit will be reached where the trouble is not indicated by the speaker; upon moving to the next circuit, the trouble is indicated by the speaker. The trouble is between these two points.

When the trouble originates in the power supply, or some circuit common to several stages, this method will have to be used with reservation. For instance, trouble may appear to be coming from the output stage, when it is actually coming from the supply to this stage.

Conclusions: It is evident from this that signal tracing on an r-f amplifier is similar to that of an audio amplifier. The method is the same, but an indicator that will respond to radio frequency signals is necessary.

Notes: If a separate indicator is not available the detector and audio amplifier of a receiver may be used to check the r-f stages provided the detector and audio amplifier are operating satisfactorily. There are several commercially manufactured indicator units. They usually contain r-f and audio amplifiers, an oscillator, and a detector; and are so arranged that any stage of a receiver may be checked. They may use a vacuum tube voltmeter, oscilloscope, or even a "magic eye" tube to indicate the presence and strength of the signals in the receiver.