CHAPTER 17

ANTENNAS

Function of the Antenna.—The antenna is the first link in the receiver signal channel. Radio waves from all stations sweep across the antenna. Radio waves are one of the variety known as "electro-magnetic" waves. When such waves sweep across a wire conductor like an antenna, they generate a voltage in the wire, which in turn drives a feeble current through the antenna-ground system in the receiver. The current produced has the same frequency as that of the current in the broadcasting-station antenna and possesses the same modulation that represents the desired intelligence.

Types of Antennas Commonly Used.—Almost any wire connected to the antenna post of the receiver will function to some degree as an antenna. However, an antenna that is properly installed will result in far superior receiver performance than a makeshift one. It is wisest to install the type recommended by the receiver manufacturer. For cases where none is recommended, a standard antenna is described below. Other types will be presented under antenna variations.

The old standby most frequently recommended is the Marconi antenna, in which the ground is an important part. The most common variety of these grounded antennas is the inverted L. Here a wire is suspended horizontally between two insulators and is known as the "flat-top." Another wire, known as the "leadin," is connected to the flat-top—near one end—and brought down to the antenna post of the receiver. The ground post of the receiver is then connected to a well-grounded object. Within the receiver, the antenna and ground posts are connected to the terminals of the antenna-coil primary. Figure 17–1 shows such a setup.

The inverted-L antenna is a fairly efficient one for most surrounding stations. However, if not blocked by surrounding objects, it will have a little greater pickup from the direction in which the longer part of the flat-top points. This condition is shown by the arrow in Fig. 17–1.

Signal-to-noise Ratio.—The purpose of the antenna is to pick up signals from the various broadcasting stations, and to conduct them to the receiver. Unfortunately, the antenna cannot differentiate between desired signals and undesirable radio waves that result in
noise in the loudspeaker. Both signals come in simultaneously with disturbing effects for the listener, as indicated in Fig. 17–2.

What is the origin of these undesirable noise waves? The explana-

![Diagram of antenna setup with labels](image)

**Fig. 17-1.—Simple inverted-L antenna.**

![Diagram of signal and noise pickup](image)

**Fig. 17-2.—Noise and signal pickup by an antenna.**

tion is simple. Any electrical machinery, especially rotary equipment, that emits a spark is a noise producer. A spark is an oscillatory discharge across a gap that produces radio waves of many frequencies. These latter waves chop up the desired signal and give
the noisy effect. All motor-driven devices, such as elevators, refrigerators, vacuum cleaners, and fans, are noise producers. Pressing irons and diathermy and X-ray equipment are stationary devices that produce sparks and radiate undesired noise waves. Power lines will also pick up noise due to sparking devices along them and will act as an antenna for such noise.

It has become common usage to compare the pickup of the antenna with respect to desired signal and undesired noise. The relationship is referred to as the signal-to-noise ratio. A high signal-to-noise ratio produces relatively noise-free reception from the receiver, since signal pickup is large while noise pickup is small. A low signal-to-noise ratio produces noisy reception from the receiver, since signal pickup may be large or small, but noise pickup is relatively great in comparison. Figure 17-3 shows a high and a low signal-to-noise ratio pickup by the antenna and leadin. The associated noise producer is the near-by power lines.
The antenna should be so designed that noise pickup is at a minimum. As stated previously, any wire will serve to some extent as an antenna, but its noise pickup may be high. A properly installed antenna attempts to reduce noise to a minimum.

Because of the conditions stated above, indoor antennas, especially in city apartment houses, have low signal-to-noise ratios. This is because of the presence of many noise-producing electric machines within the building and near-by power lines. For the same reason, the leadin close to the building will also pick up much noise, unless special types of leadins are used. This condition is not so bad in rural areas.

So far, the antenna has been discussed only from the point of view of reducing noise pickup to give a higher signal-to-noise ratio. The ratio may also be increased by designing the antenna more efficiently so that its signal pickup will be greater. The factors entering into antenna efficiency will therefore be discussed in the following section.

**Efficiency of the Antenna.**—A highly efficient antenna has a maximum signal pickup with a minimum noise pickup. Many factors enter into the over-all efficiency of the antenna.

One factor is its length. A long outdoor antenna, about 25 to 75 ft in length including the length of the leadin, is recommended by many manufacturers. Such a long antenna will usually carry the wire away from the vicinity of near-by noise producers.

A second factor in antenna efficiency is its height. The greater the height of the antenna, the greater the signal voltage generated in it by the radio wave from any particular station, and the less the noise voltage generated in it.

Another efficiency factor is the placement of the flat-top of the antenna and the leadin. Wherever possible, the antenna should not be close to metal objects that absorb radio waves and block the antenna from the signal. Many a receiver with an indoor hank antenna has been dead in a steel-frame building.

Further, the antenna should be as far as possible from devices likely to produce noise. In this regard, near-by power lines and house elevators are troublesome noise producers. Antennas should be far from power lines and at right angles to them for minimum noise pickup. It is well to point out that at no time should an antenna wire cross over, or under, a power line because of the danger of contact. Elevator shafts usually terminate in a small housing on the roof covering the elevator motor which may radiate noise waves. Antennas should be located as far from the motor housing as possible. The serviceman should remember that the leadin is an integral
part of the antenna system and may pick up noise signals if near noise producers.

A fourth efficiency factor is the directional characteristic of the inverted-L antenna. For any one station, the antenna may be turned so that it obtains the greatest signal pickup. However, since all stations do not transmit from the same direction, the placement of the receiver antenna will at best be a compromise for all stations.

A fifth efficiency factor is the associated antenna resistance. The feeble voltage generated in the antenna will be quickly dissipated if resistances along it are too great. All connections must be carefully soldered. Twisted mechanical connections should be avoided.

A sixth efficiency factor is the antenna installation itself. Leakage from it will tend to weaken the signal current delivered by the antenna to the receiver. Therefore, supporting insulators should be made of such materials as pyrex glass or glazed porcelain, which do not absorb moisture and thereby do not provide a leakage path. Further, the flat-top must be taut. If it swings, two defects may appear. One is regular fading of the receiver signal. The other, if the swinging antenna touches grounded objects, is the production of noise in the receiver. Since the leadin usually lies close to the grounded building, a rubber-covered leadin should be used.

The final efficiency factor is the ground connection. The ground lead is an integral part of the antenna system. As such, it may pick up noise. Therefore, it should be as short as possible and away from noise-producing devices. It, too, is made of wire, size No. 14, in rubber insulation. It should be attached to a grounded object, like a radiator or cold-water pipe; never a gas pipe. Good contact with the grounded object must be made. Paint or rust on the pipe should be scraped off, and use should be made of a good ground clamp for firm contact. A good ground connection may improve receiver reception, although many operate well without it.

**Installing a Receiver Antenna.**—The discussion of the antenna installation will be confined to the inverted-L type. Before actual construction, the serviceman must size up the situation. He must consider all the factors of antenna efficiency and then proceed to erect the antenna. Typical installations are shown in Fig. 17–4. Two rigid supports, sufficiently far apart and properly located, are chosen. Attach one antenna insulator firmly to one support, using a piece of the antenna wire. Then attach one end of the antenna wire by means of a nonslipping knot to the other end of the same insulator, as shown in Fig. 17–5. Antenna wire most commonly used is bare No. 14 copper wire, or stranded wire of an equivalent
size. Then attach the other end of the antenna wire firmly to the other insulator. Before proceeding with the mounting, solder the leadin near one end of the flat-top. This gives an L type of antenna. If the antenna wire used is of the enameled type, scrape the enamel away carefully before making this connection.

Fig. 17-4.—Typical receiver antenna installations.

Now attach a pulley to the other rigid support. Tie a rope firmly to the other end of the second insulator and pass it over the pulley wheel. Draw hard on the rope until the flat-top becomes taut, and tie down the end of the rope to maintain the tautness. The result is shown in Fig. 17–6. Bring the leadin down the side of the building, guided by means of insulated nail knobs.

At the window for entry, there is danger of breaking the lead-in wire because of window pressure. To avoid this possibility, the leadin is connected to an insulated flat copper mesh, called a "window lead-in strip," which can take more flexing and pressure. The window strip is in turn connected to a lead that goes to the antenna terminal of the receiver. All connections should be soldered, including those at the window strip, even if the latter is supplied with Fahnestock clips. The ground terminal of the receiver is then connected to the ground clamp and fastened firmly around a grounded pipe, as shown in Fig. 17–7.

The last requirement is one made by the National Board of Fire Underwriters, namely, the use of a lightning arrester, designed to
Fig. 17–5.—Attaching one end of the antenna.

Fig. 17–6.—Attaching the second end of the antenna.

Fig. 17–7.—Antenna accessories.
pass any heavy currents due to lightning to ground, rather than into the receiver. The arrester is merely connected directly from the antenna lead-in wire to a good ground connection, as shown in Fig. 17–8.

**Fig. 17–8.—The installation of lightning arresters.**

**TROUBLES COMMON TO THE ANTENNA**

Complaints related to the operation of the antenna may be divided into two main groups: weak signals delivered to the receiver, and noise pickup. Weak signal and its associated phenomenon, fading, will be considered as a servicing problem rather than an installation problem; that is, it will be considered as a problem arising after the antenna has been functioning properly for some time. Noise will be considered both as an installation and as a servicing problem and will be taken as the effect producing a low signal-to-noise ratio.

**Weak Signal and Fading.**—To check whether a condition of weak signal or fading is due to the antenna system, remove the connection of the antenna to the antenna post of the receiver. Then connect a length of wire to the post and see if the condition improves. If the receiver operates normally, making allowance for the short antenna of course, the trouble is in the antenna installation. If the condition does not improve, the receiver should be checked for the cause.
If this check shows a faulty antenna, a careful inspection of the entire antenna system must be made. Wires must be carefully checked for breaks. Corrosion at soldered connections is a common trouble. The antenna insulators must be checked to see if accumulated dirt has provided a leakage path across them for the signal current. The lightning arrester, in parallel with the leadin, must be checked to see that dirt has not provided a shunt path to ground for the desired signal.

Where fading occurs, the antenna should be inspected to see that it is not loose and swinging. Drawing the antenna taut and refastening it to the support will help the condition. Intermittent breaks, which make and break contact, will also cause fading. These are often found in window strips where constant opening and shutting of a window has broken the metal strap under the insulation. Another intermittent break may result from a poor connection at the junction of the flat-top and lead-in wire.

Noise Pickup.—Noise produced in a receiver may be traced to many sources, which may be grouped as follows:

1. Antenna pickup of noise—from natural electrical phenomena like lightning (called "static"), or from a noisy area produced by man-made electrical machinery.
2. Noise from the power lines.
3. Noise pickup by the receiver leads.
4. A noisy receiver.

For this section, the first source is of prime importance. But the others may not be dismissed, since the serviceman must know how to limit noisy reception to that source.

Lightning is simply a giant oscillatory spark from a cloud to ground, or from cloud to cloud. This spark produces a splash of radio waves of many frequencies, which produce noise voltages in near-by antennas. Nothing can be done about this situation. However, the serviceman need not be concerned about this fact because the noise will be infrequent, and this is generally recognized and understood by the average customer.

Much more significant is man-made noise picked up by the antenna or the receiver power lines. It is likely to be more or less constant and annoying to the listener, and therefore a valid servicing problem. The first question that must be answered by the serviceman is that of determining the source of the noise. To do this, the serviceman should remove the antenna and ground connections to the receiver, and short the antenna post to the ground post. Then the receiver is turned on. If the noise still persists, the noise orig-
inates either through the power lines or in the receiver itself. If the noise is eliminated, the antenna is probably at fault.

If the antenna is found to be at fault, a thorough visual check of the mechanical construction of the antenna system itself should be made. Possible mechanical trouble sources are tabulated below:

1. A grounding flat-top or lead-in. This may be due to swinging of the wires against some grounded object like a drain duct.

2. A break or poor connection in the system: flat-top to lead-in wire, ground lead to ground post, ground and antenna connections to the receiver, the window strip, etc.

3. Conductive dirt across the antenna insulators or the lightning arrester.

Fig. 17-9.—An antenna installed in a noise area.

Fig. 17-10.—Moving antenna out of the noise area.

Noise produced in the antenna system by the above defects will usually be of the type that produces irregular crackles. A simple check for breaks in the lead-in is to pull on the lead-in wire while listening to the radio. Increased noise indicates a break in the wire.

If the noise is more or less regular as picked up by the antenna, the trouble is that the antenna is in an area of noise. In modern apartment houses with elevator motors and other rotary or sparking electric machinery, there is likely to be a region of noise-producing radio waves of sufficient intensity to affect radio reception. This condition is shown in Fig. 17-9. If the antenna is a fairly short one, the remedy is simply to lengthen it in a direction such as to bring a major part of it in a relatively noise-free area, as shown in Fig. 17-10. Or the antenna might be elevated into a similar noise-free zone. A good
rule is simply to avoid installation of the antenna near elevator shafts, power lines, and similar noise producers.

A timesaving servicing instrument to aid in locating noise-free areas for antenna location is a portable battery-operated receiver. Tune it to a nonstation spot on the dial and listen for the presence of noise. The loop antenna of the portable test receiver is quite directional. The source of the noise will always be at right angles to the broad side of the loop. When the test receiver is moved into an area of minimum noise, a good location for the permanent antenna installation is located.

Even after the antenna flat-top has been placed in a noise-free area, the trouble may not be completely eliminated. The antenna leadin, passing through the noise area and being vertical, is especially prone to pick up noise voltages.

Several methods have been designed to isolate the leadin so that it does not pick up any signals whatsoever, but merely brings the signal from the flat-top to the receiver. One method uses a completely shielded lead-in wire of the type shown in Fig. 17-11. It must have low capacity between the lead wire and shield and must be weatherproof. The outside tinned shield must be connected to a good ground. This type of leadin will be good for the broadcast band if the flat-top is long, but will be inefficient for short-wave reception because of the losses resulting from the fairly high shield-to-conductor capacity. By the use of coupling transformers at the antenna and receiver, this loss may be reduced. Such a setup is shown in Fig. 17-12.

Another method uses a standard twisted-pair leadin, of special weatherproof wire. The connections are shown in Fig. 17-13.

Complete kits of noise-reducing antennas of various types are purchasable.

If the check, in which the antenna and ground leads were disconnected and their respective receiver posts shorted together, indicates that the noise is not due to antenna pickup, the other possible sources are noise from the power lines, noise pickup by the receiver leads, and a noisy condition within the receiver.

If the serviceman suspects that noise is originating from the power lines, he should take the receiver to his shop where he knows the normal level of noise from the lines. If the noise disappears on the shop bench, it must originate in the customer's power lines.
Fig. 17-13.—Noise reduction by the installation of coupling transformers and a shielded lead-in.

Fig. 17-13.—Noise reduction by means of a twisted-pair lead-in.

Fig. 17-14.—Line filter condenser in a receiver.
To reduce noise pickup from the power lines, many receivers use a line filtering condenser, as shown in Fig. 17–14, which is internally connected. A special consideration with respect to this filter, which by-passes noise frequencies to ground, comes up. In modern power lines, one line is "hot," and the other is grounded. To be effective, the condenser must be connected to the "hot" side. This condition is shown in Fig. 17–15. Sometimes, therefore, reversing of the line plug will reduce noise. Further, this line filtering condenser should be checked to see that it is not open. If a receiver has both lines of the power cord grounded through condensers, reversal of the line cord will, of course, make no difference.

Where possible, placing a filter across the offending equipment right at the source will help to reduce noise. A typical filter for the noise producer is shown in Fig. 17–16. Unfortunately, installation of such source filters is not always feasible.

When the checks show that the noise pickup is from neither the antenna nor the power lines, another possibility is noise pickup by the leads within the receiver. To check this possible source, the serviceman should try the operation of the receiver in another room, on the theory that the regular installation spot is a noisy area. The serviceman should also check that a bottom metal shield, if provided, is on and has not been removed. In some cases, such a bottom shield may be added, even though it has not been originally supplied.
When all other sources of noise have been eliminated, there remains a noisy receiver as a possible cause. The causative factor here may be broken connections, noisy tubes, grounded leads, corroded joints, etc. If, while the receiver is operating, the serviceman gives it a sharp slap and the noise becomes worse, then something within the receiver is probably the cause. The hunt for the cause of noise within the receiver is fully described in Chap. 23.

\[\text{Hank Antenna} \quad \text{Hank Antenna Mounted On A Moulding Strip}\]

Fig. 17-17.—The hank antenna.

ANTENNA VARIATIONS

There are several variations from the inverted-L type of antenna just described. Most of them present the same servicing problems as for the standard antennas.

Indoor Antennas.—Several types of antenna have been designed for indoor use to avoid the nuisance of an outdoor antenna. They are primarily for use with portable, table-model radios. One type is the hank antenna, so called because it is merely a hank of wire. It may be stretched out along the floor of a room or mounted on the molding, as shown in Fig. 17-17. Both give good reception for local broadcast stations but are rarely effective for good short-wave reception. They are prone to be noisy, especially in large apartment houses. Little can be done to improve that condition, except the construction of a large outdoor antenna.

Flagpole Antennas.—Many apartment-house owners forbid the construction of roof antennas. As an alternative, they furnish some sort of wall antenna connection. Unfortunately, most of these are poor. Of course, an indoor hank may be used. But a commercial flagpole antenna, similar to an auto-radio whip antenna, will pro-
Antennas

duce better results. It is mounted like a flagpole from the window, as shown in Fig. 17-18.

Loop Antennas.—In recent years, the loop antenna has come into vogue, especially with small, portable superheterodyne receivers.

![Flagpole Antenna Diagram](image)

**Fig. 17-18.**—The flagpole antenna.

It consists of several turns of wire and is connected directly across the tuning condenser, as shown in Fig. 17-19.

![Loop Antenna Diagram](image)

**Fig. 17-19.**—The loop antenna.

Loop antennas have small pickup, but modern superheterodynes are so sensitive that this is no weakness. However, the receiver may be in a noisy area. Provision is made to overcome this defect. A smaller primary is wound near the main loop, and this primary may be connected to a standard outdoor antenna. Energy is then
inductively coupled from the primary to the main loop. As a result, the signal-to-noise ratio is increased. The circuit is shown in Fig. 17–20.

If the receiver is installed in a very noisy area, the addition of the outdoor antenna may not be sufficient to give satisfactory reception, since the loop may still pick up much noise. In such a case, it is necessary to remove the loop and replace it with a standard antenna coil, a shielded one being preferred. Of course, realignment of the receiver will be necessary after such a substitution.

A loop is quite directional. Rotating the receiver will increase the signal pickup and increase the volume in the receiver. This condition is illustrated in Fig. 17–21, showing the top view of the loop.

Service notes for loop antennas are given in Chap. 14.
**Hertzian Ungrounded Antenna.**—Where a receiver is designed for broadcast and short-wave reception, the antenna design is made partial to short-wave efficiency rather than broadcast efficiency. This is because the former signals are usually weaker and more subject to instability.

A good antenna for such purposes is the Hertzian ungrounded antenna, shown in Fig. 17–22. It is also known as the simple doublet or dipole. The flat-top should be about 70 to 75 ft and with both sections of equal length, making reception especially good around the 49-meter short-wave band. In this antenna, reception for a particular frequency may be made highly efficient by making the

![Diagram of a Hertzian dipole antenna]

Fig. 17–22.—The Hertzian dipole antenna.

flat-top about one-half the wave length of the particular station desired. It will be fairly efficient also for broadcast stations. The leadin is a twisted-pair transmission line.

Although no ground is associated with the dipole antenna system, the receiver itself should have a good ground to prevent chassis pickup, etc.

The doublet is quite directional, receiving maximum signal when the broad side is in the direction of the desired station.

The servicing procedure for the doublet antenna is the same in other respects as that for the standard antenna. It should be high and in a noise-free area. Broken leads and connections will produce crackling noise. Shorts and breaks in the conducting wire may result and produce noise if the weatherproof insulation corrodes. A good check is to yank the leadin from the window and listen for noise in the receiver. Increased noise indicates such defects.
In connecting lightning arresters to a doublet antenna, Fig. 17–23 will serve as a guide.

Asymmetrical Dipole Antenna for All-wave Reception.—A system often used for all-wave receivers is that in which one section of the flat-top is made responsive to a particular short-wave frequency, and

![Diagram](image-url)

Fig. 17–23.—Connecting lightning arresters to a twisted-pair leadin.

![Diagram](image-url)

Fig. 17–24.—The asymmetrical dipole antenna.

the other section is made considerably longer for better pickup on the broadcast band. Matching transformers at the antenna and receiver ends of the leadin are also common. The short section is usually one-half the wave length of the desired short-wave frequency. Such an antenna is shown in Fig. 17–24.
A-M/F-M Receiver Antenna.—Figure 17–25 shows an antenna used for a combination F-M and A-M receiver. The F-M antenna is a dipole whose size is about one-half the wavelength of the center of the F-M band. The A-M antenna is a long lead connected at one end to one of the twisted-pair lead-in wires. A choke, made by coiling a few turns in the long A-M lead, prevents interaction between the two antennas.

QUESTIONS

1. What considerations must the serviceman keep in mind when installing an outdoor inverted-L antenna?
2. List several possible sources of noise pickup by an antenna and lead-in.
3. A receiver is reported as suffering from fading. A check of the receiver shows it is perfect. What might be the cause?
4. A receiver, after perfect operation for a long time, begins to produce crackling sounds. If it checks perfect, outline the procedure for tracking down the cause.
5. An antenna is to be installed near several power lines. What precautions should be taken to reduce noise pickup?
6. A receiver picks up noise from its power mains. What can be done to reduce the interference?
7. A receiver with a loop antenna is in a noisy area. Use of an outdoor antenna fails to reduce noise sufficiently. What can be done to reduce the noise further?
CHAPTER 18

AC/DC POWER SUPPLY

The wide popularity of the AC/DC type of receiver is due not so much to its ability to operate on either AC or DC lighting mains as to the fact that it makes possible an efficient inexpensive power supply for small receivers. The percentage of AC/DC receivers in use is very large as compared with the percentage of homes supplied by 110-volt DC lighting mains. The power transformer is an expensive unit, and its elimination in the AC/DC receiver accounts for its wide prevalence.

The signal circuits of the AC/DC receiver are the same as in an AC receiver, with minor differences. The signal checks and stage-gain data are approximately the same for both. The main difference between the two lies in the power supply. Throughout the text, in the voltage data for each stage, for example, reference was made to comparable operation in AC/DC receivers. This chapter will discuss the operation and service problems connected with the AC/DC power supply and will also cover points pertinent to AC/DC receivers not previously covered in the description of the various stages.

Quick Check for Proper Operation of the AC/DC Power Supply.—If all the tubes in the receiver light, the hum level is normal, and the B plus voltage measures approximately 90 volts, the AC/DC power supply is probably functioning normally.

Function of the AC/DC Power Supply.—The function of the AC/DC power supply is like that of any other type: to furnish the necessary A, B, and C voltages to the filament, plate, and grid circuits of the rest of the receiver. In this case, the power source is the 110-volt lighting mains, to be used regardless of whether it is alternating or direct current.

THEORY OF OPERATION OF THE AC/DC POWER SUPPLY

RF and push-pull second AF stages are rarely found in AC/DC receivers. These are common adjuncts of large receivers where expense is not the main factor. Large receivers, therefore, are AC-operated. There are some AC/DC receivers incorporating RF and push-pull output stages, but these are the exceptions that were
actually designed to give large-receiver qualities in districts powered by DC mains.

The most common type of AC/DC receiver uses a 5-tube superheterodyne circuit. The stages employed are a converter, IF, detector and AVC, first AF, second AF, and power supply. The detector and first AF stage functions are combined in one tube. A receiver of this type should be kept in mind while studying the power supply stage.

The power supply can be easily subdivided into a study of the A or heater circuit and the B or plate circuit.

Heater Circuits in AC/DC Power Supplies.—The heater circuit in the AC/DC power supply is so designed as to use tubes for the receiver which draw the same heater current. The heaters are connected in series, a dropping resistor is added if necessary, and then the circuit is connected directly across the power line.

Figure 18–1 shows an AC/DC heater circuit commonly used in early receivers of this type. The heaters will light equally well on alternating or direct current in the same way that an ordinary lamp will. The tubes shown all draw a heater current of 0.3 amp. The pilot lamp draws 0.15 or 0.25 amp depending on type, the excess current being taken by the shunt resistor R-16. As shown in the diagram, the voltage drop across the tube heaters is 68 volts and the drop across the pilot light is 4 volts, leaving 45 volts across the dropping resistor R-15 to make a total voltage drop of 117 volts.

Pilot-lamp shunt resistor R-16 is usually a wire-wound 5-watt resistor whose value ranges from 20 to 30 ohms. Calculations usually allow 4 volts across the pilot lamp because, although the lamp is rated at 6 to 8 volts, it is normally operated at reduced brightness owing to the heavy initial current drawn by this type of circuit. The cold resistance of the tube heaters is low. This causes a heavy current when first the receiver is turned on; the heavy current would burn out the pilot lamp. In addition to shunting excess current from the pilot lamp, resistor R-16 has the added function of allowing the receiver to operate if the pilot-lamp filament should open.
Dropping resistor \( R-15 \) is found in many forms. Sometimes it is a heavy-duty wire-wound resistor of approximately 150 ohms; sometimes it is a ballast tube; sometimes it is in the form of a wire resistor included with the other wires in the line cord. The last type is known as a "resistor-type line cord." All three types are pictured in Fig. 18–2.

![Types of voltage-dropping resistors for 0.3-amp heater circuits.](image)

Very often, resistors \( R-15 \) and \( R-16 \) are included in one tapped unit, the tap being used for the pilot-lamp wire.

In wiring up the tube heaters, it is usual practice to place the detector and first AF heater nearest \( B \) minus or ground potential, which is the position of minimum hum. The converter is usually next, to avoid hum modulation in the oscillator section. The sensitivity of the other tubes to hum places the RF and IF amplifiers next, followed by the second AF tube and finally the rectifier. This order is shown in Fig. 18–3.

With minor modifications, the typical circuit of Fig. 18–1 is capable of a large number of possible combinations. Figure 18–3
shows a variation of the same circuit to supply an RF tube and an extra pilot light.

Modern AC/DC receivers use tubes that have a heater drain of 0.15 amp. These tubes are very similar in all characteristics to the corresponding tubes with a heater drain of 0.3 amp. In order to maintain an equivalent heating effect on the cathode, that is, to dissipate the same wattage, the heater voltage is increased. Possibly an example will help clear up this point.

<table>
<thead>
<tr>
<th>Pentagrid converter</th>
<th>6SA7</th>
<th>12SA7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater voltage, volts</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Heater current, amp</td>
<td>0.3</td>
<td>0.15</td>
</tr>
<tr>
<td>Heater wattage, watts</td>
<td>1.8</td>
<td>1.8</td>
</tr>
</tbody>
</table>

The net result of using tubes with heaters that require higher voltage and lower amperage is to eliminate the line dropping resistor. Figure 18-4 shows a modern AC/DC heater circuit.

![Fig. 18-4.—A typical AC/DC heater circuit for 0.15-amp tubes.](image)

The total voltage drop required by the tube heaters adds up to 121 volts. This is slightly higher than the line voltage, which is considered to be 117 volts for all calculations. However, actual line voltage is usually 120 volts. Operation of the receiver will be very little affected if the applied voltage is somewhat larger or smaller than the rated voltage. Receivers with a circuit and tube complement similar to that shown in Fig. 18-4 are considered suitable for operation on line-voltage ratings between 105 and 125 volts.

Note that the pilot-light shunt resistor has been eliminated also. It is replaced by part of the heater of the 35Z5-GT rectifier tube, which is provided with a special tap for the purpose.
In order to use more tubes in a receiver and still take advantage of the simplicity of the heater circuit of Fig. 18–4, some special tubes were designed. These include the 35L6-GT beam-power tube, the 6S7 RF and IF pentode, and the 6AF6-G electron-ray tube. The heater requirements for these tubes are given in the accompanying table.

<table>
<thead>
<tr>
<th>Tube</th>
<th>Heater voltage, volts</th>
<th>Heater current, amp</th>
</tr>
</thead>
<tbody>
<tr>
<td>35L6-GT</td>
<td>35</td>
<td>0.15</td>
</tr>
<tr>
<td>6S7</td>
<td>6</td>
<td>0.15</td>
</tr>
<tr>
<td>6AF6-G</td>
<td>6</td>
<td>0.15</td>
</tr>
</tbody>
</table>

An example of a 6-tube AC/DC heater circuit is given in Fig. 18–5.

![Heater circuit for a six-tube receiver using 0.15-amp tubes.]

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**B Power Supplies in AC/DC Receivers.**—The B power supply in AC/DC receivers consists of a half-wave rectifier and filter circuit. Figure 18–6 shows a typical circuit.

Condenser C-17 acts as a line filter to keep RF disturbances like those caused by refrigerator motors, electric shavers, etc., from affecting the receiver. In addition, since one side of the line is grounded, it acts to ground the receiver, no other ground connection being used with AC/DC receivers. It is usually a 200-volt condenser, capacity ranging from 0.006 to 0.25 mfd.

The rectifier tube is a 25Z5, 25Z6-GT, 35Z4-GT, or 35Z5-GT depending on the heater design of the receiver. The 25Z5 and 25Z6-GT tubes are twin diodes, but the plates and cathodes are usually connected in parallel to form the same half-wave rectifier circuit shown in Fig. 18–6. The function of the rectifier is to allow current to flow in only one direction, from cathode to plate, thereby suppressing current flow in the load on the negative phase of the applied voltage.

When the receiver is operated on a DC line, the rectifier simply acts as a series resistor. It is important that the line plug be in-
serted in the correct polarity, so that the positive side of the line is connected to the rectifier plate.

Another point is to be noted in the AC/DC power supply. Voltages on AC operation will measure higher than on DC operation. This is because the output voltage on AC operation is greater than the applied rms or effective voltage, since the condenser input filter system will give peak voltage or nearly so, depending on the load and capacity of the input filter condenser. In DC operation, the output is more nearly the same as the applied voltage.

The filter circuit consists of the speaker field, and C-15 and C-16, the input and output filter condensers. Its purpose is to smooth the pulsing rectifier output into a direct current suitable for application to the plate circuits of the other tubes in the receiver.

The speakers used in AC/DC receivers are usually 4-, 5-, or 6-in. electrodynamic units, depending on the size of the cabinet in which the receiver is housed. These speakers have a field coil of approximately 450 ohms. The inductance of these small fields is comparatively low, approximately 8 henrys as against an average of 15 henrys for the larger speakers usually found in AC receivers. Because of this and the fact that half-wave rectifiers require more filtering than is needed with full-wave rectifiers, the average AC/DC filter circuit is not so efficient as similar circuits in AC receivers. The normal hum level, however, is no higher than in the case of AC receivers, since the speakers and audio channels usually give poor low AF response. The output at 60 cycles, the hum frequency, is negligible.

Input filter condenser C-15 is most effective in reducing hum and maintaining the output voltage. Output condenser C-16 also reduces hum and acts as the decoupling filter circuit for the plate
circuits of the entire receiver. Both filter condensers are usually 20 mfd or higher electrolytic types rated at 150 volts DC. They are usually enclosed in the same container.

A voltage divider is not needed in an AC/DC power supply since the full B plus voltage is usually applied to the plate and screen circuits of all tubes. The only exception to this is the screen of a 6A8 or 12A8 pentagrid converter. When one of these tubes is used, the screen voltage is usually supplied by a suitably by-passed dropping resistor of approximately 30,000 ohms.

Some AC/DC receivers make use of a P-M dynamic speaker. In this case, the filter circuit usually employs a small choke to replace the field coil in the same circuit of Fig. 18–6. Operation is similar except for a slightly higher B plus voltage. This is due to the fact that a choke of inductance equivalent to the field winding has a lower DC resistance. Some receivers with P-M speakers use an R-C filter circuit, as shown in Fig. 18–7. Since the resistor in the filter circuit cannot be of very high ohmic value without materially reducing the output B plus voltage, filter condenser capacities are increased to 40 or 60 mfd in order to maintain efficient filtering. Another method is to make use of a two-section R-C filter.

**Floating Chassis Circuits in AC/DC Receivers.**—Early AC/DC receivers connected B minus to the receiver chassis, as shown in Fig. 18–8. Since one side of the lighting mains is always grounded, it is desirable that B minus be connected to that grounded main. However, if the plug is reversed, B minus (and therefore the chassis) would be connected to the “hot” side of the line. Various disadvantages would result.

First, the antenna may become grounded. An outdoor antenna or lead-in wire may ground on some grounded object. Some installations use a steam radiator antenna which is grounded through the water mains. All AC/DC receivers use a small condenser in series with the antenna circuit to isolate the antenna and to avoid
possible short circuits resulting from a grounded antenna. However, if the condenser were to short, then the grounded antenna would be connected to the hot side of the line and would short-circuit the power mains. Or, if the insulation of the antenna wire were to become frayed as it goes through the chassis and make contact between the wire and chassis, it would connect the chassis ground to the grounded antenna, again resulting in a short across the mains. The dotted line in Fig. 18-9 traces the path of the short circuit under these conditions.
Another way in which the chassis may become grounded is connected with the portability of small AC/DC receivers. People carry receivers of this type from room to room in their homes, set them down on any convenient spot, plug in, and enjoy their favorite programs. If the convenient spot turns out to be a steam radiator, there is likelihood of a short circuit through the chassis holding bolts which extend through the bottom of the cabinet.

This problem of possible short circuits of the lighting mains through the chassis does not occur with AC receivers, since the power transformer automatically insulates B minus and the chassis from any direct contact with the line. In AC/DC receivers B minus must be connected to one side of the line.

Many modern AC/DC receivers avoid the possibility of short-circuiting the line through the chassis by "floating" it, that is, insulating the chassis from B minus and consequently the line. A receiver of this type is the Motorola 61X11 series shown in Fig. 18–10.

The line switch connects to B minus. Note the use of the special symbol to denote B minus. This makes the diagram easier to read, since so many circuits are connected to B minus that connecting them with a line would complicate the drawing. The chassis is connected to B minus through the 0.25-mfd condenser near the line switch. Since this condenser offers practically no impedance to RF currents, it permits many components to be connected to the chassis and still act as if they are grounded. These components are the rotor of the gang-tuning condenser, the tube and coil shields, and the antenna coil primary. Its impedance is high with regard to low frequencies and therefore serves to isolate B minus from chassis for them.

NORMAL TEST DATA FOR THE AC/DC POWER SUPPLY STAGE

Quick Check.—The AC/DC power supply stage is probably functioning properly when

All tubes light or heat.
The hum level is normal.
There are no bad squeals or motorboating.
The B plus voltage measures approximately 90 volts to the common negative terminal.

This is the quick check for the stage.

The serviceman should familiarize himself with the normal brightness of tube heaters, since any marked variation is indicative of trouble in the heater circuit. Another aid to determining trouble in this regard is the length of time it takes for the tubes to reach
Fig. 18–10.—Schematic circuit of the Motorola 61X11 receiver.
their proper operating temperature. Tube brightness is not of great importance when AC receivers are serviced, since variations in applied heater voltage are infrequent.

If the quick check indicates trouble in the power supply, disconnect the plug and discharge the filter condensers by shorting them before proceeding to further checks. The filter condensers may retain a charge with subsequent danger of shock or damage to test equipment. This precaution is especially necessary in AC/DC receivers because there is usually no bleeder to discharge the filter condensers automatically.

**Normal Resistance Data.**—Normal resistance data are given in the following table:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line plug prong to prong (switch closed)</td>
<td>200–400 ohms</td>
</tr>
<tr>
<td>Rectifier cathode to B plus</td>
<td>450 ohms</td>
</tr>
<tr>
<td>Rectifier cathode to common negative</td>
<td>Condenser action</td>
</tr>
<tr>
<td>B plus to common negative</td>
<td>Condenser action</td>
</tr>
</tbody>
</table>

The reading from plug prong to prong takes in the heater circuit. There will be considerable variation in this reading depending on whether the tubes are still warm or not. Resistance of tube heaters, as of most conductors, varies with temperature. At the time of testing, the tube heaters may be anywhere from room temperature to several hundred degrees with a consequent difference in the resistance reading.

Readings in all AC/DC receivers should be taken from the common negative terminal rather than from the chassis. The common negative terminal is found either at the line switch or at the negative terminal of the filter condenser, both of these being easily identified parts.

The readings from the common negative to B plus or rectifier cathode are called "condenser action" because the electrolytic filter condensers are connected across these points. Since there is usually no bleeder in an AC/DC power supply, the point at which the ohmmeter needle comes to rest will indicate the leakage of the electrolytic condensers. Reverse the test prods and take the higher reading as the leakage resistance.

**Standard Circuit.**—The standard circuit is shown in Fig. 18–11.

**Normal Voltage Data.**—Normal voltage data are shown in the following table:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common negative to rectifier plate</td>
<td>117 volts AC (line)</td>
</tr>
<tr>
<td>Common negative to rectifier cathode</td>
<td>110–120 volts DC</td>
</tr>
<tr>
<td>Common negative to B plus</td>
<td>85–95 volts DC</td>
</tr>
</tbody>
</table>

Heater voltages should be measured across each tube heater. The normal heater voltage for each tube is the rated voltage as
found in the tube manual. An easy way of knowing the normal heater voltage is the first number in the tube designation. For example the heater of the 50L6-GT is rated at 50 volts, 25Z5 at 25 volts, etc. Loctal tubes, an exception to this, can be recognized by the numbers 14 and 7. The 14B6 and the 7C6 are locking-base detector and first AF tubes. Their heaters are normally operated at the same 12 and 6 volts, respectively, as the corresponding 12SQ7 and 6SQ7 octal base tubes.

![Diagram of a typical AC/DC power supply]

Fig. 18–11.—Schematic diagram of a typical AC/DC power supply.

Note: Common negative is connected to the chassis unless the receiver is of the floating-chassis type. In this case, common negative is connected to the chassis through a condenser.

COMMON TROU BLES IN THE AC/DC POWER SUPPLY

**Troubles Common to 0.3-amp Heater Circuits.**—Since the heater circuit in an AC/DC receiver is a series chain, any open in any part of the circuit will cause the entire circuit to be open and the tubes will not light. The series chain includes the line cord, the dropping resistor, the pilot-light circuit, the tube heaters, and the switch. A break in any one of these can cause failure of the tubes to light, and all of them are common troubles. The serviceman must be able to find the break quickly and efficiently.

When the tubes in an AC/DC receiver do not light, a good way of determining the cause is to make a continuity check of the heater circuit with an ohmmeter. Checking across the two prongs of the line plug with the switch turned to the on position should, of course, show an open circuit. If it shows the normal reading of 200 to 400 ohms, the receiver had been plugged in to a defective or dead line outlet.

The next check should be from the common negative side of the switch to each of the line-plug prongs, as shown in Fig. 18–12. One of the line-plug prongs should show continuity (zero resistance) to the common negative wiring. If neither prong shows continuity,
the trouble is in the line cord connected to the switch or in the switch itself. Which of these two is at fault is determined by further checking across the switch terminals.

![Fig. 18-12.—Checking the line cord and switch in an AC/DC heater circuit.](image1)

If the check from common negative to the line plug shows continuity to one of the line-plug prongs, the test prod is shifted to the other prong that connects to the heater wiring, and this circuit is checked.

The heater circuit of a receiver whose tubes draw 0.3 amp is shown in Fig. 18–13, R-15 and R-16 being a ballast tube, a heavy-duty resistor, or a resistor in the line cord. The checks will be the same for all three.

![Fig. 18–13.—Checking the voltage-dropping resistor in an AC/DC heater circuit.](image2)

The plug prong that connects to the heater circuit has already been determined. Checking from this prong to the rectifier heater shows whether the dropping resistor is open. Checking from the plug prong to the rectifier plate shows whether the line cord to the plate is open. If these show continuity, the open is in one of the tube heaters. The tubes are then checked in a tube checker or by an ohmmeter check across each pair of heater terminals. Of the tubes commonly used in receivers of this type, all heater pins are terminals 2 and 7 except the 6SQ7 detector and first AF tube, the heater pins of which are 7 and 8.
A word of caution might be mentioned at this point. When any defective condition in an AC/DC power supply is found and repaired, the filter circuit should be checked from rectifier cathode to the common negative, before plugging in. A shorted filter condenser will ruin a rectifier tube.

**Repairing Breaks in Resistor-type Line Cords.**—If the continuity check shows an open-line dropping resistor in a resistor-type line cord, it may be an easily repaired break. As was mentioned before, AC/DC receivers are often carried from room to room thereby giving the line cord and plug a greater than normal amount of handling. The resistance wire is attached to one of the plug prongs or to its associated wire, and, being a solid wire, it is much more easily broken by handling at this point than the other stranded line cord wires.

![Diagram of line cord repair](image)

**Fig. 18-14.**—Repairing a break at the line plug in a resistor-type line cord.

The plug should be taken apart and inspected. If a break in the resistance wire is found at this point, a repair is easily effected, since a slightly shorter length will not make much difference. When making the repair, the serviceman should, of course, be careful to connect the resistance wire to the proper lead. This is the one that shows continuity to the rectifier plate, as shown in Fig. 18-14. Taping the asbestos-covered resistance wire to its associated plate wire adds strength against future breakage.

Breaks in other parts of the line cord are not easily found and call for replacement of the entire cord.

**Replacement Notes on Resistor-type Line Cords.**—Replacement resistor-type line cords have various values of resistance, usually 135, 160, 180, 200, 220, 250, and 290 ohms. Some larger sizes are also available as well as various tapped units. The taps are for purposes of a pilot-lamp connection as well as to make the line cords more universally adaptable.

The proper resistance value is calculated as follows. The tube
heater voltages are added. In the receiver of Fig. 18-15, this would come to 68 volts. Adding 4 volts for the pilot lamp makes a total of 72 volts for the heaters and pilot lamp. Subtracting from 117 volts leaves 45 volts to be dropped in the line cord resistor. The resistance value can then be found by substituting in Ohm's law, knowing that the tubes, and therefore the circuit, draw 0.3 amp.

\[ R = \frac{E}{I} = \frac{45}{0.3} = 150 \text{ ohms} \]

The standard resistance-type line cord nearest in value is 160 ohms. The serviceman should always choose the value just higher than the calculated value in order to conserve the life of the tubes in the receiver. A 180-ohm line cord, tapped at 160 ohms, could also be used, 20 ohms being the correct shunt for a 150-ma brown-bead pilot lamp.

If separate pilot-lamp shunt resistors are employed, 5-watt/20-ohm resistors should be used for the 150-ma brown-bead pilot lamps, and 5-watt/30-ohm resistors for the 250-ma blue-bead pilot lamps. The bead mentioned is the glass bead that supports the filament in the pilot lamp, as shown in Fig. 18-16.

How to Identify Leads in a Resistor-type Line Cord.—The leads of a resistor-type line cord are usually color-coded for identification, but the coding has not been standardized. It is usually possible to recognize the resistor lead by its asbestos covering, but sometimes even this is replaced by an ordinary lead.

The following procedure identifies the leads in a tapped resistor-type line cord. It can be applied even more easily to an untapped resistor.

Connect one prod of the ohmmeter to either prong of the line.
plug. Connect the other test prod to each lead coming out of the line cord. As can be seen by referring to the diagram of Fig. 18–17, it will show continuity to either three leads or one, depending on the prong used. This identifies the single lead, which is usually coded red and connects to the switch in the receiver.

Connect one test prod to the plug prong that shows continuity to the three leads. Check resistance to each of these three leads on the $R$ or $R \times 10$ scale of the ohmmeter. One will show a resistance of zero ohms or short. This lead, which is usually colored black, connects to the plate of the rectifier tube.

Then carefully check the resistance from the same plug prong to each of the other leads. The one showing the higher value of resistance is the end of the resistor. This lead, usually white (asbestos), connects to the heater of the rectifier tube. The last lead is the tap that connects to the pilot lamp.

Sometimes the braided covering of the resistor-type line cord is brought to a tie-cord finish at the lead end. Do not mistake this for a lead. After the line cord has been installed in the receiver chassis, fasten the tie cord to a convenient point. Its purpose is to take the strain from the other leads.

Replacement Notes on Ballast Tubes.—When a ballast tube is replaced, the serviceman should be careful to use the proper replacement. Failure to do so may cause inefficient operation of the receiver, or a shortened life for the other tubes in the receiver. The R.M.A. coding for ballast tubes is given for ease in determining the proper ballast tube to be used.

Standard R.M.A. Designation Code for Ballast Tubes.—Ballast tubes are designated by a letter, followed by a number, and followed by a second letter as in the following example: K-55-B.
The first letter designates the type of pilot lamp:
K = 6- to 8-volt/150-ma lamp (brown bead).
L = 6- to 8-volt/250-ma lamp (blue bead).

The numbers designate the total voltage drop produced by the ballast including the pilot-lamp voltage.

The last letter designates the type of base wiring, as shown in Fig. 18–18.

![Diagrams of different base wirings for ballast tubes]

Fig. 18–18.—Standard base wiring for ballast tubes.

Some manufacturers use the letters BK for the first or pilot-lamp designation. This denotes a special pilot-lamp shunt section which limits the current delivered to the lamp when the receiver is first turned on.

The accompanying table lists the usual voltage drops (including pilot-lamp voltages) provided by the manufacturers of ballast tubes and the receiver tube complements for which they are intended.

<table>
<thead>
<tr>
<th>Dropping voltage</th>
<th>Rectifier</th>
<th>Second AF</th>
<th>No. of 6-volt tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>12Z8</td>
<td>48</td>
<td>2</td>
</tr>
<tr>
<td>61</td>
<td>12Z8</td>
<td>48</td>
<td>3</td>
</tr>
<tr>
<td>55</td>
<td>25Z5</td>
<td>25L6</td>
<td>2</td>
</tr>
<tr>
<td>49</td>
<td>25Z5</td>
<td>25L6</td>
<td>3</td>
</tr>
<tr>
<td>42</td>
<td>25Z5</td>
<td>25L6</td>
<td>4</td>
</tr>
<tr>
<td>36</td>
<td>25Z5</td>
<td>25L6</td>
<td>5</td>
</tr>
<tr>
<td>30</td>
<td>25Z5</td>
<td>25L6</td>
<td>6</td>
</tr>
</tbody>
</table>

As an example of how the R.M.A. listing can be used, assume that the receiver of Fig. 18–19 has an open ballast tube on which the markings cannot be read.
6A7  T2  6D6  T3  6Q7G  25L6G

I-F peaked at 456 KC
Switch shown in broadcast position
Position No.1 Police
Position No.2 Broadcast

View looking at pins of ballast tube R12, which has an overall voltage drop of 49V at 3 amp. Voltage drop across pilot light is 4 volts

6 Tube AC DC Receiver

Fig. 18-19.—Schematic diagram of the Emerson Model BH-203 receiver.
Inspection of the pilot lamp shows a blue bead supporting the filament. This makes the first letter L. Adding up the heater voltages brings the total heater voltage to 68 volts. Subtracting 68 volts from 117 volts (the nominal line voltage) gives a voltage drop of 49 volts for the dropping resistor and pilot lamp. This makes our ballast L-49. Next the wiring is examined to determine the pins connected to the pilot lamp. This is compared with the type of base wiring shown in Fig. 18-18 and found to be type B. The correct replacement ballast is a type L-49-B.

**Replacement Notes on Line Dropping Resistors.**—When a line dropping resistor of the type pictured in Fig. 18-20 is replaced, the serviceman should try to get an exact replacement. When this is not obtainable, mounting and space requirements and the possibility of harming near-by parts by heat dissipation make it advisable to replace the unit with a resistor-type line cord rather than a resistor of proper resistance and wattage specifications. Calculating the resistance value and making provision for the pilot-lamp shunt is considered under the replacement notes for resistor-type line cords.

When an exact replacement is used, examine and replace the connecting leads if the insulation has deteriorated because of heat.

**Troubles Common to 0.15-amp Heater Circuits.**—The 0.15-amp heater circuit of the more modern AC/DC receivers is the same series chain as the 0.3-amp circuit, uncomplicated by a line dropping resistor. The same procedure described on page 329 can be used to determine an open line cord, pilot-lamp circuit, tube, or switch.

The pilot-lamp circuit is somewhat different and deserves special attention. The pilot-lamp shunt resistor is part of the heater of the 35Z5-GT rectifier tube. In addition, the plate of the rectifier tube is usually fed from the pilot-lamp tap as shown in Fig. 18-21.

If the pilot-lamp shunt section of the rectifier tube opens, the pilot lamp burns out owing to the overload, and the heater circuit opens. When making a continuity check, the serviceman, in finding the open circuit, should remember that this is a shunt circuit and that both branches are open, requiring replacement of both the pilot-lamp and rectifier tube.

**Blinking AC/DC Receivers.**—A fairly common complaint with AC/DC receivers is that, when the radio is turned on, it seems to operate normally for a short time but then stops and the pilot lamp goes out. A few seconds later, the lamp lights up again, reception
may or may not be resumed only to go off again, and blink on and off intermittently.

This condition is caused by an intermittent thermal open in one of the tube heaters. When the tube heats up, the circuit opens; when it cools down sufficiently, it heals again. The offending tube may or may not act the same way in a tube checker where the conditions of applied heater voltage are likely to be different from those in the receiver.

![Pilot-lamp circuit for a 0.15-amp heater line.](image)

When servicing a blinking AC/DC receiver, if the tube checker gives no indication, the serviceman may use either one or two methods. He can replace the tubes one at a time and observe receiver operation after each replacement. In doing so, it is best to start with the rectifier and second AF tubes since these turn out to be at fault more often than the other tubes in the receiver.

The other method is to operate the receiver with the AC voltmeter (150-volt scale) hooked across individual tube heaters in turn. A good tube will show normal heater voltage when the receiver is on. This will drop to zero voltage when the receiver blinks off. The offending tube will also show normal heater voltage while the receiver is on, but this will rise to line voltage, 117 volts, when the receiver blinks off.

Troubles Due to a Short between Heater and Cathode.—Heater-type tubes are so constructed that the heater is inside a closely fitted cathode, and shorts between the two are fairly common. In an AC receiver, both heater and cathode are near ground potential so that a short between them will affect a bias potential or introduce a hum, confining the trouble to one stage. In an AC/DC receiver, a similar trouble will have more widespread effects.

Consider the circuit of Fig. 18–22 and assume a short between the cathode and heater of the 12SA7 converter tube. Since the converter cathode is connected to the common negative through the
low resistance of the feedback coil, a short between its heater and cathode will short out the detector first AF tube heater.

With glass tubes, the situation would be sufficiently obvious as trouble somewhere in the heater circuit; when metal tubes are used, the trouble would be more obscure. Signal check would show a normal second AF stage and a dead first AF stage, and the serviceman would lose time checking a perfectly good first AF stage until he reaches the point of replacing the tube, when he would notice that it is not even warm.

Similarly, a short between heater and cathode of the 12SK7 IF tube would short out the converter and detector first AF tubes. In either of the above cases, the line voltage would divide itself among the remaining tubes and make them much brighter than normal.

![Diagram of cathode-to-heater short](image)

Fig. 18–22.—How a cathode-to-heater short affects other tubes.

The fastest way of recognizing troubles of this sort is for the serviceman to be on the alert for troubles in the heater circuit. These constitute a large proportion of all service difficulties experienced with AC/DC receivers. Even if the tubes in the IF, converter, and detector first AF stages are metal tubes, the rectifier and second AF tubes are usually glass. When the heaters in these tubes appear to be too bright, a heater-cathode short should be suspected and checked for.

The tubes can be tested in a tube checker which discloses cathode-heater shorts. Possibly a faster method of finding the offending tube is to remove the detector first AF tube, fully expecting the others to remain lighted. When this happens, the cathode-heater short is confirmed and the converter tube is also removed. If the other tube heaters start to dim down, the short is in the converter tube; if they remain bright, the shorted tube is still in the receiver. It is probably in the IF tube, which is then removed for confirmation.

Troubles in the B Power Supply in AC/DC Receivers.—The $B$ power supply in AC/DC receivers is similar to the $B$ power supply in AC receivers except for the lower voltages involved. The unit is subject to the same troubles in the rectifier, the choke, and the input and output filter condensers which were described in detail in Chap.
8. To avoid repetition, the trouble and service procedures will be briefly outlined here except for those circumstances which apply to AC/DC receivers only.

When the quick check discloses normal heater operation, coupled with hum, motorboating, low or no $B$ plus voltage, the trouble is probably in the $B$ power-supply section of the receiver.

**Troubles Common to the Rectifier Tube.**—Aside from trouble in the heater, the rectifier tube may become weak or entirely inactive, resulting in low or no $B$ plus voltage. When this is the case, a tube checker will confirm the condition. Before replacing the tube, the serviceman should first check the filter circuit. This should be done because rectifier tubes used in AC/DC receivers have an easily fused cathode lead inside the tube. This internal cathode lead will melt on any overload, such as that caused by a shorted filter condenser, thereby ruining the new tube.

**Troubles Common to the Input Filter Condenser.**—The input filter condenser commonly opens and occasionally shorts. When the condenser is open, the receiver hums and the $B$ plus voltage is low—approximately 30 volts. The receiver may still operate weakly at the low voltage, but the quality of the reception will be badly garbled by hum.

The low voltage is due to the use of a half-wave rectifier, the output of which is half of the average of the applied voltage, when the rectifier is not followed by a condenser input filter. This is the condition when the input filter condenser is open. The rectifier output drops to approximately 50 volts, which is reduced to 30 volts on the $B$ plus end of the filter. The best check for this condition is to substitute a test condenser.

When the condenser shorts, it will short the rectifier output, giv-
ing zero $B$ voltage. The condition will be found on resistance check, the resistance from the rectifier cathode to $B$ minus checking short instead of the charge reading of the condenser. The condenser should be replaced with one of the same capacity and voltage rating as the original. The rectifier tube will also have to be replaced since the short will have ruined it.

When replacing either filter condenser in an AC/DC power supply, the serviceman should be careful to use the correct capacity and voltage rating. Using condensers with higher voltage rating is not advisable, since experience has shown that electrolytic condensers rated at 450 volts used for replacement purposes in AC/DC receivers deteriorate rapidly.

**Fig. 18-24.—Skeleton $B$ circuit of a typical AC/DC receiver.**

**Troubles Common to the Output Filter Condenser.**—The output filter condenser $C-16$ also opens and rarely shorts. When it is open, the receiver operates, $B$ plus voltage is normal, the receiver may hum slightly but it surely will squeal or motorboat, or both. This effect is much more apparent in AC/DC receivers than a similar condition in AC receivers, since the output filter condenser is usually the sole by-pass agent for all screen and plate circuits.

The best check for this condition is to bridge the condenser with a test condenser.

The output filter condenser may also short. This condition will be found by no voltage at $B$ plus and almost normal voltage at the rectifier cathode. The rectifier tube may not be harmed owing to the intervening resistance of the speaker field. Since a short at this point may be due to other agencies—for example, the IF plate trim-
mer shorting to its shielding—Fig. 18–24 shows a complete B circuit of a typical receiver, for analysis of the likely locations of the short.

**Troubles Common to the Speaker Field.**—The speaker field is the filter choke in the AC/DC power supply and the common difficulty encountered is an open field winding. This would cause no reception and no voltage at B plus. Voltage at the rectifier cathode would be high—150 volts or more, the peak voltage of the line.

When this condition is found, the receiver plug is removed from the outlet, and the filter condensers discharged by shorting them before making a resistance check to confirm the condition.

An open field winding usually necessitates replacing the entire speaker. The replacement chosen should be exactly like the original or match it as closely as possible in physical and electric details.

**General Service Notes Pertaining to AC/DC Receivers.**—The circuit of an AC/DC receiver causes some problems in service procedure and techniques. For example, when a signal generator is connected for signal check or alignment, a bad hum may be experienced. This is especially prevalent in the floating-chassis type of receiver. It can usually be avoided by connecting the shielded lead from the signal generator to the common negative rather than to the chassis. Another expedient that sometimes gives good results is to connect the shielded ground lead through a 0.1-mfd condenser. The isolating condenser will still be used in the “hot” lead.

Another difficulty often experienced is when the test bench is ringed with a grounded metal trim. This will cause shocks to the serviceman and danger of short circuits if the chassis should touch the metal trim. Another danger of short circuits exists when the signal generator test lead is connected. If this has exposed shielding, it is likely to touch any grounded object such as the plate of an electrical outlet, thereby causing a short circuit.

### Variations in AC/DC Power Supplies

**Fixed Bias in AC/DC Receivers.**—Some AC/DC receivers develop a voltage in the B minus lead for use in fixed-bias circuits. Figure 18–25 shows the schematic diagram of the Pilot B-3 receiver. The two resistors in the upper right corner of the diagram marked “47 ohms, part No. 30–352” are connected from B minus to ground. The negative end feeds C voltage to the grid of the 35L6 tube, the cathode of which is grounded. The tap between the two resistors is brought to the AVC bus to furnish the delay voltage for the AVC system.
Fig. 18-25.—Schematic diagram of the Pilot Model B-3 receiver.
From the servicing point of view, the power supply should be checked with the $B$ minus end of the switch as the reference point, rather than the chassis. Then all checks would be the same as for the standard circuit with the exception of the output filter condenser and the bias circuit. These should be checked by referring to the diagram.

**Filter Circuits in AC/DC Receivers That Use P-M Speakers.**—Most AC/DC receivers use dynamic speakers, the field coil acting as the filter inductance. When P-M speakers are used and the field coil is replaced by a small choke in the filter circuit, operation and service problems are the same as when a dynamic speaker is used. When an R-C filter is used, certain service problems arise.

Figure 18–26 shows one type of such a filter circuit. The filter choke is replaced by a resistor, the value of which varies in different circuits from 600 to 1,500 ohms. It is usually a 2-watt size or larger. The filter condensers are usually at least 40 mfd in capacity. When working on a receiver of this type, the serviceman should expect the $B$ voltages to measure 70 to 80 volts rather than the 90 volts of most AC/DC receivers.

The filter resistor is subject to considerable heating and may change in value or open. If this resistor has to be replaced, the serviceman should try to get the same values of resistance and wattage rating as the original. A smaller resistance value will give less efficient filtering while a larger value will give less $B$ plus voltage and be more subject to heating. Also, if replacement of the filter condensers becomes necessary, the same or larger capacity values should be used.

**Two-section R-C Filters.**—Some receivers use a two-section filter, as shown in Fig. 18–27. Since the second AF tube is the last amplifier, it does not require so much filtering as the other tubes in the receiver. Also the signal-handling capacity of the tube is improved by the larger $B$ voltage available at the mid-point of the filter. The first resistor is usually a low-ohmage value, 100 to 300 ohms. The second varies from 1,000 to 1,500 ohms in different receivers. Both resistors are usually the 1-watt size. The filter condensers are each at least 20 mfd. Frequently, the first and third condensers $C-15$ and $C-16$ are 40 mfd or greater. The voltage rating is 150 volts.
When servicing a receiver of this type, the serviceman should expect a high voltage reading at the second AF plate, and normal voltage readings for all other points in the receiver. An open output condenser C-16 will cause squealing, motorboating, or a combination of both. An open input filter condenser C-15 will cause low B voltage and hum. An open mid-section filter condenser C-115 will cause hum. The service notes on the filter resistor previously given for the single-section R-C filter also apply to the two filter resistors in the two-section R-C filter.

![Diagram of a circuit with labels B+, B-, and values 100-300 Ω, 1000-1500 Ω, 20 MFD, and 80-90V.]

**Fig. 18-27.—Two-section R-C filter.**

**Tapped Output-transformer Filter Systems.**—Some receivers make use of a tap on the output transformer to introduce a humbucking voltage to cancel the hum that would otherwise appear in the speaker. Figure 18-28 shows an R.C.A. 16X-1 receiver which uses a filter circuit of this type.

The cathode of the rectifier connects to the input filter condenser C-24 and the tap on the output transformer. The lower section of the output transformer is in series with the filter resistor R-16 which furnishes the B-plus voltage to the rest of the receiver. Condenser C-25 is the output filter condenser. The location of the tap on the output transformer is designed so that just the right amount of humbucking voltage is introduced.

From the servicing point of view, all checks are the same as for the usual AC/DC receiver except for the higher than usual second AF plate voltage. If the output transformer should become defective, it would be necessary to obtain an exact replacement. An ordinary center-tapped output transformer could not be used since this would introduce too much hum. In replacing the transformer, the serviceman should be careful to connect the leads properly since any reversal would cause hum, weak output, or both.

If an exact replacement transformer cannot be obtained, an
Fig. 18-26—Schematic diagram of the RCA Victor Model 10X-1 receiver.
ordinary matching transformer can be used and the filter circuit revised in any one of the following ways.

1. Use the circuit of Fig. 18–29. In case the hum level is high, it may be reduced by adding a 20-mfd/150-volt condenser as shown by the dotted lines.

![Fig. 18–29.—Replacing a hum-bucking-type output transformer. Method 1.](image)

2. Use the circuit of Fig. 18–30. This filters the second AF plate voltage supply also and will decrease the B plus voltage. The filter resistor should be replaced by one of higher wattage.

![Fig. 18–30.—Replacing a hum-bucking-type output transformer. Method 2.](image)

3. Use the circuit of Fig. 18–31. This replaces the filter resistor with a small choke. This method is satisfactory, provided that there is room in the receiver to mount the choke.

4. Use the circuit of Fig. 18–32. This provides a second section R-C filter.

5. Use the circuit of Fig. 18–33. This replaces the P-M speaker with an electrodynamic unit.
Fig. 18-31.—Replacing a hum-bucking-type output transformer.  Method 3.

Fig. 18-32.—Replacing a hum-bucking-type output transformer.  Method 4.

Fig. 18-33.—Replacing a hum-bucking-type output transformer.  Method 5.
SUMMARY

Quick check for normal operation of the AC/DC power supply.

All tubes light at normal brightness.
The hum level is normal.
There are no bad squeals or motorboating.
The $B$ plus voltage measures approximately 90 volts to the common negative terminal.

Standard circuit.

This circuit is shown in the accompanying figure.

![Circuit Diagram]

**Note:** Common negative is connected to the chassis unless the receiver is of the floating-chassis type. In this case, common negative is connected to the chassis through a condenser.

**Normal resistance data.**

Plug prong to prong (switch on) ........................................... 200–400 ohms
Rectifier cathode to $B$ plus ........................................... 450 ohms
Rectifier cathode to common negative .............................. Condenser action
$B$ plus to common negative ........................................... Condenser action

**Normal voltage data.**

Common negative to rectifier plate .......................... 117 volts AC (line)
Common negative to rectifier cathode ......................... 110–120 volts DC
Common negative to $B$ plus ........................................... 85–95 volts DC
## AC/DC POWER SUPPLY

**SERVICE DATA SHEET**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Abnormal reading</th>
<th>Look for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubes do not light</td>
<td>Plug prong to prong checks open</td>
<td>Open line cord. Open switch. Open dropping resistor (resistor, resistor-line cord, or ballast). Open pilot light and pilot-light shunt resistor. Open heater in one of the tubes</td>
</tr>
<tr>
<td>Pilot lamps keep burning out</td>
<td></td>
<td>Open pilot-lamp shunt resistor</td>
</tr>
<tr>
<td>Pilot lamp blinks on and off</td>
<td></td>
<td>Intermittent thermal open in the heater of one of the tubes</td>
</tr>
<tr>
<td>Some tubes are overly bright, others do not light or warm up</td>
<td></td>
<td>Cathode-heater short circuit in one of the tubes</td>
</tr>
<tr>
<td>Tubes light—no reception</td>
<td>No B plus voltage</td>
<td>Dead rectifier tube, short-circuited input filter condenser, or both</td>
</tr>
<tr>
<td>Tubes light—no reception</td>
<td>No B plus voltage. Low voltage from common negative to rectifier cathode</td>
<td>Short-circuited output filter condenser. Short in the B plus wiring</td>
</tr>
<tr>
<td>Tubes light—no reception</td>
<td>No B plus voltage. Voltage from common negative to rectifier cathode measures 150 volts</td>
<td>Open filter choke (speaker field). (Discharge filter condenser before checking)</td>
</tr>
<tr>
<td>Tubes light—bad hum</td>
<td>B plus voltage measures 30 volts</td>
<td>Open input filter condenser</td>
</tr>
<tr>
<td>Tubes light and receiver motorboats, squeals, or both</td>
<td>B plus voltage normal but jumps with the motorboat</td>
<td>Open output filter condenser</td>
</tr>
<tr>
<td>Modulation hum</td>
<td>All tests normal</td>
<td>Open line filter condenser C-17</td>
</tr>
</tbody>
</table>

**QUESTIONS**

1. The tubes in an AC/DC receiver do not light. List the possible causes and explain how you would check for each.

2. A dead AC/DC receiver is brought in for repair. All the tubes light, there is no hum or squeal, and the B plus voltage measures zero. List the likely causes of trouble and outline how you would check for each.
3. An AC/DC receiver continues to burn out pilot lamps. What is likely to be wrong and how would you check for it?

4. The receiver of Fig. 18–19 needs a new ballast tube. The necessary L-49-B ballast tube is not in stock, but a K-49-F and an L-42-B are on hand. Draw a wiring diagram of the heater circuit indicating the necessary changes needed so that the K-49-F ballast tube could be used. Repeat for the L-42-B.

5. When an AC/DC receiver hums, what is likely to be wrong and how would you check for it?

6. It is desired to add a 6AF6-G electron-ray tube to the receiver of Fig. 15–2. It is proposed to accommodate the extra heater by changing the 50L6-GT tube in the second AF stage to a 35L6-GT. Redesign the heater circuit to accomplish these changes. Give the value of the needed resistor in ohms and watts.

7. What precautions should be taken before replacing a dead rectifier tube in an AC/DC receiver?

8. In an AC/DC receiver, the 35Z5-GT and the 50L6-GT tubes light up very brightly. The receiver does not play. What is likely to be wrong and how would you check for it?

9. What is the most probable cause of a tunable hum (modulation hum) in an AC/DC receiver?

10. Calculate the values of the line dropping resistor and pilot-lamp shunts needed for the circuit of Fig. 18–1. Assume 150-ma pilot lamps and a voltage drop of 4 volts across each. Give the values in resistance and wattage rating.

11. When an AC/DC receiver squeals badly, which unit in the power supply can cause this condition? How would you check to determine whether or not this unit is at fault?

12. In the B circuit breakdown of Fig. 18–24, assume than an ohmmeter check from common negative to B plus gives a reading of 40 ohms. List some of the likely locations of the short. Outline a procedure that could be used in tracking down the short.

13. The receiver of Fig. 18–10 chirps at a staccato rate. A voltmeter connected from the common negative to B plus reads about 80 volts, but the meter pointer fluctuates with each beat of the motorboat. What is the probable cause of the trouble and how would you check for it?

14. List the bench provisions and techniques that should be observed when working with AC/DC receivers relative to the use of grounds, accidental grounding, and connections to a signal generator.

15. What is the most probable cause of a blinking pilot light in an AC/DC receiver? Outline a test procedure that will determine the exact cause.

16. The receiver of Fig. 18–28 has an open output transformer. An exact replacement is unobtainable. What method would you use to repair it?
CHAPTER 19

AUTOMOBILE RADIO INSTALLATION

Radios designed to operate in automobiles are, for the most part, superheterodyne receivers incorporating radio frequency, converter, intermediate frequency, detector, two audio stages, and a power supply. This chain makes the auto receiver very similar to the standard home receiver. The differences lie in the special provisions made for operation under the conditions found in an automobile. These include reception with a small antenna, operation in a field of considerable radio noise disturbance due to the electrical system of the car, and utilization of the power source available—the 6-volt storage battery.

The same servicing procedures which locate a defective IF transformer, for example, in a home receiver, will locate a similar fault in an auto receiver. This chapter and the next, therefore, will deal with the special servicing problems which relate to auto receivers alone—to repeat, operation with a short antenna, electrical noise, and the auto radio power supply.

The first two are primarily design and installation problems rather than service problems. However, since the radio serviceman is often called upon to install auto radios, change them from one car to an-
other, or check for motor noise, these items will be covered in some detail in this chapter. The next chapter deals with the auto radio power supply.

Typical Auto Radio Installation.—Figure 19–1 shows a typical auto radio installation. The receiver itself is usually mounted to the dash of the car behind or below the instrument panel. The antenna shown is the one in most common use, the side-cowl antenna, sometimes called the “buggy whip.” It is insulated from the car and is

![Image of a car with an antenna](image)

Fig. 19–2.—Common automobile radio antennas. (A) Side-cowl; (B) insulated section of car body; (C) topper; (D) disappearing-cowl.

connected to the radio receiver by a length of low-capacity, shielded leadin wire. Power for the receiver is usually obtained through a lead connected to the ammeter on the instrument panel, and the ammeter is in turn connected to the “hot” side of the storage battery. The car frame or chassis acts as the common return lead. The receiver picks up a ground connection through its mounting bolts to the dash, and the ground side of the battery is connected to the car frame by a heavy bonding strap. The radio controls, dial, volume, etc., are usually mounted in a cut out designed for the purpose on the instrument panel of the car.

Antennas for Auto Radios.—The auto radio antenna most often used is one of the types that mount on the cowl of the car. This is a
vertical telescopic antenna, the maximum length of which averages about 4 ft. The telescopic sections are plated for appearance and freedom from corrosion. The type illustrated in Fig. 19–2D is adjustable in length from inside the car. These antennas are extended to full length to permit maximum signal pickup. The topper antenna illustrated in Fig. 19–2C is a similar type and is mounted over the roof of the car. The topper is usually not adjustable.

Some car manufacturers insulate a section of the car body and use this insulated portion as the radio antenna. The part chosen for the purpose may be a door, the cover of the trunk compartment, or a section of the roof. Older cars that did not use the all-metal body construction often were equipped with an antenna that consisted of a wire mesh screen built into the roofing material. In addition to these there are some antennas designed for mounting under a car.

These various antennas may be classified into two general groups: low-capacity and high-capacity types. The low-capacity antennas which act like a condenser of from roughly 25 to 250 micromicrofarads include the side-cowl and topper types. The high-capacity antennas whose capacity is roughly 250 to 2,500 micromicrofarads include the metal insert top, the roof screen, insulated door, and trunk cover. Under-car antennas may belong to either grouping depending on the area of the antenna and its closeness to the car frame. In general, the high-capacity antennas will pick up greater signal strength.

**Auto Radio Antenna Coupling Circuits.**—The coupling between the antenna and the RF amplifier grid is somewhat different in automobile radios than in home radios, in that provision is made to tune the input circuit so as to match it with the antenna being used. This allows for maximum transfer of energy and compensates for the comparatively small signal pickup of the small antennas used. A typical automobile radio antenna coupling circuit is shown in Fig. 19–3. The antenna signal is impressed across the 0.006-mfd condenser and condensers C-2 and C-2A. The junction feeds the main tuning section made up of coil L-1 and condenser C-1. Condenser C-1 is the antenna section of the gang tuning condenser. Parallel condenser C-1A is a trimmer and is used to align the circuit at 1,400 kc in the usual way. Condenser C-2 and its associated trimmer condenser C-2A are used to match the receiver to the antenna being used. Trimmer condenser C-2A is located so that it is accessible for adjustment after the radio is installed and connected to its antenna. The procedure is to tune the radio to a weak station at about 600 kc and adjust the trimmer for maximum response.
The range of trimmer condenser C-2A is usually not great enough to permit alignment with all automobile antennas. Usually the radio is designed to work with a side-cowl or other low-capacity antenna, since these are the most popular types. If such a radio were to be installed in a car equipped with an insulated top section or other high-capacity antenna, the adjustment would not bring the 600-kc station to a peak response. In that case, a condenser of approximately 500-microfarad (0.0005-mfd) capacity is con-

![Diagram of radio antenna coupling circuit](image)

Fig. 19-3.—Automobile radio antenna coupling circuit.

nected in series with the antenna, thereby lowering the capacity and bringing the antenna system within the scope of the trimmer.

Similarly, the condition is sometimes encountered where a custom-built radio, designed to work with a high-capacity antenna, is reinstalled in another car equipped with a low-capacity antenna. Again, the antenna compensation condenser would be ineffective and reception would be poor—weak signals and a high noise level even on local stations. In this case, the condition could be rectified by connecting a condenser of approximately 250-microfarad (0.00025-mfd) capacity from antenna to ground, thereby increasing the capacity and bringing the antenna system within the scope of the trimmer.

**Motor Interference.**—From the point of view of the generation of RF interference, the ignition system of an automobile is really a spark transmitter. The sparks at the distributor and the spark plugs feed RF energy to the ignition wiring, which may be looked upon as the transmitting antenna or source of the ignition interference. The radiations feed energy to the entire electric system of
the car and to any ungrounded metal parts in or near the motor compartment. The diagram of Fig. 19–4 represents the ignition system as a transmitter.

The signal generated by the ignition system is very broadly tuned and will cover the entire broadcast band. Its strength in the near vicinity of the motor compartment is about equal to that of a strong local broadcast station. As a result, if no provisions were made to reduce the ignition signal, it would be received by an automobile radio all over the tuning range equally as strong as a strong local station, thereby interfering with all reception. Interference from this source is called "ignition" interference and can be identified as a series of ticks in the speaker at the same rate of speed as the spark plugs are firing in the motor.

The generator is an additional source of disturbance because of the sparking at the brushes. The generator noise is distinguishable because its pitch is higher than that of ignition noise. Still another source of noise is a static electricity charge, generated by the rotating wheels, discharging periodically to the axle.

**General Notes on Reduction of Motor Interference.**—The reduction of motor interference to a point where it will not disturb broadcast reception takes in three main factors. The RF radiation is reduced at the source by means of suppression, shielding, etc. The antenna is placed in a position where it will receive a minimum of signal from the motor. The radio itself is thoroughly shielded, so that the only signal applied to it comes from the antenna.

**Reduction of Ignition Interference.**—Radiation from the ignition system can be reduced by installing a suppressor resistor in series with the high-tension lead, which connects the ignition coil and the center connection of the distributor. Figure 19–5 shows a typical
distributor-suppressor installation. The suppressor should be installed close to the distributor connection.

The resistor in the distributor lead reduces oscillations produced by the spark and, therefore, radiation. In the case of early automobile radios, suppressor resistors were also installed in each spark-plug lead. This procedure would affect the motor performance by reducing the intensity of the spark and is not recommended. Fortunately, a careful installation makes it unnecessary to use more than

![Diagram of distributor-suppressor installation.](image)

the one suppressor resistor in the distributor lead. This does not materially affect motor performance.

In the case of some cars, the high-tension wiring to the distributor is inaccessible. On these cars, a distributor suppressor cannot be used.

In modern motors, the distributor is usually centrally located with respect to the cylinders, and the ignition coil is close by, thereby making for short high-tension leads with a consequent reduction in radiation from these leads. In addition, some car manufacturers route the high-tension leads through metal conduits or spreaders that are grounded to the motor block, thereby partly shielding the leads and further reducing radiation.

The metal hood that covers the motor compartment is an important point in the reduction of ignition noise. When the hood is well grounded, a shield is interposed between the motor compartment and a roof or side antenna. The hood hinges and its holding clamps may
not make good electric contact with the car frame. A hood bond is usually employed to ensure the effectiveness of the shield.

Figure 19–6 shows a typical hood-bond installation. The bond is a piece of brass one surface of which has been serrated to give an effect like the teeth of a rasp. The bond is attached to the cowl panel by means of a self-tapping screw in such a way that the teeth are on top of the hood weather stripping. The self-tapping screw gives a good contact to the cowl panel while the teeth of the hood bond make good contact to the hood when it is closed. The hood bond need not be installed when the antenna is located under the car.

In the above discussion, the importance of shielding the motor compartment has been stressed. However, the serviceman should be warned against making any attempt to shield the high-tension wires themselves. Although this may be effective in reducing ignition noise, it must be remembered that the shielding would constitute a near-by ground to leads which are carrying current at extremely high voltage, and excessive leakage would result.

Removing Interference from Conductors near the Antenna.—Since the high-tension wiring is the main source of ignition noise, and the dash, hood, and car chassis form a shielded compartment around the source, any antenna installed outside of this compartment will be relatively free of ignition noise. This is particularly true for antennas installed outside of the cowl and over the roof of an all-metal body construction, where the nearest conductors are the grounded body cowl or roof. The other types of antennas, however, may pick up ignition interference from near-by wiring or other ungrounded conductors.

An antenna that consists of an insulated section of the roof or a screen in the roof will be subject to interference from the dome-light wiring. This type of interference can be identified by the fact that
it will be reduced slightly when the dome light is turned on. Interference from this source is removed by installing a condenser on the dome-light wiring, as shown in Fig. 19-7.

The dome-light wiring usually goes up the right-hand corner post. The condenser is connected to the wire near the point where it goes up the corner post, thereby by-passing the ignition signal out of the wire. Some manufacturers recommend the use of a filter at this point. The filter includes an RF choke as well as the condenser and is therefore somewhat more effective. The filter or condenser is grounded to the cowl panel near the corner post.

![Diagram of dome-light wiring with condenser and filter](image)

**Fig. 19-7.**—Condenser installation to remove ignition interference from the dome-light wiring.

An under-car antenna may be subject to interference from the near-by gas gauge or stop-light wiring. The same wiring may cause interference in an antenna that consists of an insulated trunk cover. The under-car antenna may also pick up interference from the transmission housing or muffler, which extends toward the rear from the motor compartment, and may not be well grounded. This type of interference may be eliminated by installing condensers on the wiring and bonding on the ungrounded conductors. Figure 19-8 shows the installation of a gas-gauge condenser. Figure 19-9 shows the installation of a grounding bond on a transmission housing. When a bonding strap is used, it should be as short and heavy as possible and all paint and grease should be cleaned away under the connection nuts so as to provide good ground contacts. Although the bonding strap should be short, it should provide some slack to avoid breakage from vibration.

**Reduction of Chassis Pickup.**—The radio itself is thoroughly shielded by its container so that there will be no pickup of signal (motor noise or otherwise) from any source but the antenna. Figure 19-10 shows a top view of a typical installation. The mounting
nut that holds the radio to the dash provides the ground for the radio. The installation man should carefully remove paint from under the nut so as to make sure of this ground contact. Another good ground contact is established at the antenna end of the shielded lead-in wire. The cup that encloses this contact usually has a serrated surface, which makes good contact to the body cowl when the antenna assembly is tightened in place.

In spite of the shielding, motor interference sometimes gets through to the radio owing to its position in a relatively noisy field. Interference of this type is known as “chassis pickup.” It can be identified by its presence even after the antenna is disconnected from the radio.
Interference of this type is usually carried to the radio by the steering column, temperature and oil-line tubing, and brake, throttle, and speedometer cables that lead through the dash to the motor compartment. It can be removed by bond-grounding the cables where they enter the dash from the motor compartment. Figure 19-11 shows a method of connecting the ground. The cables, tubing, and steering column are cleaned with fine emery or sandpaper. The bonding braid is wrapped and connected under the holding screws as shown. Paint is removed from under the screw head. The connection can be made permanent by spot-soldering the braid to the cable.

Any wiring, other than the antenna, entering the radio, like the battery lead or the leads to an external speaker, is also a possible source of noise. However, the original design of the radio places filters at the entrance point for this wiring inside the radio, to bypass any motor interference. These filters are in a low-voltage circuit and do not break down. From the servicing point of view they may be neglected.

Reduction of Generator Interference.—Sparking at the generator-commutator will also cause interference. This type will be recognized as a high-pitched whine which increases in pitch and intensity as the motor speed is increased.

Generator interference is reduced by installing a condenser on the battery side of the generator. Two typical installations are shown.
in Fig. 19–12. The installation man should remember the usual precaution of removing paint from under the ground connection.

**Reduction of Wheel Static Interference.**—The wheels, in turning, generate static electricity which discharges to the axle, thereby radiating some RF interference. This interference will not usually affect a roof or topper antenna, owing to the shielding of the car body. However, its effect will be noticeable when an under-car antenna is used, and sometimes a cowl antenna will also pick up some disturbance from this source. The front wheels are the greater offenders, since they are usually weighted for wheel-balancing purposes. In addition, the rear wheels are usually grounded more effectively, thereby preventing the generation of static charges.

![Diagram of static collector and spring installation](image)

**Fig. 19–13.—Front-wheel static-collector-spring installation.**

Wheel static interference usually starts when the car is traveling at a fair speed on a smooth, dry road. It can be recognized by driving until the interference starts and then turning off the ignition key and coasting. If the interference persists with the motor turned off and gradually disappears as the car loses speed, it is caused by wheel static.

This type of interference can be reduced by installing static-collector springs. The latter are spring contacts that ground the wheel to the axle, thereby eliminating the static. Various types of collector springs are available to fit the various makes of automobiles. Figure 19–13 shows the installation of two typical static-collector springs. Wheel weights should be cleaned for good contact to the tire rims.

**Checking for Motor Interference.**—Motor interference need not be entirely eliminated. Like hum in a home radio receiver, a certain amount of motor interference is permissible. Good judgment should
be used as to just how much interference is objectionable. The car owner, of course, is the final judge in this regard, but the serviceman should have some idea of a normal degree of motor interference.

In general, reception from local stations should be completely free of motor interference. A slight amount of it may be tolerated when listening to weak distant stations, since a high noise level is the general expectation in this case. When the radio is tuned to a position between stations, the AVC circuit brings the receiver to a condition of maximum sensitivity, and some motor interference can be expected. Some automobile radios have noise-reducing squelch circuits. When this is the case, the receiver is prevented from reaching maximum sensitivity, and there should be no motor interference, regardless of the position of the receiver dial.

After the receiver has been competently installed and the motor interference is eliminated, there is usually very little service work needed in connection with motor interference. The interference condensers operate in low-voltage circuits and rarely break down. Occasionally, a condenser or bonding strap is removed in connection with general repair work on the automobile and is not replaced. A bonding strap may break, or grounding nuts may become loose. Any of these will cause complaints of motor interference. Usually, a visual inspection of the installation will locate the faulty condition.

The motor compartment should include a properly installed generator condenser and distributor resistor. Further inspection takes in the mounting nut for the radio and the ground connection at the antenna end of the shielded lead-in wire. The hood bond comes next, if the antenna is of the cowl or roof type. A roof an-
Antenna also calls for an inspection of the dome-light filter. An undercar antenna calls for inspection of the bonds on the transmission housing and muffler, and filters on the gas-gauge wiring.

To antenna in roof

Lead-in shielding grounded to cowl

Dome light wiring filtered at corner post

To dome light

Filter grounded to cowl

Dome light filter

Outline of instrument panel which is removed to permit better view

Corner post

Note
A generator condenser distributor suppressor and hood bond are also needed for this type of installation. These are as illustrated in figure 19-14

Fig. 19-15.—Standard automobile radio installation for cars with built-in roof antennas.

If the inspection does not reveal the trouble, the source of the motor interference may be more quickly localized by disconnecting the antenna plug from its receptacle and substituting a specially prepared antenna plug which grounds the antenna wire to the plug casing. If the motor noise stops, the antenna installation should be rechecked more carefully. If the motor noise continues, it is caused by chassis pickup, and the receiver ground-and bonding of
the tubing, which leads through the dash, should be more carefully checked.

As an aid in locating check points, Fig. 19–14 shows a standard installation for cars with cowl antennas, Fig. 19–15 shows a standard installation for cars with roof antennas, and Fig. 19–16 shows a standard installation for cars with under-car antennas.

GLOSSARY OF AUTOMOBILE RADIO TERMS

Bond. A lead used for grounding to the car chassis. It is usually a short, heavy, flat, flexible piece of tinned and braided copper, provided with connection lugs.

Buggy-whip Antenna. Same as the side-cowl antenna.

Cowl. The section of the body that is between the motor section and the front doors.

Dash. The wall between the motor compartment and the driver’s compartment. The dash is sometimes called the “fire wall.”

Distributor. The part of the ignition system that operates like a rotary switch to transfer the ignition current from the ignition coil to the various spark plugs in rotation.

Generator. The part of the automobile electric system that charges the storage battery. It is operated by the motor, usually by means of the fan belt. A generator is shown in Fig. 19–12.

Hinge Antenna. An antenna similar to the side-cowl type, but with a one-point mount designed to be fitted to the pin of the door hinge.

Hood. The hinged cover of the motor compartment.

Ignition coil. The part of the ignition system that supplies the high voltage required for firing at the spark plugs. It is cylindrical in shape and is usually mounted in the motor compartment.

Ignition Wiring. The varnished high-tension leads that carry the ignition current from the ignition coil to the distributor, and from the distributor to the spark plugs. The distributor, ignition coil, and ignition wiring are shown in Fig. 19–5.

Instrument Panel. The panel directly below the windshield on which is mounted the ammeter, speedometer, gas gauge, etc. It is sometimes called the “dashboard.”

Roof Antenna. A wire screen mesh antenna placed in the roof of cars that have a fabric-top construction.

Running-board Antenna. A plate or series of metal straps designed to be mounted below the running board.

Side-cowl Antenna. An antenna mounted on the cowl.

Topper Antenna. An antenna designed to be mounted over the roof of the car.

Turret Top. An all-metal body construction, which includes the roof of the car and prevents the use of any antenna inside the car.
SUMMARY OF GENERALIZED INSTALLATION NOTES

The installation of radios in automobiles offers individual problems depending on the type of car and the type of radio. The serviceman is referred to the instruction sheets that come with the radio for dealing with specific cases. Certain recommendations will apply to all installations, and these are tabulated below.

1. Clean the area around the holes cut for mounting the radio so as to establish a good chassis ground contact.

2. Establish a good ground connection for the antenna end of the lead-in wire.

3. Connect the antenna and "hot" battery lead, and adjust the antenna compensating condenser. Where a high-capacity antenna is used with a radio designed for a low-capacity antenna, connect a series condenser in the antenna lead.

4. Install the generator condenser and distributor suppressor.

5. Install (a) hood bonds for a cowl, top, or roof antenna, (b) a dome-light filter for a roof antenna, (c) a gas-gauge filter, wheel static collector springs, and bond muffler and transmission housing for an under-car antenna.

6. Bond steering column and control cables as they enter the dash.

7. Check for motor interference.

8. Check for wheel static.

QUESTIONS

1. An automobile radio has the following motor interference complaint: a high-pitched whine which gets louder and higher pitched as the car speed is increased. What is likely to be wrong? How would you correct it?

2. An automobile radio is removed from a car with an insulated top antenna and installed in a car with a cowl antenna. The antenna compensating adjustment will not come to a peak. What is wrong and how would you correct it?

3. An automobile radio is troubled with motor interference only while the car is in motion. What is likely to be the cause of the trouble, and what is the remedy?

4. An automobile radio operating with a cowl antenna is troubled with motor interference, which stops when the antenna is disconnected. Outline your check procedure in servicing this complaint.

5. A check establishes motor interference as coming from an under-car antenna. How would you proceed to eliminate the trouble?

6. A car with an insulated top antenna is troubled with excessive motor interference. Outline a check procedure for eliminating the trouble.

7. An automobile radio is installed in a car with an insulated top antenna. The antenna compensating adjustment will not peak. What is wrong and how may it be corrected?

8. What is the check for chassis pickup? How is interference from this source reduced?
CHAPTER 20
AUTO RADIO POWER SUPPLIES

Quick Check.—If all the tubes in the receiver light, the vibrator is buzzing, the hum and hash level are normal, and the $B$ plus voltage measures approximately 200 volts, the auto radio power supply is probably functioning normally.

Function of the Auto Radio Power Supply.—The function of the auto radio power supply is like that of any other type: to furnish the necessary $A$, $B$, and $C$ voltages to the filament, plate, and grid circuits of the rest of the receiver. In this case, the power source is the 6-volt storage battery, which is standard equipment for the electric system in the automobile.

![Diagram of auto radio heater circuit]

Fig. 20–1.—Typical auto radio heater circuit.

THEORY OF OPERATION OF THE AUTO RADIO POWER SUPPLY

The $A$ power or heater circuit of the auto radio is quite simple. All tubes are of the 6-volt heater type, and are connected in parallel and fed directly from the battery. The only special provision made is the installation of a filter circuit designed to prevent motor noise from entering the radio through the "hot" battery lead. Figure 20–1 shows a typical $A$ power-supply circuit.

The condenser marked s.p. is connected to the "hot" battery lead at the point where it enters the receiver. It consists of a metal plate insulated from the chassis by a thin sheet of mica. The piece of
metal is one plate of the condenser, and the chassis is the other. Condensers of this type are called "spark plates." Figure 20-2 shows such a spark plate connected in the circuit. They have a very small capacity but are effective in filtering RF currents. The rest of the filter consists of the 0.5-mf condenser C-1 and the RF choke L-1. The latter is about 30 to 50 turns of heavy wire wrapped in the form of a flat coil, the diameter of which is approximately 1 1/2 in. The choke offers opposition to any current at radio frequency, while the two condensers offer an easy path to ground, thereby keeping radio frequency out of the receiver from this source. The choke is wound with heavy wire in order to carry the heavy current of the receiver (5 to 8 amp).

![Diagram of spark-plate filter]

**Fig. 20-2.**—Spark-plate filter connected to the "hot" battery lead at the point of entry to the receiver.

**Auto Radio B Power Supplies.**—Early auto radios were entirely battery-operated. The car battery was used for the A supply and a set of B batteries took care of the plate requirements of the receiver. The next step was replacing the B batteries with a dynamotor powered by the car battery. The dynamotor combines motor and generator in one unit, the motor operating from the 6-volt battery, and the generator delivering an average DC output of 180 volts at 50 ma. Dynamotors are still used as the source of high potentials suitable for B power in a large number of mobile electronic devices. However, in automobile radio, a vibrator type of B power unit was developed and has been universally adopted. This chapter, therefore, will confine the discussion entirely to the vibrator type of B power supply.

**Vibrator-type B Power Supplies.**—Vibrator-type B power supplies operate by changing the magnetic field that results from a direct current in the primary of a step-up transformer. The changing field induces high alternating voltage in the secondary of the transformer. The secondary voltage is then fed through a rectifier and a filter in the usual way to supply the high-voltage direct current
necessary to operate the plate circuits of the receiver. This sequence can be illustrated by the block diagram of Fig. 20-3. Grid bias voltage or C power supply is obtained in the usual way by self-bias or voltage divider circuits.

Some receivers use a mechanical rectifier consisting of an extra pair of points on the vibrator. Such a system is known as a "synchronous-vibrator" type of power supply and is described in the variations section of this chapter.

![Block diagram of a vibrator-type B power supply.](image)

**How the Vibrator Works.**—To understand vibrator operation consider first the circuit of Fig. 20-4. The battery sets up a steady magnetic field in the core of the transformer. A steady magnetic field does not induce voltage in the secondary. If the battery terminals are reversed, the magnetic field goes through a reversal, which is a change that induces voltage in the secondary winding.

![Transformer fed with direct current.](image)

![Reversing direct current through a transformer primary.](image)

The reversal of the magnetic field could be accomplished by using a single-pole, double-throw switch and the circuit of Fig. 20-5. The primary winding is center-tapped, and the battery connected to the tap. When the switch is in the position shown, current flows through the top half of the primary winding and sets up a magnetic field. When the switch is thrown and makes contact with the bottom terminal, current flows through the bottom half of the primary winding and sets up the opposite magnetic field. The changing field induces voltage in the secondary winding. When the switch is thrown again, the magnetic field is reversed again, inducing a secondary voltage.
again, this time in the opposite direction. If the switch is thrown rapidly, an alternating voltage is set up in the secondary winding.

If the switch of Fig. 20–5 is replaced by a pair of contacts on a magnetically vibrating reed, we have the basic circuit of all vibrator type B power supplies. This is shown in Fig. 20–6. At the starting position, current flows through the top half of the transformer primary winding and the vibrator coil, which are in series. The vibrator coil becomes an electromagnet which attracts the reed upward, making the top contact. The top contact shorts out the vibrator coil, and a heavy current flows through the top half of the primary winding. The deenergized vibrator coil allows the reed to break the top contact, swing through the starting position, and make the bottom contact. This drives a heavy current through the bottom half of the transformer primary reversing the magnetic field. The

![Diagram of a typical vibrator used in auto radio power supplies and a basic vibrator circuit.](image)

broken top contact removes the short across the vibrator coil, and it is energized once again, attracting the reed upward. This cycle of events repeats itself continuously. The constant reversal of the magnetic field in the core of the transformer induces an alternating voltage in the secondary winding. The frequency of this alternating voltage is determined by the mechanical structure of the vibrator. This is adjusted by vibrator manufacturers to be approximately 115 cycles per second.

**Vibrator Hash.**—The making and breaking of current at the vibrator contacts are accompanied by sparking. The sparking decreases the life of the vibrator points and causes RF interference in the receiver. This interference is known as “hash.” Practical vibrator circuits include provision for spark suppression and hash filters. A typical circuit is shown in Fig. 20–7.

Condenser C-3 is known as the “buffer” condenser. It takes up the high-voltage surges that would otherwise result from the rapid magnetic changes taking place during the time the reed is traveling
between contacts. It also is effective in reducing sparking at the contacts. The condenser stores energy during high-voltage periods. The discharge circuit is the transformer, and the inductance of the transformer forms an oscillating circuit with the capacity of the condenser. For this reason, the capacity of the buffer condenser is an important factor in the design of the power supply, and its value should not be changed in service work. The buffer condenser is sometimes called a "surge condenser" or a "timing capacitor." Common values for the buffer condenser vary from 0.005 to 0.03 mfd. The condensers used are of the oil-filled type with a rating of 1,600 volts.

Resistors $R-1$ and $R-2$ are connected across the vibrator contact points and are also effective in reducing sparking and hash. These resistors vary in different circuits from 50 to 200 ohms.

They form a discharge path for back electromotive force in the primary which would otherwise cause a heavier spark at the contact break. These resistors rarely cause any service difficulty. Sometimes condensers are used in the same circuit instead of resistors $R-1$ and $R-2$.

The vibrator choke and condenser $C-2$ form a hash filter. The choke acts to keep RF current from the vibrator out of the receiver heater lead, while the condenser offers a short path to ground for
the same currents. A similar hash filter is sometimes also connected to the B plus output lead.

Other methods used for hash suppression are the total shielding of the vibrator, and sometimes of the power supply itself. The

vibrator is shielded by being enclosed in a metal can. The entire power supply is often shielded by being enclosed in a metal compartment of the receiver assembly, as shown in Fig. 20-8.

Rectifiers Used in Auto Radio Power Supplies.—The vibrator and transformer convert 6 volts DC to a high-voltage alternating current. This is fed to a conventional full-wave rectifier and filter circuit.

The rectifier in most common use is a full-wave, high-vacuum rectifier of the heater-cathode type. The circuit is shown in Fig. 20-9.
The heater-cathode type of construction is necessary because the heater is fed by the battery and is therefore at ground potential. The rectifier cathode in a full-wave circuit, on the other hand, is at the highest DC potential.

The 6X5-G and 6X5-GT tubes are the most widely used rectifier tubes in auto radio receivers. Receivers that feature locking-base tubes use the 7Y4 type. Older auto radio receivers use the 6Z4 and 84 types. All these types have about the same ratings and characteristics.

**Cold-cathode Rectifiers.**—Some receivers use a cold-cathode type of rectifier tube, like the OZ4 and OZ4G, which do not use a filament or heater to obtain electron emission from the cathode. Instead,

![Diagram of OZ4 Rectifier Circuit](image)

**FIG. 20–10.—Cold-cathode type of rectifier circuit.**

they contain a gas which ionizes when the AC potential is applied. The cathode of the tube is bombarded by gas ions until it emits electrons, after which the tube rectifies in the usual way. Figure 20–10 shows the circuit of the cold-cathode type of rectifier tube. The tube emits a purplish glow when it is operating.

Gas-filled rectifiers introduce an RF disturbance or hash of their own. Circuits of this type, therefore, require an extra hash filter. Condensers C-4 and C-5 serve this purpose in the circuit of Fig. 20–10. The condensers function as RF by-pass units. Their usual value is 0.0008 mfd.

Some receivers are wired so that either a 6X5-G heater-cathode type or an OZ4 cold-cathode type rectifier may be used. This is very easily arranged, since the plate and cathode pin numbers of both types of tubes are the same.

**Auto Radio B Filter Circuits.**—The auto radio power supply uses
a standard L-C filter circuit to smooth the rectifier output. It consists of a small B choke and two electrolytic condensers, as shown in Fig. 20–11. The input and output filter condensers are usually rated at 10 mfd/300 volts. The choke usually has an inductance of 10 to 20 henrys. Auto radio receivers do not use the field of an electrodynamic speaker as a B choke. The speakers in these radios are either of the P-M dynamic type or, when electrodynamic units are used, the field winding is a 4- to 6-ohm coil, which is fed by 6 volts DC from the heater line.

![Fig. 20–11.—Filter circuit in the vibrator-type power supply.](image)

Some receivers use an R-C filter circuit. In this case, the B choke is replaced by a resistor, the value of which is 1,000 to 2,000 ohms. The filter condensers may also be increased in capacity to 20 mfd to maintain efficient filtering. It must be remembered that filtering in auto radios is more efficient than is the case in home receivers, because of the higher hum frequency, resulting from the vibrator frequency of approximately 115 cycles per second.

Finally, some auto receivers include an RF filter in the B plus lead for hash suppression. A typical circuit is shown in Fig. 20–12. Condenser C-6 is a 0.01-mfd RF by-pass unit rated at 400 or 600 volts. The RF choke is wound with fine wire and has an average inductance of 20 mh.

Auto radio receivers rarely use a voltage divider. Screen voltages are usually obtained from B plus by suitably by-passed dropping resistors.

![Fig. 20–12.—An RF filter in the B plus circuit for hash suppression.](image)
A Typical Auto Radio Power Supply.—Figure 20–13 shows the schematic diagram of the Motorola Model 401 auto radio. Note the following points of interest in the power supply. The "hot" battery lead filter is composed of the A choke, part (10), the 0.25-mfd condenser (37), and the two spark plate condensers labeled s.p. The hot lead then goes through the switch on the volume control, from which point it branches off to feed the dial lamp, speaker field, tube heaters, and power supply. RF choke (11) feeds the tube heaters, and vibrator choke (9) feeds the power supply. Note the spark plate condenser as the lead enters the power supply. The vibrator choke feeds the vibrator and also the 6X5-GT rectifier tube heater, the latter being separated from the other tube heaters for reasons of hash suppression. Condenser (45), connected across the high-voltage winding of the power transformer, is the buffer condenser. Resistors (34) and (35) are connected across the vibrator points for reduced sparking and hash. The B filter is an R-C filter composed of resistor (28) and condenser block (15).

In this circuit, the common condenser connection in the block is not grounded, indicating a resistor in the negative B lead for bias. The C bias resistor is part number (31) near the second AF tubes. The 20-mfd/25-volt condenser in the power supply by-passes the bias voltage.

NORMAL TEST DATA

Quick Check for Normal Operation of the Auto Radio Power Supply.

Vibrator is buzzing.
Hum and hash level are normal.
All tubes in the receiver light.
B plus voltage measures 150 to 250 volts.

The mechanical noise or buzz made by the vibrator is well damped by rubber cushions, etc., but is still discernible as soon as an auto radio is turned on. When he works on an auto radio, the serviceman’s first check is to turn on the receiver and listen for this buzz. Its absence is an indication of a blown fuse or a defective vibrator, both of which are common troubles in auto radios.

Then, as the tubes warm up, the hum and hash become noticeable. A normal level for these may be established as an amount that is just discernible when the receiver is tuned to an off-station position. Hum is higher pitched than for a home receiver, owing to the higher frequency of the vibrator. Hash is a steady tearing sound. Too high a hum or hash level indicates trouble in the filter or hash-suppression circuits.
Fig. 20-18—Schematic diagram of the Motorola Model 401 receiver.
To check that the tubes light or warm up in the case of metal tubes, the receiver cover must be removed. B plus can be measured at the screen pin of the second AF tube or any other convenient B plus point. The wide variation (150 to 250 volts) given for the B plus measurement is not because vibrator power supplies operate over wide limits, but rather that the receivers have been designed for this wide variation. As a general rule, small receivers are designed to operate at the low voltages.

**Normal Voltage Data for the Auto Radio Power Supply.**—Normal voltage data for the auto radio power supply are given in the accompanying table. It is assumed that the test battery is in good condition and the charger is not operating.

<table>
<thead>
<tr>
<th>Point to point</th>
<th>0Z4 and 6X5 pin No.</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassis to “hot” battery lead</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Chassis to center tap of transformer primary</td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td>Chassis to rectifier plates</td>
<td>3 and 5</td>
<td>150–250 AC</td>
</tr>
<tr>
<td>Chassis to rectifier cathode</td>
<td>8</td>
<td>160–260</td>
</tr>
<tr>
<td>Chassis to B plus</td>
<td></td>
<td>150–250</td>
</tr>
<tr>
<td>Current drain</td>
<td></td>
<td>5–8 amp</td>
</tr>
</tbody>
</table>

In actual operation in the car, the battery voltage varies considerably, depending on the condition of the battery, the operation of the changer, and the charging rate. The normal B voltage shown has wide limits, which depend on the design of the receiver. The actual normal B voltage may be ascertained by reference to the receiver schematic or to the voltage rating stamped on the filter condenser block. When the filter block is stamped “200 volts,” the serviceman will know that the receiver has been designed to work at a low B voltage.

An ammeter check of the current drawn from the battery, if convenient, is indicative of trouble in the power supply. The normal current drain of auto receivers is 5 to 8 amp, depending on the number of tubes in the receiver, the maximum B voltage, and the type of speaker used—P-M or electrodynamic. Trouble in the form of shorts in the B circuits of the receiver would cause a current drain increase of approximately 1 to 2 amp. A shorted buffer condenser would cause an even heavier increase in battery current. When vibrator points stick, the current drain exceeds 15 amp.

The ammeter check can be made in the automobile by connecting the “hot” battery lead to the proper terminal of the charge-discharge ammeter on the instrument panel. To make this check on the test
bench, an ammeter could be connected in series with the test battery. It is not advisable to use the ammeter range of the bench multimeter for this purpose. A shorted vibrator could draw sufficient current to damage the instrument. Instead, a single-unit ammeter with a range of 20 amp and of a rugged construction should be used. Ammeters designed for the instrument panel of an automobile are satisfactory.

**Standard Diagram.**—The standard diagram is shown in Fig. 20-14.

![Diagram](image)

**Fig. 20-14.—Typical auto radio vibrator-type power supply.**

**Normal Resistance Data for the Auto Radio Power Supply.**—Normal resistance data for the auto radio power supply is given in the following table:

- Chassis to rectifier plate ................................................. 150–300 ohms
- Rectifier plate to plate .................................................. 300–600 ohms
- Chassis to B plus .......................................................... Condenser action
- Transformer primary winding .......................................... Less than 1 ohm

The rectifier plate readings measure the resistance of the high-voltage winding of the transformer. Large receivers with heavy B current drain will give the lower readings. When half the winding (chassis to rectifier plate) reads as high as or higher than the full winding, the B circuit is of the type that obtains C bias by means of a resistor in the B minus lead.

The reading from chassis to B plus shows the charging current of the electrolytic filter condenser, since there is usually no bleeder in
an auto radio receiver. The reading after the charging current has subsided is indicative of the leakage of the electrolytic condensers. Reverse the test prods and take the higher reading as the leakage resistance.

**COMMON TROUBLES IN THE AUTO RADIO POWER SUPPLY**

The troubles that commonly develop in auto radio power supplies are in the vibrator, rectifier tube, buffer condenser, filter condensers, and switch. The power transformer and the B choke rarely cause a defective receiver. The other components operate in low-voltage circuits and breakdowns are also rare.

On occasion, however, normal vibration in an automobile causes a grounding lug or screw to work its way loose. The resulting open circuit would most probably affect hash suppression. A servicing procedure for complaints of excessive hash includes checking for loose shielding and grounding screws.

**Troubles Common to Vibrators.**—Vibrators are subject to many ills. Shorts and overloads in the B circuit of the receiver place an abnormally heavy load on the vibrator. In addition, it is a component that is normally in constant motion, and deterioration due to wear may be expected. The spring loses its tension, the contact points wear, and sometimes the points become pitted and stick. A defective vibrator can sometimes be repaired by filing the points and adjusting the spring tension and contact break distance. This, however, requires special techniques and equipment, and the repair effected may not be lasting. It is best to replace a defective vibrator with a new unit similar to the old one.

As the vibrator points wear or the spring weakens, the unit will sometimes fail to start. The car owner soon discovers that, if he flips his switch rapidly two or three times or hits a bump that gives his entire car some extra vibration, the receiver starts to play. The radio then seems to operate normally until the next time it is turned on.

When a receiver is brought in with a complaint describing the above symptoms, the serviceman may be reasonably certain that the vibrator is at fault. To check, he verifies the condition by turning on the radio and listening for the vibrator buzz. If it is not heard, he gives the corner of the radio a sharp slap. When this starts the vibrator and normal operation, the condition is confirmed. If the vibrator does start buzzing immediately after turning on the switch, the intermittent operation must be checked by other means.

A good check for vibrator starting is to operate the receiver at a lower battery voltage. The “hot” battery lead is clipped to the
4-volt intercell connection strap on the storage battery. A vibrator that gives intermittent service, owing to the widened space between the worn points, will not start on a 4-volt input source, unless it is jarred. Even then, it will probably stop soon after having been started. A good vibrator will start without being jarred and will continue to operate when the input supply is 4 volts.

When pitted vibrator points stick, there is a heavy current drain through the half of the transformer primary winding that is fed by that point. The heavy current blows the fuse in the "hot" battery lead. Again, it sometimes happens that the car owner finds the blown fuse and replaces it himself. This may restore normal operation, but it will be short-lived, since the pitted points will stick and blow the fuse again. Continued blowing of fuses and checking with an ammeter comprise the method for determining sticking vibrator points.

As mentioned before, when the symptoms and checks indicate that the trouble is definitely in the vibrator, replacement with a new unit is the best service procedure. There is considerable variation among vibrators, not only in the method of making connections but also in the construction and operating characteristics. For this reason, the replacement should be made with an exact duplicate of the original or, at least, with one that is specified by its manufacturer as being correct for the receiver being repaired. In the latter case, the replacement is not always the same size as the original, and the serviceman should be sure that provision is made for properly grounding the vibrator shield can and for holding it in place when sponge-rubber vibration-damping devices are provided.

**Troubles Common to the Buffer Condenser.**—The buffer condenser often breaks down owing to voltage overload. When this

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**Fig. 20-15.**—A typical buffer condenser and its position in the circuit.
happens, the radio is inoperative because of the absence of \( B \) voltage. The receiver draws heavier than normal current from the battery to feed the short across the secondary of the power transformer.

The shorted buffer condenser will be found when a voltage check shows no \( B \) plus voltage and no AC plate voltage being fed to the rectifier plates. Then a resistance check shows the short from plate to plate of the rectifier tube instead of the normal 300- to 600-ohm reading of the power transformer secondary winding.

The condenser should be replaced by one of the same capacity rating as the original, and the same or a higher voltage rating. Any change in the capacity of the buffer condenser may cause a shortened life for the vibrator, increased hash, or both. The replacement condenser should be of the oil-filled type, with a rating of 1,600 volts.

In replacing the buffer condenser or any unit in an automobile radio, the serviceman should remember that mobile equipment is subject to a considerable amount of vibration, and parts should be installed with this point in view. With improper installation, normal vibration may break the connection leads of the replacement unit. Most of the parts in an automobile radio are strapped down to take the vibration strain off the leads. The serviceman should be careful to use the original, or a similar, secure fastening to hold down the replacement unit. Also, connections should be well wrapped and soldered.

**Variations in the Buffer Condenser Circuit.**—The buffer condenser is sometimes connected in circuits like those shown in Fig. 20–16. The function of the buffer circuits shown is the same as the single condenser connected directly across the high-voltage winding. The common trouble is also the same; that is, the condenser is likely to become shorted. The effect on the receiver, however, may be different. If either condenser in Fig. 20–16A should become shorted,
there would be a heavy load on the transformer and vibrator, but there may be some $B$ plus voltage from the half of the transformer connected across the good condenser. If the buffer condenser of Fig. 20–16B should become shorted, $B$ plus would not be shorted out. The voltage would be lower, however, depending on the size of the series resistor and the decreased efficiency of the vibrator without its timing capacitor. The receiver may play, but the hash content would be high.

A shorted buffer condenser in either of the two examples of Fig. 20–16 would be found in a routine voltage and resistance check of the power supply. They would both give incorrect readings for $B$ plus voltage, and AC plate voltage. A resistance check would readily show the short in the circuit of Fig. 20–16A, and the hash level would focus attention on the buffer condenser of Fig. 20–16 B.

**Troubles Common to the Rectifier Tube.**—The rectifier tube in an automobile receiver has the usual ills of any rectifier tube: weak or no electron emission. In addition, cathode-to-heater leakage causes trouble, since any leakage here acts like a short on the $B$ power supply. The heater is at chassis potential, and the cathode is the point of highest voltage in the receiver.

When the rectifier tube is weak or entirely inactive, low or no $B$ plus voltage will result. The same condition can also result from other causes. Low battery voltage, a weak vibrator, an open or shorted filter condenser, or a heavy drain in the $B$ plus line can cause the same effects. Checking the tube in a tube tester will eliminate the tube as the cause of the trouble. Before a poor tube is replaced, the $B$ circuit should be checked for shorts and overloads, since a short here may harm the new tube as well as be the cause of failure of the old one. Figure 20–18 is a skeleton diagram of the $B$ circuit of a typical auto radio and should be an aid in locating shorts in the $B$ plus circuit.

When the trouble is due to a cathode-heater short, $B$ plus will be shorted out and the receiver will not operate. This condition may or may not be indicated by the tube checker, depending on its design. A resistance check may not reveal the trouble either, since the short may not be present except when the tube is functioning, and the expanded heater touches the cathode.

In this set of circumstances, the cathode-heater short would be found by a process of elimination. The vibrator is working. A heavier than normal battery drain indicates a shorted condition. A voltage check shows a reading of AC voltage at the rectifier plates. This reading would be lower than usual, but any reading at all clears the transformer and buffer condenser of suspicion. The voltage check
also shows a condition of no voltage in the $B$ plus line, placing the short in this circuit. A resistance check then shows no apparent short in the $B$ plus line, a contradiction that is possible only when the short appears under operating conditions. This makes the rectifier tube a likely suspect, since cathode-heater shorts that appear only when the heater is expanded by normal operation are quite common. Replacing the tube with one known to be good is the final confirmation.

Cold-cathode rectifier tubes have the same failings as the thermionic types, with the exception, of course, of cathode-heater leakage. Not all tube checkers are equipped to test this type of tube, however. If this is the case and the serviceman suspects the rectifier because of low or no $B$ voltage, and no sign of a short, the tube is checked by replacing it with one known to be good.

![Fig. 20-17.—The auto radio $B$ filter circuit.](image)

**Troubles Common to the Filter Circuit.**—The chokes in the filter circuit rarely cause any service troubles. The electrolytic condensers $C-15$ and $C-16$, however, open and sometimes short. When input filter condenser $C-15$ opens, the receiver will hum. The serviceman is again reminded that hum in an auto radio is higher pitched than hum in the usual AC home radio. The condition will be found when a test condenser of approximately the same capacity is bridged across the input filter condenser. When the output filter condenser $C-16$ opens, the receiver will hum and oscillate. Again, the condition is found by bridging a test condenser across condenser $C-16$. If RF by-pass condenser $C-6$ should open, the hash level may increase. The condition would be found in a routine check for hash.

If any of the three condensers should become shorted, there would be no voltage at $B$ plus and the receiver would be inoperative. The shorted condenser would be found by an ohmmeter check. It must be remembered that a short at any point in the $B$ plus line may be difficult to find, because of the many parallel branches in which it may be located. Figure 20–18 shows the complete $B$ circuit of the
typical receiver of Fig. 20–13, to serve as an aid in locating shorts in the B supply.

When a filter condenser is replaced, it would be advisable to use an exact replacement unit. If this is not obtainable, the unit chosen should have the same or higher capacity rating, the same or higher voltage rating, and in addition, should have some mounting provision to ensure against lead breakage by vibration.

![Skeleton B circuit of the auto radio receiver of Fig. 20–13.](image)

When the filter circuit includes an R-C filter, the filter resistor rarely gives any service trouble unless it has been overloaded by a short in the B plus line. When this is the case, the resistor should be replaced with one of the same resistance and wattage rating as the original.

![Partial auto radio A circuit.](image)

Troubles Common to the Power Switch and Battery Lead.—On-off switches in automobile receivers give more trouble than similar switches in home receivers. This is because the switch must break 5 to 8 amp, whereas the AC receiver switch breaks only 0.3 to 1 amp. In addition, although a 110-volt supply will override the slight resistance caused by a poor contact in a switch without overheating, the same circumstance in the low-voltage, high-amperage...
circuit of the auto radio switch will cause considerable loss of power, heating, and finally burning of the switch.

Poor operation of an auto radio, due to switch contact resistance, would be found in a voltage check. The reading at the “hot” battery lead would show the normal 6 volts, but the reading at the center tap of the transformer primary would be considerably lower than the 5.5 volts given as the normal reading in the voltage chart. Reference to Fig. 20–19 shows that the voltage loss may be due to poor contact in the fuse receptacle, or switch, or possibly to a rosin joint at one of the connections. Which item is at fault could be determined by inspection, overheating, or a voltage check across the individual units. If the switch or fuse shows 1 volt across its terminal points, there is no doubt as to where the contact resistance is located.

When replacing a defective switch, or volume control and switch, in an auto radio, the serviceman should make sure that the replacement unit has been designed for auto radio use. Auto radio switches usually have double contacts connected together either internally or externally, and are marked with their rating specifications. The replacement switch should be labeled at least “10A—12V,” indicating that it has been designed to break a 12-volt/10-amp circuit.

Hash Suppression.—Hash suppression is a design problem, and for an individual type of receiver has been solved in its original design. Subsequent complaints of excessive hash in the receiver are caused by the breakdown of one or more of the hash-suppression components. Different types of receivers use various methods of hash suppression, and, as a result, the generalized service procedure for curing excessive hash may include the checking of items that are not incorporated in the receiver being serviced.

Service Procedure for Excessive Hash.

1. Tighten all chassis screws. This procedure is particularly important in the power-supply compartment.

2. Check all ground connections. Most of the ground connections are established by the chassis screws; some may be soldered directly to the chassis. These should be resoldered with a heavy-duty soldering iron. Occasionally, a chassis rivet may be used for a grounding connection. These should be carefully cleaned and spot-soldered to the chassis.

Spring contacts of various types are used for grounding purposes in various parts of the receiver. The ground connection for the vibrator shield can is usually of this type. Spring contacts are also used between the metal cabinet and the chassis and the top and bottom covers. These spring contacts should be cleaned and resprung.
3. Try replacing the vibrator.
4. Try replacing the rectifier tube. If the receiver is wired for either an OZ4 or 6X5, the 6X5 is less likely to cause hash.
5. Replace the RF by-pass condenser in the B plus lead.
6. Check the resistors or condensers across the vibrator contact points for opens or poor connections.
7. Check the buffer condenser for correct capacity rating.

VARIATIONS OF AUTO RADIO POWER SUPPLIES

The Synchronous Vibrator.—Some receivers use an extra pair of points in the vibrator to act as a mechanical rectifier, which replaces the rectifier tube. The circuit used is that of Fig. 20-20.

![Synchronous Vibrator Circuit Diagram](image)

Fig. 20–20.—The synchronous vibrator: operation position 1.

When the contact at $A$ is made, the magnetic field in the core caused by the flow of primary current, induces a voltage in the secondary, the polarity of which we shall assume to be as marked in the diagram. The voltage, in the lower half of the secondary, drives a current through the load in the direction of the arrow through the contact at $C$, which is also closed when the $A$ contact is closed.

As the contact at $A$ is broken by the vibrator action, the contact at $C$ also opens.

When the vibrator swings up, the contact at $B$ reverses the magnetic field in the core, reversing the polarity of the voltage induced in the secondary, as shown in Fig. 20–21. But current still flows through the load in the same direction as previously, because it is now being furnished by the top half of the secondary through the closed contact at $D$.

In this manner, the contacts at $C$ and $D$ serve as a full-wave rectifier for the load which, of course, is the $B$ circuit of the receiver.
Battery Polarity When Synchronous Vibrators Are Used.—In discussing automobile radio up to this point, we never mentioned the polarity of the car battery. The only distinction made was reference to the "hot" lead and the grounded lead. However, some automobile manufacturers ground the negative terminal of the car storage battery; others ground the positive terminal. Furthermore, the same manufacturer may change the polarity of the grounded lead in his models from one year to the next. As a result, the "hot"

![Diagram](image)

**Fig. 20-21.—The synchronous vibrator; operation position 2.**

battery lead may be either the positive or the negative terminal, depending on the make and year of the car.

In the case of a radio with a nonsynchronous vibrator and a rectifier tube, this is a matter of no importance, since this type of power supply will function regardless of the polarity of the source battery. However, in the case of a radio that uses a synchronous vibrator, the polarity of the "hot" battery lead is an important factor, since it will determine the polarity of the rectified output. Since the B supply must connect B minus to the chassis and B plus to the plate circuits of the receiver tubes, reversed polarity of the car battery will cause nonoperation of the receiver.

A radio with a synchronous vibrator must, therefore, include some provision for reversing the output B polarity, since the radio may be installed in any automobile, and either the positive or the negative battery terminal is the hot lead. Either one of two methods is commonly employed to reverse the B output when necessary. In one, the two ends of the high-voltage winding are brought to a screw-terminal strip and equipped with spade lugs to permit a convenient
reversal. In the other, the vibrator and its socket are so constructed that the vibrator may be installed in either one of two positions. In one position, the receiver will operate properly with the negative terminal of the battery grounded, and the other position accommodates a grounded positive. Figure 20–22 shows a receiver of this type.

A Typical Auto Radio Using a Synchronous Vibrator.—Figure 20–22 shows the schematic diagram of the R.C.A. Model 67M1 auto radio receiver, which uses a synchronous vibrator. Note the following items of interest. The power supply is enclosed in a shielded compartment, as indicated by the dotted line surrounding it. There is no filter on the pilot-lamp lead. This is unnecessary since the pilot lamp is installed in a remote-control head and therefore cannot bring hash or ignition interference into the radio receiver. There is a spark plate condenser C-40 connected to the hot battery lead as it enters the receiver. Condenser C-43 and RF choke L-12 make up the hash filter for the transformer primary and vibrator. Condenser C-41 and RF choke L-10 form an additional hash and ignition noise filter to feed the heater line.

The vibrator socket has six prong holes and a center-pin hole. Prongs 2 and 3 are thicker than the others so that the vibrator can be inserted in only two positions. In either position, pin No. 1 is grounded and pins 4 and 5 remain unchanged because of the reversing connections of the two unmarked pins. The location of the rectifier contacts, however, with respect to the ends of the high-voltage winding, will be reversed as the vibrator is shifted from one position to the other.

Resistors R-18 and R-19 and condensers C-45 and C-46 function as the buffer circuit. Condenser C-47 is an RF by-pass which functions as a hash filter in the B plus lead. The B filter circuit consisting of L-13, C-48, and C-49 is conventional.

Servicing Synchronous Vibrator-type Power Supplies.—From the serviceman’s point of view, the synchronous vibrator type of automobile radio includes some problems of its own. First, he must observe polarity when connecting the radio for operation on his test bench. To do this he must connect the “hot” battery lead to the same terminal on his test battery as the “hot” lead in the car from which the receiver was taken.

If the automobile is available, polarity is easily determined with a voltmeter. Simply clip the negative lead of the multimeter to the instrument panel or other convenient ground. Adjust the meter for the 10-volt DC range. Touch the positive voltmeter lead to either
Fig. 20-22—Schematic diagram of the RCA Model 67M1 receiver.
terminal of the ammeter on the instrument panel. If the meter reads 6 volts, the negative terminal of the car battery is grounded. If the meter pointer swings backward, the positive terminal of the car battery is grounded. If the car is not available but known as to model and year, the grounded battery terminal can be ascertained by reference to charts that list this information. These charts are obtainable from the publishers of the various automobile trade periodicals. One such chart is included in the Appendix. If the car is unknown, the receiver may be connected with either battery terminal connected to the hot lead, and the voltmeter test prods are connected to chassis and B plus. A reversed reading of the voltmeter indicates incorrect battery polarity. No harm is done if the receiver is operated for a short time with the battery reversed.

Another instance where battery polarity becomes of importance in the synchronous vibrator type of auto radio is when such a radio is removed from one car and reinstalled in another. In this case, the polarity of the grounded lead is checked with the voltmeter in both the old car and the new. If there is any change, the appropriate switch must be made in the receiver.

When servicing a receiver, like the one of Fig. 20–22, where the polarity change-over is accomplished by the position of the vibrator in its socket, if the vibrator is removed for test or replacement, it is important to note the position identification. Then the vibrator may be replaced with the correct polarity setting.

The quick check for a synchronous-type power supply is the same as for the more common nonsynchronous type. The voltage and resistance data are the same, if due allowance is made for the difference in test points. The AC voltage readings are taken from the proper vibrator socket terminals, rather than from the plate pins of the rectifier tube. B plus would be checked at the filter condenser terminals. Common troubles and service notes are also the same for both types of power supply.
SUMMARY

Quick check of the auto radio power supply.
Vibrator is buzzing.
Hum and hash level are normal.
All tubes in the receiver light.
B plus measures 150 to 250 volts.

Standard circuit.
The accompanying figure shows the standard circuit.

Normal voltage data for the auto radio power supply.
Normal voltage data for the auto radio power supply are given in the accompanying table.

<table>
<thead>
<tr>
<th>Point to point</th>
<th>0Z4 and 6X5 pin No.</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassis to hot battery lead</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Chassis to center tap of transformer primary</td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td>Chassis to rectifier plates</td>
<td>3 and 5</td>
<td>150–250 AC</td>
</tr>
<tr>
<td>Chassis to rectifier cathode</td>
<td>8</td>
<td>160–260</td>
</tr>
<tr>
<td>Chassis to B plus</td>
<td></td>
<td>150–250</td>
</tr>
</tbody>
</table>

Current drain                              | 5–8 amp             |

Normal resistance data for the Auto Radio Power Supply.
Chassis to rectifier plate                  | 150–300 ohms        |
Rectifier plate to plate                    | 300–600 ohms        |
Chassis to B plus                           | Condenser action    |
Transformer primary winding                  | Less than 1 ohm     |
<table>
<thead>
<tr>
<th>Symptom</th>
<th>Incorrect check results</th>
<th>Look for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver does not operate</td>
<td>No buzz from vibrator</td>
<td>Disconnected “hot” battery lead. Blown or defective fuse. Burnt or inoperative switch. Defective or worn vibrator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One or more tubes do not light</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$B$ plus measures low or zero</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power-supply checks give normal results</td>
</tr>
<tr>
<td>Receiver operation is weak</td>
<td>Low or erratic $B$ voltage</td>
<td>Worn-out vibrator. Weak rectifier tube. Resistance in fuse. Resistance in switch. Incorrect capacity of buffer condenser. Component in the receiver drawing too much $B$ current. Make a voltage check of the receiver</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power-supply checks give normal results</td>
</tr>
<tr>
<td>Excessive hum</td>
<td></td>
<td>Open filter condensers. Defective tubes. Poor ground connections in the receiver</td>
</tr>
<tr>
<td>Excessive hash</td>
<td></td>
<td>Poor ground connections in the receiver and power supply. Defective vibrator. Defective rectifier tube. Open hash filter. Incorrect buffer condenser capacity</td>
</tr>
<tr>
<td>Intermittent operation</td>
<td>Power-supply checks give normal results</td>
<td>Worn-out vibrator which sometimes fails to start. (Check at 4 volts.) Trouble in the receiver. Check tubes, condensers, etc.</td>
</tr>
<tr>
<td>Fuse blows repeatedly</td>
<td>Power-supply checks give normal results</td>
<td>Vibrator with sticking points. Intermittent cathode-heater short circuit in rectifier tube</td>
</tr>
</tbody>
</table>
QUESTIONS

1. The vibrator in an inoperative auto radio fails to start. List the possible causes and explain how you would check for each.

2. An auto radio is brought in with a complaint of intermittent operation. What unit in the power supply can cause this condition? How would you check to make sure?

3. An auto radio blows fuses repeatedly. What are the possible causes and how would you check for each?

4. An auto radio is brought in with a complaint of weak operation. A voltage check gives the following results:

   Chassis to “hot” battery lead ......................... 6 volts (normal)
   Chassis to center tap of transformer primary .............. 4 volts (low)
   Chassis to rectifier plate ................................ 120 volts AC (low)
   Chassis to rectifier cathode ................................ 120 volts (low)
   Chassis to B plus ........................................... 110 volts (low)
   Current drain ............................................... 4 amp (low)

   What is the most probable cause of the trouble? How would you make sure?

5. An inoperative auto radio gives the following results in a voltage check:

   Chassis to “hot” battery lead ......................... 6 volts (normal)
   Chassis to center tap of transformer primary ................ 5.4 volts (normal)
   Chassis to rectifier plate ................................ 120 volts AC (low)
   Chassis to rectifier cathode ................................ 100 volts (low)
   Chassis to B plus ........................................... 0 volt
   Current drain ............................................... 9 amp (high)

   What are the most probable causes of the trouble? How would you check for each?

6. If the receiver of question 5 gives a reading of 0 volts at the rectifier cathode and all other readings remain the same, what are the likely causes of the trouble? How would you check for each?

7. An auto radio that does not use a rectifier tube is to be transferred from a car with the negative battery terminal grounded to one with a grounded positive. What change should be made in the receiver?

8. An inoperative auto radio draws a heavier current than normal. The B plus check shows a reading of zero volts. There is no AC voltage at the rectifier plates, and there is no apparent short from B plus to chassis. What is likely to be wrong? How would you check to make sure?

9. List the causes for excessive hum in an auto radio and indicate how you would check for each.

10. Outline a procedure for removing excessive hash in an auto radio.

11. An inoperative auto radio draws a heavier current than normal. The B plus voltage checks zero, AC rectifier plate voltage checks low, and there is no apparent short from B plus to chassis. What is likely to be wrong? How would you check to make sure?