CHAPTER 5

SIGNAL GENERATOR—INTRODUCTORY

Fundamentally, the signal generator is a device for placing into the input of a stage a signal similar to that of the input signal, when the receiver is operating normally. In this way, it can be determined if a stage is operating normally. By placing the signal from the generator at various strategic points, interstage coupling components can also be tested for breakdown. Finally, the signal generator is an invaluable aid in receiver alignment.

Types of Currents.—A better understanding of the use of the signal generator will be obtained if time out is taken for a review of the various types of currents. The simplest type is the pure direct current. It is a flow of electrons at a steady rate in one direction through a circuit. Such a current would result from the use of a battery as a power source. The build-up and steady flow of such current could be represented as shown in Fig. 5-1. The fact that the current is steady is shown by the horizontal current line. The fact that the current flows in one direction is shown by the fact that the current line (graph) is always above the zero base line, in the plus direction.

Another type of current is the pulsating or varying direct current. Here, the electrons always flow in one direction but at a varying rate. Such a current would result from a varying voltage source or from a varying resistance in the circuit. Figure 5-2 represents the varying
direct current resulting in a circuit that includes a flasher button which changes the resistance from that of the lamp alone to an infinite (open) resistance. Notice that the direct current flows only in one direction, as shown by the fact that the graph is always above the base line.

A third important type of current is the pure alternating current. This current continually changes in magnitude and periodically reverses in direction. An AC generator as a power source would produce such a current, often called a “sine-wave current.” Figure 5–3 represents a pure alternating current. That the magnitude is constantly changing is shown by the fact that every point of the current curve is different in value from every point adjacent to it. That the direction of electron flow is regularly changing is shown by the fact that the current curve regularly rises above and dips below the zero base line, first in the plus direction and then in the minus direction.

Alternating and direct currents need not be mutually exclusive. They may be mixed and combined in a single circuit. Figures 5–4 and 5–5 show two such combinations. In Fig. 5–4, a pure direct
current from a 3-volt battery and an alternating current (1-volt peak) are mixed in a circuit. The result is a varying direct current, whose average is 3 amp, varying 1 amp above and below the average at the same rate as the alternating current. In Fig. 5–5, two alternating currents from two generators of different outputs and different frequencies are mixed. Sometimes their phase relationships are such as to add to each other; at other times, they oppose each other. The result is the regularly recurring AC waveform in the diagram that is like neither of the two pure sine-wave components.

Types of Alternating Currents.—Alternating currents present many interesting aspects that require explanation. Refer again to Fig. 5–3. The complete movement of electrons back and forth through the circuit is called one “cycle.” The figure shows one cycle completed in 1 sec. Hence the frequency of the current through the circuit is said to be one cycle per second. It is possible to have currents of any frequency, even up to millions of cycles per second.

On the basis of different frequencies and therefore use, alternating currents are divided into various categories. The first are the power frequencies, which are the alternating currents used to deliver power...
to lamps, radios, electrical appliances, etc. The most common frequency in this group is 60 cycles per second. Other power frequencies are 25 and 40 cycles per second.

The second category makes up the audio frequencies (AF). These are alternating currents of frequencies from 20 to 20,000 cycles per second. They are characterized by the fact that, when fed into a reproducer like a pair of earphones or a speaker, they produce an audible sound.

A third category makes up the radio frequencies (RF). These are alternating currents of frequencies above 20,000 cycles per second. Currents of such high frequencies have two important characteristics. If fed into a pair of earphones, they will not produce an audible sound. Also, they tend to radiate energy, in the form of radio waves out into space, from the circuit in which the current is flowing.

Audio Frequencies.—Sound, as it comes to our ears, consists of nothing more nor less than vibrations of the air particles. However, our ears are limited to a relatively small range of vibration frequencies, about 20 to 20,000 vibrations per second. Anything below or above that range will not be heard; within it, different vibration rates will produce sounds of different pitch.

When a sound falls on our eardrums, it causes them to vibrate at the same frequency as that of the sound itself. Similarly, when it falls on a microphone, it sets up vibrations at the same frequency as the sound. A microphone is designed to produce alternating currents at the same frequency as the mechanical vibration produced by the sound. If these alternating currents are amplified and fed into a reproducer, like a loudspeaker, they make it vibrate mechanically at a frequency equal to that of the currents. This mechanical vibration of the speaker makes the air around it vibrate at the same frequency, and the original sound is reproduced. This sequence is illustrated in Fig. 5–6. If the sound is complex instead of one frequency, the electrical currents produced will also be complex as a result of the combination of various alternating currents. The end result will be the same.
Radio Frequencies.—The problem confronted by a broadcasting station is to radiate into space energy that will eventually result in sound at the reproducer of the radio receiver. Unfortunately, AF currents will not radiate into space to any great extent. When we get up to currents of frequencies above 20,000 cycles per second, the radio frequencies, radiation of energy into space as radio waves becomes efficient. Unfortunately, the radio frequencies will not produce sound at the receiver reproducer.

To obtain the desired results, the sound-producing audio frequencies must be combined with the radiating radio frequencies. In this combination the radio frequency is called the "carrier" and the audio frequency the "modulating currents." The combined current is called a "modulated carrier." This relationship is shown in Fig. 5-7. The carrier is shown as a pure sine current at 1,000 kc (1,000,000 cycles per second). The audio current is shown as a pure sine current at 400 cycles per second. The modulated carrier is an RF current whose peaks (envelope) vary at the audio rate (400 cycles per second).

This type of modulation of a carrier wave is known as "amplitude modulation" (abbreviated A-M), since the amplitude of the carrier wave is made to increase and decrease at the same rate or frequency as the modulating or audio signal.

Another type of modulation of a carrier wave is known as "frequency modulation" (abbreviated F-M). In this system, the audio...
signal does not alter the amplitude of the carrier but alters the frequency instead, at a rate equal to the frequency of the audio signal. For example, if a 400-cycle audio note were modulating an RF carrier whose frequency is 42 megacycles per second, the carrier would be made to shift above and below 42 megacycles 400 times each second. A graph of the F-M system is shown in Fig. 5–8.

![RF Carrier (42mc) frequency-modulated by 400-cycle audio note.](image)

The branch of F-M receivers is a system by itself. Since most receivers at the present time are still A-M receivers, this book will confine itself to that type alone. This procedure does not intend, however, to imply that F-M receivers are of minor importance.

**Nature of an Electric Current.**—The question of the nature of an electric current should be cleared up at this point. Too much confusion has arisen from comparing different books. About 1765, Benjamin Franklin evolved a theory of electricity that became widely accepted. He believed that electricity (whatever it was) flowed in an electric circuit. By convention, he and many others assumed that electricity flowed from the + pole to the − pole. This conventional current flowing from + to − was described in technical literature for many years after, and still leads a virile life.

However, in 1897, J. J. Thomson discovered the electron, and the true nature of an electric current in a circuit became known. An
electric current is the flow of negatively charged electrons through a circuit. Hence, the electrons must always flow from \(-\) to \(+\), an idea opposite to that of the conventional theory. The confusion arises because many authors do not define which concept they have in mind when referring to current. As a result, many beginning students confuse the two ideas and erroneously assume that when we say current flows from \(+\) to \(-\) (Franklin’s convention), we mean that electrons flow from \(+\) to \(-\). On the contrary, when we say current flows from \(+\) to \(-\), we should forget all about electrons. Franklin did not know that they existed when he adopted that convention. When we say current flows from \(-\) to \(+\), we are up to date and talking about electrons. Throughout this book, the authors will use the newer concept of the current; a flow of electrons from \(-\) to \(+\).

Signal-generator Output.—The description given above will make the signal output from the signal generator more meaningful. Figure 2–1 shows the block diagram and wave forms of the superheterodyne receiver. Various types of currents are encountered. Modulated radio frequency enters the aerial and produces modulated RF currents up to the mixer. The local oscillator produces pure unmodulated RF currents. From the mixer to the detector stage, modulated RF currents at a lower frequency (called “modulated intermediate frequencies,” or IF), are encountered. From the detector to the reproducer, the signal is at audio frequencies.

It is the function of the signal generator to generate all of the above current types to simulate regular receiver signals for testing. Figure 5–9 shows the output voltages and currents obtained from most generators.

![Diagram](image)

**Fig. 5-9.—Output voltages and currents from a signal generator.**

The unmodulated radio frequency of the signal generator is an alternating current or voltage of a frequency anywhere above about 75,000 cycles per second (usually written 75 kc). Any frequency above that lower limit is selected by means of the various controls. Audio frequencies are alternating currents or voltages ranging from about 20 up to 20,000 cycles per second. Most signal generators
have a fixed-frequency audio output of about 400 cycles per second, which is the standard test frequency. Another important output from the signal generator is a mixture of the radio frequency and the 400-cycle audio. This is known as "400-cycle modulated radio frequency." It simulates a modulated RF radio signal. Means are often provided for mixing the RF with an external AF signal. This gives an output on the signal generator known "as externally modulated radio frequency."
CHAPTER 6

SETTING UP THE SIGNAL GENERATOR

Block Diagram of the Signal Generator.—There are various differences in detail between one signal generator and another; basically, they are very similar. A block diagram will show to best advantage the elements that make up an average signal generator (Fig. 6-1).

The RF oscillator generates an RF voltage with a range of about 75 kc to 30 megacycles. This range includes the intermediate frequencies of any standard receiver. The output from the oscillator itself is unmodulated.

The AF oscillator, as its name implies, generates a voltage at an audio frequency, which is usually the audio test frequency of 400 cycles per second. On some signal generators, the audio output is variable from approximately 100 to 10,000 cycles per second. The AF oscillator is used to modulate the RF voltage generated by the RF oscillator. In addition, most signal generators provide front-panel terminals where the AF output is independently available. This independent AF output may vary in voltage up to several volts. It is used to check the AF stages in the receiver.

The modulation switch shown in Fig. 6-1 enables the operator to modulate the RF with the AF signal. The usual practice is to have 30 percent modulation at an audio modulating frequency of 400
cycles. The 30 per cent modulation means that the RF voltage is made to dip and rise 30 per cent below and above its peak value, as shown in Fig. 6-2. Many signal generators make provision for modulating the RF voltage with an external AF signal of any frequency.

The strength of signals at various test points throughout the receiver will vary greatly, beginning at the antenna and ending at the loudspeaker. Since the signal generator must substitute signals comparable to the actual signals, it must have a great range of output. This function of variable output is taken care of by an attenuator that breaks the complete range of output into steps and then gives smooth variation within each step. For the most part, the output readings obtained from the attenuator primarily furnish a value to any setting of the output, rather than give an exact microvolt output for radio-servicing procedures. Later chapters in this book will make this statement more significant, especially in stage-gain measurements.

Up to this point, the description of the signal generator has been generalized to give an overview picture. A more detailed discussion of the actual controls will give greater skill with the instrument. Of course, there is great variation in the control designations. Some common ones will be described and should be sufficient to aid the serviceman in understanding any other variations. The manufacturer's instructions for all signal generators should serve as the final guide for operation.

A Typical Signal Generator.—To get a better understanding of the various signal generators in existence today, it might help to synthesize a typical front panel of such an instrument and study its controls. Of course, there probably is no generator that has this exact make-up. Figure 6-3 shows the signal generator that would be constructed. On the left center is found the power switch to
energize the signal generator when it is to be used. On the right center is the output jack from which the various outputs for application to various test points in the receiver are taken.

To determine the nature of the output, there is an output select switch for obtaining pure RF, modulated RF, or audio signals. This instrument is of the usual fixed AF type with an audio output at 400 cycles per second. Therefore, when the output select switch is in the mod. RF position, the output is an RF signal modulated approximately 30 per cent by a 400-cycle audio note.

![Diagram](image)

The entire RF coverage is accomplished by the large tuning dial in the center. This frequency range of RF output is quite large and could not be covered in one sweep of the tuning dial. Therefore, a band selector switch (band sw.) is provided to divide the complete coverage into bands. The complete swing of the tuning dial will therefore cover only one band. Four distinct bands are shown in our typical signal generator. They are labeled A, B, C, and D, each with a different range. Figure 6-3 shows band C chosen for coverage.

The output level is controlled by the two dials marked microvolts and multiplier. The first of these controls gives the number of microvolts from 0 to 10. It is usually a potentiometer control. The second is a 5-point switch for a step attenuator and determines by what value to multiply the reading from the microvolts dial to get
the output level. The multiples shown are 1, 10, 100, 1K (1,000), and 10K (10,000). For example, the reading shown in Fig. 6-3 would be $6 \times 1K$, or 6,000 microvolts. The caution given in the previous section about the true value of this reading should be kept in mind.

The general information given above is important because the serviceman should see in what ways all signal generators are alike. However, each specific instrument will have its own variations, and the service manual supplied by the manufacturer should serve as the guide. The next few sections will describe three different signal generators, to show how the controls should be operated to get the various outputs and output levels that are required in service work.

The Precision E-200 Signal Generator.—In the Precision signal generator, the usual tuning dial is found in the upper center part of the front panel (see Fig. 6-4). Frequency coverage from 90 kc to 22 megacycles is performed in six bands, indicated as A, B, C, D, E, and F. The BAND SELECTOR switch is located at the lower left end of the panel. The frequencies covered by each band are as indicated below.

- **A** 90—250 ke
- **B** 215—600 ke
- **C** 550—1,700 ke
- **D** 1.56—5.0 me
- **E** 3.75—10.0 me
- **F** 7.4—22 me

RF output is taken from two jacks above the BAND SELECTOR switch. When large output is desired, the jack labeled HIGH is used; when low output is required, the jack labeled LOW is used. From these two jacks are obtained either unmodulated RF signals or RF signals that are modulated by the audio oscillator signal.

The type of output is determined by the setting of the control at the lower right end of front panel. The settings of this dial are RF, UNMOD., MOD. RF, EXT. MOD., and 400 ~ AUDIO, giving unmodulated RF, modulated RF, externally modulated RF, and 400-cycle audio signal, respectively. The audio signal for the last-named position is obtained from two jacks labeled AUDIO SIGNAL under this control.

The level of the audio output is determined by the setting of a control at the upper right end of the panel. This is labeled MODULATION CONTROL. The setting of this dial also determines the percentage modulation of the RF signal when the output type control is in the MOD. RF position. The AF output is very high—sufficient to operate a high-impedance speaker directly without an intervening amplifier.
Attenuation of the RF output signal is accomplished by two controls at the upper left end of the panel. They are labeled **RF CONTROL — 1** and **RF CONTROL — 2**. Each of these dials is arbitrarily divided into 10 main units. **RF CONTROL — 1** delivers increasing outputs at each position as the knob is turned clockwise. The outputs in these various positions are not calibrated but are relative. **RF CONTROL — 2** is a decimal multiplier. Thus, if the first dial is in position 3 and dial 2 is in position 7, it means that \( \frac{7}{10} \) of the total available output for position 3 of dial 1 is available. If dial 2 is turned to position 9, it means that \( \frac{9}{10} \) of the maximum available output for position 3 of dial 1 is delivered. If dial 2 is at position 10, then \( \frac{10}{10} \), or all, of the available output for position 3 of dial 1 is available. To get more output, return dial 2 to zero and set dial 1 in position 4. The greatest available output is delivered when dial 1 is at position 10 and dial 2 is also at position 10. In other words, dial 1 sets the limit of output and dial 2 tells us how many tenths of that limit are being delivered. Note, again, that the two dials give no actual output reading but merely arbitrary positions for any output obtained.

A final control on this signal generator is one marked **AVC CONTROL**. It determines the level of steady AVC voltage delivered to two jacks.
marked AVC voltage beneath it. This AVC voltage is used for checking AVC operation in receivers, and in aligning receivers with AVC control.

**R.C.P. Model 704 Signal Generator.**—The Model 704 signal generator produced by the Radio City Products Company (R.C.P.) is shown in Fig. 6-5. The large tuning dial is at the center of the front panel. Frequency coverage from 95 kc to 25 megacycles is performed in five bands, indicated as \(A\), \(B\), \(C\), \(D\), and \(E\). The band-

![Fig. 6-5.—The Radio City Products signal generator, Model 704.](image)

selector switch is marked **FREQUENCY BANDS** and is located at the upper left portion of the panel. The frequencies covered by each band are as indicated below:

\[
\begin{align*}
A & : 90-290 \text{ kc} \\
B & : 280-900 \text{ kc} \\
C & : 825 \text{ kc}-2.7 \text{ mc} \\
D & : 2.5-8.3 \text{ mc} \\
E & : 8.2-25 \text{ mc}
\end{align*}
\]

It should be noted that there is a sixth band on the tuning dial, labeled \(F\). There is no position on the **FREQUENCY BANDS** control for this band; it represents a frequency coverage of 16.4 to 50 megacycles and represents the second harmonic output of band \(E\). Note that analogous positions of the hairline on bands \(E\) and \(F\) always have a 1 to 2 ratio.
RF output is taken from the phone jack marked RF OUTPUT at the right end of the panel. From this jack are obtained either unmodulated RF signals or RF signals that are modulated by the audio oscillator signal.

The type of output is determined by the setting of the toggle switch at the lower left of the front panel. In the UNMOD. position, the output is unmodulated radio frequency. In the MOD. position, the output is radio frequency internally modulated by a 400-cycle audio signal.

Two pin jacks at the lower left end of the front panel, labeled AUDIO OUTPUT, furnish an audio signal at a frequency of 400 or 1,000 cycles per second, depending upon the position of the toggle switch above the jacks. Audio output is obtained only when the MOD.-UNMOD. toggle switch is in the MOD. position.

Attenuation of the RF output signal is accomplished by the two controls marked OUTPUT MULTIPLIER and ATTENUATOR. The attenuator is a potentiometer whose coverage is divided into 50 divisions. The OUTPUT MULTIPLIER is a step attenuator with multiples of 1, 10, 100, 1,000 (1M1), and 10,000 (10M). Thus, if the first control were at 35 and the second control at 1M, the indicated output would be 35 × 1M, or 35,000 microvolts.

A toggle switch at the lower right of the panel, marked ON-OFF, turns the signal generator on or off.

General Electric Model SG-3A Signal Generator.—In the General Electric signal generator, the tuning dial is found in the upper center part of the front panel (Fig. 6-6). Frequency coverage from 100 kc to 33 megacycles is performed in five bands, indicated as A, B, C, D, and E. The BAND SWITCH is located to the left of the tuning dial. The frequencies covered by each band are as indicated below.

\[
\begin{align*}
A & : 33 - 10 \text{ mc} \\
B & : 10.6 - 3.2 \text{ mc} \\
C & : 3.2 - 1.0 \text{ mc} \\
D & : 1.0 - 0.32 \text{ mc} \\
E & : 0.32 - 0.10 \text{ mc}
\end{align*}
\]

RF output is taken from two jacks at the lower left end of the front panel. The one labeled HIGH OUTPUT furnishes 1.5 volts of RF output, which is directly metered by a vacuum-tube voltmeter whose meter is at the right of the tuning dial. This high output is obtained at all frequencies except the very highest, where the capacity of the output cable limits the output. A potentiometer knob to the right and below the meter permits adjusting the meter to zero

\footnote{Note that this manufacturer uses M for 1,000.}
when used. For all test signals up to 100,000 microvolts, connection is made to an attenuator at the jack marked LOW OUTPUT. In the latter case, the vacuum-tube voltmeter measures the RF input to the attenuator.

For outputs up to 100,000 microvolts the LOW OUTPUT jack is used, while maintaining 1.0 volt in the meter by means of the control marked POWER at the lower right of the front panel. The output is then the setting of the MICROVOLT scale (0 to 10) multiplied by the setting of the MULTIPLIER. Both of these latter controls are at the lower left of the panel. The MICROVOLT control operates a potentiometer, and the MULTIPLIER controls a step attenuator with the following multiples: 1, 10, 100, 1,000 (1K), and 10,000 (10K). When higher meter settings are used, the output should be multiplied by the meter reading.

For outputs over 1 volt, the HIGH OUTPUT jack is used. The attenuator controls are then disregarded, and the output is set by the POWER control and read directly on the meter.

The type of output obtained is controlled by the knob at the lower right, marked OUTPUT. In the UNMOD. position, the output is unmodulated radio frequency. In the MOD. position, the output is radio frequency modulated by a 400-cycle audio signal with 30 per cent modulation. In the AUDIO position, a 400-cycle signal up to 1 volt may be obtained from the LOW OUTPUT jack.

Energizing power to the signal generator is controlled by the POWER control. The positions AC OFF and ON are self-explanatory.
Checking Signal-generator Calibration.—It is important that the frequencies of the signal generator should be accurately calibrated and regularly checked. To make such a check, it is necessary to have a standard for comparison that is accurate. The frequencies of the broadcast stations are valuable in this respect, since each station is assigned a fixed carrier frequency from which it deviates to a negligible degree.

It is not necessary to check the frequency calibration of the signal generator all over the dial. In radio service work a few test frequencies are important. These are 455, 600, 1,000 and 1,500 kc. The instrument will be extremely useful if these frequencies are accurately determined on the dial.

Let us see how we could make the check suggested above. Suppose that it is desired to see if 600-ke output from the generator is obtained when the frequency dial is set at 600. The output lead from the instrument should be connected through a 0.00025-mfd/600-volt condenser to the antenna of a broadcast receiver. The generator ground and receiver ground should be commonly connected to a good ground.

If there is a station whose carrier frequency is exactly 600 kc, the check will be quite simple. We first tune our receiver sharply to that station. Then set the output selector switch of the signal generator to unmodulated RF output. As we tune the frequency dial close to 600 kc, a high-pitched whistle is heard. This effect is due to a phenomenon known as "beats." For example, if the signal generator were producing an output at a frequency of 605 kc, it would mix with the station signal of 600 kc and produce a beat note of 5 kc—the difference between the two signals. Since 5 kc is in the audio frequencies, it would be heard in the receiver as a whistle. As the generator output approaches the station frequency, the difference becomes less, producing a lower and lower pitched sound in the speaker, since the beat frequency becomes less. When the two frequencies are identical or very nearly so, the beat note tends to disappear. At that position we have tuned for zero beat. As we tune the frequency dial past zero beat, we again begin to get the beat note. At zero beat, we could safely assume that the signal generator is at the same frequency as the station; namely, 600 kc.

It is not always possible to find a broadcast station with the exact frequencies that we wish to check. Such would be the case in the metropolitan New York area. Suppose the serviceman in that vicinity wanted to check 600 kc on his signal generator. The nearest stations to that frequency are WMCA at 570 kc and WNBC at 660 kc. To check the signal generator at 600 kc, tune it for zero beat with
WMCA, the station to which the receiver is sharply tuned. At that position, the output of the generator is 570 kc. Suppose its tuning dial reads 560 kc. We can then assume that it is 10 kc off and that therefore an output of 600 kc would be obtained when the generator tuning dial is at 590 kc. To verify, tune for zero beat with WNBC at 660 kc and note whether it too is 10 kc off in the same direction.

Similarly, tuning-dial positions on the generator should be found for 1,000 kc and for 1,500 kc. The stations to use for 1,000 kc might be WAAT at 970 kc and WINS at 1,010 kc. The stations to use for 1,500 kc might be WHOM at 1,480 kc and WQXR at 1,560 kc.

Determining the true setting for 455 kc requires a different analysis, because it is outside the broadcast band. At first, it would seem impossible to check until we realize that, when a signal generator oscillator is set at 455 kc, it is not only producing an output of 455 kc or thereabouts but also whole-number multiples thereof. Therefore, there would be concurrent signals at frequencies of $455 \times 2 = 910$ kc, $455 \times 3 = 1,365$ kc, $455 \times 4 = 1,820$ kc, etc. These simultaneous multiple signals are known as "harmonics." The fundamental frequency of 455 kc is often known as the "first harmonic," $455 \times 2$ as the "second harmonic," $455 \times 3$ as the "third harmonic," etc. Now, if we use the second harmonic of 455, or 910 kc, we find that it falls in the broadcast band. Therefore, set the signal generator up as before, but tune on the band including 455 kc. The two stations for comparison near 910 kc are WCBS at 880 kc and WAAT at 970 kc. If we are tuning for zero beat with WCBS, our generator tuning dial should be at 440 kc, since we are using the second harmonic. If we obtain zero beat at 445 kc, the signal generator is off 5 kc. An output of 455 kc will then be obtained at a dial position of 460 kc. Again, this fact should be verified by beating the second harmonic of 485 kc from the signal generator with station WAAT at 970 kc.

A special precaution is required when checking calibration in the IF band. If the check receiver employs an IF amplifier tuned to 455 kc, a confusing double beat may be obtained, since the signal-generator output may beat with the signal in the IF amplifier as well as with the test station. However, if the receiver is equipped with an RF stage and an IF wave trap, there is little likelihood of the signal generator's output beating with the signal in the IF amplifier, and it may be used. Another way of avoiding this effect is to use a receiver whose IF amplifier is tuned to a frequency quite different from the signal being tested. Furthermore, a TRF receiver, if available, could be used for calibration purposes, since it has no IF amplifier.
The proper settings for the important test frequencies should be recorded in some manner by the serviceman for later use. The same technique may be used for regions other than the metropolitan New York area by similarly choosing local stations close to the test frequency points.
CHAPTER 7

SIGNAL-GENERATOR APPLICATIONS

Uses of the Signal Generator.—Throughout this text, various purposes will be served by means of the signal generator. First, the instrument will be used to determine if a stage and its associated coupling circuits are functioning properly. By placing the “hot” lead at various points in the radio receiver, this fact can easily be determined. This system of servicing is known as the “signal substitution” method and will receive more elaboration throughout the text.

Another use to which the signal generator may be put is that of receiver alignment. For most receivers brought into the service-man’s shop, this will not be a usual procedure. Where alignment is necessary, it is advisable to follow instructions given by the radio manufacturer. However, a generalized procedure will be given for those cases where the manufacturer’s notes are not available.

A third use of the signal generator is to determine if each stage is giving proper gain. In this respect, a standard output will be measured by means of an output meter. Then the settings of the output of the generator will be compared with those necessary for each stage on a known good receiver, to obtain the above-mentioned standard output.

How to Connect the Signal Generator to a Receiver.—The output from the signal generator is fed to the receiver being tested through a coaxial cable or a shielded connector cable. In either case, the external conductor is grounded within the generator and the center, or hot, lead is connected to the receiver test points. The hot lead is usually coded red, and the ground lead is either black or bare braiding.

Both the signal generator and the receiver should be at the same ground potential. This condition may be obtained by connecting the ground lead of the signal generator to the receiver chassis, which in turn should be connected to a good ground. In AC/DC receivers, where the chassis is connected directly to one side of the power line, there is danger of a short circuit in following this direction. This danger may be overcome by connecting a condenser of about 0.1 mfd/400 volts in series with the ground lead.
Where the hot lead is to be connected to an inductance like an antenna coil, it is advisable to use the Institute of Radio Engineers (I.R.E.) standard dummy antenna in series with the lead. This is shown in Fig. 7–1.

Under normal circumstances in using the signal generator for signal substitution service work, it is necessary only to connect a condenser in series with the hot lead. This prevents high DC potential points of the receiver from ruining the test instrument. In each case, the manufacturer's instructions should be followed. Generally, a 0.1-mfd/600-volt condenser should be used where IF and AF signals are delivered to the set. Where RF signals are delivered to the receiver, a 0.00025-mfd/600-volt condenser may be used. When short waves (high-frequency RF signals) are fed to the receiver, a 400-ohm resistor is used.

**Signal Substitution Method of Servicing.**—The signal generator, as used through the remainder of this book, will primarily concern itself with signal substitution for servicing receivers. At various test points in the receiver it will introduce a signal, similar to the one received in normal broadcast reception, and the results will be observed. Where observed results are not normal or typical, trouble is indicated.

A brief description will serve at this time to set down the outline of testing to check that each stage is operative. Figure 7–2 shows a simplified diagram of a superheterodyne with strategic points indicated by the balloononed numbers. Above each number is indicated the type of signal input for testing the applicable stage. The sequence of the numbers is the order in which to make the test.

Point ① tests the speaker itself. The test cannot be made unless a signal generator with a high level of AF output is available. Where such is the case, the audio note should be heard in the speaker.

Point ② checks the operation of the second AF stage, once the speaker has been found to be in good shape. Because of the stage...
amplification, a lower level AF signal is required at the input. If operation of the stage is normal, the audio signal should be heard clearly.

Point (2) is the test point for operation of the first AF stage, if the preceding tests check perfect. Once again a lower level AF input signal is required. Normal operation would result in a strong, clear audio note in the speaker.

Point (4) is the test point for operation of the detector stage. It should be remembered, as always, that all previous checks have shown proper stage operation. A modulated IF signal introduced at this test point should produce a clear modulation note in the speaker. The intermediate frequency, of course, is that for the particular receiver.

![Fig. 7-2.—Signal chain of a superheterodyne receiver showing test points.](image)

Point (5) is the test point for the IF amplifier. A modulated IF signal from the signal generator, at the IF for the particular receiver, should produce a clear modulation note in the speaker. The level of this signal input should be less than that for point (4), because of the gain of the IF amplifier.

Point (6), the signal grid of the mixer, is the test point for the mixer and oscillator. A modulated RF signal injected at this point should produce the modulation note in the speaker if the oscillator and the mixer are both operative. If no note is heard, then introduce a modulated IF signal at this point. If the note is now heard, then the mixer is functioning and the oscillator may be assumed to be inoperative.

Point (7) is the grid of the RF amplifier tube. A modulated RF signal is introduced at this point to check the operation of the RF stage. Again, it should require less input signal at point (7) than
was needed at point ⑥, the converter grid, because of the gain of the RF tube.

Point ⑤ is the test point for the antenna coil. A modulated RF signal at a lower level than for point ⑦ should produce a clear modulation note in the speaker, if all else is well.

The check procedure presented briefly here will be elaborated in the stage analyses given later in the book. It should be noted that, where coupling devices are to be checked, introduction of the proper signal at the input and the output of the coupling device should produce modulation notes in the speaker. If the note is heard at the output but not at the input, then the device or its associated circuit is presumed to be defective.

Using the Signal Substitution Method of Servicing.—An example of how to use the signal substitution method in localizing a defect will make clear its value. Refer to the receiver whose schematic is shown in Fig. 7-3. We assume a defect and try to localize it. Suppose IF trimmer condenser C-14 is shorted. The receiver is brought in with the complaint that it does not work.

Voltage analysis will not disclose the defect, because the DC resistance of parallel coil L-6 is quite low, and the DC voltage drop across it is very small. Ohmmeter analysis of the receiver would be too lengthy if used by itself.

Let us proceed by the signal substitution method. An audio signal from the signal generator is delivered to the signal grid of the output tube. It is heard clearly in the speaker. This stage is considered to be all right. The audio signal is then introduced to the grid of the type 14B6 tube. Again the audio note is heard in the speaker and the first audio amplifier is assumed to be good. A modulated IF signal is now introduced on the signal grid of the IF amplifier. The modulation note is heard clearly in the speaker and the detector, and IF stages need no further investigation. Now, when a modulated IF signal is introduced on the signal grid of the type 14Q7 converter, the modulation note is not heard. This indicates that the trouble is between the converter signal grid and the IF amplifier grid. Then a modulated IF signal is introduced on the plate of the converter, and still no modulation note is heard. This localizes the defect between the plate of the converter and the signal grid of the IF amplifier. Thereafter, a simple ohmmeter check across the primary and the secondary (L-6 and L-7, respectively) of the first IF transformer will show the short across L-6.

Receiver Alignment.—The average superheterodyne receiver has seven or more tuned circuits, each one of which has to be in resonance at its proper frequency for best operation of the receiver. The pro-
Fig. 7-3.—The Stromberg-Carlson No. 1100 AC/DC receiver.
procedure for bringing these circuits to resonance at their operating frequencies is called "alignment."

The signal generator is an invaluable tool in receiver alignment, since it is used to feed the proper aligning frequency to each circuit. The procedure consists essentially in connecting an output-measuring device across the speaker, which is the output of the receiver; feeding a voltage at the proper frequency to the circuit being aligned; and adjusting the variable component, usually trimmer condensers provided for the purpose, to a maximum deflection of the output meter.

Alignment is necessary when one of the components of any tuned circuit becomes defective and is replaced. Alignment will also perk up a receiver where, owing to natural aging of the components with time and moisture, the tuning-circuit parts change in value.

**Stage-gain Measurements.**—In a superheterodyne receiver, each stage, except the diode detector, amplifies the signal before it passes it on to the next stage. When the serviceman has an idea of the approximate amplification or gain that may be expected from each stage and is equipped to measure it while making a signal check of the receiver, he has a powerful service tool for quickly determining the location of many troubles.

For example, assume an open cathode by-pass condenser in a stage of a receiver that is perfect in all other respects. The receiver would produce a weak output. In servicing such a receiver by the old methods, tubes would check good, voltage measurements would be normal, and a routine ohmmeter check would also show nothing. The serviceman would then proceed to substitute parts, more or less at random, until he came to the defective condenser.

With the aid of stage-gain measurements, he would be examining the defective stage in a matter of minutes. Although he would still be confined to the substitution of parts, he would be doing so for the components of only one stage found to be defective.

Accurate stage-gain measurements, as made in engineering laboratories, would require a considerable outlay in the matter of test equipment. However, for servicing purposes, great accuracy is not necessary since the offending stage will usually be far below normal when the receiver is brought in as defective. Adequate stage-gain measurements can be made with the equipment that the serviceman has on hand—a signal generator and an AC voltmeter.

The theory underlying stage-gain measurements is quite simple. The receiver is held at all times during the check at one output, known as "standard" output. A signal from the generator is fed in to the input of a stage, and the voltage of that signal, necessary to
produce standard output, is noted. Then the signal is fed into the output of the stage. The voltage level of the signal is increased until standard output is again obtained. By dividing the second voltage by the first we obtain the gain of the stage. This sequence is illustrated in Fig. 7-4.

Let us take an example to illustrate the point. If 1 volt of signal at the input of a stage gives standard output, and the signal level must be increased to 10 volts to maintain the standard output when it is connected to the output of the stage being tested, then the gain of the stage is 10/1, or 10.

![Diagram of measurement process](image)

**Fig. 7-4.—Sequence of measurements to obtain the gain of a stage.**

The standard output used in stage-gain measurements has been set by the I.R.E. at 50 mw of signal power fed into the speaker. The output power may be measured by connecting an AC voltmeter across the speaker voice coil or, more conveniently, across the primary of the output transformer. In stage-gain measurements, the signal input level is adjusted to keep the output meter at the proper fixed value. This value corresponds to approximately 16 volts across the output transformer primary for most receivers. During stage-gain measurements, the AVC system must be inoperative, or it will invalidate results. For this reason, the receiver output is maintained at the low level of 50 mw so that input signals necessary to attain that level will be too weak to activate the AVC system.

The measurement points in the receiver for stage-gain checking are usually taken from one grid to the next. The amount of signal necessary to give standard output from any point in the receiver is often called the "sensitivity" of the receiver from that point on. When a signal of 3,500 microvolts is required at an IF amplifier grid to give standard output, the sensitivity of the receiver at the IF amplifier grid is said to be 3,500 microvolts.

For the practical serviceman, exact sensitivity measurements are not necessary. Comparative sensitivity measurements will serve as
Sensitivity, Generator Generatorhot Output from average input frequency lead connected to receivers at set to 5-12 microvolts 600 kc Antennaterminal Standard 50 microvolts 600 kc Modulator grid Standard 3,500 microvolts 455 kc (or other IF) IF grid Standard 0.032 volt 400" FirstAF grid Standard 1.6 volts 400~ Second AF grid Standard

SIGNAL-GENERATOR APPLICATIONS

well. These may be obtained by actually making sensitivity measurements from various points in receivers known to be in perfect operating condition. In each case, the attenuator reading of the signal generator necessary to give standard output should be recorded. When completed, the readings for each point are averaged. As a result, the serviceman will have comparative data for determining proper sensitivity from various points for any receiver brought in. For example, if the attenuator position varies greatly at the grid of the IF amplifier of an unknown receiver from the average setting just obtained, a defect in the IF amplifier stage is indicated, if all later stages check perfect.

On the average, the sensitivity of radio receivers from various points may be summarized in the accompanying table. The diode detector is omitted because its purpose is not amplification but rather demodulation.

<table>
<thead>
<tr>
<th>Sensitivity, average input</th>
<th>Generator frequency set at</th>
<th>Generator hot lead connected to</th>
<th>Output from the receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-12 microvolts</td>
<td>600 kc</td>
<td>Antenna terminal</td>
<td>Standard</td>
</tr>
<tr>
<td>50 microvolts</td>
<td>600 kc</td>
<td>Modulator grid</td>
<td>Standard</td>
</tr>
<tr>
<td>3,500 microvolts</td>
<td>455 kc (or other IF)</td>
<td>IF grid</td>
<td>Standard</td>
</tr>
<tr>
<td>0.032 volt</td>
<td>400~</td>
<td>First AF grid</td>
<td>Standard</td>
</tr>
<tr>
<td>1.6 volts</td>
<td>400~</td>
<td>Second AF grid</td>
<td>Standard</td>
</tr>
</tbody>
</table>

After having obtained the attenuator setting at various points to give standard output, the serviceman may assume that the input values are those given in the table. Thereafter, he may make due allowance if he has service literature from the receiver manufacturer giving sensitivity at various points. For example, if the service data indicate that, for a particular receiver, the sensitivity at the IF grid is 3,000 microvolts to give standard output, he knows that he must turn the attenuator up to give less than his comparative output, which is presumed to be 3,500 microvolts.

Stage-gain measurements are readily obtained from sensitivity measurements. Suppose that the signal generator delivered an output of 50 microvolts to the converter signal grid to develop standard output. The sensitivity of the receiver from that grid would be 50 microvolts. Now, suppose that the generator delivered an output of 3,500 microvolts to the grid of the next IF amplifier to develop standard output. The sensitivity of the receiver from the IF grid would be 3,500 microvolts. The gain of the converter stage would
then be found by dividing the latter sensitivity by the former. It is found to be 3,500/50, or 70.

Gain per stage varies in different receivers; therefore a small range of figures rather than a single figure would be desirable for comparative work. The accompanying table lists the various stages of a superheterodyne receiver, gives the test frequencies to the input of each, the ranges of gain for many receivers, and an average gain used in this book. For specific receivers, gain data furnished by the manufacturer in his service notes should be followed, if available.

Examination of the service notes of a typical receiver will now show the value of this stage gain technique. Figure 7–5 shows the schematic for the receiver. Service notes given by the manufacturer give the data shown in the accompanying table. The dummy antenna capacity indicates values to be connected in series with the hot lead of the signal generator. In each case, the input signal is given which results in standard output. From the data given, it is seen that, from antenna to modulator grid (at the same modulated RF frequency), there is a voltage gain of 55/15, or approximately 3.7. From modulator grid to IF grid (at the same modulated IF frequency) there is a voltage gain of 3,700/50, or 74. Any wide variations from these gain measurements would result in an indication of a defective stage.

Another method of indicating stage gain is shown in Fig. 7–3. Here, stage gain is indicated between specified points. Beneath the

<table>
<thead>
<tr>
<th>Stage</th>
<th>Test frequency</th>
<th>Range of gain</th>
<th>Average gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second AF</td>
<td>400 ~</td>
<td>5– 15</td>
<td>10</td>
</tr>
<tr>
<td>First AF (high-mu)</td>
<td>400 ~</td>
<td>40– 60</td>
<td>50</td>
</tr>
<tr>
<td>IF</td>
<td>455 ke</td>
<td>80–120</td>
<td>100</td>
</tr>
<tr>
<td>Converter</td>
<td>600 ke</td>
<td>60– 80</td>
<td>70</td>
</tr>
<tr>
<td>RF</td>
<td>600 ke</td>
<td>21– 40</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average microvolt input</th>
<th>Generator set at</th>
<th>Generator feeder connected to</th>
<th>Dummy antenna capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,700</td>
<td>455 ke</td>
<td>IF grid</td>
<td>0.1 mfd</td>
</tr>
<tr>
<td>50</td>
<td>455 ke</td>
<td>Modulator grid</td>
<td>0.1 mfd</td>
</tr>
<tr>
<td>55</td>
<td>600 ke</td>
<td>Modulator grid</td>
<td>0.1 mfd</td>
</tr>
<tr>
<td>15</td>
<td>600 ke</td>
<td>Antenna terminal</td>
<td>400 ohms</td>
</tr>
</tbody>
</table>
Fig. 7-5.—The Motorola Model 56X1 AC/DC receiver.
stage-gain value is indicated the frequency to which the signal generator must be set in making the check.

The data may be analyzed as follows. The level of input signal from the signal generator at a modulated 1,400-kc frequency should be 11 times as great at the signal grid of the converter tube as it is at the RF tube signal grid, to give standard output. This means that there is a voltage gain of 11 due to the amplification of the RF tube. The level of input signal at a modulated 1,400-kc frequency should be 61 times as great at the signal grid of the IF amplifier as it is at the signal grid of the converter tube, to give standard output. The level of input signal at a modulated 455-kc frequency at the detector plate should be 100 times as great as it is at the signal grid of the IF amplifier, to give standard output. The level of input signal at 400 cycles per second should be 31 times as great at the signal grid of the output tube as it is at the signal grid of the first audio amplifier, to give standard output. And finally, the level of input signal at 400 cycles per second should be 5.8 times as great at the plate of the output tube as it is at the signal grid of the same tube, to give standard output.
CHAPTER 8

AC POWER SUPPLY

Quick Check.—If all the tubes in the receiver light, there is no sign of overheating, the hum level is normal, and the B plus voltage measures 200 to 300 volts, the power supply is probably functioning properly, and the trouble shooter proceeds to check the next stage.

Function of Power-supply Stage.—The power supply furnishes A, B, and C voltages for the rest of the receiver. The A supply lights the filaments of the tubes, the B supply furnishes the necessary DC voltage to operate the plate circuit of the tubes, and the C supply furnishes DC grid voltage for the tubes.

The power-supply stage can be a set of batteries, as is the case in portable and emergency equipment. Usually, the lighting mains are employed to furnish the power. The power-supply stage, therefore, converts the 110-volt lighting supply into the necessary A, B, and C voltages for the receiver.

Two main types of power supplies will be considered: the AC power supply for use on AC mains, and the so-called AC/DC type which permits receivers to be plugged into either AC or DC mains. The AC/DC power-supply stage will be treated in a later chapter.

Theory of Operation of AC Power Supplies.—The basic parts of the power supply can be shown by the block diagram of Fig. 8-1.

![Block diagram of AC power supply](image)

Fig. 8-1.—Block diagram of AC power supply.

The power transformer, by stepping voltage up and down, supplies high voltage for the rectifier in the B supply, and low voltage for the tube filaments. The low-voltage windings of the power transformer are all that is needed for the A supply.

The rectifier allows current to flow in one direction only. Its output, therefore, is pulsating direct current.
The filter circuit smooths the pulsating direct current from the rectifier into unvarying direct current, for use as the $B$ supply.

The voltage divider, as its name indicates, subdivides the available $B$ voltage into lower values, as needed in various plate and screen circuits. Sometimes additional taps are added, so that $C$ voltage is obtained from the same source.

**Standard Circuit.**—See Fig. 8–2.

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**Functions and Values of Component Parts.**—Transformer $T-7$ is the power transformer. It operates on the principle of electromagnetic induction. Current in the primary sets up a magnetic field in the iron core. Since the primary current is alternating, the magnetic field is constantly changing in magnitude and direction: building up, collapsing, building up in the opposite magnetic direction, collapsing, etc., with each change in the alternating current. A changing magnetic field induces voltage in any winding that is exposed to it, and the greater the number of turns, the greater will be the induced voltage. At this point, the inability of transformers to operate on direct current can be easily seen. Direct current sets up a steady magnetic field, and voltage will not be induced in the windings.

Power transformers for radio work are usually designed to operate at 2 to 4 turns per volt. Assume a 2-turns-per-volt transformer. Then the 120-volt primary will be wound with 240 turns. (Although the lighting mains are usually called "a 110-volt line," line voltage will actually measure more nearly 120 volts. Design work assumes a line voltage of 117.) Each 2 turns of secondary winding will have 1 volt induced in it. The 5-volt winding for the rectifier filament will be wound with 10 turns, and the wire will be comparatively
heavy to carry the 2 amp, that the rectifier filament draws. The high-voltage winding, usually 700 volts, will be wound with 1,400 turns. This will be fine wire, since the radio requires only about 70 ma (0.07 amp) of B current.

**Caution:** 700 volts is dangerous. Care must be exercised in handling and measuring the high-voltage leads.

The filament winding for the other tubes in the receiver will be wound with 12 turns for 6 volts, and the wire will be heavy enough to carry the current drain of several tubes. In the older receivers, this winding is designed for 2½ volts at heavy amperage, to accommodate the 2½-volt tubes used.

The high-voltage winding is always center-tapped for use in the full-wave rectifier circuit. The other windings are sometimes also tapped: the primary at the 220th turn, for use in areas where line voltage is low. The amplifier and rectifier filaments may also be tapped in the center.

In table-model receivers, the power transformer is usually smaller, the main difference being in the high-voltage winding, which is approximately 500 volts at 50 ma rather than 700 volts at 70 or 90 ma.

The rectifier is a conventional full-wave circuit. Vacuum tube V-6 is an 80, 5Y3-G, or 5Y4-G. In large radio sets where the B current drain is heavy, the rectifier may be a 5Z3 or 5U4-G. The full-wave rectifier, operating from a 60-cycles-per-second source, will deliver to the filter 120 pulses per second.

The filter circuit consists of L-15, C-15, and C-16. L-15 is usually the speaker field. It consists of a large number of turns of wire, wound on an iron core. Its action in the filter circuit is that of an inductor or choke. An inductor acts to retard any change in current through it in the following way. Any change in current will produce a change in the magnetic field. The changing magnetic field will induce voltage in any winding exposed to it, as it does in the case of the transformer. In the case of the choke, where there is only one winding, the voltage will be induced in that winding. Since the induced voltage is opposite in direction to the original source, it will always tend to oppose any change in current in the coil due to the varying magnetic field. The choke, therefore, has a high opposition to any change in current (alternating current or pulsating direct current), while its opposition to direct current (unchanging magnetic field) is comparatively low. Since the choke is connected in series with the power-supply output circuit, it tends to keep pulsations out of the output.

Condensers C-15 and C-16 are connected across the power-supply output, one on each side of the choke. The action of a condenser in a
circuit containing pulsations is to stabilize the voltage across it. When the voltage across a condenser is exceeded by the momentary peak from the rectifier, the condenser charges and absorbs the peak. During the lull between peaks from the rectifier, when the voltage would drop, the condenser discharges and maintains the voltage. Condensers $C-15$ and $C-16$ are high-capacity, high-voltage electrolytic condensers. Often they are in the same container, which is called a "filter-condenser block." A common size would be labeled "20–20 mfd–450 volts DC–Surge voltage 525." Sometimes the block contains three condensers, such as the one pictured in Fig. 8–3.

![Fig. 8-3.—A filter-condenser block.](image)

$R-15$ and $R-16$ form the voltage divider. These vary considerably in size and ohmage in different receivers, depending on the voltage required. Where more than one intermediate voltage is required, there will be more than two resistors. In some circuits, intermediate voltages are obtained from series voltage-dropping resistors, as is done for the screen of $V-3$ in the standard circuit (Fig. 1–1), and $R-15$ and $R-16$ may be omitted entirely. Although $R-15$ and $R-16$ may be as low as 5,000 ohms and as high as 50,000 ohms, they do not differ very much from each other. The value of 30,000 ohms each has been chosen for the standard average receiver.

Switch $S-1$ is the on-off switch for the radio. It is often ganged with the volume control. Switch replacement notes will be found together with volume control replacement notes in Chap. 11 on the first AF stage.

Condenser $C-17$ is the line filter. Its action is to remove various RF line disturbances, such as those caused by sparks caused by sparking brushes on electric motors, from entering the radio. The value of $C-17$ is not critical. Values ranging from 0.002 to 0.5 mfd are found in various radios.
NORMAL TEST DATA FOR THE POWER-SUPPLY STAGE

Check for Normal Stage Operation.

All tubes light or heat.

No sign of overheating.

Voltage check—B plus to chassis—200 to 300 volts.

Hum level—normal.

Most receivers normally have a slight hum, since it is rather costly to remove the last traces. This is known as “residual” hum, and the serviceman must have some way of determining whether the amount present is normal or excessive. A good check is to place the ear close to the speaker with no station tuned in. If the hum is just discernible, call it normal. This small amount will not be objectionable when the ear is at its usual distance from the speaker and a station is tuned in. If noises from the RF amplifier interfere with the test, the RF end of the receiver can be made inoperative by removing the IF amplifier tube. If the test is being made with the speaker out of its cabinet, as is usual at the bench, the serviceman should remember that the cabinet baffle accentuates low-frequency response and, since 120-cycle hum is low-frequency, he should allow accordingly.

If the quick check indicates trouble in the power supply, disconnect the line plug and, before proceeding to further tests, discharge the filter condensers by shorting them. The filter condensers may retain a charge, with subsequent danger of shock or damage to test equipment.

Normal Resistance Data.—Normal resistance data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Resistance Description</th>
<th>Resistance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plug prong to prong</td>
<td>5–15 ohms</td>
</tr>
<tr>
<td>Chassis to rectifier plates</td>
<td>150–200 ohms</td>
</tr>
<tr>
<td>Rectifier filament to B plus, across speaker field</td>
<td>1,000–2,000 ohms</td>
</tr>
<tr>
<td>Chassis to rectifier filament</td>
<td>61,000 ohms</td>
</tr>
</tbody>
</table>

The last reading will vary considerably, depending on the voltage divider design of the particular receiver. Presence of electrolytic condensers C-15 and C-16 will also affect the reading. In circuits containing electrolytic condensers, always reverse the test prods and take the higher reading.

Normal Voltage Data.—Normal voltage data are given in the accompanying table.

<table>
<thead>
<tr>
<th>Voltage Description</th>
<th>Voltage Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectifier filament to filament</td>
<td>5 volts AC</td>
</tr>
<tr>
<td>Across other tube heaters</td>
<td>6 volts AC</td>
</tr>
<tr>
<td>Chassis to rectifier plate</td>
<td>250–380 volts AC</td>
</tr>
<tr>
<td>Chassis to rectifier filament</td>
<td>265–400 volts DC</td>
</tr>
<tr>
<td>Chassis to B plus</td>
<td>200–300 volts DC</td>
</tr>
<tr>
<td>Chassis to screen</td>
<td>90–100 volts DC</td>
</tr>
</tbody>
</table>
Small receivers tend toward the lower $B$ voltages. Large receivers tend toward the higher $B$ voltages. The measured voltage from chassis to rectifier plate is the rms or effective value. The rectifier voltage, measured from chassis to rectifier filament, is usually a little higher than the AC input owing to the action of condenser $C\cdot15$, which maintains the rectified voltage at more nearly the peak value.

**COMMON TROUBLES IN THE POWER SUPPLY**

All the component parts in the power supply are common sources of trouble. Even the rectifier-tube socket is not immune. In the case of the socket, dirt between the rectifier plate pins causes the high voltage to arc across, burning up the socket material. This is found by inspection, and the cure is obvious: replacement of the socket. The power transformer should be carefully checked, since the heavy drain may have damaged it.

**Troubles Common to Power Transformers.**—The power transformer develops many ills, the chief cause of which is overheating due to overloads within the transformer or to external shorts. The ohmmeter check is not entirely reliable. For example, a few shorted turns in the high-voltage winding will not affect the ohmmeter reading to any great extent, while it will cause a heavy drain from the primary and consequent overheating. In a case like the above, even though the voltage would be considerably reduced, the radio would keep on playing, and it might not be brought in for repairs until the overload had caused the primary finally to open or the owner had become concerned about the smell from his radio. In-

![Fig. 8-4.—The power transformer.](image-url)
cidentally, the smell from a burned transformer is unmistakable, and
the serviceman need only follow his nose to the trouble. When the
trouble has been determined, it is wise to check for external shorts
before replacing the transformer. As an example of the necessity for
this, assume a partial short in the dial-light wiring of a radio. The
radio continues to play, and finally the overload causes the trans-
former primary to open. The serviceman quickly finds the open
transformer, replaces it, checks the radio, which appears to operate
satisfactorily, returns it to the customer, and, before long, the new
transformer is burned owing to feeding current to the partial short
that is still in the dial-light wiring.

How to Check the Power Transformer.—The best check for
normal operation of the power transformer is a wattmeter, or AC
ammeter, connected in the primary circuit. The serviceman's
multitester, however, rarely includes scales and ranges that are
suitable for this purpose. A good check with inexpensive equip-
ment can be made as follows:

1. Remove all tubes from the radio.
2. Plug the radio into an outlet that contains an ordinary 25- or
40-watt lamp in series with the line, as shown in Fig. 8-5.
3. A good transformer will cause the lamp just to glow.
4. Any short that is present will cause the lamp to glow brightly.
5. If a short is present, remove the transformer secondary leads
from their connection points, one winding at a time, to determine
whether the short is internal or external; in the latter case, to de-
termine which circuit contains the short.

![Fig. 8-5.—Checking the power transformer.](image)

To interpret the above checks, it might be well at this point to
give some more transformer theory. With all the tubes removed,
the secondaries are not drawing current, and consequently, the
primary should not be drawing current. This would be true if the
transformer were 100 per cent efficient. Since this is not so, the
primary will draw a small amount of current to overcome the hysteresis and eddy-current losses in the iron core. With the average radio power transformer, this small amount of current is sufficient to cause the series 25-watt lamp just to glow. This is the test for a good transformer.

Now, assume some shorted turns, or a short in the 6-volt amplifier-filament wiring. The primary must furnish the power that this short consumes. The added primary drain causes more current to flow through the series 25-watt lamp, and the lamp glows more brightly. Now, suppose that we disconnect the 6-volt transformer leads. If the lamp brightness drops to just a glow, we must inspect the receiver filament circuit for a short. If the lamp filament continues to glow brightly, even after all circuits have been opened, the short is within the transformer.

When a power transformer is replaced, an exact duplicate is to be preferred. If this is unobtainable, the serviceman is beset by a number of questions. What size shall I use? Which winding is which? How can I tell the windings apart? What shall I do with the extra leads?

_What Size of Replacement Power Transformer Should Be Used?_  
—Replacement transformers are usually rated in the voltages and currents obtainable from the various secondary windings. These data must be compared with the calculated requirements of the tubes in the receiver being serviced. For example, checking the requirements of our standard receiver with the tube manual, we obtain the information shown in the accompanying table.

<table>
<thead>
<tr>
<th>Tube complement</th>
<th>$A$ requirements</th>
<th>$B$ requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volts</td>
<td>Amp</td>
</tr>
<tr>
<td>5Y3-G</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>6V6-G</td>
<td>6.3</td>
<td>0.6</td>
</tr>
<tr>
<td>6SQ7</td>
<td>6.3</td>
<td>0.3</td>
</tr>
<tr>
<td>6K7</td>
<td>6.3</td>
<td>0.3</td>
</tr>
<tr>
<td>6A8</td>
<td>6.3</td>
<td>0.3</td>
</tr>
<tr>
<td>6K7</td>
<td>6.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total...........</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>
Allowing 100 volts for the speaker field, adding this to the plate voltage requirement, and allowing for the voltage divider drain, a replacement transformer with the following rating can be used:

- 5 volts at 2 amp
- 700 volts (center-tapped) at 90 ma
- 6.3 volts at 2 amp

The high-voltage winding is sometimes labeled "350-0-350," which indicates 350 volts on each side of the center tap. This is the way the transformer is used in a full-wave rectifier.

A good rule to follow, as a check of the calculations, is that the replacement transformer should be about the same physical size as the original.

Power Transformer Color Code.—Most transformer manufacturers color their leads in accordance with the Radio Manufacturers Association (R.M.A.) color code. This can be used to advantage for replacement and is given in Fig. 8-6.

How to Identify Leads of an Uncoded Transformer.—In case the manufacturer does not follow the code, the leads can be determined with an ohmmeter and voltmeter as follows:

1. Pair up the winding leads by means of an ohmmeter.

   a. First connect the ohmmeter to any lead and check for continuity with all the other leads, as shown in Fig. 8-7A. The lead that shows continuity is the other end of that winding or a
tap. In the case of a tapped winding, three leads will show continuity.

![Diagram A](image)

**Fig. 8-7.—Pairing the leads.**

b. Separate these two or three leads, as the case may be, and repeat to find the other windings, as shown in Fig. 8-7B.

d. Read the resistance of each winding, as shown in Fig. 8-8.

![Diagram B](image)

**Fig. 8-8.—Resistance of each winding.**

a. The primary will show a resistance of 5 to 15 ohms (240 turns).
b. The high-voltage winding will show a resistance of 200 to 400 ohms (1,400 turns) for the entire winding.

c. The filament windings will show a reading of less than 1 ohm (10 or 12 turns).

There will be no mistaking the high-voltage winding. Tape the leads so there will be no danger of shock.

3. Connect the primary to the AC line, and check the voltage of the filament windings to determine which is the amplifier and which the rectifier filament winding (Fig. 8–9).

What to Do with Unused Leads.—The replacement transformer often has leads that are not used in the original wiring diagram of the receiver. The filament center taps, for example, may not be used. If this is the case, tape the unused leads so that they will not short and dress them neatly in the receiver chassis. If the unused center tap is of the type that has two separate wires in a single piece of spaghetti, solder these two wires together before taping the end.

Sometimes the replacement transformer has an uncoded lead that does not show continuity to any of the other leads. This lead will be the connection to a noise-reducing Faraday shield, between the primary and the secondary windings. If the transformer has such a lead, connect it to a chassis soldering lug.

General Replacement Notes.—Before concluding this section of replacement notes on power transformers, the authors would like to remind the serviceman that it is a sign of good workmanship always to be careful of wiring and soldering and that this is especially important when replacing the power transformer. A poor connection or resin joint can cause much trouble when it is in the low-voltage high-amperage filament circuit. Poor insulation and sloppy soldering can also cause a messy recall job from flashovers in the high-voltage circuit. Of course, the line cord should be examined for frays, the
grommet should be examined for breaks, and the knot should be in place behind the grommet on the inside of the chassis.

**Troubles Common to the Rectifier Tube.**—Rectifier tubes usually have a long life. The 5Y3-G, for example, is rated at 125 ma of output current. This is rarely exceeded or even reached by the typical receiver; when it is, a larger tube, the 5U4-G, is usually employed. As the tube ages, it gradually loses its emission, with a consequent loss in output voltage. Tube checkers are reliable in indicating this condition. Another check is a comparison of output voltage with another rectifier tube that is known to be good. Occasionally, rectifier tubes become gassy and glow with a purplish light. In this case, the receiver will not operate at all, or its speaker might emit only a low tearing growl. Replacement of the tube is the answer. The above applies only to high-vacuum rectifiers like the 80, 5Y3-G, 5Y4-G, 5U4-G, etc. It is normal for a glow to appear in gas rectifiers like the OZ4-G and in mercury-vapor rectifiers like the 82 and 83.

**Troubles Common to the Filter Choke (Speaker Field).**—The common fault with filter choke L-15, the speaker field, is that the winding opens. This will be found on check, by no voltage at B plus and abnormally high voltage at rectifier filament. When he finds this condition, before checking to make sure that the field is open, the serviceman should pull the receiver plug and discharge the filter condensers. Input filter condenser C-15 remains at full charge, since there is no discharge circuit when the field is open.

When the ohmmeter shows an open field, the serviceman should not rush too soon for a replacement. Especially when the speaker is not mounted directly on the chassis, speaker plug contacts and connecting cables should first be inspected carefully for the open. Sometimes the open is due to corrosion or a break at the soldered connection between the field wire itself and the connection leads that leave the field, and this can often be repaired. The field covering is cut into near the lead to expose the connection. The broken end is then picked up, cleaned with fine sandpaper, and tinned before soldering the new connection. The lead must be securely taped into position, since mechanical stress will break the fine field wire.

Replacement field coils are not often obtainable, nor are speakers often of a type that can be taken apart for this purpose. A procedure for replacing field coils where feasible is given in Chap. 9, on Speakers. As a general rule, the entire speaker must be replaced. Where the exact duplicate cannot be obtained, the chosen replacement must match the original as nearly as possible in size, mounting details, wattage rating, resistance of the field coil, and impedance of the
voice coil. The output transformer can usually be transferred from the old speaker to the replacement.

**Troubles Common to the Input Filter Condenser.**—The input filter condenser \( C-15 \) is the most common cause of trouble in the power-supply stage. It is a high-voltage, high-capacity electrolytic condenser of either the wet or the dry type. With time, electrolytic condensers lose capacity and open. When this is the case, the \( B \) plus voltage will be low and the receiver will hum. The defect is confirmed by bridging the condenser with a good one of similar capacity and noting the improvement.

Condenser \( C-15 \) also has the highest DC voltage in the receiver across it. In addition, there are large surges in voltage across it. As a result, it is subject to voltage breakdown and shorting. When this happens, the \( B \) plus voltage is zero, and the rectifier-tube plates become red hot from the heavy drain of current into the shorted \( C-15 \).

**How to Check an Electrolytic Condenser.**—The handiest check for an electrolytic condenser is a resistance measurement on the high-resistance range of the ohmmeter. When the condenser is checked, the meter pointer will kick up and then drop. The meter test prods are then reversed. The meter pointer should kick up further and then drop again. The surge of current, indicated by the kick, is caused by the condenser's being charged by the battery in the ohmmeter. When the test prods are reversed, the charged condenser adds its voltage to the battery in the ohmmeter, causing an increased surge of current, as indicated by the increased kick. An open electrolytic condenser will show very little of this charge-and-discharge current.
Electrolytic condensers normally have leakages, which will be different, depending on the polarity of the ohmmeter connections and that of the condenser. Definite values cannot be assigned to the ohmmeter readings of this leakage resistance, owing to differences in condensers as well as in ohmmeters. An approximation for condenser C-15 is 50,000 ohms with the test prods connected one way, and 500,000 ohms on reversal. The difference is due to the fact that the condenser is polarized. Condenser C-15 must be disconnected from the circuit for this test, since other circuits are connected in parallel with it. The above explains the general rule when making resistance tests in a circuit bridged by an electrolytic condenser: Reverse the test prods and take the higher reading.

**Replacement of the Input Filter Condenser.**—When filter condenser C-15 is replaced, the capacity and voltage rating of the original should be used. A lower capacity may cause hum; a lower voltage rating may soon cause breakdown. Correct polarity must be observed since, if it is reversed, the condenser will overheat and possibly explode.

Sometimes, input-filter replacement condensers continually break down. This is due to high surge voltage and is found in large receivers. The high surge voltage is due to the fact that, when the receiver is turned on, the filament-type rectifier immediately furnishes high voltage, while the cathode-type amplifiers, which constitute the load, have not yet warmed up and are not drawing current. During the period of no load or low load as the amplifier tubes warm up, the voltage output of the power supply is high. Normally, in the average receiver, this is of no consequence, since the surge voltage developed from a 350–0–350 high-voltage winding is approximately 450 volts, well under the 525 surge-voltage rating.
of an electrolytic condenser. In large receivers, however, where the tube complement includes a 5U4-G and two 6V6-G or 6L6-G tubes, the high-voltage winding may deliver higher voltage, and the voltage across C-15 may be 550 volts until the output tubes warm up. Where this is the case, there will be repeated breakdowns of condenser C-15.

Surge voltage is easily checked. Simply allow the receiver to cool down, connect the voltmeter across condenser C-15, turn the receiver switch on, and watch the voltmeter. If the voltmeter goes up to 425 or 450 volts when the switch is first turned on, and then settles back to about 350 volts as the tubes warm up, there is little likelihood of trouble from surge voltage. If the surge voltage climbs above 525, the safest procedure is to replace condenser C-15 with two condensers in series, as shown in Fig. 8-12. Condensers C-15A and C-15B should each be twice the capacity of condenser C-15, since two equal condensers in series have a total capacity of half of one of them. The resistors should be 1 watt, 1 megohm (1,000,000 ohms) apiece. Their purpose is to equalize the voltage across condensers C-15A and C-15B. Each condenser, therefore will have half of the total voltage across it. A circuit of this type, employing condensers of the same voltage rating, will withstand any surge.

When condenser C-15 is replaced with a wet electrolytic, it is considered good practice to re-form the condenser plates, which may have deteriorated from shelf life. To do this, connect the replacement condenser (observing polarity) across the output filter condenser C-16, where the voltage is smoother and more suited to forming plates. Leave the radio turned on for about half an hour. If the replacement condenser heats, it needed the re-forming process.
When a shorted input filter condenser is replaced, it is advisable to check the rectifier tube to make sure that it was not damaged by the heavy overload.

**Troubles Common to the Output Filter Condenser.**—Output filter condenser C-16 is usually similar to the input condenser C-15 and is subject to the same troubles; it opens and shorts. When it opens, there is no effect on the $B$ plus voltage, but there may be excessive hum, squeal, or motorboating, or a combination of all three. Substituting another condenser to see its effect is the fastest check. When it shorts, $B$ plus voltage is zero, and the rectifier tube overheats, but not to the point of red plates.

Before condemning condenser C-16, the serviceman should look for even a small $B$ plus voltage. In parallel with condenser C-16 is the plate circuit of every tube in the radio, and the short may very well be elsewhere. Figure 8–13 is a skeleton diagram of the receiver, showing only the plate and $B$ plus circuits. If, for example, condenser C-12 were shorted, $B$ plus voltage would be low, the voltage at the rectifier filament would be almost normal, and the plate voltage of the second AF tube, V-5, would be zero. It would be a good idea, therefore, to check all plate voltages before going further. Another good indication as to the location of the short would be an overheated resistor. Resistor R-4, R-22, or R-25 would be badly overloaded if condenser C-4, C-22, or C-25 were shorted. If these methods do not locate the short, it would be necessary to open C-16 as well as the rest of the $B$ plus circuit, one wire at a time, and hunt for the short with an ohmmeter. When the short is located, if it is an item other than condenser C-16, replacement notes will be found for it in the chapter dealing with its particular stage.
When replacing condenser C-16, the serviceman must be careful to observe polarity. Also, when replacing an open output filter condenser, he should be careful to remove the connection from it when, for one reason or another, the original condenser is left physically on the chassis. Even though the soldering lug might be handy for the replacement condenser, leaving the old one connected in the circuit is a potential source of trouble. Output filter condenser C-16 is not nearly so susceptible to high surge voltage as input filter condenser C-15, and the usual surge voltage rating of 525 volts is adequate.

Finally, condensers C-15 and C-16 are often contained in one filter block. The fact that one condenser has proved defective is no indication that the other cannot still give long, satisfactory service.
If either $R_{15}$ or $R_{16}$ changes in ohmic value, the screen voltage will be abnormal and the radio may oscillate. Again the ohmmeter is the final check. It must be remembered in making these ohmmeter checks on resistors $R_{15}$ and $R_{16}$ that electrolytic condenser $C_{16}$ is across the pair of them and will affect the readings. In all cases, the ohmmeter test prods must be reversed and the higher ohmic reading taken.

In replacing either $R_{15}$ or $R_{16}$, it would be well to check the wattage rating against the wattage formula $W = \frac{E^2}{R}$. In the case of $R_{15}$, $E$ is the potential difference between $B$ plus and the screen voltage; in the case of $R_{16}$, $E$ is the screen voltage. For example, $R_{15}$ in the typical circuit is 30,000 ohms, $B$ plus is 250 volts, and screen is 100 volts. Then

$$W = \frac{E^2}{R} = \frac{150 \times 150}{30,000} = \frac{15}{20} = \frac{3}{4} = 0.75 \text{ watt}$$

Since a resistor should have at least a 100 per cent safety factor, the required wattage rating for $R_{15}$ is 1.5 watts. There is no 1.5-watt size, and the next larger size usually stocked is 2 watts. The replacement for $R_{15}$, therefore, should be a 2-watt 30,000-ohm resistor, even though the original may have been a 1-watt size.

Voltage-divider resistors $R_{15}$ and $R_{16}$ are a possible cause of fading in the receiver. As they warm up in operation, they may change in ohmic value. This causes a change in screen voltage, which will cause a change in the amplification of the tubes whose screen voltage is controlled by $R_{15}$ and $R_{16}$, with a consequent change in volume, known as “fading.” This condition can be checked by clipping the voltmeter from screen to chassis, leaving the radio turned on, and noting the reading before and after the fading.

Voltage-divider resistors $R_{15}$ and $R_{16}$ are sometimes tapped wire-wound resistors, as in Fig. 8–15. The defect common to this type is that the resistors open; they rarely change in value. Defects are found by the same procedure as was explained above for the carbon resistor type. When replacing a section, any resistor of the proper ohmic value and wattage rating may be used. However, it is not wise to leave the old unit connected in the circuit. The open may heal intermittently, with consequent noise and fading. A trouble-free replacement for a section is shown in Fig. 8–16.
Troubles Common to the Line Filter Condenser.—Line filter condenser \( C-17 \) is a paper tubular condenser, whose usual capacity is 0.1 mfd. With the usual rating of 400 volts, voltage breakdowns are unknown. The condenser may open, and this would theoretically cause greater interference from line disturbances. An open line filter condenser, however, may cause entirely different effects. Owing to its position in the circuit, the receiver chassis is grounded through condenser \( C-17 \) by the lighting mains, one side of which is grounded. The receiver installation may have no ground at all or an indifferent ground, in which case \( C-17 \) takes on a new function—that of grounding the receiver. This explains why reception (absence of hum or noise) is often improved by reversing the plug on AC receiver installations. It also explains why a tiny spark or small shock is experienced when connecting a ground to a receiver. When \( C-17 \) is open, its grounding function is gone. The most annoying manifestation of this is known as “modulation hum”; that is, the receiver does not hum when making a hum check. The hum comes on as a station is tuned in. There will be no hum between stations. Standard procedure for modulation hum is to check the ground and condenser \( C-17 \). Bridging condenser \( C-17 \) with another condenser of like value is the check for an open condenser.

VARIATIONS OF THE POWER-SUPPLY STAGE

There are many variations of the power-supply stage having to do with transformer taps, voltage dividers, two-section filters for better
elimination of hum, and methods of feeding current to the speaker field. These have all been incorporated in Fig. 8–18, which is fairly representative of many large, high-quality receivers.

Condensers C-17 and C-117 filter both sides of the line. The electrostatic shield in T-7 aids in reducing line disturbances. The primary is tapped so that the receiver can be easily adapted for high- or low-line voltage. The line is also protected by means of a low-amperage fuse, F-1. The high- and low-line switch and fuse are usually combined in a simple arrangement, as shown in Fig. 8–19. Clipping fuse F-1 into the position marked 110 VOLTS automatically connects the line to the 110-volt primary tap. The connections for the fuse clip terminals are indicated in the schematic diagram of Fig. 8–18 by the circles near fuse F-1. For the sake of long life for the filter condensers, the 190-volt position is safest.

The filament windings are shown center-tapped. There may also be a second filament winding of 2.5 volts, for lighting the filaments of 2A3 power output tubes. The other tubes are of the usual 6-volt type. A second filament winding is not necessarily for 2.5-volt tubes only. Since these are multtube receivers, the filament drain is quite heavy, and the filament circuit is often split up into two lines fed by individual windings. If there is only one winding, the receiver filament hookup wire is very heavy to take the heavy current load.

The rectifier used is usually the 5Z3 or 5U4-G. In this type of receiver, the rectified output voltage is considerably higher than is the case in the standard receiver, and surge voltage may cause problems. This was discussed in the section dealing with replacement notes for input filter condenser C-15.
Filter choke L-115 is a low-resistance, high-current choke coil. It is usually very rugged and rarely gives trouble. If it should open (probably owing to corrosion in a moist climate), the procedure for finding it is identical with that given for speaker field L-15. Speaker field L-15 and condenser C-116 form the second section of the filter circuit and offer no new problems. Voltage divider R-15 and R-16 is usually a wire-wound tapped resistor of lower ohmic value and higher wattage rating than is found in the standard circuit. The lower resistance drives more magnetizing current through the speaker field and also provides a load known as a “bleeder,” which is always connected across the rectifier output, whether the amplifier tubes have warmed up or not, and is therefore instrumental in keeping down the surge voltage. Incidentally, when 2A3 or 6A3 tubes are used in the power output stage, since these are filament-type tubes, they draw current as soon as the filament-type rectifier tube is able to deliver it. In this case, surge voltage can be neglected entirely.
Fixed-bias Type Power-supply Stage.—Another common variation in the standard circuit occurs where the filter choke is connected in the negative \( B \) supply lead. The action of filter choke \( L-15 \), as an inductance in series with the load to offer high opposition to pulsations, is the same whether it is connected in the positive or negative side of the \( B \) supply line.

Since the center tap of the high-voltage winding is of necessity the most negative voltage point in the receiver, by placing choke \( L-15 \) in the negative power-supply lead the transformer end of choke \( L-15 \) is more negative than the \( B \) minus or ground end, by the voltage drop across the choke. Control grids in amplifier tubes are kept at a potential that is negative with respect to cathode. This is called the "grid-bias" voltage, or, more simply, \( C \) voltage. In the above circuit, the amplifier cathodes will be grounded and the grids returned to the point in choke \( L-15 \) which will develop the proper negative bias voltage. Choke \( L-15 \) is usually an 1,800-ohm speaker field, tapped at 300 ohms for bias voltage.

Modern variations of this circuit use a resistor in the negative \( B \) lead to replace the tap on the choke. This resistor is often tapped, as shown in Fig. 8–21, where the resistor is represented by \( R-115 \) and \( R-116 \). The purpose of the tap is to give more than one bias voltage. This is done to provide a low value of \( C \) bias for the RF tubes, and a higher value for the last audio stage. The tapped resistor is called a "\( C \) voltage divider." In circuits of this type, the speaker field \( L-15 \) may be found in the positive leg of the \( B \) power

Fig. 8–21.—Power supply furnishing \( C \) voltage by means of a \( C \) voltage divider.
supply, since the bias voltage is developed across R-115 and R-116. The most common type of C voltage divider is a wire-wound tapped resistor.

Either of these systems of obtaining C voltage is known as "fixed bias," because the voltage is due to the entire B current of the receiver passing through the resistor or speaker field.

All the component parts serve the same purpose as in the standard circuit, and most of the replacement notes are applicable. The fixed-bias circuit is quickly recognized, since the cans of the electrolytic filter condensers are insulated from chassis and will show negative voltage with respect to chassis. If the electrolytic condensers are of the cardboard-covered type, the negative leads do not connect to chassis. If C-15 and C-16 are enclosed in one filter-condenser block, the positive is the common lead.

In the test procedure, readings are not taken from chassis. For example, chassis to rectifier plate would not be checking the high-voltage winding but would include R-115 and R-116 and the speaker field. It would be best, when servicing a power supply of this type, to keep the receiver wiring diagram constantly at hand for reference to the proper test points for checking each component part. A good reference point for readings would be the center tap of the high-voltage winding.
Quick check for normal operation of stage.

All tubes light.
No signs of overheating.
Hum level is normal.
$B$ plus voltage measures 200 to 300 volts.

Typical AC power supply.

Typical AC power supply is shown diagrammatically in the accompanying figure.

Normal resistance data.

Plug, prong to prong ........................................... 5–15 ohms
Chassis to rectifier plates ....................................... 150–200 ohms
Rectifier filament to $B$ plus, across speaker field .......... 1,000–2,000 ohms
Chassis to rectifier filament ..................................... 61,000 ohms

Normal voltage data.

Rectifier filament to filament .................................. 5 volts AC
Across other tube heaters ....................................... 6 volts AC
Chassis to rectifier plate ....................................... 250–380 volts AC
Chassis to rectifier filament .................................... 265–400 volts DC
Chassis to $B$ plus ................................................ 200–300 volts DC
Chassis to screen .................................................. 90–100 volts DC
<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 with ohmmeter</td>
<td>Defective line cord and plug.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open fuse. Defective line switch S-1. Open power transformer T-7 (primary)</td>
</tr>
<tr>
<td>Rectifier-tube plates show red</td>
<td>Chassis-to-rectifier filament checks short circuit with ohmmeter</td>
<td>Shorted input filter condenser C-15. Check surge voltage on replacement</td>
</tr>
<tr>
<td>Rectifier tube overheats</td>
<td>B plus voltage checks zero.</td>
<td>Shorted output filter condenser C-16. Short circuit in B plus wiring</td>
</tr>
<tr>
<td>Rectifier tube overheats</td>
<td>B plus voltage low</td>
<td>Zero plate voltage on amplifier tubes. Short-circuited plate filter condenser</td>
</tr>
<tr>
<td>Hum</td>
<td>B plus voltage low</td>
<td>Open input filter C-15</td>
</tr>
<tr>
<td>Hum</td>
<td>B plus voltage normal</td>
<td>Open output filter C-16. Open grid</td>
</tr>
<tr>
<td>Oscillation or motorboating</td>
<td>B plus voltage normal, or fluctuating with motorboat beats. Screen voltage normal</td>
<td>Open output filter C-16 (or C-116)</td>
</tr>
<tr>
<td>Rectifier tube shows purplish glow</td>
<td></td>
<td>Gassy high-vacuum type of rectifier tube</td>
</tr>
<tr>
<td>Weak reception. No sign of overheating</td>
<td>B plus voltage checks low</td>
<td>Weak rectifier tube</td>
</tr>
<tr>
<td>No signal from speaker. No sign of overheating</td>
<td>B plus voltage checks zero (discharge filter condenser)</td>
<td>Dead rectifier tube. Open filter choke L-15</td>
</tr>
<tr>
<td>No reception. No hum. B plus voltage normal</td>
<td>Screen voltage zero</td>
<td>Open voltage-divider resistor R-15, short-circuited screen by-pass condenser, or both</td>
</tr>
<tr>
<td>Modulation hum</td>
<td></td>
<td>Poor ground, open line filter condenser C-17, or both</td>
</tr>
<tr>
<td>Fading</td>
<td></td>
<td>Screen voltage changing, owing to defective voltage-divider resistors R-15 and R-16</td>
</tr>
<tr>
<td>Oscillation</td>
<td>Screen voltage high</td>
<td>Open voltage-divider resistor R-16</td>
</tr>
</tbody>
</table>
QUESTIONS

1. The tubes of an AC radio receiver do not light. List the various possible sources of trouble in the order in which you would check them.

2. An AC receiver does not play, and the rectifier plates get red hot. What is the most likely cause of the trouble?

3. An AC receiver is brought in for hum. How would you check to see if the hum originates in the power-supply stage?

4. An AC receiver does not play. A check of the receiver shows that the tubes light and that there is no sign of overheating or hum, but there is no B voltage. List the possible causes of the trouble, and explain how you would check for each one.

5. After a shorted input filter condenser has been replaced, what two checks should be made before checking the receiver for normal operation?

6. The power transformer of an AC receiver overheats. The radio plays, the hum level is somewhat high, and B voltage is low. A voltage check of the power supply shows 280 volts AC on one rectifier plate and 80 volts AC on the other. What is wrong?

7. Describe the series lamp check for a short in a power transformer or its associated circuits.

8. When using the series lamp check on a receiver with an overheating power transformer, the lamp glows brightly until the amplifier filament wires are removed. Where would you look for trouble?

9. When a 5Y3-G rectifier tube glows with a purplish light, what is likely to be wrong?

10. Thordarson lists the following general replacement power transformers:

<table>
<thead>
<tr>
<th>Type No.</th>
<th>T-13R11</th>
<th>T-13R12</th>
<th>T-13R13</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV winding......</td>
<td>580 volts CT at 50 ma</td>
<td>700 volts CT at 70 ma</td>
<td>700 volts CT at 90 ma</td>
</tr>
<tr>
<td>Rectifier filament</td>
<td>5 volts at 3 amp</td>
<td>5 volts at 3 amp</td>
<td>5 volts at 3 amp</td>
</tr>
<tr>
<td>Filament No. 1</td>
<td>6.3 volts CT at 2 amp</td>
<td>6.3 volts CT at 2 amp</td>
<td>6.3 volts CT at 3 1/2 amp</td>
</tr>
</tbody>
</table>

Which one would you choose as a replacement for the receiver of Fig. 10–14?

11. Which of the power transformers listed in question 10 would you use as a replacement for the receiver of Fig. 10–17?

12. The receiver of Fig. 11–24 does not play. In checking the power supply, B voltage measures 260 volts, screen voltage measures zero. What should the next check be?

13. The receiver of Fig. 10–14 motorboats. What component in the power supply is likely to cause this condition?
14. The receiver of Fig. 10–17 does not play. A voltage check shows $B$ plus to ground voltage equals zero, and $B$ plus to the center tap of the high-voltage winding measures low—about 100 volts. The $C$ voltage divider, resistors (46) and (47), overheats. A resistance check shows $B$ plus to ground checks short, and $B$ plus to high-voltage center tap is 350 ohms. What is likely to be wrong?

15. The hum level in a receiver is normal, but the receiver hums badly when certain stations are tuned in. What component in the power supply can cause this condition?

16. Resistor $R-3$ of Fig. 11–24 is found to be open. The $B$ plus voltage measures 260 volts, and the IF screen voltage measures 85 volts. What should be the wattage of the replacement resistor?