ELEMENTS
OF
RADIO SERVICING

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PREFACE

The field of radio servicing has reached adulthood. Receiver circuits have become so complex that the day of the tinkering repairman is over. Definite and intricate areas of information are a necessity, but perhaps even more important is an approach to servicing. It is the dual purpose of this book to furnish both the information and the approach required for successful radio servicing, especially for the beginner.

It is assumed that the reader has acquired an elementary background of radio theory prior to delving into service work. Nevertheless, elementary theory is presented in this book wherever it serves to make more clear a particular procedure.

Design theory has been eliminated, since it is felt that such theory does not fall within the province of the serviceman. It is axiomatic that the serviceman must never redesign a receiver brought in for repair, unless so advised by the receiver manufacturer.

A book of this size could not possibly cover all the variations in radio receivers, so the authors have confined their survey to the most widely used practices of the past ten years. It is felt that on this basis the serviceman will be able to comprehend other variations.

William Marcus
Alex Levy

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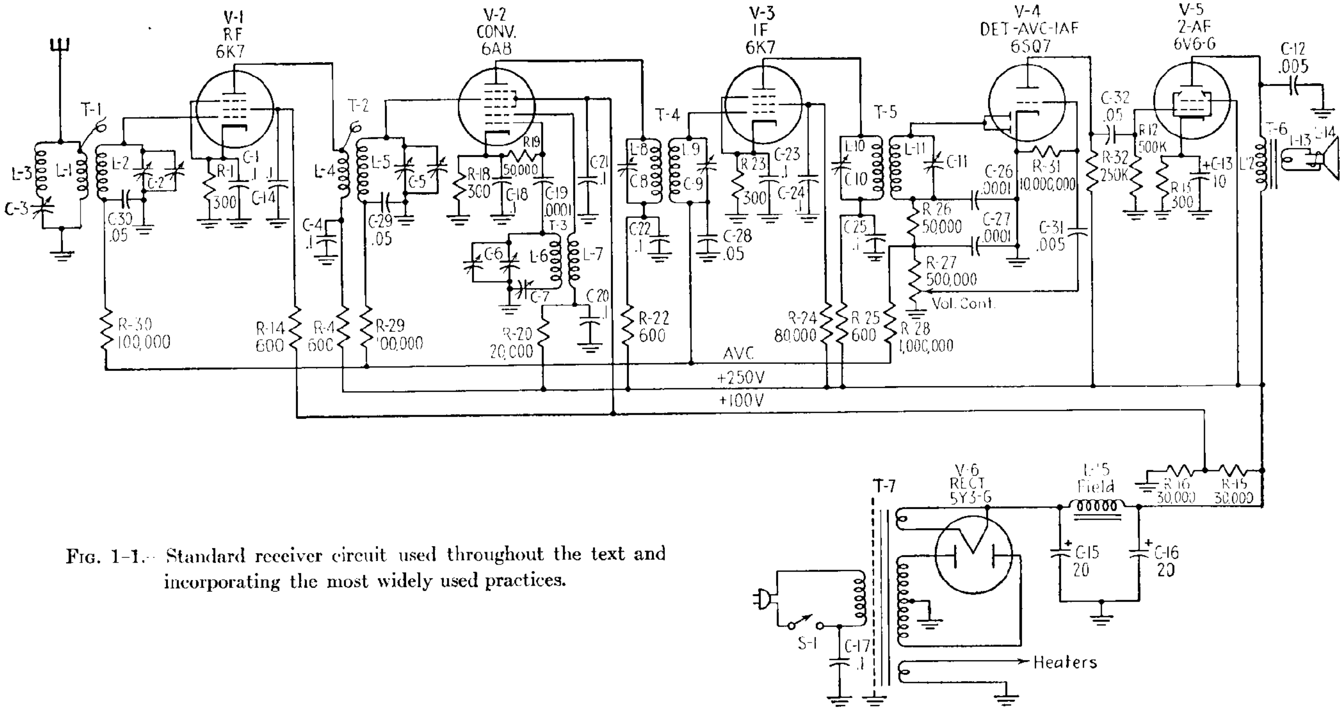


Fig. 1-1.— Standard receiver circuit used throughout the text and incorporating the most widely used practices.

CHAPTER 1

INTRODUCTION

Functional Servicing.—Thinking, especially in the solving of problems, involves the application of random bits of information to a particular situation. Two distinct elements are involved in this procedure. The first is that sufficient information to draw from is available. The second is that the information necessary for the solution is applied to the particular problem. The first element is a static one; the information may be compiled in a book for continuous reference. The second element is a dynamic one and cannot be assumed to develop from the first element unless specific exercise is provided.

Too many servicing manuals and books are organized on the premise that servicing skills can be developed if only enough bits of information are presented. In this respect, they fail to develop functional skills. The learner finds his path a slow and uncertain one.

The purpose of this book is to apply the psychology of learning to radio servicing. Basic information is presented at all times. In addition, the information is so organized that it develops whole dynamic procedures for application to specific radio troubles.

Scope of the Book.—It would be impossible to present in any small book procedures for servicing all types of radio receivers, as well as all the variations of each type. For this reason, the scope is restricted to the most widely used receiver—the superheterodyne.

All the individual variations could not be given. Therefore, a standard circuit, based on the most widely used practices, is presented as the basis for study. This circuit is shown in Fig. 1–1. In all probability, there is no receiver that incorporates all the features indicated; but for study purposes, such a standard circuit will be found invaluable. Throughout this book, the standard circuit is broken down and analyzed by stages, in accordance with the plan described in the following section.

All modern practices could not possibly be indicated in one schematic diagram. Therefore, a section on widely used variations in design is included in each chapter of stage analysis. It is felt that enough information will be obtained from the standard circuit and the variations sections to understand and service any other variation.

Finally, the latter part of the book is concerned with important topics that could not be handled in connection with the standard circuit. These topics are the AC/DC power supply, the auto power supply, the service bench, etc. Each of them is important enough to merit a separate chapter.

Organization of Dynamic Material.—In order to make the material of this book dynamically functional, information is presented in the sequence that it would be used practically in servicing a superheterodyne receiver. Instead of proceeding from stage to stage in the order that a radio signal would pass from the antenna to the speaker, the stages are presented in the order that a serviceman would investigate a defective receiver. Standard radio-servicing procedures are given for each stage. In addition, simple practical tests performed by servicemen on the bench are presented. These tests are based on years of practical servicing experience.

Each stage is analyzed in a similar manner. The outline of analysis is presented below:

1. Quick check for normal functioning of the stage.
2. Typical or basic circuit schematic.
3. Function of the stage.
4. Function and common value for each component part.
5. Normal test data for the stage.
6. Common troubles encountered in the stage.
   a. How they are found.
   b. Special problems involved in replacement of components.
7. Variations from the typical stage that are frequently used; special trouble-shooting procedures in these variations.
8. Summary of tests including outline of procedure to be followed in tracing various symptoms to their cause.

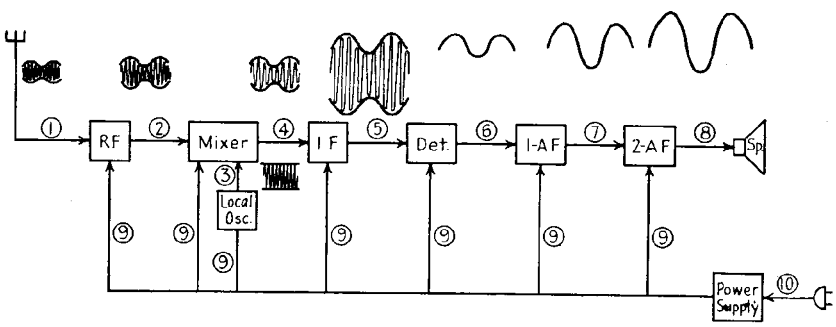
The organization of the information, as outlined above, is the method by which the material information will become quickly functional. A little practice in its use will assure a quick practical approach to radio servicing problems.

It should be understood that this book is not intended to be an encyclopedia of radio servicing. Once the method of attack is mastered, reference to service notes distributed by radio-receiver manufacturers will be more useful than before. Where an unusual circuit is encountered, such notes will prove to be of great value.

CHAPTER 2

SUPERHETERODYNE RECEIVERS

Block Diagram of a Superheterodyne Receiver.—Before the stage analysis of the superheterodyne receiver is presented, it is advisable for the serviceman to have an overview concept of how it works. This picture will be obtained readily from a block diagram. Each block represents a stage that will be shown later in schematic and more detailed form. The accompanying wave forms or pictures of the types of electric currents show how each stage alters the signal entering it. It will be seen later that some of these stages may be omitted or that two stages may be combined into one. The block diagram of the superheterodyne receiver is given in Fig. 2-1.



1. *RF* (550 to 1,600 kc)—modulated at audio frequencies.

2. Tuned and amplified *RF* (550 to 1,600 kc)—modulated at audio frequencies.

3. Unmodulated *RF* (*RF* ① + 455 kc).

4. *IF* (455 kc)—modulated at audio frequencies.

5. Amplified *IF* (455 kc)—modulated at audio frequencies.

6. Audio frequencies (50 to 10,000 cycles) for high-fidelity receivers.

7. Amplified audio frequencies (50 to 10,000 cycles) for high-fidelity receivers.

8. Amplified audio frequencies (50 to 10,000 cycles) for high-fidelity receivers.

9. DC *B*—supply.

10. 110-volt, 60-cycle AC supply or 110-volt DC supply.

FIG. 2-1.—Block diagram of a superheterodyne receiver with associated wave forms.

How the Superheterodyne Receiver Works.—An analysis of the block diagram shown will clarify this matter. Down the antenna come the modulated RF carrier signals of all stations within the receiving area of the set. In the broadcast band, they vary from 550 to 1,600 kc. Before passing through the RF stage, one station is selected by tuning and its signal is passed on. The modulated RF carrier signal is a high-frequency wave modulated or varied by a lower frequency wave known as the "audio modulation." The audio modulations represent the useful component that will eventually drive the speaker.

The RF stage merely amplifies the station to which we are tuned and passes the amplified signal with its audio modulation on to the mixer. The audio modulation retains the same wave form as the signal received at the antenna.

The mixer and local oscillator work together as a team. Often the two stage functions are performed by one tube, which is called a "converter." The local oscillator is a generator of unmodulated RF waves, automatically adjusted to a frequency of about 455 kc above that of the received station RF frequency. When the output of the local oscillator is mixed with the RF station frequency in the mixer stage, the resulting output of the mixer is at a frequency of 455 kc, with the same audio modulations as that of the original signal that came down the antenna.

The 455-kc signal is then fed into the IF stage, which is fixed-tuned to about 455 kc. Here the signal is amplified and fed into the detector. The audio modulations still retain the original wave form.

The detector stage removes the 455-kc RF component from the audio modulation component and passes the latter into the first audio stage. This detector is frequently referred to as the "second" detector, and the mixer or converter is called the "first"detector.

The audio component enters the first audio stage, where its voltage is amplified. It still retains the same wave form as that of the original audio modulation on the station carrier.

The second audio stage amplifies the audio signal even more, developing sufficient power to drive the speaker, which is a power-driven device. The audio signal still retains its same wave form at the input to the speaker. The speaker response is a series of sound waves.

Power for the entire receiver is usually obtained from a 110-volt, 60-cycle AC source or a 110-volt DC source. The power supply will rectify the AC supply, where such power is supplied, and will filter the rectified voltage to obtain a fairly smooth direct current, which now becomes our *B* supply. Where 110-volt DC power is furnished, the power supply will merely filter it to obtain the *B* supply. In portable sets the *B* supply is obtained directly from batteries.

Using the Block Diagram.—It is important that the block diagram shown in Fig. 2–1 be committed to memory before going on. Where test instruments are used, the input and the output waves of each stage will determine how to make proper settings. This is especially important in signal-substitution methods where a signal generator is used.

CHAPTER 3

SERVICING PROCEDURE

Receiver Servicing Systems.—When a radio receiver is brought in for servicing, the demand made of the serviceman is that he put the set back into normal operation. The means is of relatively no importance to the customer. Although this end also becomes the aim of the serviceman, he is confronted with a more immediate goal. What method shall he follow in locating the defect?

The various techniques that he uses can be grouped into a few systems of procedure, which are listed below:

1. Reliance on sight, touch, smell, and past experiences with the same type of receiver.
2. Part-substitution method.
3. Voltage measurements across components.
4. Point-to-point resistance measurements.
5. Electrode-current checking.
6. Signal substitution.
7. Dynamic-signal tracing with a vacuum-tube voltmeter and oscilloscope.

The first system is a self-evident one. Wherever a component appears to be broken or burned, or smells as if it has been overheated, or feels too hot, the assumption might reasonably be made that it is defective and should be replaced. Similar difficulties previously experienced with the same type of receiver might guide the serviceman. Unfortunately, too many defects will not result in extremes of breakdown. Also, the defective component is not disclosed as the cause of the receiver failure or the result of some other defect. Finally, experience as the guide can at most be a helpful rather than an infallible aid.

The second system involves the substitution of a part, known to be good, for a similar part that seems to be defective in the receiver. The weakness in this procedure is that it is too time-consuming by itself and may be useless where the trouble involves a number of defective components.

The third system is one in which voltage measurements are taken across various components. When the observed values are compared with normal voltage data, defective components are readily found. There are several weaknesses in this system when used alone. The time required to make all voltage checks in a modern complex receiver makes it extremely inefficient. At the very best, it may be used alone for making routine checks. In addition, many defects will not alter voltage readings to an extent that would indicate where the defects may be found.

The fourth system is similar to the third, except that resistance measurements are taken with an ohmmeter across the various components, rather than voltage measurements with a voltmeter. Used alone, this system has the same weaknesses as the voltage test.

The fifth system is one in which current measurements are made in various portions of the receiver to locate deviations from normal values. It is not often used, because it involves either the opening of circuits to insert ammeters in series, or the use of special adapters.

The sixth system is a popular one. A signal, similar to the one normally encountered in operation, is fed into the input of a stage, and the result at the output is then observed and compared with normal expectations. It is not suitable when used alone, since it primarily locates a defective stage without indicating the defective component.

The last system is one that involves expensive equipment and complex techniques. Commercial instruments are of various types, but most attempt to analyze the stages of the receiver under actual working conditions. Basically, all are combinations of vacuum-tube voltmeters, capable of making measurements without loading the circuits tested, and are excellent for measuring weak signals in the order of microvolts. The signal indicators are of various types: oscilloscopes, electron-ray tubes, loudspeakers, meters, etc. These instruments readily indicate loss of gain of stages, distortion, intermittents, regeneration, oscillation, noise, and other conditions. However, they still require supplementation by the multimeter and the signal generator.

Which Servicing Procedures Shall We Use?—No one of the servicing systems referred to in the above section can be used with speed and efficiency when taken alone. Experience has shown that it is most efficient first to determine the defective stage by means of a signal check and then carefully to analyze that stage for defective components.

This book assumes that the intelligent and combined use of the first four systems listed, plus the signal-substitution system, will give a highly efficient trouble-shooting procedure. Reference to the stage analysis in later sections will give great facility in the proper combined use of the suggested systems.

What instruments should the serviceman have? To follow the suggestions that are recommended, a voltmeter, an ohmmeter, and a signal generator are required. Two of these are combined in one popular instrument called a "multimeter," which combines a voltmeter, ammeter, and ohmmeter in one unit, with a switching device to obtain the desired function as well as the proper range.

Order of Use of Instruments.—The advantages of the recommended procedures will become evident with use. The general rule to be followed in servicing a receiver is, first, to use the signal generator in order to locate the defective stage or interstage components. The voltmeter and ohmmeter are then applied in order to close in for the kill, that is, the determination of the actual defective components.

The latter part of this book breaks down a typical superheterodyne receiver into its stages and gives procedures for testing the normal operation of each one. For each stage, typical test voltage and resistance measurements are listed for comparison with those actually found in the defective receiver. In addition, where possible, practical methods of testing stages are listed.

Finally, the order of presentation of the stages analyzed is, in general, the order in which a serviceman would be expected to subject the defective receiver to analysis. It is felt that in this way he will use this book with a more functional approach to his problem.

The question might arise at this time as to the place of a tube tester in a service shop, since many receiver defects may be due to faulty tubes alone. A word with regard to this matter will explain the lack of emphasis placed on that instrument.

There are two types of tube testers: the mutual-conductance type of tester and the emission tester. In the first, a small designated change of grid voltage is applied to the tube. The resulting change of plate current determines whether to call the tube good or bad. In the emission tester, the current flow or emission that results when the filaments are heated and a fixed voltage is placed on the plate determines whether to call a tube good or bad. Emission decreases with the age of the tube. In addition, both types of testers have circuits for determinating whether there is leakage or a short between the tube elements.

The tube tester is suitable for testing rectifier tubes. However, for other tubes, it does not measure their operation under the same dynamic conditions that they encounter in actual operation. Tubes that test good in it may be poor in actual receiver operation. A far better check for the serviceman is to hook up the signal generator and an output meter to the receiver and observe the output. Then substitute a good tube for the one believed to be bad and compare the two outputs. Of course, where the customer brings only his tubes for testing, the tube tester is the instrument to use, its limitations being understood.

CHAPTER 4

MULTIMETERS

A Typical Multimeter.—The multimeter is one of the radio serviceman's constant companions. It is the instrument that finally localizes troubles in the receiver after the defective stage is found. A typical multimeter is shown in Fig. 4-1. Its purpose is primarily to make voltage, current, and resistance measurements throughout the receiver.

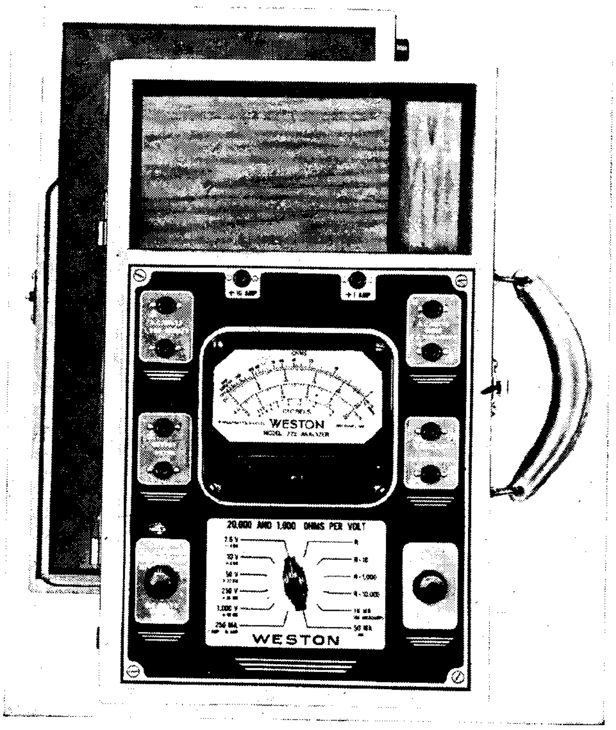


Fig. 4-1.—The Weston Model 772 multimeter.

To perform its functions, the multimeter is a milliammeter, voltmeter, and ohmmeter combined in one case. In addition, it is designed to furnish various ranges of current, voltage, and resistance measurements. To select a particular function and a particular range from the instrument, a front-panel selector switch is provided. Each position of the switch is labeled for that purpose.

In describing the components of the multimeter, it is better to treat the voltmeter and ohmmeter as though they were separate. Nothing will be said about the milliammeter as a current-measuring device, since few servicemen will make such measurements without adapters. The only principle to be kept in mind, when currents are measured, is to be sure to be on the correct range. A good policy is to start at the highest range and switch down to lower ones until the correct one is reached.

General Principles of the Voltmeter.—The purpose of a voltmeter is to indicate the potential difference or voltage between two points of a circuit. This is accomplished by connecting the two input terminals of the voltmeter to the two points to be tested in the circuit. The placement of the voltmeter, in parallel with the circuit to be measured, brings up some interesting factors that will be described later.

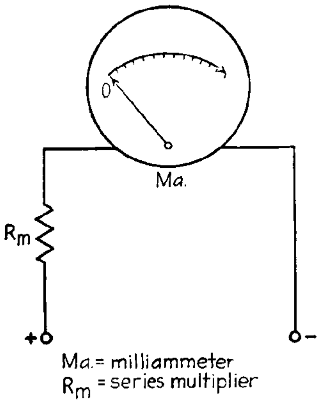


FIG. 4-2.—A basic voltmeter.

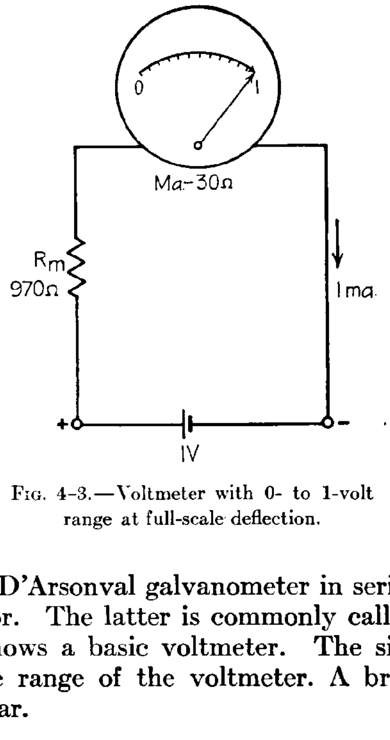


FIG. 4-3.—Voltmeter with 0- to 1-volt range at full-scale deflection.

Essentially, the voltmeter is a D'Arsonval galvanometer in series with a fairly high-ohmage resistor. The latter is commonly called the "multiplier." Figure 4-2 shows a basic voltmeter. The size of the multiplier determines the range of the voltmeter. A brief analysis will make this point clear.

Begin with a galvanometer that gives full-scale deflection at 1 ma (0.001 amp). Such an instrument is usually called a "one-mil milliammeter." Assume that it has an internal resistance of 30 ohms. What must be the resistance of the multiplier to convert it into a 0 to 1 voltmeter? When so converted, 1 volt placed across the milliammeter and multiplier will drive 1 ma through it to give full-scale deflection, as shown in Fig. 4-3. Using Ohm's law, determine the resistance that will give this condition.

$$R = \frac{E}{I} = \frac{1}{0.001} = 1{,}000 \text{ ohms}$$

Since the milliammeter has a resistance of 30 ohms, the multiplier R_m must have a resistance of 1,000 minus 30, or 970 ohms. An instrument of this sort is called a 1,000-ohms-per-volt voltmeter, because 1 volt is applied across 1,000 ohms: (1,000/1) = 1,000. This designation is an indication of its sensitivity.

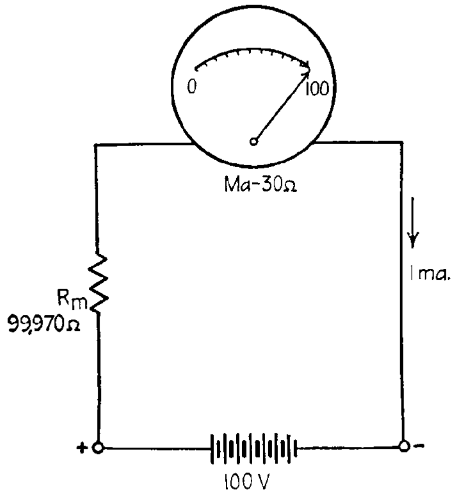
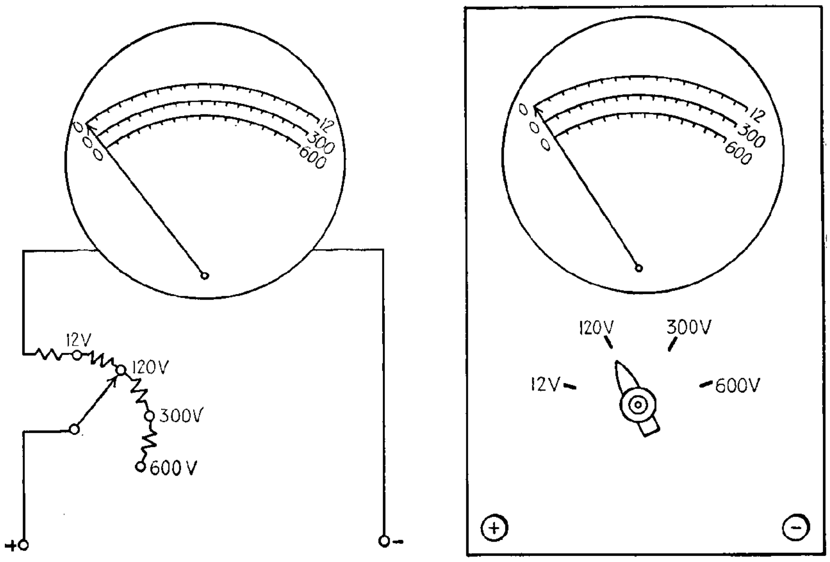


FIG. 4-4.—Voltmeter with 0- to 100-volt range at full-scale deflection.

Suppose that it was desired to convert the same milliammeter into a voltmeter of 0 to 100 volts. What must be the resistance of the multiplier? By similar reasoning, 100 volts now placed across the milliammeter and multiplier will drive 1 ma through it to give full-scale deflection, as shown in Fig. 4–4. Using Ohm's law for the total resistance,

$$R = \frac{E}{I} = \frac{100}{0.001} = 100{,}000 \text{ ohms}$$

Again subtracting the milliammeter resistance from the total resistance, we find that the multiplier must have a resistance of 100,000 minus 30 = 99,970 ohms. Its sensitivity is still found to be 100,000/100, or 1,000 ohms per volt. A switch is usually provided on the multimeter to give a voltmeter of different ranges by cutting in different multipliers. Such a switching device is shown in Fig. 4–5.



Schematic View　　Front Panel View

FIG. 4–5.—Multirange voltmeter showing range switch.

In using various voltmeters, the serviceman may be surprised when he measures the voltage across two points of a circuit and obtains two different readings. His first impulse might be to say that one of the instruments is inaccurate. Yet they may both be right, and the serviceman must interpret his results more carefully.

The explanation for this condition lies in the different sensitivities of the voltmeters. The example given above was for a 1,000-ohms-per-volt voltmeter. Commercial voltmeters with different sensitivities have been made. There are voltmeters with sensitivities of 100, 125, 1,000, 2,000, 2,500, 5,000, 10,000, 20,000, and 25,000 ohms per volt. For example, let us assume that a galvanometer requires 50 microamperes (0.00005 amp) for full-scale deflection. What must be the size of the total resistance to give a voltmeter with a range of 0 to 1 volt? From Ohm's law,

$$R = \frac{E}{I} = \frac{1}{0.00005} = 20{,}000 \text{ ohms}$$

The sensitivity of this voltmeter is 20,000/1, or 20,000 ohms per volt. Similarly, with the same basic movement, we could convert it into a voltmeter with a range of 0 to 100 volts. From Ohm's law,

$$R = \frac{E}{I} = \frac{100}{0.00005} = 2{,}000{,}000 \text{ ohms}$$

The sensitivity is still 2,000,000/100, or 20,000 ohms per volt. Now, consider the following circuit in Fig. 4-6, across which 60 volts are dropped.

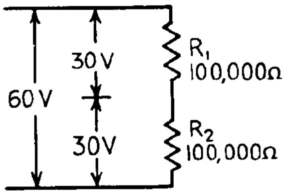


FIG. 4-6.—Voltage distribution across two equal resistors.

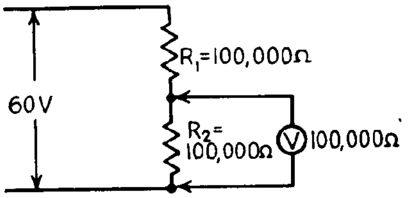


FIG. 4-7.—Measuring voltage with a 1,000-ohms-per-volt meter.

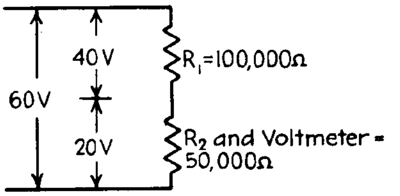


FIG. 4-8.—Voltage distribution resulting from loading the circuit with a 1,000-ohms-per-volt meter.

Since $R_1 = R_2$, the voltage dropped across each is equal and is 30 volts. If the 1,000-ohms-per-volt voltmeter is connected across R_2, we have the condition indicated in Fig. 4-7. The voltmeter and R_2 are equal in resistance and in parallel. The combined resistance of the parallel branch is now 50,000 ohms, and the circuit now appears as in Fig. 4-8. Since the two resistors are now not equal, the voltage divides differently, (100,000/150,000) × 60, or 40, volts across R_1, and (50,000/150,000) × 60, or 20, volts is dropped across R_2 and the voltmeter. The voltmeter reads 20 volts. If the 20,000-ohms-per-volt voltmeter is substituted for the 1,000-ohms-per-volt voltmeter, the condition indicated in Fig. 4-9 prevails. The combined resistance of the voltmeter and R_2 is

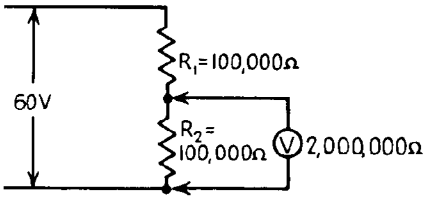


Fig. 4-9.—Measuring the voltage with a 20,000-ohms-per-volt meter.

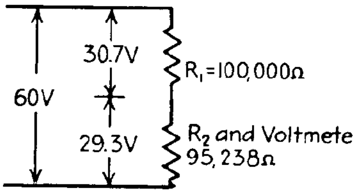


Fig. 4-10.—Voltage distribution resulting from loading the circuit with a 20,000-ohms-per-volt meter.

about 95,238 ohms. The circuit now appears as shown in Fig. 4-10. Across R_1, (100,000/195,238) × 60, or about 30.7 volts are dropped. Across R_2 and the voltmeter are dropped (95,238/195,238) × 60, or about 29.3 volts. The voltmeter reads 29.3 volts. In both cases above, the effects of change of current when the voltmeters were connected have not been taken into consideration because the relative results would still exist.

Which voltmeter was correct in its reading? If interpreted properly, both gave correct results. The serviceman may use either of the two voltmeters of different sensitivities, but at all times he must interpret his results. Generally, it is true that, when the voltage across a high-resistance circuit is measured, the voltmeter of the higher ohms-per-volt sensitivity will give a more accurate reading. However, many radio manufacturers often give voltage tables in their service data, and specify "Readings taken with a 1,000-ohms-per-volt voltmeter"; and some multimeters have switches for changing from 20,000 to 1,000 ohms per volt for the above purpose.

Where the voltage is measured across a low-resistance circuit, the difference in readings between the voltmeters of different sensitivities is not so great. This fact is tabulated in Fig. 4-11.

To summarize, the voltmeter of higher sensitivity gives the more accurate readings, especially when measured across high-resistance circuits. Thus, when cathode voltages across a resistor of several hundred ohms are measured, the 1,000- and 20,000-ohms-per-volt voltmeters will give about equally accurate results. However, when voltages in the plate circuits across resistors of hundreds of thousands of ohms are measured, the voltmeter of greater sensitivity will be the more accurate, and the limitations of one of low sensitivity should be kept in mind. The 1,000-ohms-per-volt voltmeter may be used almost everywhere, except in very high-resistance circuits like the AVC bus and the actual cathode to control grid voltage in the audio stage, where the usual grid load is 500,000 ohms. A 20,000-ohms-per-volt voltmeter will give a reading on the AVC bus, but it will load the circuit and throw off its operation. For best measurement in this case, a vacuum-tube voltmeter, with a high internal impedance in the order of 15 megohms, will load the circuit least by

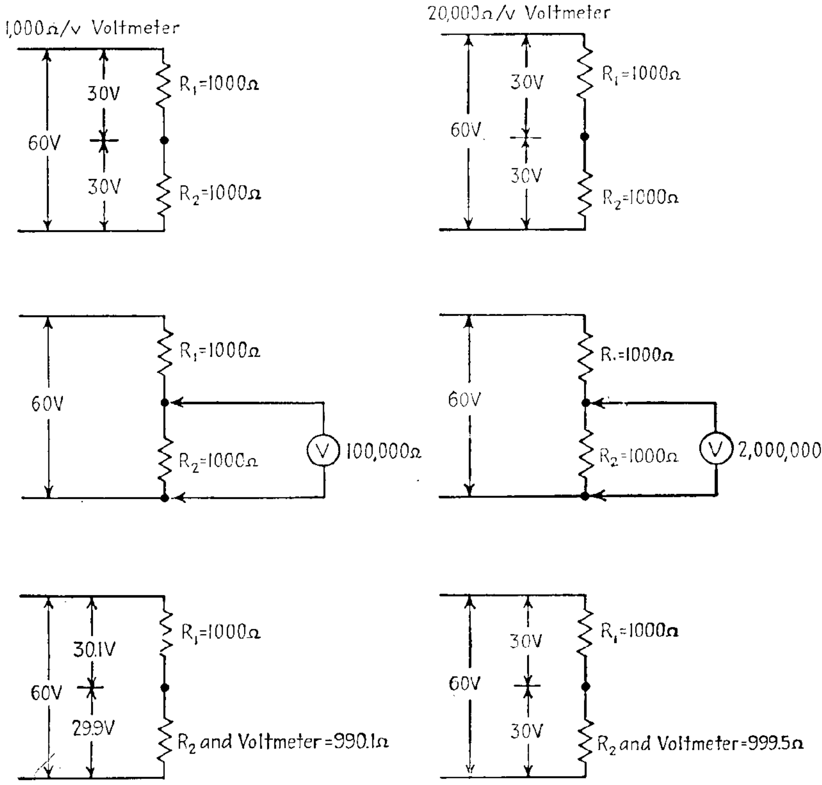


FIG. 4-11.—Comparison between a 1,000-ohms-per-volt meter and a 20,000-ohms-per-volt meter in a low-resistance circuit.

drawing only an infinitely small current. Regardless of which meter is used, the results must always be properly interpreted.

The voltmeter section of the multimeter is usually designed for various ranges of AC as well as DC voltage measurements. The voltmeter is converted into an AC meter by placing a rectifier in the circuit, as shown in Fig. 4-12. The rectifier converts the alternating current to direct current, which is then read on the DC meter. Different ranges of AC voltage may be measured by use of the range switch, as was done for the DC voltmeter. The rectifier is switched in and out of the circuit by a separate switch, one position of which is marked AC and the other DC.

Several considerations must be kept in mind when using the voltmeter. When used as a DC voltmeter, polarity must be observed.

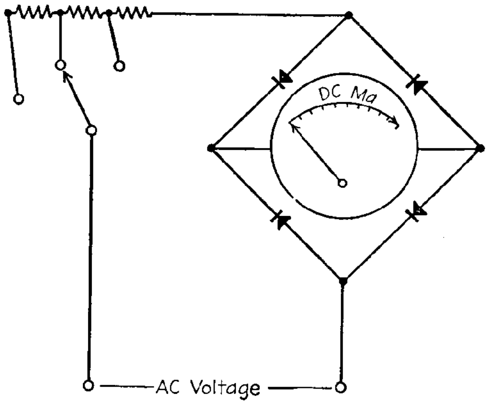


FIG. 4-12.—Typical multirange AC voltmeter.

There is a positive terminal and a negative terminal. The test leads are color-coded, one red and the other black. The usual convention is to connect the red lead to the positive terminal and the black lead to the negative terminal. It is advisable to clip the black, or negative, lead to the *B* minus of the power supply or the chassis, and to tap the red, or positive, lead to points to be tested in the receiver. This latter step should be done with one hand to avoid severe shocks.

When using the instrument as an AC voltmeter, such polarity need not be observed. Either terminal may be connected to any point. The rectifier takes care of the polarity required by the voltmeter itself.

A final important precaution to remember is that a high voltage, applied across the voltmeter when it is switched to a low-voltage range, will burn out the meter. Good practice is to switch to the highest range and then to decrease the range by steps until the proper one is attained. Of course, voltmeter readings in the receiver are always taken with the power from the mains turned on. Voltage measurements on a receiver are usually taken with the volume control turned full on, and the tuning dial in an off-station position.

General Principles of the Ohmmeter.—The ohmmeter is an instrument indicating the amount of resistance that a component offers to the flow of a direct current. When used to make such measurements in a radio receiver, the power must be shut off if we do not wish to ruin the ohmmeter by placing an external voltage across it.

Basically, the ohmmeter is a milliammeter that requires current to energize it. Since the power in the receiver is off, another driving source of voltage is required. A battery is included in the instrument itself for this purpose. To compensate for any change in battery voltage as time goes on, a zero-adjusting rheostat is included. A basic circuit for an ohmmeter is shown in Fig. 4-13. The component to be measured is placed across the points marked *x*—*x* in the figure. If the component has practically no resistance, the milliammeter will be fully deflected. The higher the unknown resistance, the less the amount of current through the milliammeter, and the less the deflection. For this reason, the zero of the ohmmeter scale is at the right and the scale increases toward the left.

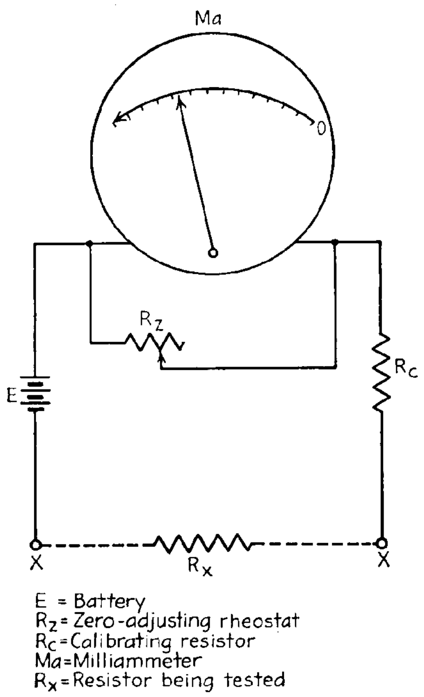


FIG. 4-13.—Basic ohmmeter circuit.

Unfortunately, the scale is not linear; that is, the units are not equal. Values of resistance at the upper, or left, end of the scale are very crowded and hard to read. For this reason, a switching device is included to give various ranges. In some ohmmeters, the switch markings and scales present a problem in reading. For this reason, an example in reading would be of great value. Figure 4-14 shows the ohmmeter scale of a typical multimeter, with the meter needle

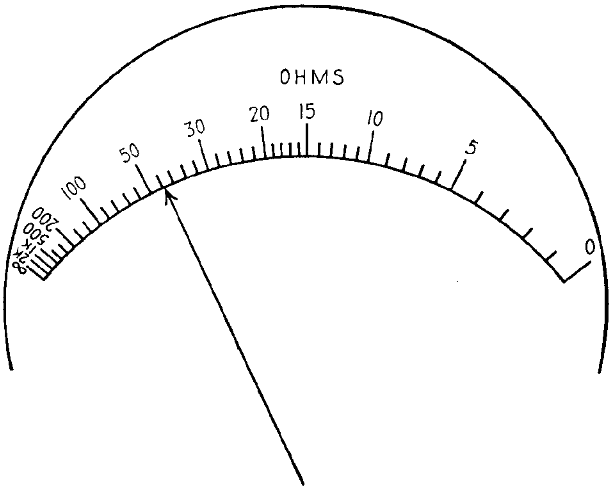


FIG. 4-14.—Typical ohmmeter scale.

indicating a particular reading. Note that the left end of the scale shows 2K. The letter K stands for 1,000. Unfortunately, owing to previous practice, the letter M is often used for 1,000. This latter practice leads to confusion. For example, 2M ohms equals 2,000 ohms, while 2Mc equals 2,000,000 cycles. It therefore becomes necessary for the serviceman to interpret the meaning of M in schematics. This book will use K for 1,000 and M for 1,000,000.

The ranges of such an ohmmeter are 0 to 2,000 ohms; 0 to 200,000 ohms; and 0 to 2 megohms. The switch ranges are indicated in either of two ways by multimeter manufacturers. These are shown in Fig. 4-15.

The switch designation in Fig. 4-15*B* is more convenient, since it tells directly by what value the scale reading must be multiplied in order to get the true reading for each range. It is suggested that, if the ohmmeter of the servicemen has scale indications as indicated in Fig. 4-15*A*, he paste over the ranges multipliers similar to those at *B*.

Now what is the reading if the switch of our meter is at *R*? Here the scale is read directly as 43 ohms, approximately. If the switch is at the *R* × 100 range, the reading is 43 × 100, or 4,300 ohms.

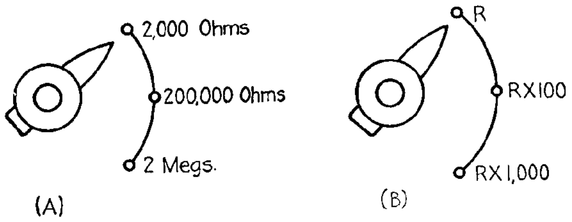


FIG. 4-15.—Typical ohmmeter range switches.

When the switch is at the *R* × 1,000 range, the reading is 43 × 1,000, or 43,000 ohms.

A good rule to follow is to select the range that gives the resistance reading about the middle of the scale. Of course, since a battery is included in the ohmmeter and is properly polarized, no polarity need be observed when the resistance of components is measured.

A final word must be said about making resistance measurements in the receiver with an ohmmeter. The serviceman must be sure that there is no parallel branch across the component that he is measuring. Reference to a schematic of the receiver being tested will aid in such determination. When in doubt, disconnect one terminal of the component under test. The serviceman will also encounter difficulty where an electrolytic condenser is in parallel with a tested unit. Normally, condensers are practically infinite in resistance to direct currents. But electrolytic condensers have a fairly low leakage resistance (from 1 to 50 megohms). The rule to follow, where such is the case, is to measure the resistance of the component, then reverse the ohmmeter prods, and measure again. This is done because the polarized electrolytic condenser will show less leakage in one direction than in the other. Use the higher of the two readings obtained as the reading for the unit being tested. If there is any doubt, disconnect one terminal of the component, as for parallel resistors.

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.

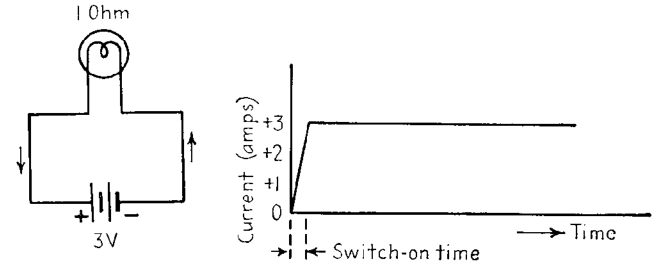


FIG. 5-1.—Circuit and wave form for a pure direct current (DC).

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

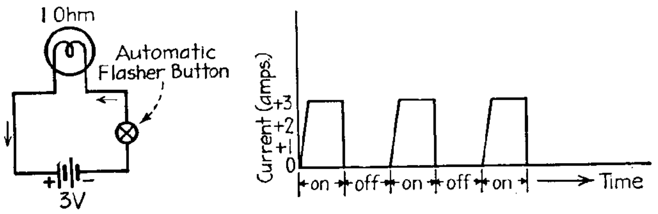


FIG. 5-2.—Circuit and wave form for a varying direct current.

(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

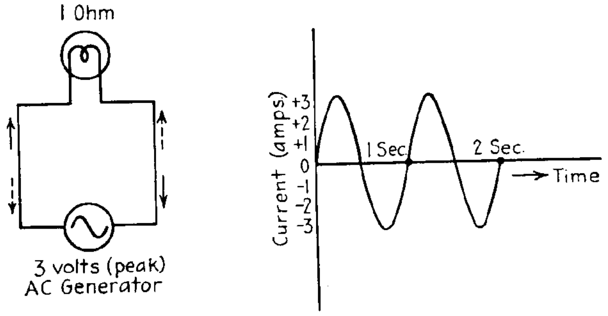


FIG. 5-3.—Circuit and wave form for a pure alternating current (AC).

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 wave form in the diagram that is like neither of the two pure sine-wave components.

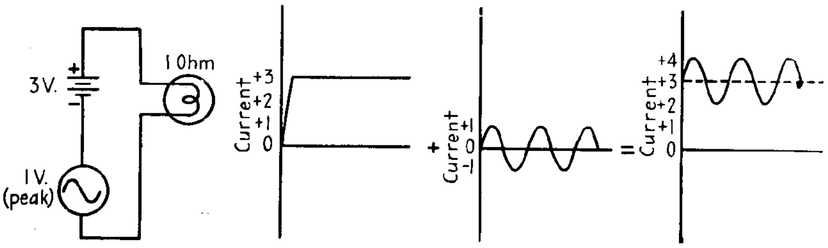


Fig. 5-4.—Circuits and wave forms for mixture of DC and AC currents.

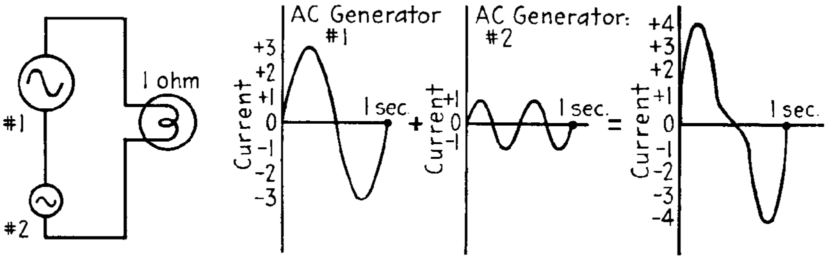


Fig. 5-5.—Circuits and wave forms for mixture of two AC currents.

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.

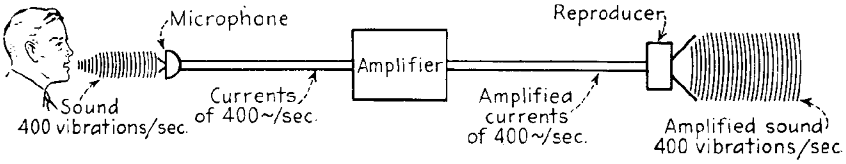


FIG. 5–6.—Basic sound system.

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).

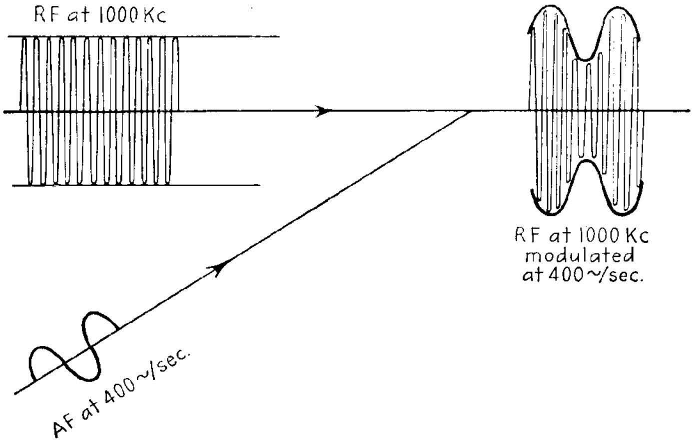


FIG. 5-7.—RF carrier (1,000 kc) modulated by 400-cycle audio note.

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.

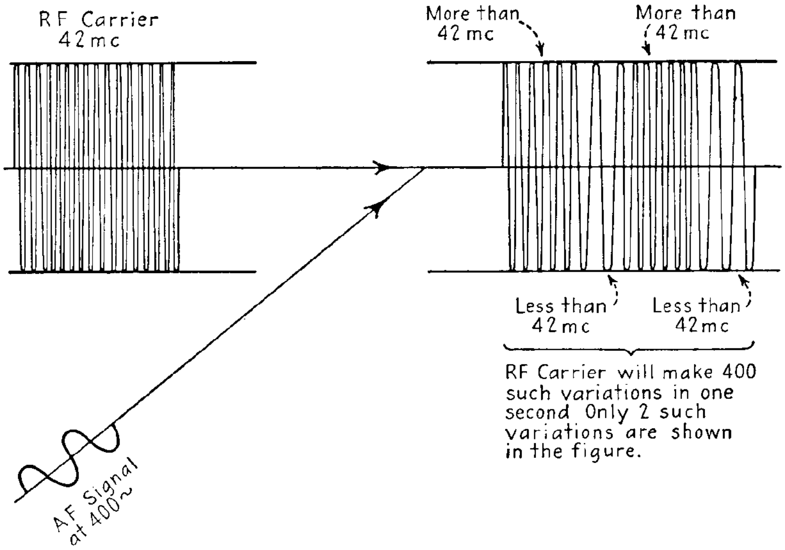


FIG. 5-8.—RF carrier (42mc) frequency-modulated by 400-cycle audio note.

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.

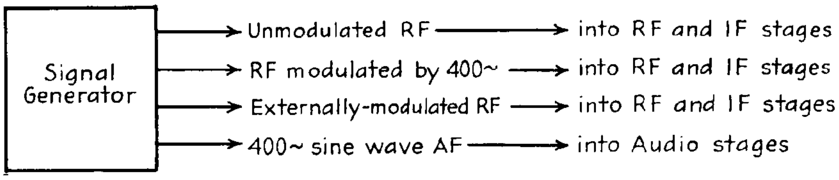


FIG. 5–9.—Output voltages and currents from a signal generator.

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).

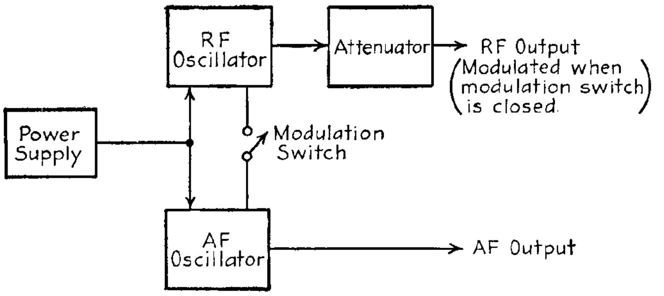


FIG. 6–1.—Block diagram of a signal generator.

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.

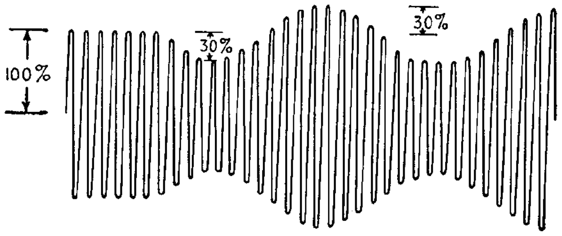


Fig. 6–2.—A 30 per cent modulated RF signal.

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.

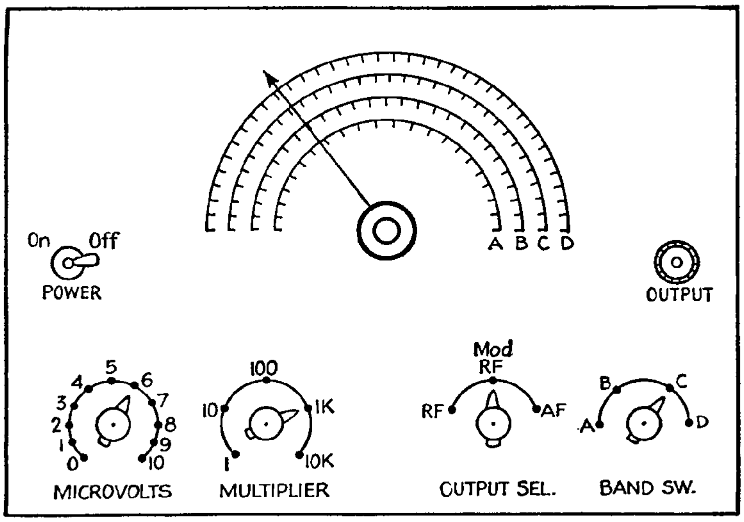


FIG. 6-3.—Front panel, showing controls of a typical signal generator.

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 × 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 kc
B	215—600 kc
C	550—1,700 kc
D	1.56—5.0 mc
E	3.75—10.0 mc
F	7.4—22 mc

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 $^{7}/_{10}$ of the total available output for position 3 of dial 1 is available. If dial 2 is turned to position 9, it means that $^{9}/_{10}$ of the maximum available output for position 3 of dial 1 is delivered. If dial 2 is at position 10, then $^{10}/_{10}$, 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.

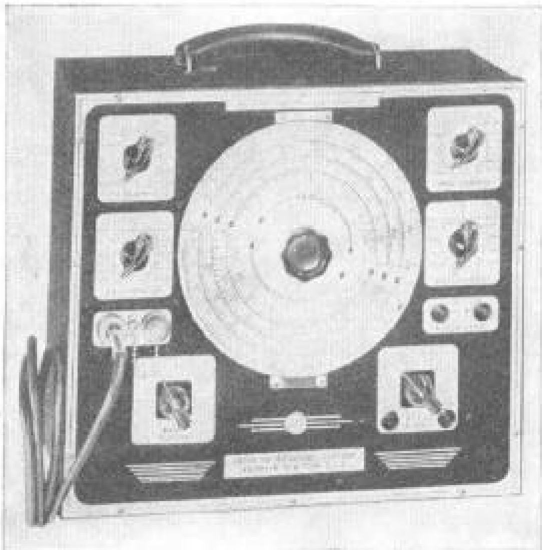


FIG. 6-4.—The Precision signal generator, series *E*-200.

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-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:

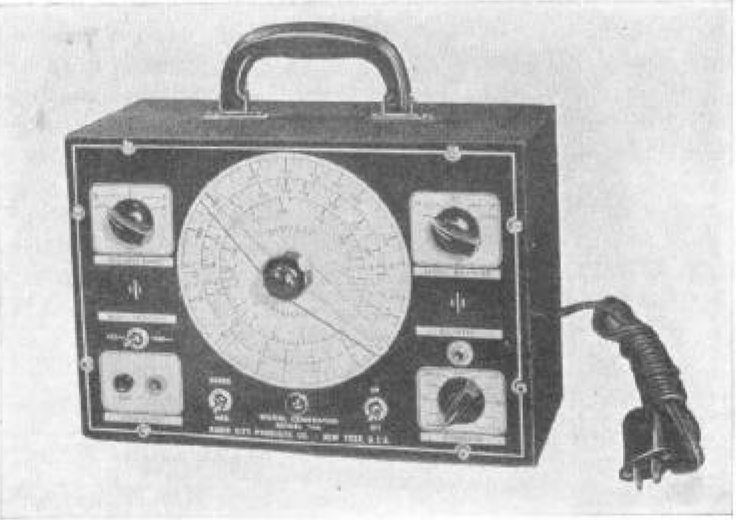


FIG. 6-5.—The Radio City Products signal generator, Model 704.

A	90—290 kc
B	280—900 kc
C	825 kc—2.7 mc
D	2.5—8.3 mc
E	8.2—25 mc

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.

Attentuation 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 (1M[1]), 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.

A	33—10 mc
B	10.6—3.2 mc
C	3.2—1.0 mc
D	1.0—0.32 mc
E	0.32—0.10 mc

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

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[1] 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.

FIG. 6-6.—The General Electric signal generator, Model *SG-3A*.

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-kc 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 × 2 = 910 kc, 455 × 3 = 1,365 kc, 455 × 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 × 2 as the "second harmonic," 455 × 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 serviceman'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.

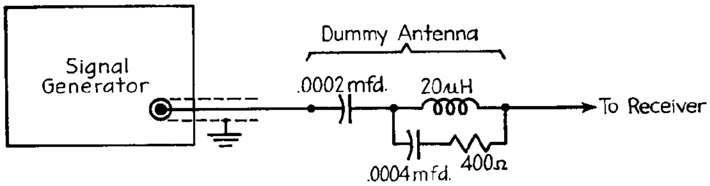


FIG. 7-1.—The I.R.E. standard dummy antenna, connected to signal generator and receiver.

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 ballooned 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 ③ 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.

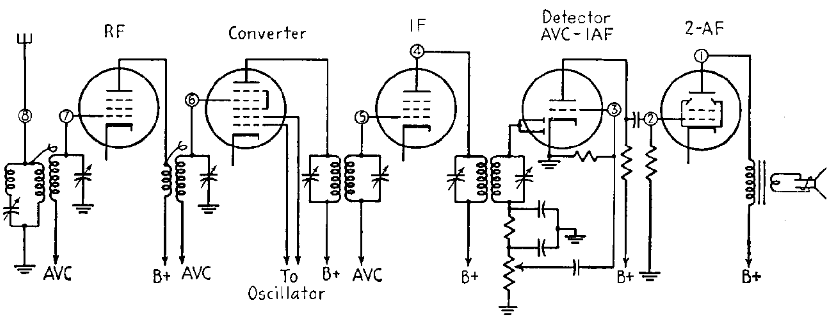


FIG. 7-2.—Signal chain of a superheterodyne receiver showing test points.

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 ⑧ 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-

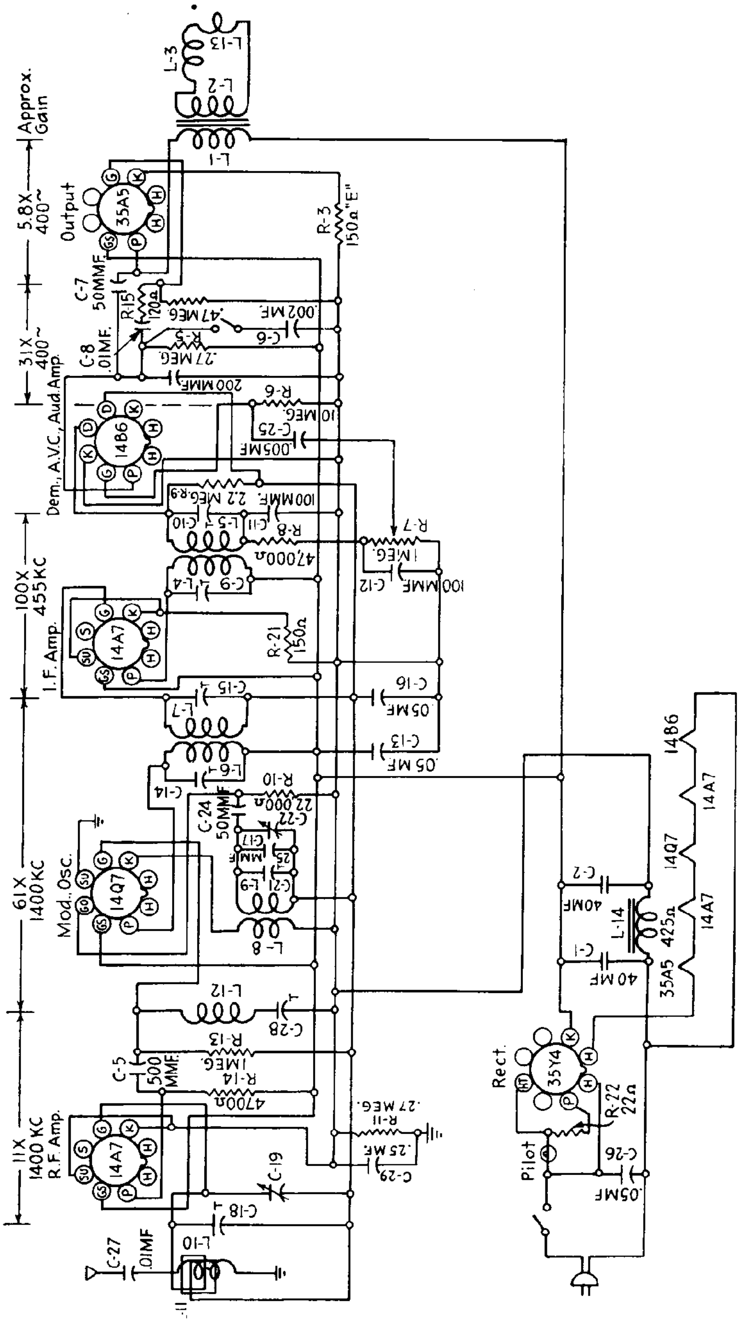


FIG. 7-3.—The Stromberg-Carlson No. 1100 AC/DC receiver.

cedure 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.

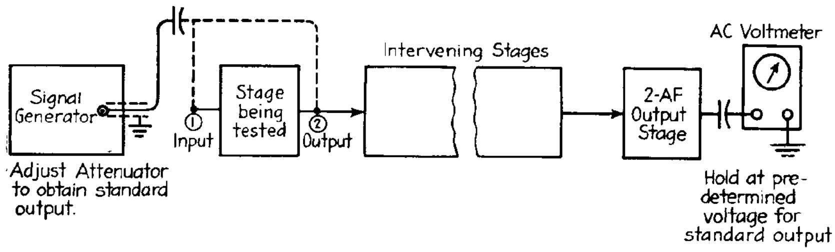


FIG. 7–4.—Sequence of measurements to obtain the gain of a stage.

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 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.

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

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.

Stage	Test frequency	Range of gain	Average gain
Second AF	400 ~	5–15	10
First AF (high-mu)	400 ~	40–60	50
IF	455 kc	80–120	100
Converter	600 kc	60–80	70
RF	600 kc	20–40	25

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.

Average microvolt input	Generator set at	Generator feeder connected to	Dummy antenna capacity
3,700	455 kc	IF grid	0.1 mfd
50	455 kc	Modulator grid	0.1 mfd
55	600 kc	Modulator grid	0.1 mfd
15	600 kc	Antenna terminal	400 ohms

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

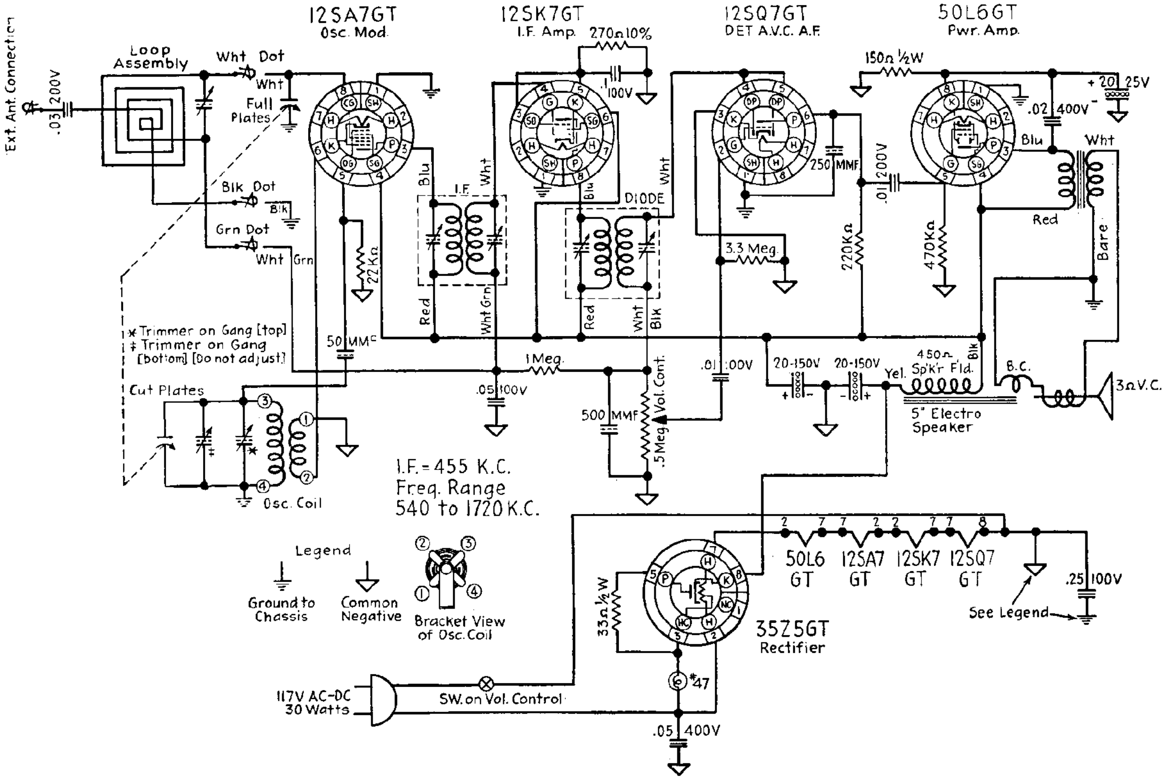


FIG. 7-5.—The Motorola Model 56X1 AC/DC receiver.

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.

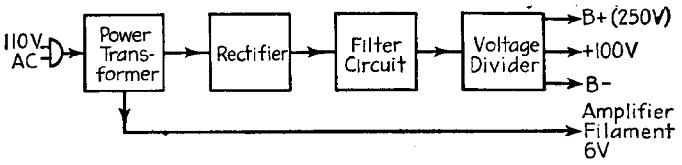


Fig. 8–1.—Block diagram of AC power supply.

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 smoothes 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.

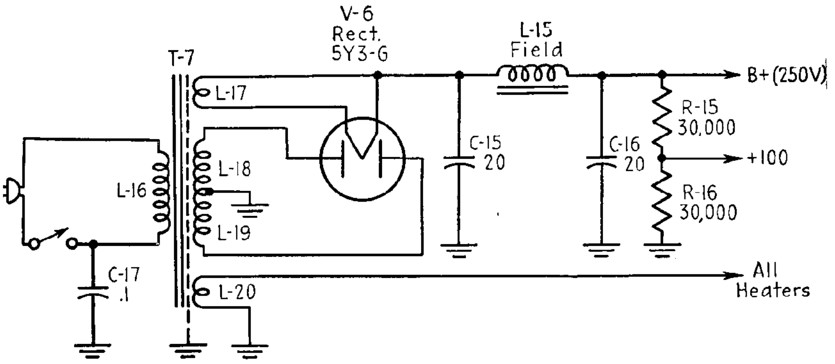


FIG. 8–2.—Standard circuit of AC power supply.

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.

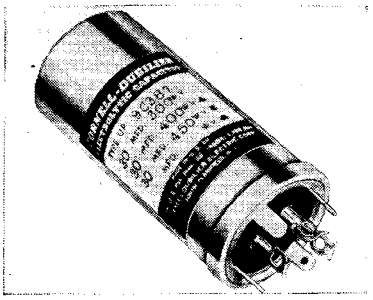
The high-voltage winding is always center-tapped for use in the full-wave rectifier circuit. The other windings are sometimes also tapped: the primary at the 220th turn, for use in areas where line voltage is low. The amplifier and rectifier filaments may also be tapped in the center.

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.



Note: The triangle, square, and half-circle on the label are to identify the individual condensers in the block. They are repeated on the insulating strip near the proper soldering lugs.

FIG. 8–3.—A filter-condenser block.

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 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.

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

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.

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

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*-15, 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.

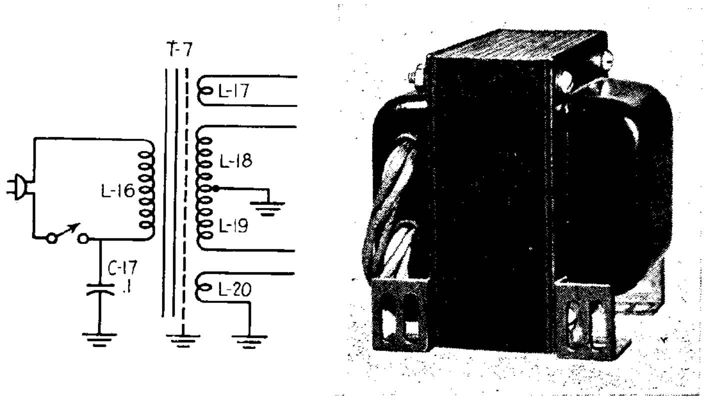


FIG. 8-4.—The power transformer.

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. Incidentally, 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 transformer 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 equipment 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 determine which circuit contains the short.

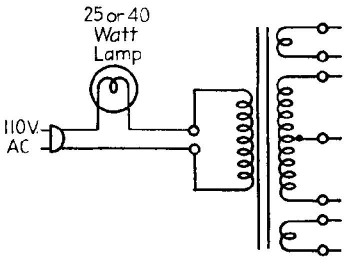


FIG. 8-5.—Checking the power transformer.

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.

Tube complement	*A* requirements		*B* requirements		
	Volts	Amp	Volts	Plate current, ma	Screen current, ma
5Y3-G	5	2			
6V6-G	6.3	0.6	250	45	4.5
6SQ7	6.3	0.3	250	0.9	
6K7	6.3	0.3	250	7	1.7
6A8	6.3	0.3	250	3.5	2.7
				4	
6K7	6.3	0.3	250	7	1.7
Total......	5	2	250 volts at 78 ma		
	6.3	1.8			

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.

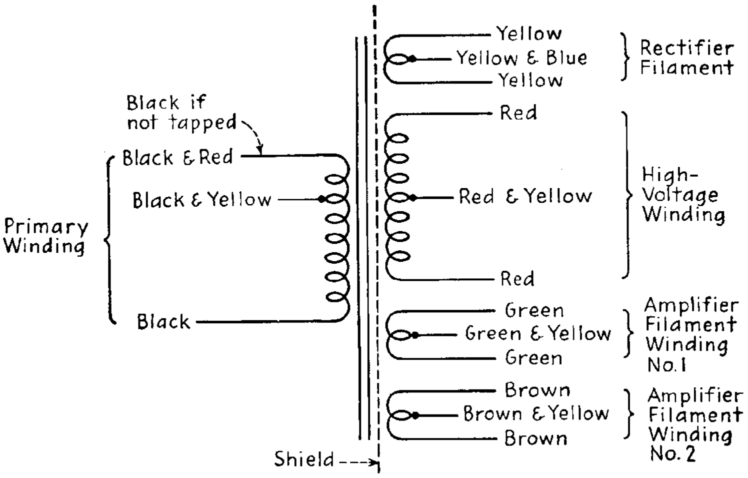


Fig. 8-6.—Power-transformer color code.

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. 8-7*A*. 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.

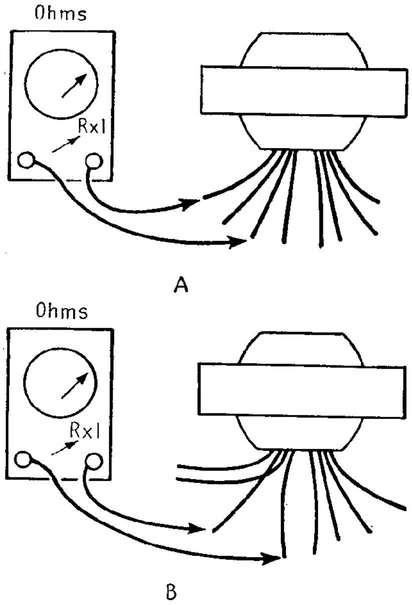


FIG. 8-7.—Pairing the leads.

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

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

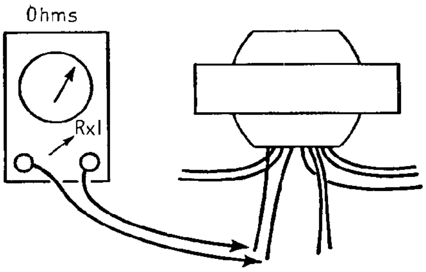


FIG. 8-8.—Resistance of each winding.

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).

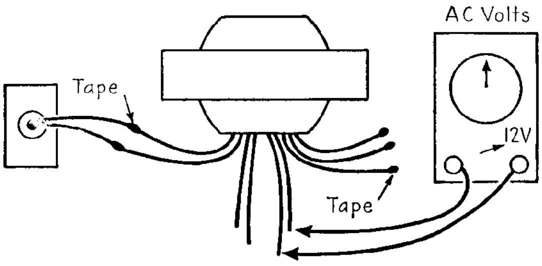


FIG. 8-9.—Identifying the amplifier heater winding.

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.

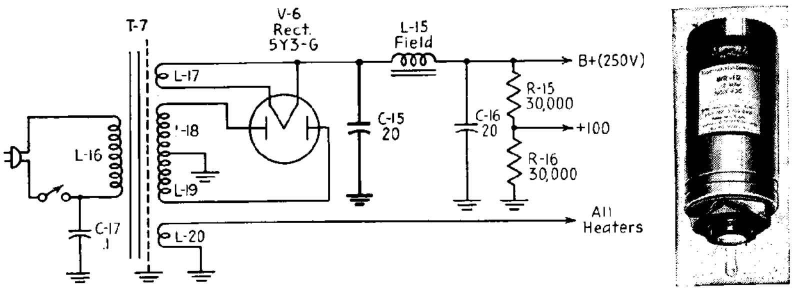


FIG. 8-10.—A typical input filter condenser, and its position in the power-supply circuit.

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.

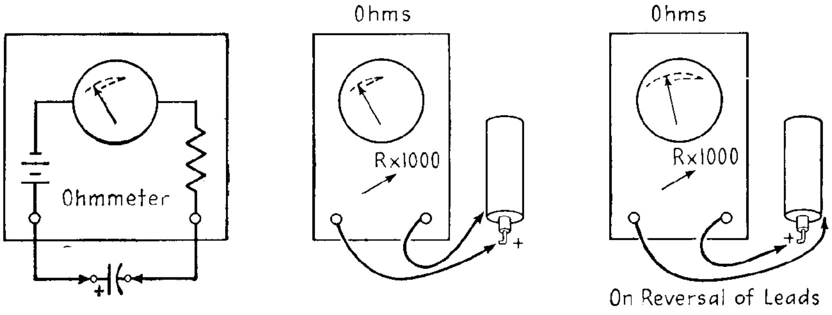


FIG. 8-11.—Checking an electrolytic condenser with an ohmmeter.

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*-15*A* and *C*-15*B* 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*-15*A* and C-15*B*. 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.

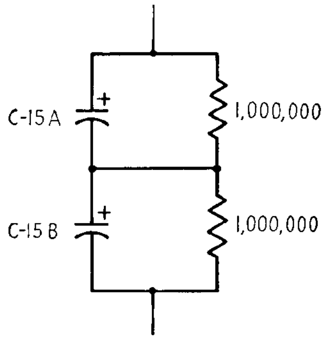


Fig 8–12.—Connecting two condensers to increase voltage rating.

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.

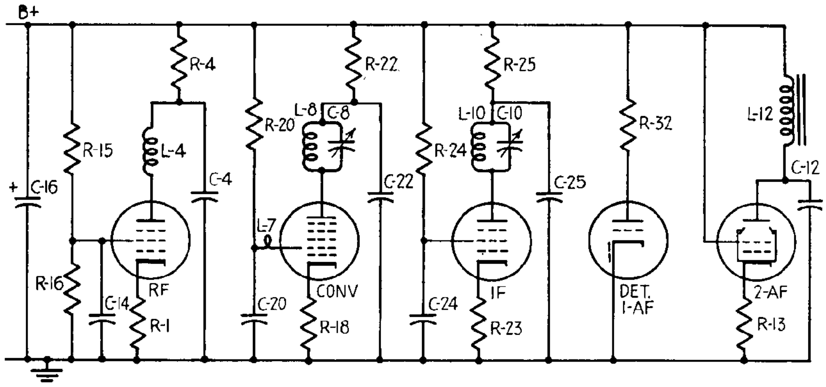


FIG. 8–13.—Skeleton diagram of the standard receiver showing the *B* circuit.

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.

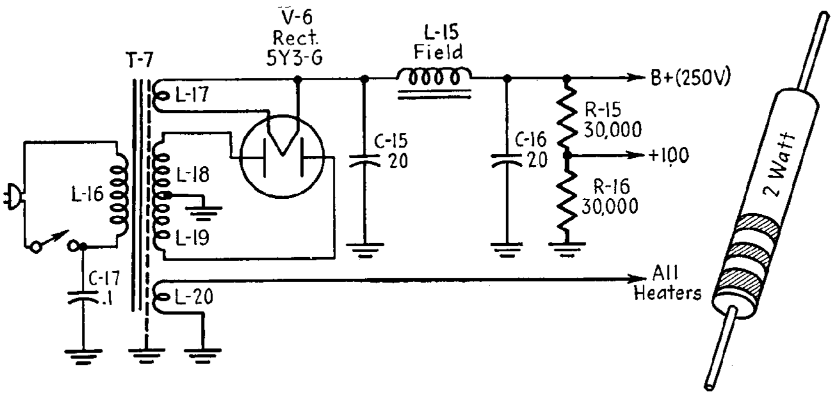


FIG. 8-14.—A typical voltage-divider resistor and its position in the AC power supply.

Whether to replace the single unit or the entire block is up to the indidivual serviceman. Usually, it is preferable to replace the block.

Troubles Common to the Voltage-divider Resistors.—Voltage-divider resistors R-15 and R-16 in modern receivers are usually of the 1- or 2-watt carbon type. The defects common to both are that they open or change in value.

When R-15 is open, the radio will not play and the screen voltage will be zero. The ohmmeter then confirms that R-15 is open. Before going further the serviceman checks resistance from chassis to screen, since a shorted screen by-pass condenser may have been the cause of its failure.

When resistor R-16 is open, screen voltage is high and the radio may oscillate. An ohmmeter check confirms the condition.

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 $W = E^2/R$. 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.

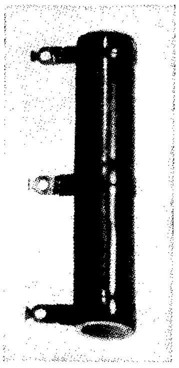


FIG. 8-15.—Tapped wire-wound resistor used as a voltage divider.

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.

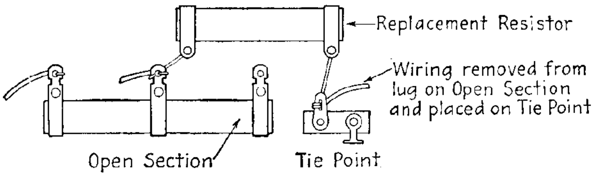


FIG. 8-16.—Replacement for an open section of a voltage divider.

FIG. 8-17.—Paper tubular 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 120-volt position is safest.

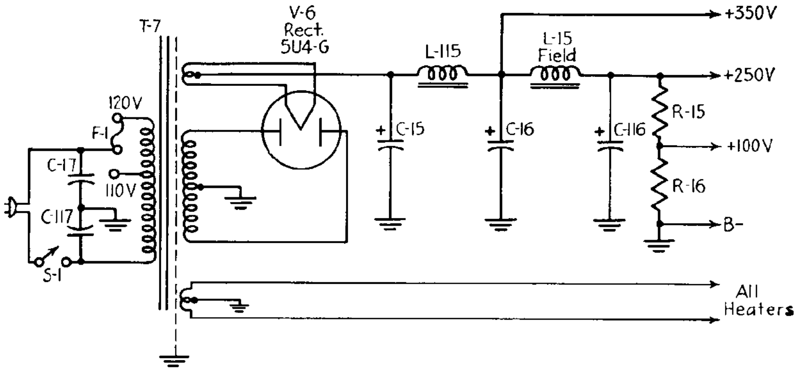


FIG. 8–18.—Typical power-supply stage for a large high-quality receiver.

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 multitube 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.

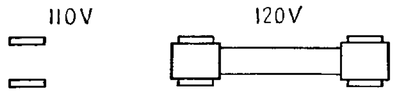


Fig. 8-19.—Line-voltage adjustment fuse.

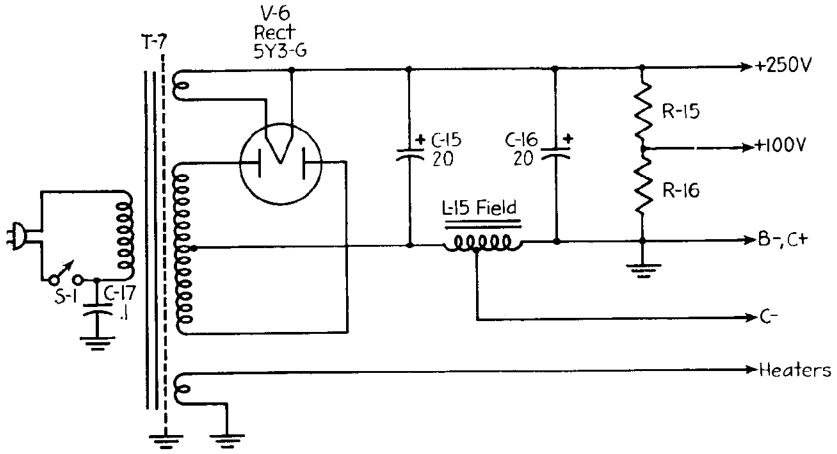


FIG. 8-20.—Fixed-bias type power supply, using a tapped speaker field in the negative *B* lead.

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.

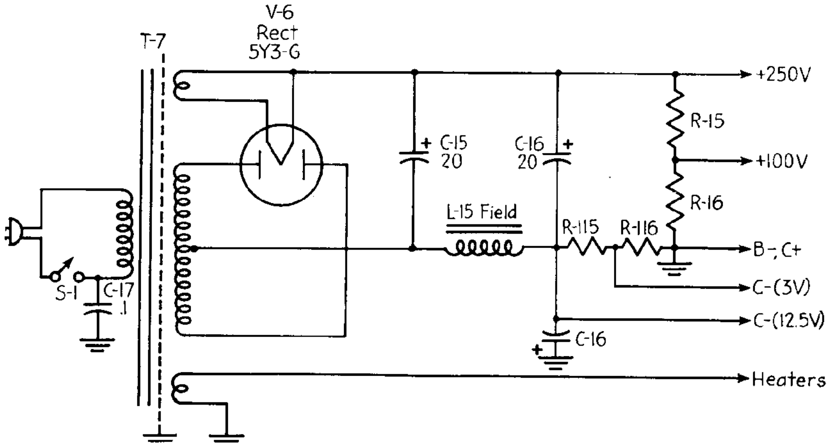


FIG. 8–21.—Power supply furnishing *C* voltage by means of a *C* voltage divider.

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 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.

SUMMARY

Quick check for normal operation of stage.

All tubes light.

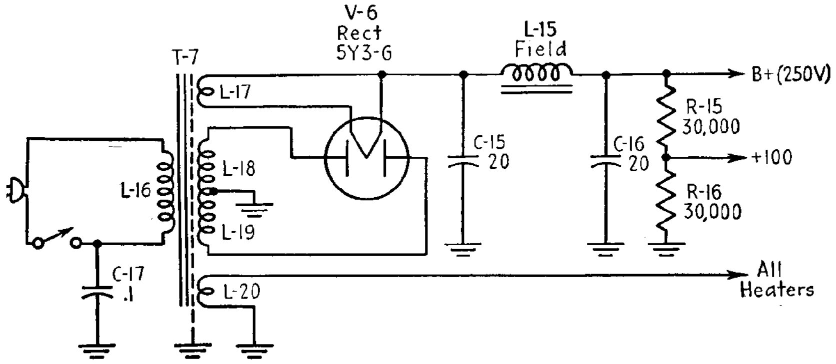
No signs of overheating.

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

SERVICE DATA CHART

Symptom	Abnormal reading	Look for
Tubes do not light	Plug prong to prong checks open with ohmmeter	Defective line cord and plug. Open fuse. Defective line switch *S*-1. Open power transformer *T*-7 (primary)
Rectifier-tube plates show red	Chassis-to-rectifier filament checks short circuit with ohmmeter	Shorted input filter condenser *C*-15. Check surge voltage on replacement
Rectifier tube overheats.	*B* plus voltage checks zero. Chassis to *B* plus checks short circuit with ohmmeter	Shorted output filter condenser *C*-16. Short circuit in *B* plus wiring
Rectifier tube overheats	*B* plus voltage low	Zero plate voltage on amplifier tubes. Short-circuited plate filter condenser
Hum	*B* plus voltage low	Open input filter *C*-15
Hum	*B* plus voltage normal	Open output filter *C*-16. Open grid
Oscillation or motorboating	*B* plus voltage normal, or fluctuating with motorboat beats. Screen voltage normal	Open output filter *C*-16 (or *C*-116)
Rectifier tube shows purplish glow		Gassy high-vacuum type of rectifier tube
Weak reception. No sign of overheating	*B* plus voltage checks low	Weak rectifier tube
No signal from speaker. No sign of overheating	*B* plus voltage checks zero (discharge filter condenser)	Dead rectifier tube. Open filter choke *L*-15
No reception. No hum. *B* plus voltage normal	Screen voltage zero	Open voltage-divider resistor *R*-15, short-circuited screen by-pass condenser, or both
Modulation hum		Poor ground, open line filter condenser *C*-17, or both
Fading		Screen voltage changing, owing to defective voltage-divider resistors *R*-15 and *R*-16
Oscillation	Screen voltage high	Open voltage-divider resistor *R*-16

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:

Type No.	T-13R11	T-13R12	T-13R13
HV winding	580 volts CT at 50 ma	700 volts CT at 70 ma	700 volts CT at 90 ma
Rectifier filament	5 volts at 3 amp	5 volts at 3 amp	5 volts at 3 amp
Filament No. 1	6.3 volts CT at 2 amp	6.3 volts CT at 2½ amp	6.3 volts at 3½ amp

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?

CHAPTER 9

LOUDSPEAKERS

Quick Check.—To determine whether a loudspeaker is functioning, momentarily unseat the second AF tube. A loud click should be heard. Where the output stage is of the push-pull type, removing either tube will produce the same result.

Function of the Loudspeaker.—The loudspeaker is a device that takes electrical energy or power at audio frequencies from the second AF output stage and converts it into sound energy. Its fidelity of reproduction depends on its ability to convert into sound all the component frequencies at the second AF output.

Types of Loudspeakers.—Many varieties of loudspeaker have paraded across the stage throughout the period of radio evolution. All of them, however, can be grouped into three main types: the magnetic loudspeaker, the crystal loudspeaker, and the dynamic loudspeaker. Much could be said about each of these, but the trend in recent years has been toward the dynamic type. Therefore, the balance of the description will concern itself with that type.

Theory of Operation of the Dynamic Loudspeaker.—The theory of operation of a dynamic speaker is quite simple. In these speakers, the AF signal from the second AF stage is impressed across a small, free-floating coil of wire (called the "voice" coil), which is suspended in a strong stationary magnetic field. The AF current causes a varying magnetic field around this coil. This varying field reacts with the stationary field and causes motion of the voice coil. The latter is cemented to a paper cone which vibrates with the voice coil and produces the audible sound waves.

Two main varieties of dynamic loudspeakers have been developed. The difference between the two lies in the manner in which the stationary magnetic field is produced. The two types are the electromagnetic dynamic speakers and the permanent-magnet (P-M) dynamic speakers.

In the electromagnetic type of dynamic speaker, a powerful stationary magnetic field is created by passing a direct current through a field coil, wound on an iron core which is part of an electromagnet. The pole pieces of the electromagnet are brought very close together.

The voice coil, suspended freely by means of its paper cone, rides between the field poles. AF currents are fed to the voice coil from the output transformer coupled to the second AF stage. (The output transformer may be mounted on the speaker unit itself.) The result is a vibratory motion of the voice coil and its attached cone. The outer edge of the paper cone is attached by means of soft leather or plastic, or even directly to its basket, so that the voice coil may float freely. A typical electromagnetic dynamic speaker is shown in Fig. 9–1. A flexible membrane, called a "spider," is usually attached to the voice-coil form and guides its motion within the space between the center pole piece and the pot. A dust cap, usually made of felt, is cemented at the front end of the voice-coil form to prevent dust or other grit from getting in between the voice-coil form and the adjacent poles.

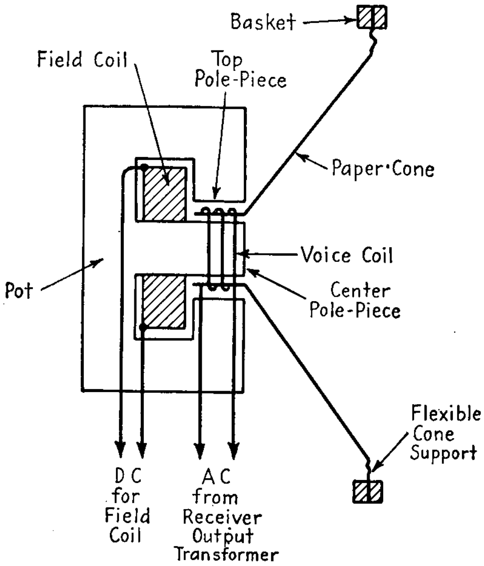


Fig. 9–1.—A typical electromagnetic dynamic speaker.

The other type of dynamic speaker is the P-M dynamic speaker. This type is exactly like the electromagnetic dynamic speaker except that the field is created by a permanent magnet, made of such material as alnico, rather than by an electromagnet. In all other respects, the construction and operation of the two speakers are identical.

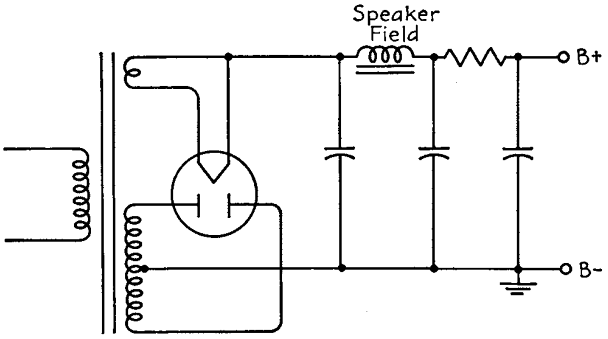


Fig. 9-2.—Energizing the field coil; field coil used as filter choke.

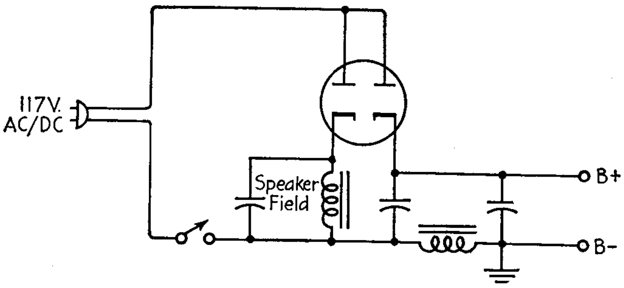


Fig. 9-3.—Energizing the field coil; field coil across the rectifier.

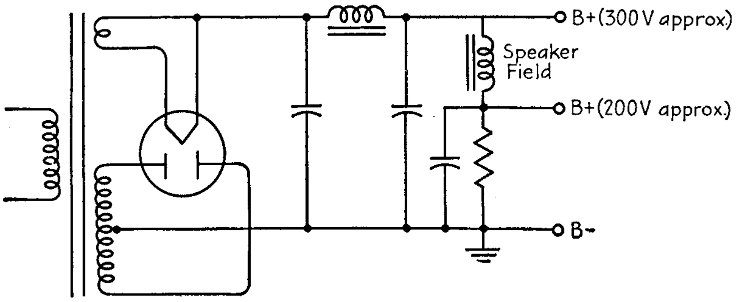


Fig. 9-4.—Energizing the field coil; field coil used as a voltage divider.

Energizing the Electromagnetic Dynamic-speaker Field.—The field of the electromagnetic dynamic speaker must be energized by means of a direct current. This DC supply is usually obtained from the power supply itself.

In most cases, the speaker field serves as a filter choke and therefore passes through it direct current with a small ripple component. Such a circuit is shown in Fig. 9–2.

In other circuits, the field coil receives its DC supply by being placed across the rectifier output. Such a circuit is shown in Fig. 9–3.

In other circuits, the field coil receives its DC supply by acting as a voltage divider across the filter circuit in the power supply. This circuit is shown in Fig. 9–4.

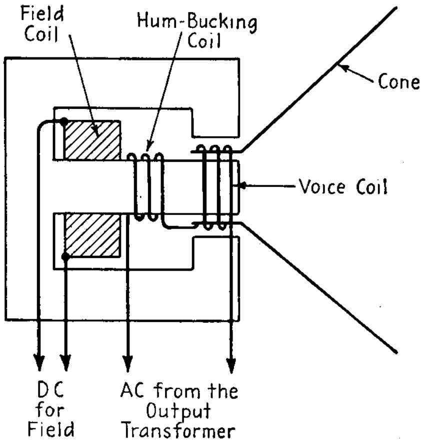


FIG. 9–5.—Electrodynamic speaker with a hum-bucking coil.

The Hum-bucking Coil.—The electrodynamic speaker is very likely to have a high hum component. This condition occurs because the DC supply for the field is not pure direct current but has a ripple component that affects the voice coil. Several devices have been employed to reduce this hum in the speaker so that it is not objectionable. The most widely used device is the hum-bucking coil, which consists of a few turns of wire, wound on the center core and fixed stationary to the field coil. This hum-bucking coil, however, is connected in series with the voice coil. The two coils are connected in such manner that any voltage induced in them will be in opposite phase and cancel out. Thus, the hum component from the field coil will be canceled out in the voice coil. Figure 9–5 shows an electrodynamic speaker with a hum-bucking coil.

Another device used to reduce hum from the field is the shading ring. Here, a thick copper ring, fixed between the field and the voice coil, acts as a single-turn coil in which eddy currents are produced and tends to shield the voice coil from the ripple component in the field coil.

The hum-bucking coil is used in speakers in which the field coil is the filter choke. Speakers in which the field is connected across the rectifier output use a hum-bucking coil or a shading ring. Speakers in which the field coil acts as a voltage divider do not require any hum-bucking device, since they are being fed direct current from which the hum ripple has been removed.

CHECKS FOR LOUDSPEAKER OPERATION

When the quick check indicates trouble in the speaker or if the servicing complaint is rattles or poor tone quality, the speaker should be carefully tested. The following section describes the quick check in detail and discusses other tests that may be applied to the loudspeaker.

Quick Check for Speaker Operation.—In the quick check, the second AF tube is unseated. When this is done, a click should be heard in the speaker. Unseating of the tube causes the *B* plus voltage to the plate pin of the tube to rise to maximum, with a consequent surge through the primary of the output transformer. This surge, induced in the secondary of the transformer, momentarily energizes the voice coil and produces the click,

This quick check does not tell us how well the speaker is functioning, merely that the voice coil is not open.

To determine if the field coil of an electromagnetic dynamic speaker is open, a blunt piece of iron, like a socket wrench, should be held near the center pole piece. A perfect field coil will cause the tool to be attracted strongly. An open field coil will give either no attraction or a slight attraction due to residual magnetism. Unfortunately, the dust cover may in some cases make this test somewhat unreliable. Of course, this latter test is not necessary for a P-M dynamic speaker.

Signal-substitution Check for Speaker Operation.—In the signal-substitution test, an audio signal is fed into the speaker, and its response observed. The test may be made with a signal generator whose level of audio output is sufficiently high to drive the speaker directly.

The "hot" lead from the signal generator is connected, in such case, to the primary of the output transformer, and output from the generator is turned on full. The receiver is turned on to energize the speaker field, if the speaker is of the electrodynamic type. The receiver should be tuned to an off-station position, and its volume control set to minimum position to remove any station signal from interfering with the test. When the signal generator is turned on, the audio note should be heard clearly and loudly, if the speaker is operative. If no note is heard, the voice coil is probably open. If the note is weak, the field coil is open or not receiving sufficient current.

If the signal generator is of the type delivering a variable-frequency output, other checks may be made. After the test just described indicates that the speaker is operative, its frequency response may be checked by swinging the signal generator output from low audio frequency through high audio frequency. In addition, this last check will indicate rattles from the speaker or a vibrating component in the receiver. Sympathetic vibrations of objects in the receiver, at any one audio frequency, will also be found.

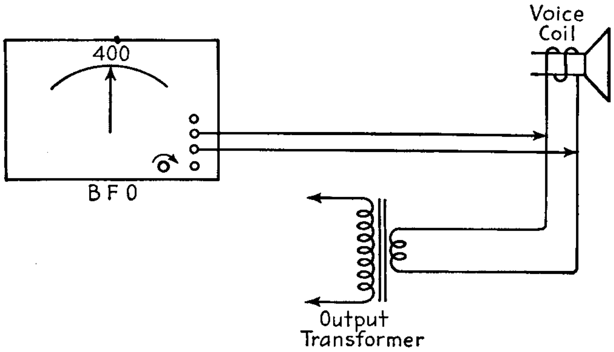


Fig. 9–6.—Checking a speaker with a beat-frequency oscillator.

The tests just described may be made with a beat-frequency oscillator (BFO), if that instrument is available on the service bench. It furnishes high-level, variable-frequency audio output. The output from the BFO is a pure audio wave form, with good frequency and output stability.

In using the BFO to check speakers, the speaker and the BFO are hooked up as shown in Fig. 9–6. Its proper impedance output is connected across the voice coil. It is not necessary to disconnect the voice coil from the secondary of the output transformer. If the speaker is of the P-M dynamic type, the test may now be made. If it is of the electrodynamic type, the receiver must be turned on to energize the speaker field. Then tune the receiver to an off-station position and reduce its volume control to minimum position. Adjust the BFO at a low output level for a 400-cycle note, which should be heard in the speaker. As with the signal generator, no note indicates open voice coil; a weak note indicates that the field coil is open or not receiving sufficient current.

If a normal response is heard, the BFO frequency control is rotated from low to high frequency. The sound will indicate the frequency response of the speaker. In addition, rattles and sympathetic vibrations will be found.

Substitution of a Test Speaker.—When the serviceman is not sure that the speaker is the cause of weak operation or distorted output, substitution of a test speaker will resolve this doubt. If the distortion also appears in the test speaker, the cause is in the receiver, etc. A description of a bench test speaker is given in Chap. 24 on the Service Bench.

Resistance Check for the Loudspeaker.—In the final analysis, the speaker is checked with an ohmmeter. To test that the voice coil is neither open nor shorted, disconnect it from the secondary of the output transformer and measure its ohmic resistance with the ohmmeter. It should have the resistance indicated by the receiver manufacturer on his schematic. If this information is not indicated, voice-coil resistance measurements are found to vary from 2 to 15 ohms, the higher values being found in larger speakers.

The resistance of the field coil may be measured without disconnecting. There will be considerable variation from receiver to receiver, and it is best that its value be determined by actual reference to the schematic diagram. However, average values will be given where schematics are not available.

Where a field coil acts as a filter choke in the power supply, as shown in Fig. 9–2, its value may be found on the average to be as follows:

For AC receivers	800–2,000 ohms
For AC/DC receivers	450 ohms

Where a field coil is connected across the rectifier output, as shown in Fig. 9–3, its value may be found on the average to be as follows:

For AC receivers	6,000–10,000 ohms
For AC/DC receivers	3,000 ohms

Where the field coil is part of the voltage-divider system, as shown in Fig. 9–4, no average value can be given, and the serviceman should refer to the schematic diagram and service notes for the receiver being checked.

TROUBLES COMMON TO THE LOUDSPEAKER

From the servicing point of view, the loudspeaker may be responsible for many receiver defects. The receiver may be dead because the voice coil is defective, or because the field coil, acting as a filter choke in the power supply, is open. The receiver may produce a weak output because the speaker field, used across the rectifier output, is open. Strange rattles may develop because of loose parts, torn cone, off-center voice coil, dirt between the voice-coil form and the field poles, or sympathetic vibrations of parts within the receiver. Each defect will be described from the point of view of its source.

Troubles Common to the Voice Coil.—Many receivers are brought in for servicing because of troubles attributed to the voice coil and its associated paper cone. Such conditions may be an open voice coil, an off-center voice coil, dirt and grit between the voice coil and the field pole pieces, loose voice-coil wires, broken cement between the voice coil and the paper cone or spider, and a broken lead from the voice coil to the voice-coil connection strip.

If a receiver is brought in as dead and unseating of the second AF tube does not produce a click, the voice coil may be presumed to be open. The signal-substitution and resistance check for continuity may then be used to confirm the condition. If an open is found, the leads to the voice coil should be inspected to see if one has not broken loose. The lead may be resoldered. If the open is in the voice coil, it is not advisable to try to rewind it. Rather, it and its associated paper cone must be replaced with an exact duplicate.

Replacement of a voice coil and cone involves several steps, executed with extreme care. First, an exact duplicate is necessary. If such is not obtainable, a new speaker unit must be obtained. Second, the voice coil must be properly centered around the center pole piece.

Centering of the voice coil is dependent upon the variety of speaker used. Usually, the outer edge of the paper cone is fastened to the outer housing or basket of the speaker by means of a ring and several bolts and nuts or cement. The voice coil itself is kept centered and freely floating by means of a membrane, called a "spider," which is cemented to the voice coil. The spider permits movement of the voice coil parallel with the length of the center pole piece but restrains it from making sidewise movements.

Several types of spiders are used. One, shown in Fig. 9–7, is attached to the paper cone near the voice coil. A bolt through the center attaches it to the center pole piece. When a replacement is made, the new voice coil and cone should be placed over the center pole piece. By means of cone-centering shims, which are flat steel or fiber strips made for the purpose, the voice coil should be centered around the center pole piece. The shims are inserted through the spaces in the spider between the center pole piece and the voice-coil form, as shown in Fig. 9–8. Use three or four shims evenly spaced, depending on the spider structure. Then tighten the centering screw. This retains the voice coil in a centered position. Then fasten the outer rim of the cone, by means of cement or nuts and

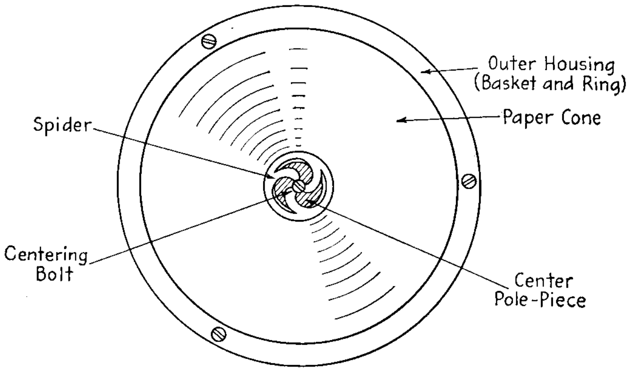


Fig. 9–7.—Front view of a speaker, showing the spider.

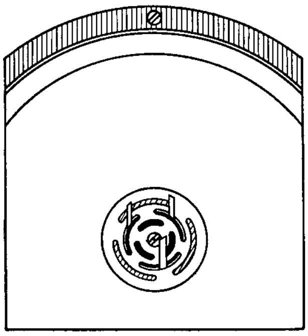


Fig. 9–8.—Centering a voice coil with three shims.

bolts, to the basket of the speaker. Finally, remove the shims. A check is then made to see that the voice coil floats freely. Move it gently in and out manually, and watch for rubbing against its surroundings. The dust cap of the speaker, if one is used, should be cemented over the end of the voice-coil form.

As a final step in replacing the voice coil of an electrodynamic speaker, the hum-bucking coil, if present, must be reconnected to the new voice coil and be in such phase that it reduces hum. If, after connection, hum is excessively loud, reverse the connections of the hum-bucking coil to the voice coil.

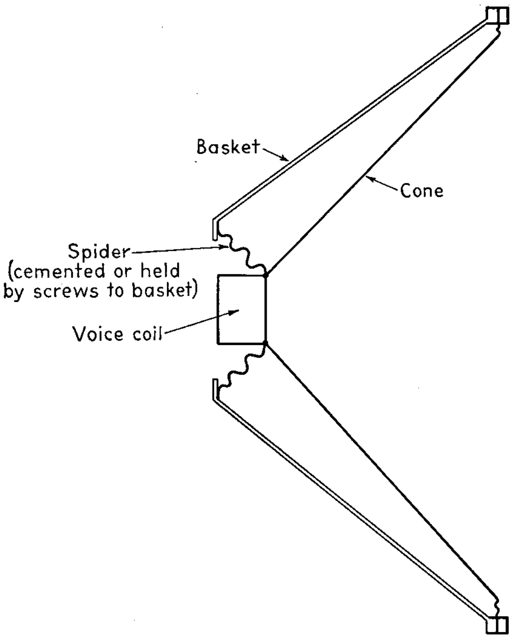


FIG. 9-9.—Inside spider connected to speaker basket.

Another type of spider consists of a membrane, attached to the voice-coil form at its center and connected to the housing either by cement or by machine screws. This type is shown in Fig. 9-9. Here again, in replacement, the voice-coil form is centered around the center pole piece by means of shims. The spider is cemented or bolted to its support to keep the voice coil in position, and the outer rim of the cone fastened to its basket. Then the centering shims are removed. Move the voice coil gently in and out, and observe that it floats freely. Finally, cement the dust cap over the voice coil and reconnect the hum-bucking coil, if present.

Another condition that may develop from the voice coil is rattle. If the spider in some way becomes loose, it will permit the voice coil to go off center and rub against adjacent parts. The result is rattle and loss of power in the speaker, as well as distortion. The condition may be checked by moving the voice coil in and out manually, and observing if rubbing occurs; or a substitute test speaker will show improvement in power, tone, and elimination of rattle. Where such is the condition, repair is fairly simple. The voice coil is recentered in the manner just described, and the spider screws are retightened.

Sometimes, the same condition of a rubbing voice coil may be caused by grit and dirt collecting between the voice-coil form and the center pole piece or pot. Here, the cone and voice coil are removed, the dirt is cleaned out with a pipe cleaner, and the coil and cone unit are replaced and recentered.

A rubbing voice coil may result from a voice coil whose shape has become warped. This condition may be presumed when repeated recentering of the voice coil does not remedy the condition. It is not advisable to try to reshape the coil. Replacement of the voice coil and cone is suggested.

Sometimes, the cement binding the voice coil itself breaks, and the turns come loose. This condition, too, will cause mysterious buzzes. The voice coil and cone should be removed, and new coil cement carefully applied. Then replace and recenter, as described.

Again, rattles may occur if the voice coil loosens its cement connection to the cone or spider. Recementing is the cure. Then replace and recenter as before.

Infrequently, the pot and center pole piece may loosen or warp, giving the effect of an off-center voice coil. This condition will become obvious when repeated centering of the voice coil does not remedy the condition. The voice coil is removed under the impression that it may be warped, but inspection shows that it is round but the field gap is not uniform. In some cases, the field gap is adjustable, and a procedure for resetting the top pole piece is given in the section describing the replacement of field coils. When the gap cannot be adjusted, the entire speaker must be replaced.

Troubles Common to Electrodynamic Speaker Field Coils.—The speaker field of an electrodynamic loudspeaker may be the source of many receiver defects. The manner in which it will make itself manifest depends on the way in which it receives its excitation. Where a defective field coil is indicated, replacement depends upon the construction of the speaker and the availability of a similar coil. If replacement is not possible, the entire speaker must be replaced.

Where the speaker field coil is used as a filter choke, the defect will be located in a power supply check. It will be noticed from Fig. 9–2 that an open coil will cut off the *B* plus supply, so that all stages will be inoperative. The receiver will be brought in dead. A check of the power supply will show no *B* voltage. Disconnect the power plug and discharge the filter condensers. An ohmmeter check for continuity will confirm the open field. The open may be due to a break in the field leads or in the connection between the field wire itself and the lead. These should be inspected and, if found at fault, repaired.

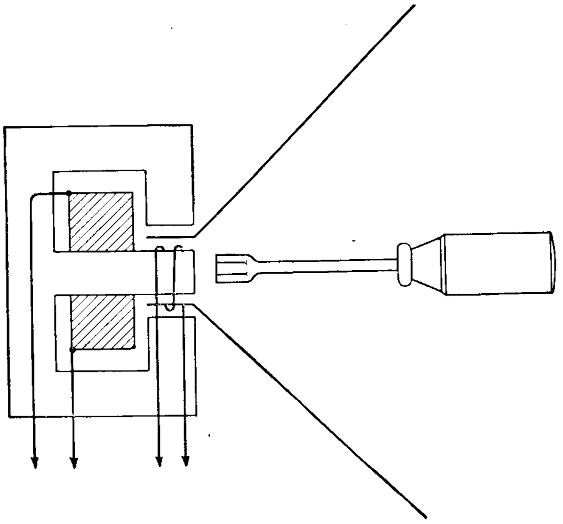


FIG. 9–10.—Checking the magnetic pull of a speaker with a socket wrench.

The effects of a defective speaker field coil across the rectifier output, as shown in Fig. 9–3, will be different from that given above. The receiver will be brought in for weak operation if the coil is open. This is because the set is operating with no field, but only the residual magnetism in the pole piece. The *B* voltage will not be disturbed. The quick check for speakers will show a weak click, focusing attention on the field. Confirmation will be obtained by trying the receiver with the test speaker or by checking the magnetic pull of the speaker field, as shown in Fig. 9–10. A blunt piece of iron like a socket wrench is brought near the center pole piece. Make this check with care, lest the tool tear the paper cone or dust cover.

When the field excitation circuit includes a separate rectifier and filter, as is the case in the circuit of Fig. 9-3, the lack of field strength may be due to defects in the rectifier or filter, while the field coil itself is perfect. These associated components should be checked.

Final confirmation of the field condition may be made with an ohmmeter. The serviceman is again cautioned to discharge any associated filter condensers before making ohmmeter checks on a speaker field.

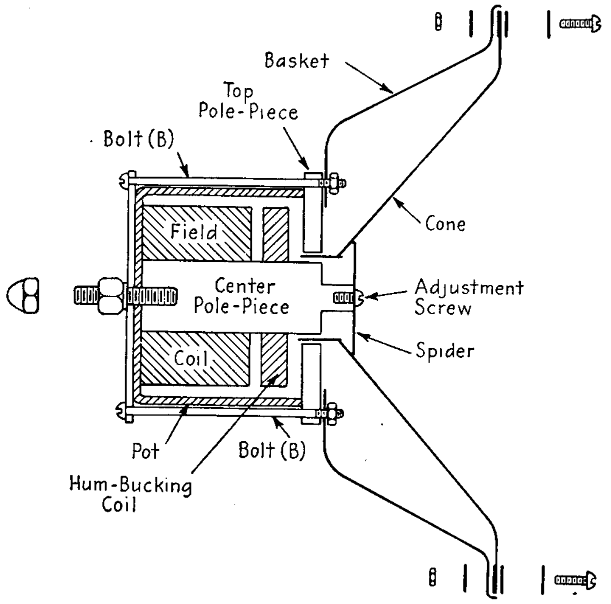


FIG. 9-11.—A typical electrodynamic speaker with a replaceable field coil.

Where the speaker field is used as a voltage divider, as in Fig. 9-4, defects would show up differently. If the field coil opened, the defect would be found in a routine check of plate voltages. The set would be dead. There would be no *B* plus voltage on the RF and IF tubes. High *B* plus would, however, be present in the other stages. The socket-wrench test would show no field strength. Substitution of a test bench speaker for both field and voice circuits would restore normal operation. The ohmmeter check for continuity would finally confirm the defect.

Another field-coil defect, common to all three excitation circuits, is that of shorts between the field winding and the center pole piece or the outside pot. If the speaker is mounted on the chassis, the short will cause partial or complete loss of *B* voltage and possible damage to the power supply. This condition will be found in a check of the power supply. The power-supply check would seem to indicate a shorted filter condenser. The actual defect would be found when removal of the suspected filter condenser does not remove the short from the circuit. If the speaker is not on the chassis, the speaker case will become "hot" with high voltage, but the receiver operation may not be affected.

Replacing a Speaker Field Coil.—The construction of the speaker pot does not always lend itself to the replacement of the field coil. Nor are field coils obtainable for all speakers. When the field coil cannot be replaced, the entire speaker must be replaced.

A typical electrodynamic speaker, which has a replaceable field coil, is shown in Fig. 9–11. Here, the entire pot can be taken apart.

The procedure for removing the field coil is outlined in the following steps:

1. Remove the voice coil and cone in the manner described under Troubles Common to the Voice Coil.
2. Remove the nuts from the bolts that hold the basket and the top pole piece to the pot.
3. Remove the field coil (and hum-bucking coil, if used) by sliding it forward over the center pole piece. This may involve first unsoldering the field-coil terminals from a terminal strip.
4. Slip a replacement field coil over the center pole piece and, where necessary, solder its leads to the terminal strip. The replacement coil should be as nearly like the original as is possible. Replace the hum-bucking coil (if used).
5. Replace the basket and the top pole piece. Replace the bolts *B*, and loosely engage them with their nuts.
6. The next step centers the center pole piece, so that the field space in which the voice coil floats is uniform. Place three or four pieces of drill rod of the proper size to fit exactly in the field space, as shown in Fig. 9–12.
7. The nuts for bolts *B* are then tightened. It is wise not to tighten any one nut completely while the others are loose. The recommended procedure is to tighten one nut loosely, then the next, and the next, etc. Continue around several times until each nut is securely tightened. A socket wrench is used in this step. The serviceman is cautioned to use care, so as not to strip the nuts or bolts.
8. Remove the drill rods.
9. Replace and recenter the voice coil and cone, as described in the section on Troubles Common to the Voice Coil.

Since the above operation may have reversed the phase of the hum-bucking coil, should a hum now develop, the serviceman should try reversing the voice coil or hum-bucking coil connections, as well as checking the power-supply filter circuit.

Where a pot and center pole piece may loosen or warp, giving the effect of an off-center voice coil, the procedure listed above must be followed, except for replacing the field coil.

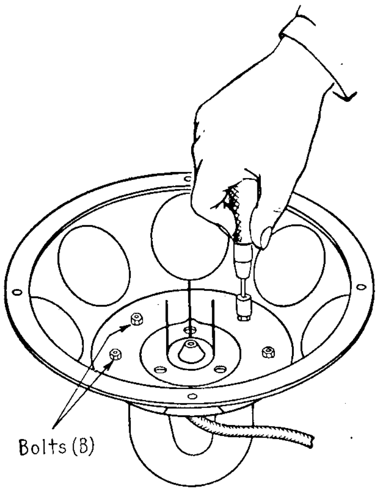


FIG. 9-12.—Centering the center pole piece with drill rod.

R.M.A. Color Code for Loudspeakers.—The various terminal wires of a loudspeaker may often be identified for servicing by means of the R.M.A. color code, tabulated below.

Voice coil:	
1. Green	finish
2. Black	start
Field coil (if any)	
1. Black and red	start
2. Yellow and red	finish
3. Slate and red	tap (if any)

Troubles Common to the Paper Cone.—The troubles common to the paper cone are those usually associated with the voice coil. The cement binding the cone to the voice-coil form may dry and crack, with resulting rattles from the speaker. This condition may be remedied by using a standard voice-coil cement for reconnection. This latter procedure should be done with care.

On occasion, the paper cone may tear or crack and produce rattles. As a rule, it is not advisable to try to patch it, because the cement usually contracts when it dries and distorts the cone shape. A distorted cone produces distortions from the speaker. The entire cone and voice coil should be replaced. Where such a replacement is not available, the patch job should be done with a standard speaker-cone cement.

In many receivers, there is a felt or cardboard ring that is fastened around the rim of the basket. Its purpose is to prevent acoustic continuity between the speaker and the baffle to which it is attached. After replacing a voice coil and cone or a speaker field coil, the ring should be either bolted or cemented back into position.

Troubles Common to Speaker Assembly and Mounting.—After continuous operation, various parts within the receiver may have a tendency to become loose. Various screws in the speaker or associated with its mounting may also loosen, because of continuous operation. Where such is the case, rattles and buzzes may mar the speaker reproduction. The serviceman may verify this condition by connecting in a substitute test speaker from his test bench and observing if improvement results. If the rattles and buzzes disappear, a careful hunt must be made for any loose part prone to vibrate. This is done by holding various parts with the fingers while the receiver is operating, and observing if the vibrations are damped. No part should be beyond suspicion. Even the cabinet must be inspected for loose or cracked parts.

Replacing a Complete Loudspeaker.—Many speaker defects require the complete replacement of the entire loudspeaker assembly. Where such is the requirement, an exact replacement is most desirable. This may not always be possible, and a speaker that resembles the original as closely as possible must be used.

Several factors must be kept in mind by the serviceman. Is there sufficient space within the cabinet? Can the new speaker be mounted with sufficient ease? Is the resistance of the field coil, if an electrodynamic speaker is used, similar to that of the original? Is the current-carrying capability of the field coil of the replacement speaker sufficient for the receiver? Is the impedance of the new voice coil the same as that of the old speaker? And finally, is the power-handling capability (wattage) of the voice coil of the new speaker sufficient for the receiver?

Replacement speakers are usually listed according to the following factors:

1. Diameter of the basket in inches.
2. Voice-coil impedance in ohms.
3. Voice-coil wattage.
4. Field-coil resistance in ohms.

Although the current-carrying capability of the field coil is not listed, it is an important factor that must not be overlooked. In this consideration, the size of the pot is an indication of the current-carrying capability of the field coil. The pot of the replacement speaker should be no smaller in size than that of the old speaker.

If the wattage output of the receiver is not indicated in the manufacturer's schematic, the proper wattage for the voice coil may be determined in another manner. The tube or tubes used in the second AF or output stage are determined by inspection. Then reference to a tube manual will give the undistorted power output for that tube. This wattage may be considered as the voice-coil wattage.

Often in making a speaker replacement, the old output transformer, mounted on the old speaker, may be removed and used with the new replacement speaker. The transformer primary will thus match the second AF stage. Care must then be taken that the transformer secondary impedance matches that of the voice coil of the new replacement speaker.

If the chosen replacement speaker has a voice-coil impedance differing considerably from the original, this will necessitate changing the output transformer for proper impedance match. Replacement notes on output transformers are found in Chap. 10.

Replacing an Electrodynamic with a P-M Speaker.—Sometimes an electrodynamic speaker has to be replaced, and a similar speaker is unobtainable. In such a case, a P-M dynamic speaker of proper voice coil, wattage, and size may be used with some provision to replace the field coil in the circuit of the receiver.

When the field excitation is obtained by connecting the field across the rectifier output, no provision for its replacement need be made. When the field coil is acting as the filter choke for the receiver, it should be replaced by a choke coil of equivalent inductance and current-carrying capability. The choke will probably have a lower ohmic resistance than the field. This will increase the available *B*-plus voltage. This increase in voltage will be small and will not alter the operation of the receiver to any great extent.

When the speaker field acts as part of the voltage divider, it must be replaced by an equivalent circuit, composed of a choke that is an equivalent inductance, and a series resistor to give the unit an equal resistance. The latter consideration is necessary to maintain proper operating potentials for the tubes in the receiver. The choke must have proper current-carrying capabilities. The series resistor plus the ohmic resistance of the choke should equal the resistance of the original field coil. The current in the field can be determined by Ohm's law, and the wattage of the resistor can be determined by substituting in the wattage formula $W = E^2/R$. Figure 9–13 shows a replacement of this type.

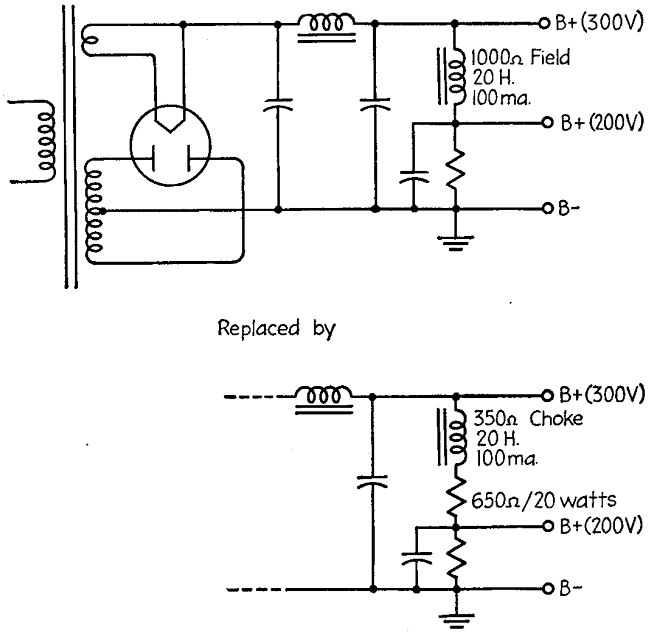


FIG. 9–13.—Replacing an electromagnetic with a P-M dynamic speaker—field-circuit adjustments.

Dual Speaker Systems.—Some receivers are built with two speakers within the same cabinet. Where a condition develops in such a receiver that one of these speakers must be replaced or requires a voice coil and cone replacement, the procedure is similar to that described for single-speaker replacements.

However, a new consideration develops. If one voice coil moves in while the other moves out, interference effects develop and reduce the volume of total output. This condition is undesirable and may be remedied by reversing the voice-coil or field-coil leads to one of the speakers. The voice coils will then move in and out together, and the speakers are said to be in phase.

To determine if the speakers are properly phased after replacement, turn on the receiver and tune to a nonstation position. Place your hands on the cones of the two speakers. Then apply the voltage of a dry cell across the output transformer secondary. The movement of the cones will be felt and seen, and proper phase may be found.

Adding a Speaker to a Receiver.—In some cases, a customer may desire a second speaker connected to his receiver and installed in another room. Since the speakers are remote from each other, phasing is not important.

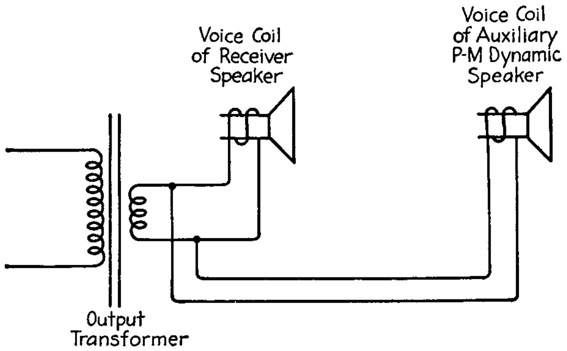


FIG. 9-14.—Adding an auxilliary P-M dynamic speaker to a receiver.

A simple procedure in this requirement is to obtain a P-M dynamic speaker and connect its voice coil in parallel with the voice coil of the receiver speaker. Of course, this will cause mismatch with the output transformer secondary, but the effect will not be too poor. Besides, the larger the impedance of the voice coil of the P-M dynamic speaker, the less will be the total mismatch, although less power will be fed to the auxiliary speaker. This may be of advantage, since it is generally desirable to operate the auxiliary speaker at a reduced volume. The combination is shown in Fig. 9-14.

In the setup described above, both speakers will operate simultaneously. If it is desired to shut off the receiver speaker while the auxiliary speaker functions, it is necessary to use a single-pole double-throw switch to cut out the first voice coil. In addition, a resistor, of comparable impedance to that of the voice coil just cut out, should be connected across the secondary of the output transformer. A second switch is connected at the auxiliary speaker to cut it out when not in use. This setup is shown in Fig. 9-15.

It is now possible to control the volume of the receiver and auxiliary speakers only by means of the receiver volume control. If it is desired to vary the volume of the auxiliary speaker at the speaker itself, a standard *L* pad control may be inserted across the voice coil of the auxiliary speaker. The ohmic rating of the pad should match the impedance of the auxiliary voice coil. The complete setup is now shown in Fig. 9–16. No switch is required at the second auxiliary speaker, since the *L* pad can replace its function. The minimum position of the *L* pad will cut out the auxiliary speaker.

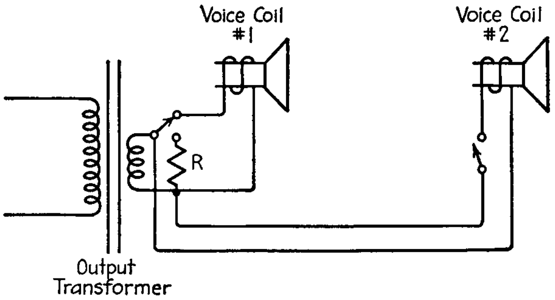


Fig. 9–15.—Switching the receiver speaker and the auxiliary speaker—individual control.

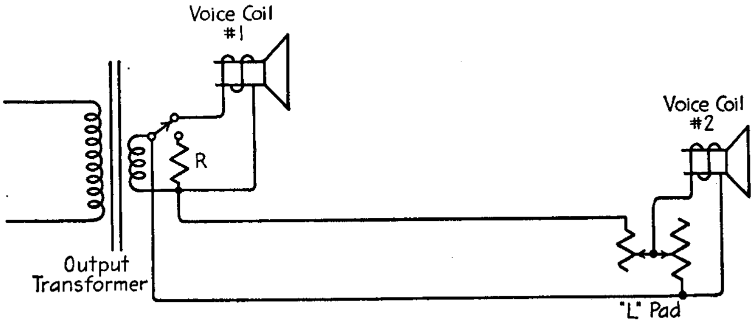


Fig. 9–16.—Volume control for an auxiliary speaker.

Adding Headphones to a Receiver.—A customer may request that headphones be installed on his receiver, so that he may turn off the loudspeaker and still listen to the radio late at night. The simplest procedure is to connect the phones across the voice coil. The high impedance of the phones will cause great mismatch and keep power fed to the phones low, giving low volume. A switch may be installed to cut out the speaker voice coil and to cut in an equivalent impedance resistor. A second switch may be used to cut out the phones. The setup is shown in Fig. 9–17.

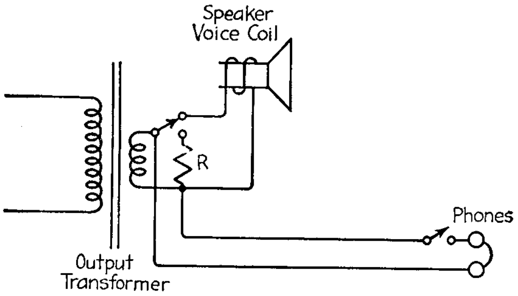


Fig. 9–17.—Circuit for connecting earphones to a receiver.

The same effect may be achieved by the installation of a circuit-switching phone jack, as shown in Fig. 9–18. Pushing the phone plug only part way in will allow simultaneous operation of the phones and speaker. Pushing the phone plug all the way in will cut out the speaker voice coil and allow operation of the phones alone.

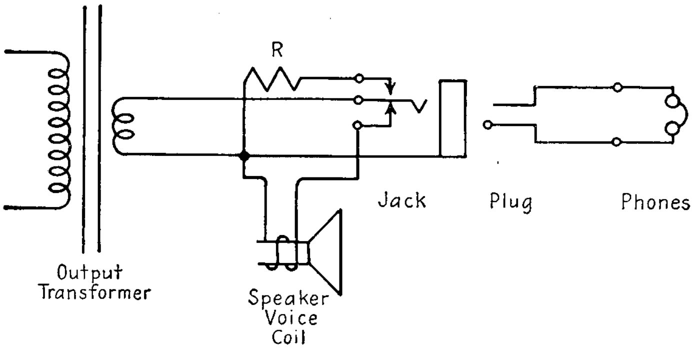


Fig. 9–18.—Circuit for adding phones to a receiver—using jack and plug.

SERVICE DATA SHEET

Symptom	Abnormal reading	Look for
No reception	No B plus voltage	Open field. See Chap. 8
	No click on quick check	Open voice coil. Open voice-coil leads
Weak reception	Weak click on quick check	Deenergized field (open field or low excitation voltage). Jammed voice coil
Distortion		Rubbing voice coil. Low field excitation voltage. Warped cone. Factors within the receiver (eliminate the speaker by substitution test)
Rattles		Rubbing voice coil. Loose voice coil. Torn paper cone. Cone loose from basket rim. Loose spider. Grit and dirt in field gap. Loose dust cap. Loose screws on speaker. Loose parts in radio

QUESTIONS

1. A receiver is brought in as dead. No plate voltage appears to be present. If you suspect that the speaker is defective, what part would you suspect? How would you test for it?

2. A new voice coil and cone are installed in a receiver. When the set is turned on, it hums excessively. What is probably wrong? What remedial measures would you take?

3. A receiver requires a new speaker. An exact replacement is not obtainable. What considerations must be made in replacing a new speaker?

4. A rattling, rasping speaker is reported by a customer. Examination shows an off-center voice coil. What remedial measures would you make?

5. A receiver has a dual speaker system. One speaker requires replacement of a voice coil and cone. List the steps in order by which you would make this replacement.

6. A customer has a receiver in his living room. He wants to add an auxiliary speaker to operate in the cellar. He wants to be able to operate either or both speakers and also to control the volume of the cellar speaker in the cellar. Design a circuit for these requirements.

7. A customer wants to use headphones with his receiver at night, so that he can cut off the loudspeaker. Design a circuit for him.

8. A receiver with a power supply like the one of Fig. 9–3 gives very weak reception. A signal check produces a very weak click in the speaker. What factors can cause this condition? How would you check for each?

CHAPTER 10

SECOND OR POWER AUDIO-AMPLIFIER STAGE

The second AF amplifier stage is also called the "power-amplifier" stage or "output" stage.

Quick Check.—If a plugged-in soldering-iron tip or finger is placed on the control grid of the second AF amplifier tube and causes a low growl to be heard in the speaker, the second AF stage is probably functioning properly, and the trouble shooter moves on to the first AF stage.

Standard Circuit.—Figure 10–1 represents our standard second AF stage.

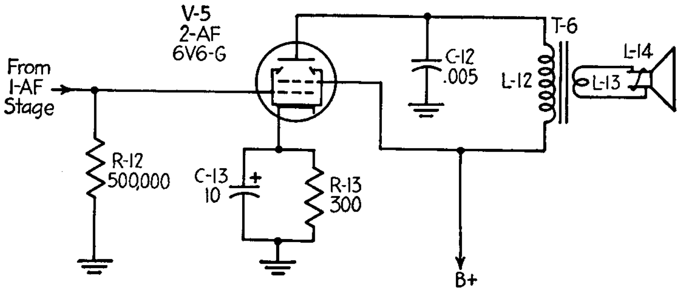


FIG. 10–1.—Standard circuit for a typical second AF stage.

Function of Second AF Stage.—The control-grid circuit is the signal input of the stage; the plate circuit is the signal output. The signal fed into the stage is an AF voltage, the magnitude of which would be about sufficient to operate headphones. It is the function of the second AF stage to amplify this signal to an amount sufficient to operate a loudspeaker. To get an idea of the magnitude of the signal voltages handled by the second AF stage, a 6V6-G tube (most commonly used) gives an output of 4.25 watts with an input grid signal voltage of 12.5 volts peak. A smaller signal-input voltage would give a smaller output power; 12.5 volts is the maximum the tube will handle without undesirable distortion. The input signal is fed from the preceding first AF stage. The plate or output circuit of the stage feeds the amplified signal to the speaker.

Regardless of whether the receiver is AC, AC/DC, or battery-operated, the function and operation of the second AF stage is the same. Indeed, this is true for all stages but the power-supply stage.

FUNCTIONS AND VALUES OF COMPONENT PARTS

Grid-load Resistor R-12.—Resistor *R*-12 is the grid-load resistor, and the input signal is impressed across it. Its value usually is 500,000 ohms. When a different ohmage is used, a lower value would result in lower gain and better frequency response, while a higher value would give slightly higher gain at a sacrifice of tone quality.

Self-bias.—Since grid-bias voltage affects tone quality and amplification and is a valuable indication of trouble to the serviceman, the theory underlying self-bias circuits should be thoroughly understood.

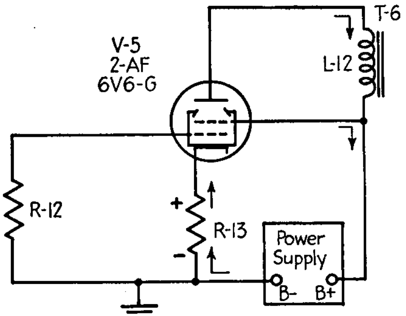


Fig. 10-2.—Circuit depicting self-bias.

Let us first remember that, in order to maintain a grid-bias voltage, the grid must be made negative with respect to its cathode. Assume no signal input voltage, and examine the amplifier circuit redrawn as in Fig. 10-2, with components unnecessary to the self-bias circuit eliminated. Observe that resistor *R*-13 and the tube *V*-5 are in series across the *B* power supply. Tracing the screen circuit, current flows from *B* minus through *R*-13, through the tube to the screen and *B* plus. Tracing the plate circuit, current flows from *B* minus through *R*-13, through the tube to the plate, and finally through *L*-12, the output-transformer primary, to *B* plus. It is seen that both screen and plate currents flow through *R*-13 and, as a result, a voltage drop is developed across it. Note also that the cathode is made positive with respect to *B* minus by this voltage drop. Then, when the grid is returned to *B* minus through *R*-12, the grid is negative with respect to the cathode. A negative grid will not attract electrons and, as a result, there is no current in the grid circuit through *R*-12 and no voltage drop across it. The full voltage developed across *R*-13, therefore, is applied to the grid as the bias voltage.

This system of obtaining grid-bias voltage is known as "self-bias," since the tube's own screen and plate currents cause the voltage drop, which is used for biasing the grid. The self-bias circuit can be used with a triode type of tube also, in which case the voltage drop is caused by the plate current alone.

The ohmic value of R-13 will depend on the tube used and its operating potentials. Several common values follow:

6V6-G	300 ohms
25L6-G	150 ohms
6K6-G	410 ohms
6F6-G	410 ohms
6L6-G	170 ohms
25A6	600 ohms

Self-bias By-pass Condenser C-13.—The input circuit of the tube is between grid and cathode. This involves grid-load resistor R-12 and self-bias resistor R-13. The input-signal voltage divides itself between them, most of the signal being across the larger grid-load resistor R-12. The output circuit of the tube is between plate and cathode. This includes the output transformer primary L-12, the B power supply, and self-bias resistor R-13. The output signal divides itself among these three, most of it being across L-12, which has the highest impedance to the output signal. Resistor R-13 is common to both the input and the output circuits, and some of the input signal and some of the output signal will mix in R-13. This is coupling. Since a tube's output signal is 180 deg out of phase with its input signal, cancellation takes place where the two signals are coupled, as across R-13. This effect of coupling, where cancellation takes place, is known as "degeneration" and results in a decrease in the gain of the tube.

The degenerative action can be minimized by bridging R-13 with a condenser. The current through R-13 has components made up of the DC screen and plate currents of the tube, the AC input signal, and the AC output signal. When R-13 is bridged by a condenser, the impedance of the parallel combination to the signal current is reduced, while its opposition to direct current remains the ohmic value of R-13. The voltages across the parallel combination therefore are reduced as regards signal voltage, while the DC bias voltage remains the same. The reduced input- and output-signal voltages across the parallel combination decrease the degenerative effect.

The action of the parallel condenser has been called "by-pass," since, from one point of view, the signal current is taken out of resistor R-13 and passed around it through the condenser. The by-pass action depends on the impedance of the condenser to the signal frequencies. To be effective, it should be lower than the ohmic value of the resistor being by-passed.

Since the signal in the second AF stage is at audio frequency, a high-capacity condenser will be necessary for adequate by-pass action. Condenser *C*-13 is usually a low-voltage electrolytic type. Capacities from 5 to 25 mfd will be found in various receivers. The higher capacities will provide better by-pass action, with a consequent improvement of the response, especially at the low audio frequencies.

Self-bias circuits similar to *R*-13 and *C*-13 are used to obtain bias voltages for the RF and IF tubes. The action in these tubes is similar, except that the cathode by-pass condensers need be only 0.1 mfd for adequate signal by-pass, owing to the higher signal frequencies at radio frequency and intermediate frequency.

Output Condenser C-12.—Condenser *C*-12 across the signal-output circuit by-passes high audio frequencies to ground. The pentode and beam-power tubes introduce a considerable amount of harmonics, which will be most noticeable in the high AF range. Placing *C*-12 across the signal output circuit by-passes some of the signal away from the output transformer. This effect will be greatest at the high audio frequencies, since the impedance of a condenser decreases as the frequency increases. Therefore, the harmonic content will be reduced by the action of this condenser.

An average value for condenser *C*-12 is 0.005 mfd. In individual receivers, this value may vary from 0.001 to 0.02 mfd. Receivers using the higher capacity values have been designed to favor the bass register, since the higher capacity by-passes more of the high frequencies out of the output transformer and speaker, making the response deeper by comparison.

Output Transformer T-6.—Transformer *T*-6, called the "output" transformer, is often mounted on the speaker. Its function is to couple the output circuit of the tube to the speaker. The average beam-power tube requires a load of 5,000 ohms, and the average speaker voice coil has an impedance of 8 ohms at audio frequencies. The coupling transformer is designed, therefore, to have a primary impedance of 5,000 ohms and a secondary of 8 ohms. Obviously, if the output transformer should become defective, the original manufacturer's part should be obtained for best results. However, where this is not possible, a universal-type transformer may be used satisfactorily. The replacement notes on output transformers explain this procedure more fully.

Vacuum Tube V-5.—Vacuum tube *V*-5 is called the "power" tube, sometimes the "output" tube, as well as the second audio tube. The tube most commonly found in this stage is the 6V6-G beam-power amplifier. Smaller receivers, where the *B* supply voltage and the power output are lower, use the 6K6-G power-amplifier pentode. Receivers equipped with locking-base type tubes use the 7C5-LT.

Older receivers use power-amplifier pentodes, like the 6F6-G, 42, or 47. Receivers of the AC/DC type use the 25L6 or 50L6 beam power amplifiers. Older AC/DC receivers use a type 43 or 38 tube.

All these tubes are characterized by high power sensitivity; that is, a low signal-input voltage causes a high power output. For example, in the case of a 6V6-G, an input signal of 12.5 volts gives an output power of 4.25 watts. By way of comparison, the very much older 45 power-amplifier triode requires an input signal of 50 volts to give an output power of 1.6 watts.

NORMAL TEST DATA FOR THE SECOND AF STAGE

Check for Normal Stage Operation.—The signal check for the second AF stage is shown in Fig. 10-3. The signal generator is adjusted to give an AF signal, and the attenuator is set for maximum output. The signal generator ground lead is connected to the receiver chassis, and the "hot" lead is connected through a 0.1-mfd/600-volt condenser to the plate terminal of the second AF tube (pin No. 3 for a 6V6-G tube). The purpose of the condenser is to prevent the DC voltage, present at the plate of the second AF tube, from affecting the signal generator circuits. Normally, the full AF output of the signal generator is just sufficient to cause an audible note in the speaker. The hot lead of the signal generator is then shifted to the grid terminal (pin No. 5 for a 6V6-G tube) of the second AF tube. The signal-generator note should be heard in the speaker at a much greater volume. The gain in volume is an indication of the gain of the tube.

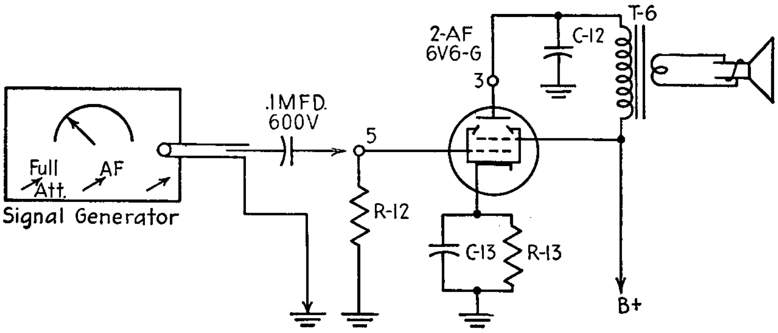


FIG. 10-3.—Signal check of the second AF stage.

Experienced servicemen rarely go to the trouble to use this method. A much faster check, given as the quick check at the beginning of this chapter, is to touch the grid terminal with a finger or the tip of a plugged-in soldering iron. In either case, a low growl will be heard from the speaker, indicating that the stage is functioning.

Normal Second AF Voltage Data.—Voltages are measured from chassis or common negative to tube terminal indicated. In some AC/DC receivers, where the circuit insulates *B* minus from the chassis, the negative terminal of the voltmeter is connected to the common negative. This is most easily found at the line switch. See Chap. 18 on AC/DC Power Supply.

Tube terminal	25L6 and 6V6-G pin No.	AC receivers, volts	AC/DC receivers, volts
Plate	3	235	85
Screen	4	250	90
Grid	5	0	0
Cathode	8	12.5	6

Voltages may vary somewhat from those given in the accompanying table. A significant point for the observant serviceman to note, however, is that the screen voltage is slightly higher than the plate voltage. This is due to the plate current of the tube, which causes a voltage drop across the output transformer primary. Variations in this voltage relationship are indicative of trouble For example. if the plate and screen voltages are exactly the same, there is no voltage drop across the output transformer primary. This fact indicates no plate current, a condition resulting from either an open self-bias resistor, or no emission in the tube.

A positive voltage reading at the grid is indicative of breakdown of the coupling condenser *C*-32 in the preceding stage. Service notes on this fault will be found in the chapter describing the first AF stage.

Normal Second AF Stage Resistance Data.—These data are given in the following table:

Chassis to cathode	300 ohms
Chassis to control grid	500,000 ohms
Plate to *B* plus	200–600 ohms

The 300 ohms of resistance from chassis to cathode is the ohmic value of self-bias resistor *R*-13. When a tube other than the 6V6-G tube is used, a different value will be found. Refer to the diagram of the receiver being tested, or to the table on page 102. The plate to *B* plus reading measures the resistance of *L*-12, the primary of the output transformer.

COMMON TROUBLES IN THE SECOND AF STAGE

Troubles Common to the Grid-load Resistor.—Resistor *R*-12 rarely causes trouble. Ocasionally it may open, thereby opening the grid circuit and causing lack of grid-bias voltage. This will result in bad distortion. At other times, signal voltage at the grid may build up and discharge periodically through dirt at the socket terminals, acting as a resistance parallel to *R*-12 and allowing a surge of current with each discharge. These surges may be heard in the speaker as a put-put known as "motorboating." If the surges come more rapidly, they will take the form of a low-pitched growl. The latter is sometimes mistaken for hum, which is also a low-pitched growl. Standard procedure in trouble shooting for hum is first to check the filter condenser in the power supply and then to look for an open grid-load resistor in this or any other stage.

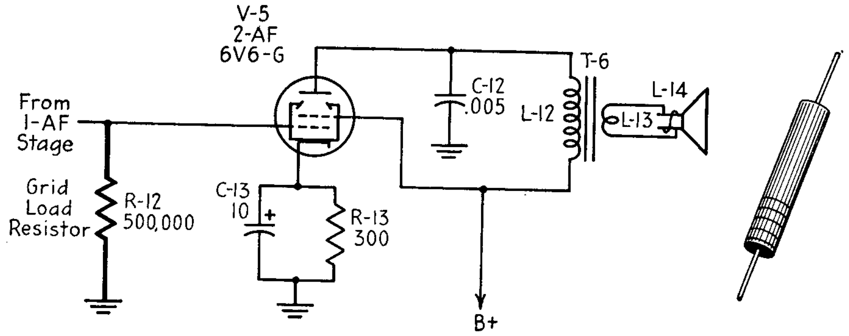


FIG. 10-4.—A typical grid-load resistor and its position in the second AF circuit.

Open *R*-12 would be found in a voltage check of the stage, since an open grid causes a much heavier plate current. This condition makes for a greater than normal voltage drop across *L*-12 and, as a result, the plate voltage is lower. Since the screen voltage remains near its normal value, there will be a greater than normal difference between plate and screen voltages. Since conditions other than an open grid-load resistor will cause heavy plate current, confirmation must be obtained. This can be done with an ohmmeter.

In replacing resistor *R*-12, nothing in particular need be stressed. An exact duplicate of the original is desirable although not necessary. An ohmic value differing by as much as 20 per cent either way will cause no noticeable difference, and the wattage rating is unimportant. However, the soldering must be carefully done, and the socket must be cleaned of dirt and excess rosin.

Troubles Common to the Cathode By-pass Condenser.—The cathode by-pass condenser *C*-13 often causes trouble. Like all electrolytic condensers, it is likely to dry out and lose capacity. As *C*-13 loses capacity, approaching an open condenser, the stage would give low gain and poor low-frequency response. This condition would be found in checking for low gain or for poor tone by bridging the condenser with one of 5 mfd or greater that is known to be good.

Less frequently, *C*-13 shorts or leaks badly, acting as a partial or complete short across *R*-13. This will result in poor tone quality due to lowered bias and would be found by a voltage check. Since plate current increases at lowered bias, a greater than normal voltage drop across the output transformer primary would be produced. This results in a lowered plate voltage and a large difference between screen and plate voltages. A shorted *C*-13 may have been caused by an open cathode resistor *R*-13. Check this condition before replacing.

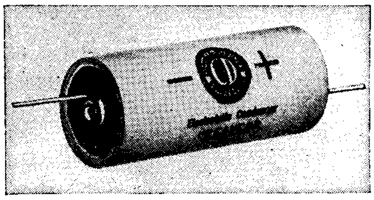


FIG. 10-5.—Typical audio cathode by-pass condenser.

In replacing condenser *C*-13, the serviceman watches for proper polarity, the positive side being connected to the cathode. The defective condenser should be removed. A capacity larger than the original may be used since, if anything, this will improve the low-frequency response. However, a condenser of capacity lower than the original will adversely affect the low-frequency response. Low-voltage electrolytic condensers are usually rated at 25 or 50 volts. Either will do for *C*-13, since the voltage across the condenser is approximately 12.5 volts for AC receivers and 6 volts for AC/DC receivers. This is the voltage developed across *R*-13 for self-bias.

It is important to emphasize again that a shorted *C*-13 may have been caused by an open bias resistor *R*-13. Therefore, when replacing a shorted *C*-13, the bias resistor should be checked immediately after the shorted condenser has been removed.

Troubles Common to the Self-bias Resistor.—Self-bias resistor *R*-13 is a likely source of trouble. It carries considerable current and is subject to heating. Sometimes it changes in ohmic value, and sometimes it opens. A change in ohmic value affects the bias voltage and, therefore, the tone quality. When *R*-13 is open, the cathode circuit is completed by the leakage resistance of parallel condenser

C-13. Since this leakage resistance is comparatively high, the voltage drop across it will be high, making for abnormally high bias voltage. The condition would be found in a voltage check. The screen and plate voltages would be nearly equal, since at the high bias voltage, plate current would be low, the voltage drop across the output transformer primary would be low, and plate voltage would be high. The open would result in a high cathode bias voltage which might damage parallel condenser *C*-13.

Any change in ohmic value of *R*-13 is found in a voltage check of the stage. If it becomes low in ohmage, cathode voltage will be low, resulting in high plate current and a large voltage drop across the output transformer, increasing the voltage difference between screen and plate.

When replacing *R*-13, it would be wise to use at least a 1-watt resistor, regardless of the size of the original. Manufacturers often cut corners on this item by using the less expensive ½-watt size.

Troubles Common to the AF By-pass Condenser.—Condenser *C*-12, the high AF by-pass, often comes up as the cause of a dead radio. Its position in the receiver is not only at a high DC potential but also where the AC signal potential (audio variation) is at its highest. This high voltage causes frequent breakdown of insulation, resulting in a shorted condenser, which shorts out the audio signal from the primary of *T*-6 and also the power supply at this point. This condition is quickly found in a voltage check. Plate voltage equals zero, and screen or *B* plus voltage is low, since the power-supply voltage drops with the heavy load.

Condenser *C*-12 may also open. However, a radio will rarely come in for this defect alone, since an open *C*-12 will merely increase the high-frequency response, and the customer may overlook this. In some radios, an open *C*-12 may cause a high-frequency oscillation. If this is the case, bridging *C*-12 with a similar condenser or with a higher capacity condenser is the standard check procedure.

When condenser *C*-12 is replaced, a good quality of condenser should be used. Regardless of the original value, the voltage rating of the replacement condenser should be at least 600 volts. The outside foil lead or ground lead should be connected to the chassis. Condenser *C*-12 sometimes is connected from plate to *B* plus. In that case, the outside foil lead is connected to *B* plus. The replacement condenser should have the same capacity as the original. If the capacity of the replacement condenser is changed for any reason, it should be borne in mind that a higher capacity will cut more highs out of the signal delivered to the speaker, while a lower capacity will increase the high-frequency response.

Troubles Common to the Output Transformer.—Output transformer *T*-6 is also a common source of trouble. In addition to carrying the audio signal, the primary winding also carries the normal DC plate current of the tube. An open primary often results. When the plate circuit opens, the positive screen attracts the total cathode emission. It was not intended to carry so heavy a current, and the screen mesh becomes red-hot. This can be seen in the case of a glass pentode and is one of the things the experienced serviceman looks for when making a visual inspection of the receiver. In the case of a metal tube, the condition cannot be seen and will be found by voltage analysis, since the open plate circuit will cause zero plate voltage.

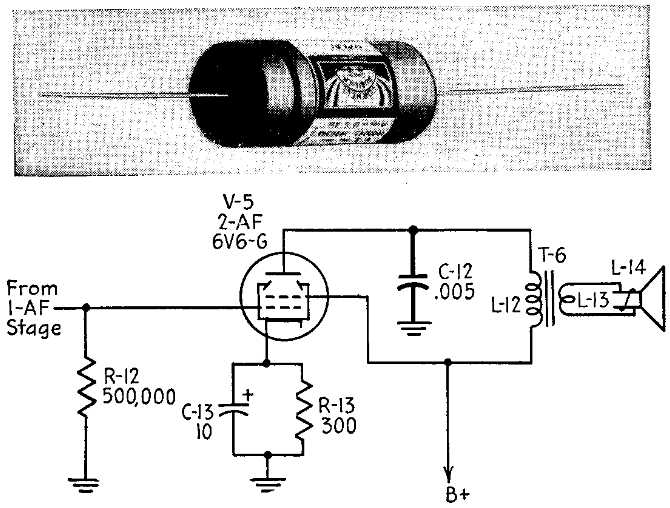


FIG. 10-6.—The AF by-pass condenser and its position in the second AF circuit.

As explained before, the output transformer should be replaced with an exact duplicate where obtainable. When this is not possible, a universal output transformer may be substituted. These usually come with an instruction sheet, but servicemen sometimes find it confusing and connect the transformers improperly. This results in poor tone quality. A bit of theory might help to clear up this matter.

The output transformer, as an impedance matching device, works on the principle of reflected load, a term the average serviceman shies away from. Let us first try to explain it.

Assume a power transformer that is being used to light lamps.

For simple arithmetical figures, let us also assume a 100-volt line, rather than the usual 110 or 120 volts, and lamps requiring 10 volts at 1 amp each. For further simplification, assume 100 per cent efficiency in the transformer; that is, watts input equals watts output. The transformer has a 10 to 1 step-down ratio to furnish the 10 volts needed for the lamps. Each lamp has a resistance of 10 ohms ($R = E/I = 10/1 = 10$ ohms).

When one lamp is connected, as in Fig. 10–7, 1 amp flows through the lamp. Wattage dissipated is 10 watts ($W = E \times I = 10 \times 1 =$ 10 watts). To satisfy watts input equals watts output, the primary current will be 0.1 amp ($I = W/E = 10/100 = 0.1$ amp). To the 100-volt line, the transformer primary looks like a 1,000-ohm impedance or resistance load, since it will drive only 0.1 amp into it

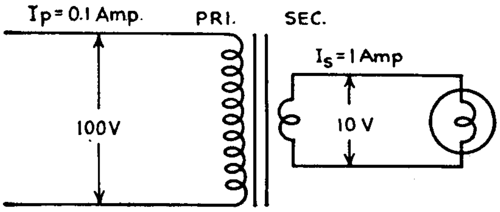


FIG. 10–7.—Transformer lighting one lamp.

($Z = E/I = 100/0.1 = 1{,}000$ ohms). Now let us light two lamps from the same transformer, as in Fig. 10–8. Two 10-ohm lamps in parallel have a combined resistance of 5 ohms and will draw 2 amp ($I = E/R = 10/5 = 2$ amp) from the secondary, which remains at 10 volts. The actual impedance therefore is 5 ohms. Watts consumed is 20 watts, ($W = E \times I = 10 \times 2 = 20$ watts). Once again to make watts input equal watts output, the primary current must now increase to 0.2 amp ($I = W/E = 20/100 = 0.2$ amp). The 100-volt line now looks at the transformer primary as though it were a 500-ohm impedance, since it must furnish 0.2 amp to it ($Z = E/I =$ $100/0.2 = 500$ ohms). This is called "reflected load." Under the above conditions, a 10-ohm actual load reflects back to the primary a 1,000-ohm load, while a 5-ohm actual load gives a 500-ohm reflected load in the primary. Note also the ratio of reflected to actual load, 100 to 1, which is the square of the turns ratio 10 to 1; that is, a transformer with a 10 to 1 turns ratio would make the reflected load in the primary 100 times (10^2) as great as the actual load in the secondary.

Now let us apply this bit of transformer theory to the output transformer. Assume a 10-ohm voice coil connected to the same

10 to 1 transformer that was used before to light lamps. The connections are shown in Fig. 10–9. The primary would look like 1,000 ohms to any line feeding it. Obviously, this transformer would not do to couple the 10-ohm voice coil to a 6V6-G tube, which requires a 5,000-ohm load resistance for optimum results. A turns ratio of 20 to 1 would make a much better match, since the reflected load in the primary of a 10-ohm voice coil in the secondary would be $(20)^2$, or 400 times as great (4,000 ohms). A turns ratio of 22.4 to 1 would be exactly right.

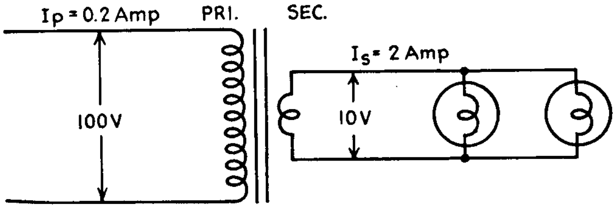


FIG. 10–8.—Transformer lighting two lamps.

A universal output transformer is one supplying many possible combinations of turns ratio, so that almost any voice coil may be matched to almost any tube or combination of tubes. A typical universal output transformer is shown in Fig. 10–10. The primary is center-tapped for use in push-pull circuits. In second AF stages using a single tube, the center tap should be taped up and disregarded. Then, either end of the primary winding is connected to the plate, and the other to B plus. The secondary usually has six taps, numbered 1 to 6, and a great number of turns ratio combinations is possible.

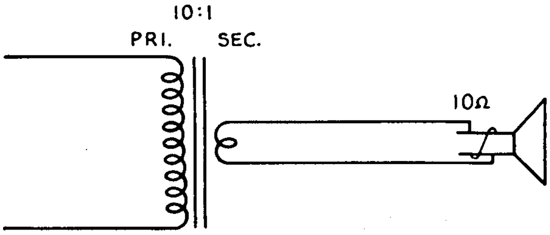


FIG. 10–9.—Transformer feeding a 10-ohm voice coil.

In using a universal output transformer as a replacement, the first requisite is to use the proper size. They are rated by wattage. Physical size of the transformer is a rough indication of the wattage. Make sure that the replacement is as large as the original. Confirmation may be obtained by comparing the wattage size used with the tube-manual rating for the output tube or tubes in the receiver. The tube manual will also give the recommended load impedance.

The next step is to determine the voice-coil impedance. To do this, determine its resistance on the low-ohm scale of your ohmmeter. Then multiply the reading by 1.25. (This rule of thumb is close enough for general service work.) Then check with the instruction sheet, which comes with the universal output transformer for the proper taps to use. Figure 10–11 is a sample instruction sheet. As an example of how the sheet is to be used, let us find the proper taps for the standard receiver. The voice coil is measured on the low-range ohmmeter and found to be 5 ohms. Multiplying by 1.25, its approximate impedance is found to be about 6 ohms. The single 6V6-G output tube requires a load impedance of about 4,000 ohms. The output transformer must therefore match about 4,000 ohms to 6 ohms. Look for the single 6V6-G, which is found in the column headed by 4,000 as the primary load impedance. Run down this column into the voice-coil impedances looking for 6 ohms. Then, read across horizontally to find secondary taps 1 and 5, which are to be used.

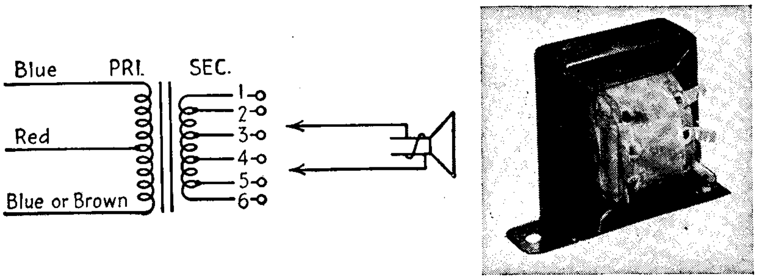
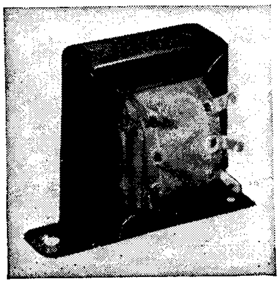


FIG. 10–10.—A typical universal replacement output transformer.

There is sometimes an inverse feedback lead connected from the secondary of the output transformer back to a previous point in the audio amplifier circuit. In this case, when the output transformer is replaced, the voltage fed back may be in the wrong phase and cause an audio oscillation or squeal, which will be present with or without any signal being fed into the amplifier. When this happens, reversal of either the primary or the secondary leads will clear up the difficulty. More will be said regarding this matter in the section on circuit variations dealing with inverse feedback.

Troubles Common to the Second AF Tube.—The tube itself may

Type No. 2774 .... 4-watt size
Type No. 2776 .... 6-watt size
Type No. 2780 .... 10-watt size
Type No. 2782 .... 12-watt size
Type No. 2788 .... 18-watt size



Simplified Chart Showing Proper Use of Secondary Taps

Primary load impedance	18,000	14,000	10,000	8,000	7,000	4,000	2,000
Single	1F4-1F5G	10-38-950-12A7-1J5G	41-49-6G6G	89 pentode-1G5G-6K6G-6A4/LA	12A-20-31-33-42-47-59 pentode-89-triode-2A5-6AC5G-6B5-6F6-6N6G-GA-PZ-PZH	43-45-50-71A-2B6-6L6-6V6-12A5-25A6-25A7G-59 triode	48-2A3-6A3-6A5G-6B4G-6Y6G-25B5-25B6G-25L6-25N6G-35L6GT
Push-pull	1J5G	41-47-1G5G-6A4/LA-6E6-6K6G-31-33-20-GA-PZ-PZH	42-2A5-6AC5G-6B5-6F6-6N6G	43-50-71A-2B6-6V6-12A5	45-6L6 Class AB_1	48-2A3-6A3-6A5G-6B4G-6L6-25L6	
Class *B*		79 250V 6Y7G 250V	19-49-52-89-6A6-6AC5G-6Z7G-1J6G	30-53-6N7	46-59-79-180V 6Y7G 180V	10	
Parallel					10	12A-31-33-41-42-49-2A5-GA-PZ-PZH	45-50-71A-59 triode
Secondary tap	Voice-coil impedance						
2–3	0.97	0.75	0.54	0.43	0.38	0.22	0.11
3–4	1.2	0.90	0.04	0.51	0.45	0.26	0.13,
4–5	1.8	1.4	1.0	0.80	0.70	0.40	0.20
1–2	3.2	2.5	1.8	1.4	1.2	0.71	0.36
2–4	4.2	3.3	2.4	1.9	1.6	0.94	0.47
5–6	4.8	3.7	2.7	2.1	1.9	1.1	0.53
3–5	5.9	4.6	3.3	2.6	2.3	1.3	0.65
1–3	7.7	6.0	4.3	3.4	3.0	1.7	0.85
2–5	11.6	9.0	6.4	5.1	4.5	2.6	1.3
4–6	12.5	9.7	6.9	5.6	4.9	2.8	1.4
1–4	14.8	11.5	8.2	6.6	5.8	3.3	1.6
3–6	21.3	16.5	11.8	9.5	8.3	4.7	2.4
1–5	27.0	21.0	15.0	12.0	10.5	6.0	3.0
2–6	31.5	24.3	17.4	14.0	12.2	7.0	3.5
1–6	54.5	42.4	30.2	24.2	21.2	12.1	6.1
Primary load impedance	18,000	14,000	10,000	8,000	7,000	4,000	2,000

Fig. 10-11.—Universal output transformer—instruction sheet.

be the cause of poor operation of the stage. Low emission will cause low gain and poor power-handling capacity. A tube checker usually shows this condition, or it will show up on voltage analysis. Low emission results in low plate current, consequently low self-bias voltage, and a too small difference between plate and screen voltages. The tube also might be noisy (possible loose elements) or cause hum (cathode-to-filament leakage). The best check for these conditions is to substitute a similar type of tube, known to be good.

A fairly common trouble, particularly in the case of 43, 25L6, and 25A6 tubes, is known as "grid emission." The complaint here is that the radio starts playing normally, but after 5 min or so begins to distort badly. A voltmeter connected from chassis to grid will begin to show positive at the grid as the distortion begins.

CIRCUIT VARIATIONS OF THE SECOND AF STAGE

Tone Control in the Second AF Stage.—There are many tone-control circuits, the most common of which is shown in Fig. 10–12. Condenser *C*-112 and variable resistor *R*-112 are in parallel with condenser *C*-12. Like condenser *C*-12, condenser *C*-112 by-passes high audio frequencies out of the speaker circuit. Condenser *C*-112 has a comparatively high capacity, 0.05 mfd being usual. By itself, it would remove most of the high audio frequencies from the signal and make the low notes seem more prevalent by comparison. Variable resistor *R*-112, which by its setting allows more or less of the by-passing of high frequencies through *C*-112 to take place, constitutes a tone control. The usual value of *R*-112 is 50,000 ohms.

All tests for the standard second AF stage are equally applicable to this variation, and all notes applying to condenser *C*-12 may also be used for tone condenser *C*-112. If this condenser should short, however, the path for the high *B* plus voltage to ground would be through the tone-control variable resistor *R*-112. This would give a variable shunt path depending on the tone-control setting. At the maximum bass position, there would be a very low resistance from plate to ground through the shorted condenser, the *B* voltage would be low, and the receiver would not operate. At the minimum bass position there would simply be a 50,000-ohm shunt path for the *B* supply, and the receiver would operate. The erratic action of the tone control would, of course, focus the serviceman's attention to this circuit, and the defect would be found by ohmmeter check. When a shorted tone condenser is replaced, the heavy current through *R*-112 may have damaged the tone control. It would therefore be wise to replace the tone control also. Replacement notes on volume controls given in Chap. 11 may be applied to the tone control.

A modern trend in the use of tone controls is to replace the variable resistor *R*-112 with a switch, thereby making a 2-point tone control. An example of this is shown in Fig. 10–13. Note the tone condenser *C*-23 and its associated switch in the plate circuit of the 50L6 tube. When the switch is open, there is no shunting action, and this is the treble position. In the bass position, where the switch is closed, *C*-23, which is 0.04 mfd, shunts some of the high audio frequencies out of the speaker.

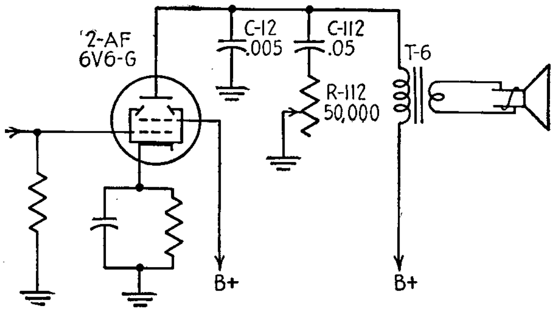


FIG. 10–12.—Tone Control in the second AF stage.

Figure 10–14 shows a similar 2-point tone control. In this case, the shunting action of *C*-21 and its associated switch is in the input circuit of the second AF tube.

Inverse Feedback in the Second AF Stage.—Inverse feedback is a form of desirable degeneration often used in the audio amplifiers of radio receivers. There are many types of inverse feedback circuits in common use. In all of them, part of the output signal is fed back in an out-of-phase relationship (hence the name "degeneration") to some point in the input signal circuit, to provide improved over-all audio fidelity by canceling out harmonic distortions. Inverse feedback is always accompanied by a loss in gain, but the amplifier is designed for higher than normal gain to compensate for this loss.

In Fig. 10–13, the cathode by-pass condenser has been omitted to provide degeneration through self-bias resistor *R*-3, which is common to both the input and output circuits of the 50L6 tube. Since the input and output circuits of a tube are 180 deg out of phase, degeneration is automatic. Condenser *C*-18, the high-frequency by-pass condenser, is returned directly to cathode rather than to ground, so that the degenerative effect is greater at the higher frequencies (especially the high harmonic frequencies), thereby making for more uniform response for the stage. In Fig. 10–14 the inverse feedback

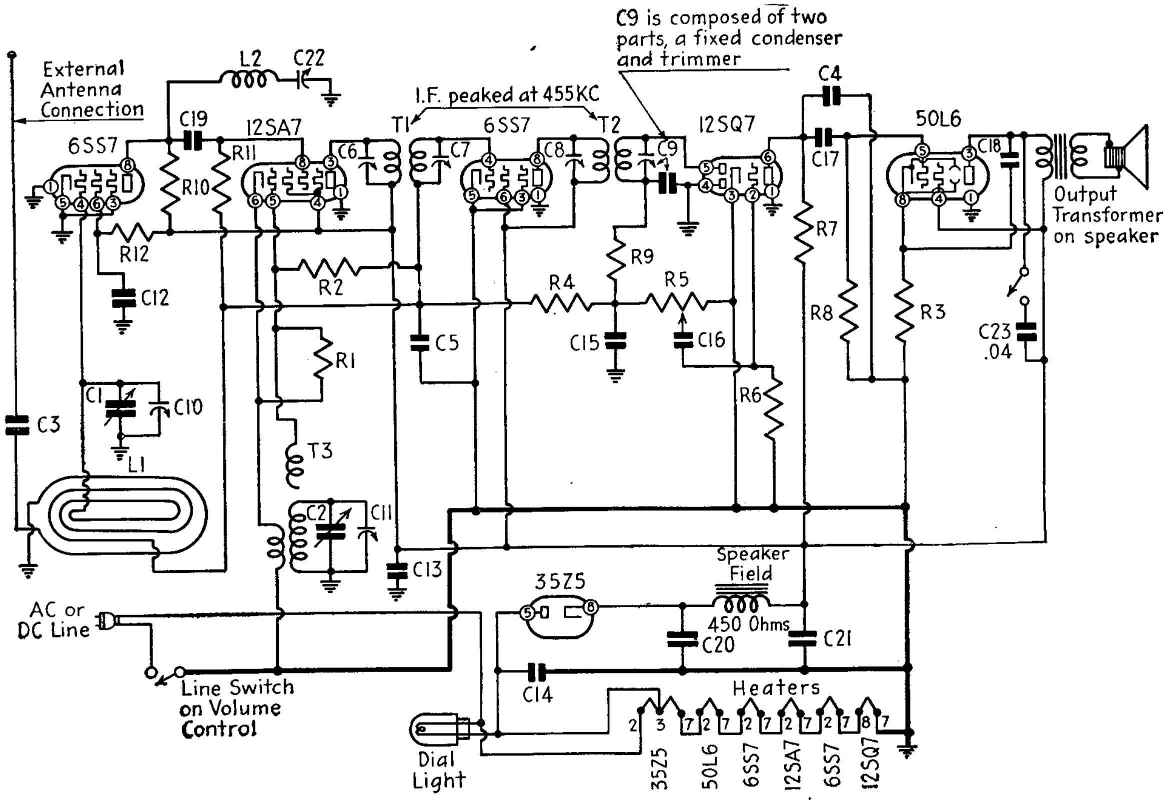


FIG. 10-13.—Schematic diagram for Emerson Model GB receiver.

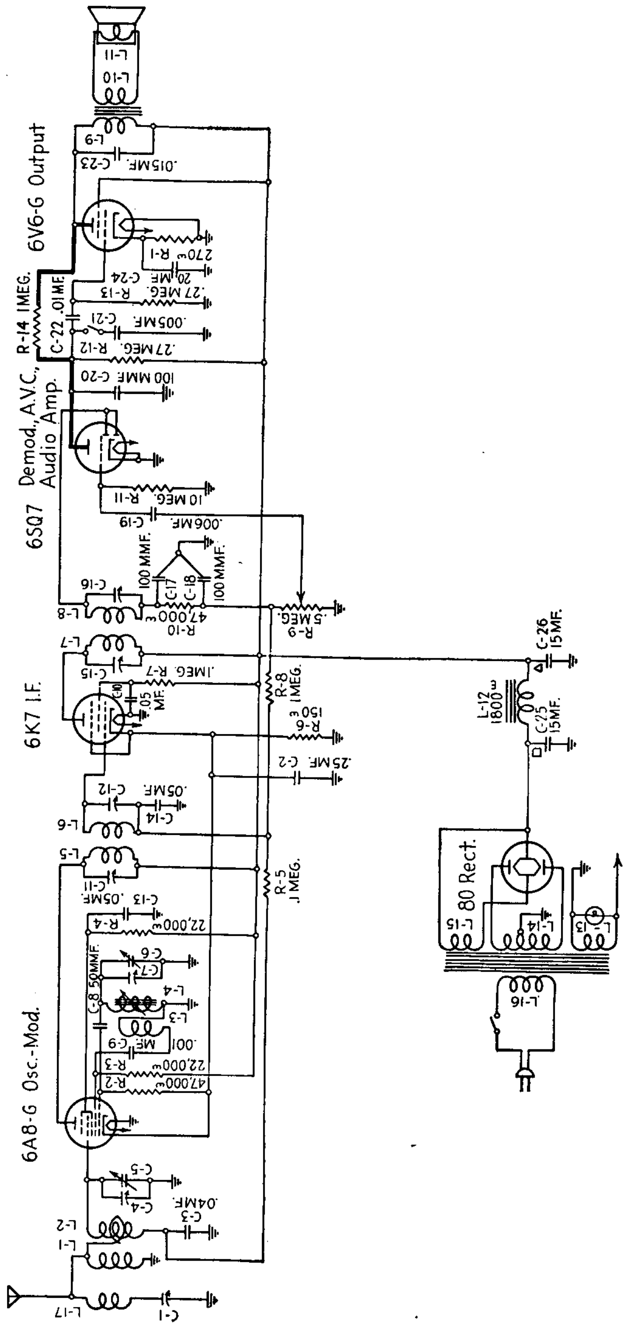


FIG. 10-14.—Schematic circuit of the Stromberg-Carlson No. 400 receiver.

circuit is shown by the heavy lines. The feedback voltage is taken from the plate of the 6V6-G output tube and fed through resistor *R*-14 back to the plate of the first AF section of the 6SQ7 tube.

As a general rule, inverse feedback circuits do not cause many complications to the serviceman. All tests and service notes pertaining to the standard amplifier circuit may be applied. Resistor *R*-14 in the feedback circuit, represented in Fig. 10–14, will rarely cause any service difficulty.

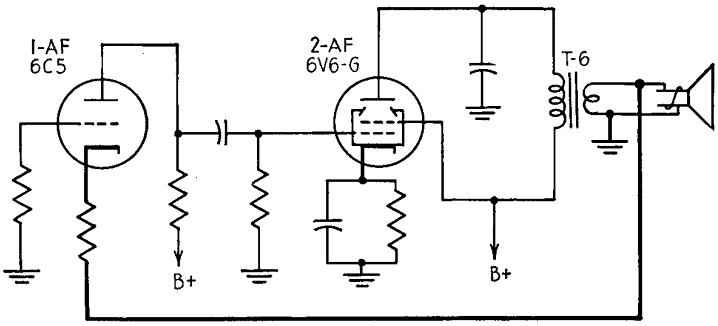


FIG. 10–15.—Inverse feedback circuit where the feedback is taken from the secondary of the output transformer.

A servicing problem pertaining to inverse feedback circuits occurs when the feedback voltage is taken from the output transformer secondary, as shown in Fig. 10–15. In this case, the feedback voltage is reintroduced into the cathode circuit of the first AF tube, which has no by-pass condenser. Another variation of this same circuit introduces the feedback voltage into a tap in the grid load of the first AF tube. In either case, if the output transformer leads should become reversed, as may easily happen when the output transformer is replaced, the feedback voltage will be in phase with the signal voltage rather than out of phase. This will produce regeneration rather than degeneration, and the audio amplifier becomes an audio oscillator. The oscillation appears in the speaker, usually as a high-pitched squeal, and will, of course, be unaffected by tuning the receiver. The serviceman must be aware of this possibility when replacing the output transformer, since the usual service procedure for oscillation will not disclose it. Reversing the primary or secondary leads, whichever is simpler, will clear up the difficulty.

Fixed Bias in the Second AF Stage.—The fixed-bias circuit is found in radios where the negative leads of the filter condenser are not at chassis potential, as shown in Fig. 10–16. In this circuit the cathode is grounded, and negative grid bias is obtained by connecting the grid return to a point in the power-supply stage more negative than ground, and therefore more negative than cathode. Various circuits for the power supply stage are given in Chap. 8. Resistor *R*-113 and condenser *C*-113 form a filter circuit for the bias voltage. Representative values are 0.5 megohm (500,000 ohms) for *R*-113 and 0.1 mfd for *C*-113. This filter circuit may be omitted.

Normal test voltage data for this type of circuit will be different from the standard circuit and are given below.

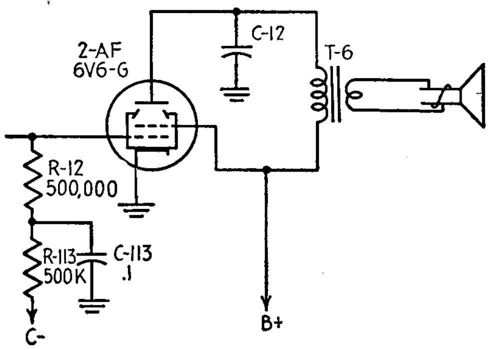


FIG. 10-16.—Fixed bias circuit in the second AF stage.

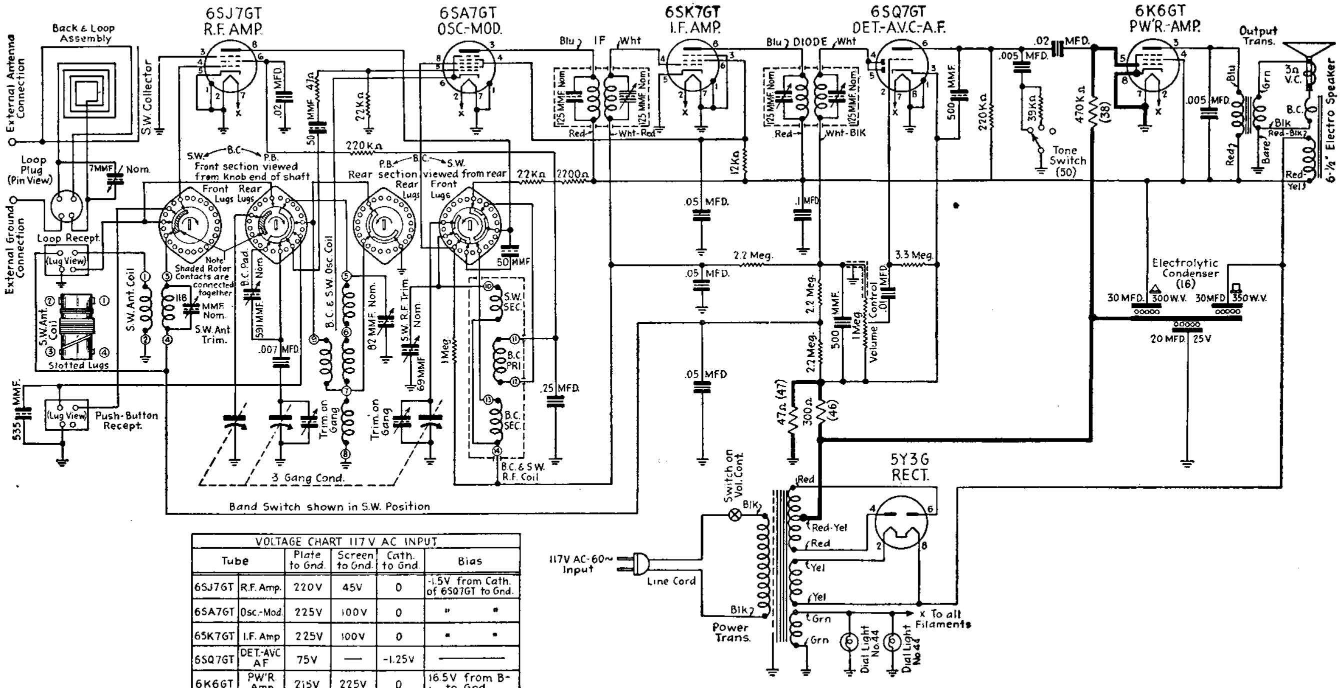
Normal Voltage Data for Fixed-bias Second AF Stage.—Voltages are measured from chassis to tube terminal indicated. In some AC/DC receivers, where the circuit insulates *B* minus from the chassis, the negative terminal of the voltmeter is connected to the common negative. This is most easily found at the line switch. See Chap. 18 on AC/DC Power Supply.

	AC receivers, volts	AC/DC receivers, volts
Plate voltage	235	90
Screen voltage	250	95
Grid voltage	Negative	Negative
Cathode voltage	0	0

The measured negative grid voltages will depend on the ohms-per-volt rating of the test voltmeter, owing to the high resistance in the circuit involved. High-resistance meters will show more voltage than low-resistance meters. All meters, however, will show some negative indication. The actual bias voltage can be measured more accurately from *C* minus to chassis in the power supply, a low-resistance circuit.

All parts have the same functions, values, and likely troubles as in the standard circuit. Of the parts peculiar to this circuit, there is little likelihood of trouble from *R*-113 in the *C*-minus bias filter. The associated condenser *C*-113 is a paper tubular condenser. Since it is in a high-resistance circuit, any leakage will cause decreased bias voltage, resulting in various degrees of distortion and power handling capacity. The condition would be found in a voltage check, since the decreased bias would cause high plate current, a large voltage drop across the primary of the output transformer, and a greater than normal difference between plate and screen voltages.

The schematic diagram of the Motorola Model 61T23 receiver, shown in Fig. 10–17, is an example of the fixed-bias type of second AF stage. The bias circuit has been indicated by the heavy lines. Note the following conditions: The common terminal of the filter condenser block is connected to the center tap of the high-voltage winding. The cathode of the 6K6-GT second AF tube is connected to the chassis. The grid-load resistor, part number (38), is connected to the negative end of the bias voltage divider, parts numbers (46) and (47). The bias voltage is filtered by the 20-mfd/25-volt condenser section of the electrolytic condenser block (16). And the bias voltage for the second AF tube is indicated in the voltage chart as being measured from *B* minus to ground. Note also the 3-point tone switch (50) in the input circuit of the second AF stage.



VOLTAGE CHART 117 V AC INPUT					
Tube		Plate to Gnd.	Screen to Gnd.	Cath. to Gnd.	Bias
6SJ7GT	R.F. Amp.	220V	45V	0	-1.5V from Cath. of 6SQ7GT to Gnd.
6SA7GT	Osc.-Mod.	225V	100V	0	" "
6SK7GT	I.F. Amp	225V	100V	0	" "
6SQ7GT	DET.-AVC AF	75V	—	-1.25V	—
6K6GT	PW'R. Amp	215V	225V	0	16.5V from B- to Gnd.
5Y3G	RECT.	AC	—	295V from Fil.	—

Note:- All voltages measured with a 1.000 Ohm per volt voltmeter. Line voltage -117 volts. Band switch in B.C position. Maximum power output -3.5 watts.

FIG. 10-17.—Schematic diagram of the Motorola Model 61T23 receiver.

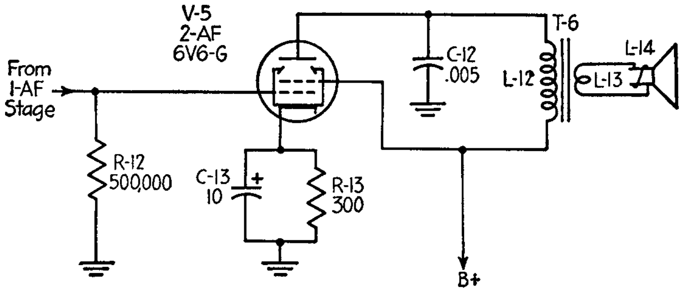
SUMMARY

Test for normal operation of the second AF stage.

The tip of a plugged-in soldering iron applied to the grid of the tube causes a growl to be heard in the speaker.

Diagram of a typical second AF stage.

The accompanying figure shows the typical second AF stage.



Normal voltage data.

Voltage is measured from the chassis or common negative lead. Voltage data are given in the accompanying table.

Tube terminal	25L6 and 6V6-G pin No.	AC receiver, volts	AC/DC receiver, volts
Plate	3	235	85
Screen	4	250	90
Grid	5	0	0
Cathode	8	12.5	6

Normal second AF stage resistance data.

Chassis to cathode	300 ohms
Chassis to control grid	500,000 ohms
Plate to *B* plus	200–600 ohms

The 300 ohms of resistance from chassis to cathode is the ohmic value of self-bias resistor *R*-13. When a tube other than the 6V6-G is used, a different value will be found. Refer to the diagram of the receiver being tested, or to the table on page 102.

The plate to *B* plus reading measures the resistance of *L*-12, the primary of the output transformer.

SERVICE DATA CHART FOR THE SECOND AF STAGE

Symptom	Abnormal reading	Look for
No signal from the speaker	Plate voltage = 0. Screen voltage = 0	Trouble in the power supply. See Chap. 8
	Plate voltage = 0. Screen voltage low	Short-circuited high AF by-pass condenser *C*-12
	Plate voltage = 0. Screen voltage normal or high. (Screen of a glass second AF tube glows)	Open primary winding of output transformer *T*-6
	Plate voltage normal or high. Screen voltage same as plate	Weak second AF tube. Open self-bias resistor *R*-13
Poor tone quality	Plate voltage low. Screen voltage normal (large difference between plate and screen voltages)	Defective second AF tube. Short-circuited cathode by-pass condenser *C*-13. Open grid-load resistor *R*-12. Shorted or leaky coupling condenser *C*-32 (see Chap. 11)
	Voltages normal	Open cathode by-pass condenser *C*-13. Mismatched replacement output transformer
Motorboating		Open output filter condenser *C*-16. Open grid-load resistor *R*-12
Squeal or oscillation	Voltages normal	Open output filter condenser *C*-16. Open high AF by-pass condenser *C*-12. Degenerative feedback connection from replacement output transformer incorrectly phased

QUESTIONS

1. A receiver is brought in for repairs, the complaint being "no reception." Visual inspection shows a red-hot screen grid in the type 6F6-G power tube. What is likely to be wrong? Indicate the tests that should be made to confirm your assumption.

2. In a dead receiver, the power supply is found to be operating normally. A voltage check of the second AF stage shows the following:

Plate	300 volts
Screen	300 volts

What are the likely causes of the trouble? Indicate the tests that should be made to confirm the actual cause of the trouble.

3. An AC receiver, using a 6V6-G tube in the second AF stage, gives a high-pitched squeal regardless of the setting of the volume control or tuning dial. What are the possible causes of the trouble? How would you check for each?

4. The receiver of Fig. 10–17 has an open output transformer. If an original replacement is not obtainable, use the universal output transformer chart of Fig. 10–11 for reference and choose (1) the type of transformer that should be used, and (2) the secondary taps that should be used.

5. The receiver of Fig. 10–14 has low volume and sounds tinny. A voltage check shows normal voltage readings. Substitution of the bench test speaker causes no improvement. What should the next check be?

6. The receiver of Fig. 10–14 motorboats. Bridging the output filter condenser *C*-26 with a 20-mfd/450-volt condenser causes no improvement. What should the next check be?

7. The receiver of Fig. 10–13 begins to distort after it has been playing for 15 min. What would you suspect is wrong? How would you confirm your suspicion?

8. A distorting receiver gives the following voltage check for the 6V6-G tube in the second AF stage:

Plate	200 volts
Screen	250 volts
Grid	0 volts
Cathode	2 volts

What is likely to be the cause of the distortion? How would you confirm your assumption?

9. The receiver of Fig. 10–13 is brought in as dead and gives the following voltage readings for the second AF stage:

Plate	95 volts
Screen	95 volts
Cathode	30 volts

What is likely to be the cause of the trouble? How would you confirm your assumption?

10. What precautions should be observed in replacing a shorted high-AF by-pass condenser?

CHAPTER 11

FIRST AUDIO-AMPLIFIER STAGE

Quick Check.—If a wet finger or a plugged-in soldering iron is applied to the input of the first AF stage and a very strong growl comes out of the speaker, the stage is probably functioning properly, and the serviceman moves on to the next stage.

Function of First AF Stage.—The control grid circuit is the stage input and is coupled to the detector output circuit. The plate circuit is the stage output, which is in turn coupled to the grid or input circuit of the second AF stage. The detector has an output of roughly 1 volt of AF signal. The second AF stage, if it contains a 6V6-G beam-power amplifier, requires an input signal of 12.5 volts to drive the speaker to full volume. It is therefore the function of the first AF stage to build up the detector output signal voltage (1 volt) to the level necessary to drive the second AF stage (12.5 volts).

Theory of Operation, Functions, and Values of Component Parts. From the function of the stage, to amplify 1 volt of signal to 12.5 volts, it would seem that a voltage amplification of 12.5 for the stage would be sufficient. However, the detector output may be less than 1 volt, in which case there would be insufficient volume. The first AF stage, therefore, is usually designed for high voltage gain, 50 or higher, so that low input signals can be amplified to the required level to operate the second AF stage. Then, should the input be excessive, the detector signal level feeding the first AF stage is reduced through a potentiometer, which is the manually operated volume control of the receiver.

The first AF stage is called a "voltage" amplifier, while the second AF stage is called a "power" amplifier. The reason for these descriptions lies in their functions. The second AF stage drives the speaker and must furnish power to vibrate the speaker cone and the surrounding air. Electric power is measured in watts, which incorporates both voltage and amperage. The second AF tube, the output transformer, and the speaker are all rated in watts. The second AF stage, therefore, is a power amplifier developing enough power to drive the speaker. The first AF stage, on the other hand, furnishes the grid excitation for the second AF tube. The grid of the second AF tube is always kept at a negative potential by the bias voltage supply, and the signal voltage does not normally exceed the bias voltage. As a result, the grid circuit does not draw current from the previous stage, and the signal grid excitation therefore requires voltage but not current. For this reason, the first AF stage, which furnishes the grid excitation for the second AF stage, is called a "voltage amplifier." If the signal voltage at the second AF grid should exceed the bias voltage and grid current result, the first AF stage would also be furnishing power. Likewise, if the first AF stage were used to drive a pair of headphones, it would be operating as a power amplifier.

The tube used as the first audio amplifier is usually a high-mu triode. Most often, it is the triode section of a dual-purpose diode and high-mu triode, like the 6SQ7, which will be used in our standard circuit. The diode section is used as the detector and will be described in Chap. 12.

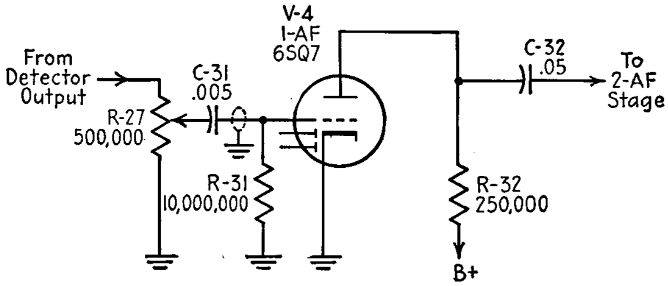


FIG. 11-1.—Typical first audio-frequency amplifier stage.

Standard Circuit.—Potentiometer *R*-27 is the manual volume control for the receiver. Its usual value is 500,000 ohms. The detector signal output is connected across *R*-27, and the position of the potentiometer arm determines how much of the detector signal output voltage is fed to the audio amplifier. For example, if the arm is near the grounded end, little of the detector output voltage developed across *R*-27 gets amplified, and this is the low-volume position. If the arm is nearer the ungrounded end, more of the available signal voltage gets amplified, and this is the high-volume position.

Condenser *C*-31 is the coupling condenser. It feeds the audio signal voltage from the volume control to the grid or input circuit of the tube and is usually 0.005 mfd. It may vary in different receivers from 0.001 to 0.02 mfd.

Resistor *R*-31 is the grid load. It returns the grid directly to the cathode in a circuit known as "contact bias." As will be explained, the grid-load resistor in a contact bias circuit usually is high: 2 to 15 megohms. The average size for the standard circuit is 10 megohms.

Operation of Contact Bias.—When the schematic diagram is studied, it would seem at first glance that there is no grid-bias voltage on the triode section of *V*-4, since the grid goes to ground through *R*-31 and the cathode is also at ground potential. To understand how a bias voltage is developed between grid and cathode, first assume a condition of no signal input. In the tube, the cathode is emitting electrons which are attracted by the positive plate, as shown in Fig. 11-2. Some of these electrons impinge on the grid located between cathode and plate, as shown in Fig. 11-3. These will flow through the grid load *R*-31 back to cathode. Since *R*-31 usually has a high resistance, it will not require very much grid current flow to develop a voltage across it. By applying Ohm's law, $E = I \times R$, a current of only 0.1 microampere (0.0000001 amp) will develop 1 volt across 10 megohms, the usual size of *R*-31. Note the arrow showing direction of electron flow through *R*-31 in Fig. 11-3. Since electrons flow from negative to positive, the grid end of *R*-31 is negative, with respect to the ground or cathode end, by this voltage drop. Therefore, a small negative bias is established on the grid. This negative bias remains constant for a particular circuit because, as fast as electrons leak off the grid across *R*-31, new electrons impinge on it, and therefore a condition of equilibrium is set up whereby a slight negative bias is maintained on the grid. Condenser *C*-31 prevents electrons from leaking across *R*-27 to ground.

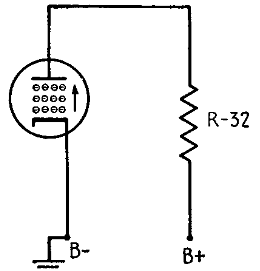


Fig. 11-2.—Electrons being attracted from the cathode to the positive plate.

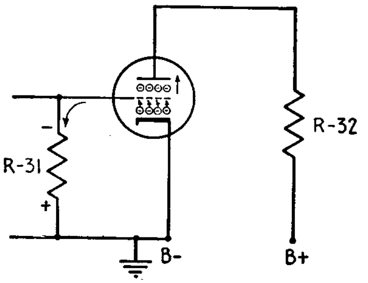


Fig. 11-3.—Electrons impinging on the grid of a tube in developing contact bias.

In amplifiers used in radio receivers, grids are maintained at all times at a negative potential. When the signal voltage is placed on the grid, it drives the grid more negative or less negative with each alternation. If the signal voltage should be larger than the steady negative grid-bias voltage, the grid will be driven positive on the positive half of the signal cycle, resulting in serious distortion. For this reason, the signal voltage must always be lower than the grid-bias potential. In the case of contact bias, the grid-bias potential is low, and as a result the signal handling capacity is low. Contact bias, therefore, is used only in the first audio stage where the input signal is at a low level of potential.

Tubes Used in the First AF Stage.—Vacuum tube *V*-4 is the voltage amplifier tube. The one most often used in the first AF stage is the high-mu triode section of the type 6Q7 or 6SQ7 tube. Receivers equipped with locking-base tubes use the similar 7C6 loctal type. When lower gain for the stage is desired or the stage is to be followed by transformer coupling, the type 6R7 tube is employed. Where a separate diode is used for the detector stage, the tube employed for the first AF stage is a 6F5 or 6SF5; these have the same characteristics as the triode section of the 6SQ7. Even in the latter case, the 6SQ7 is often used with the diode plates grounded. Older receivers used the 75 type of tube in a similar circuit arrangement.

Receivers of the AC/DC type use the 6Q7 and 6SQ7 in circuits employing 0.3-amp filament tubes, and the 12Q7 or 12SQ7 types in 0.15-amp filament tubes.

Coupling Circuit to the Second AF Stage.—Resistor *R*-32 is the plate load of the first AF tube. The value most often found is 0.25 megohm (250,000 ohms). It may go as high as 0.5 megohm and as low as 0.1 megohm. Higher values would give somewhat greater gain; lower values would result in reduced gain. When the first AF tube is a low-mu triode like the 6SR7, resistor *R*-32 is lower in value, 50,000 to 100,000 ohms being usual. In all cases, wattage dissipation is relatively unimportant. The resistors generally in use are the ½-watt size.

Condenser *C*-32 is the audio coupling condenser. This condenser, plate-load resistor *R*-32, and grid-load resistor *R*-12 of the following stage make up a resistance coupling circuit between the two stages, as shown in Fig. 11–4. Its function is twofold: It conducts the AF signal from the plate circuit of the first AF tube to the grid of the second AF tube; at the same time, it keeps the positive plate potential of the first AF tube from affecting the grid of the second AF tube.

The capacity of coupling condenser *C*-32 varies considerably with different receivers. Capacities ranging from 0.01 to 0.1 mfd are common. The standard receiver uses 0.05 mfd. The larger capacities give better bass frequency response. Some receivers purposely use a small-capacity condenser at *C*-32 and are generally designed to give a poor response to low audio frequencies so as to minimize the hum frequency (120 cycles for a full-wave and 60 cycles for a half-wave rectifier).

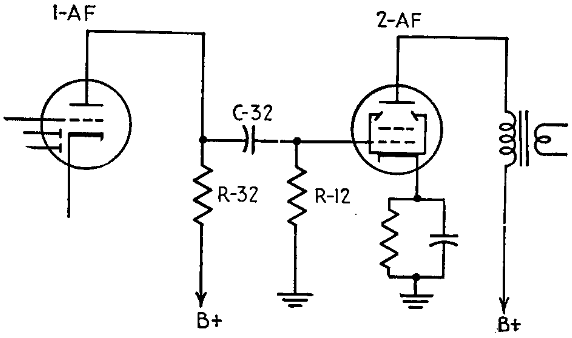


FIG. 11-4.—Resistance coupling between the first AF and the second AF stages.

The insulation of condenser *C*-32 must be good, since any leakage would put a positive bias on the second AF grid from the first AF plate. Paper tubular condensers are usually used with a voltage rating of 400 or 600 volts DC.

NORMAL TEST DATA FOR THE FIRST AF STAGE

Signal Check.—In the signal-substitution method of service procedure, only the final audio stage is measured as a single unit. Thereafter, as each stage is added, the test is over-all. In the case of the first AF stage, the test signal is applied to the first AF stage input circuit while the output indication is taken from the speaker.

Most signal generators provide a pair of terminals, where a 400-cycle current is available for the testing of AF circuits. When this test signal is applied to the input of an AF amplifier, a 400-cycle note is heard in the speaker.

When the audio output from a signal generator is not readily available, a good substitute is found on every service bench. The tip of the soldering iron is a length of copper rod, partly enclosed in a heating coil, which is energized by 60-cycle current. The heating coil induces a small voltage in the tip, which is usable as a source of signal input voltage for AF amplifiers. The test frequency is low, 60 cycles, which accounts for the note heard in the speaker being described as a growl. Also, the human body seems to pick up some 60-cycle voltage, and many practical servicemen use a moist finger as their signal source. This last procedure is not recommended for beginners, who might accidentally touch a plate lead at 300 volts instead of a grid lead at zero volts.

Quick Check for the First AF Stage.—If a wet finger or a plugged-in soldering iron tip is applied to the ungrounded (called the "hot") end of the volume control with the control in the full ON position, a very strong growl should be heard in the speaker. If it is not heard or if it is not considerably stronger than the growl heard when the second AF stage was checked, the trouble is in the first AF stage.

The quick signal check can also be used for further narrowing down the location of the trouble. Assume normal response from the second AF grid (a low growl) and no response from the ungrounded (hot) end of the volume control, as in Fig. 11–5.

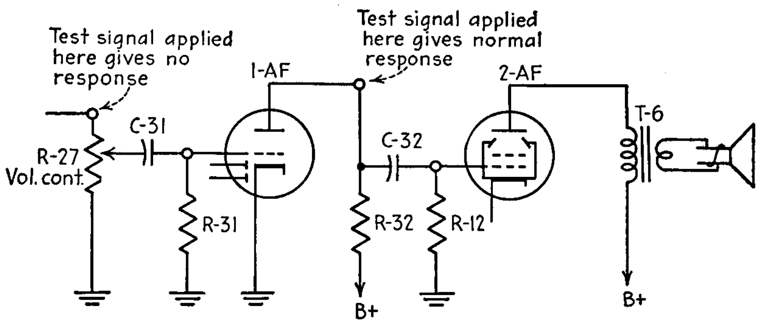


FIG. 11–5.—Trouble shooting an inoperative first AF stage by a signal check.

Then, if the test signal is applied to the plate of the first AF tube, normal response (a low growl in the speaker) indicates that coupling condenser *C*-32 is functioning and the trouble is before the first AF plate. No response at this point indicates an open coupling condenser, or a first AF plate-to-ground short.

If there is normal response from the first AF plate, the test signal is shifted to the first AF grid. Normal response (a strong growl) from this point indicates trouble in the volume control or coupling condenser *C*-31. No response means that the trouble is between the first AF grid and the plate. The likely causes are

1. *An Inoperative First AF Tube.*—Confirm by substituting a good tube.

2. *A Grounded Grid Lead.*—Confirm with an ohmmeter. (The ground is probably caused by defective shielding.)

3. *An Open Plate-load Resistor R-32.*—Confirm by voltage and resistance checks.

Use of Output Meter.—The ear, judging differences in sound intensity, can make only a rough estimate. Except at very low sound levels, the judgment of the ear is not very reliable. A more quantitative check for all receiver testing is to measure the actual signal power that is put into the speaker.

Radiomen usually work to a definite level of output from any receiver and then make comparisons of input signal necessary to attain that output. This reference level is called "standard output" and is defined as 50 mw (0.05 watt) of signal power into the speaker. Note that the 50 mw is well below the output capabilities of any radio receiver and, therefore, the test signal level at any point in the receiver, necessary to attain standard output, will not overload any tube.

The output power may be determined by measuring the signal voltage across the speaker voice coil with an AC voltmeter. For example, if we have a 5-ohm voice coil, 0.5 volt will correspond to standard output.

$$W = \frac{E^2}{R} = \frac{0.5 \times 0.5}{5} = \frac{0.25}{5} = 0.05 \text{ watt}$$

The only trouble with this is that ½ volt is not easily read on the low AC range of the usual multimeter.

A more easily read output indication is obtainable at the primary of the output transformer where, owing to the turns ratio of the transformer, standard output will correspond to approximately 16 volts. The primary of the output transformer, however, is in a circuit where direct current, the plate current of the second AF tube, is flowing, the signal itself being a pulsation of this current. To keep the direct current of the plate circuit from affecting the AC meter, a condenser must be inserted in series, so that the meter will read only the AC signal component. This is shown in Fig. 11–6, which indicates the connections for an output meter. A convenient size for this series condenser is 0.1 mfd/600 volts. Some multimeters have the output condenser built in, in which case there will be test jacks on the instrument labeled OUTPUT METER, and the 0.1-mfd condenser need not be connected externally. The meter should be used on a suitable AC range where 16 volts will give a good indication. (About half scale is best.) It might be advisable for the serviceman to work to a reading of 15 or 20 volts as his reference level, to take advantage of a convenient marker on the meter scale. Then as far as his test bench is concerned, 15 or 20 volts, as the case may be, is standard output, and he will work at this level except where service notes issued by the manufacturer of the receiver concerned specify differently. The voltage chosen to represent standard output will not vary too much from 50 mw and is sufficiently accurate for any service work.

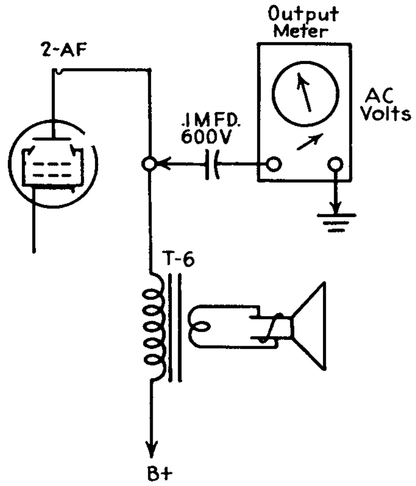


FIG. 11-6.—Connection of an AC voltmeter as an output meter.

The serviceman would do well to provide himself with some special test leads for convenience in checking the output voltage. If the multimeter has a built-in output condenser, a pair of test leads

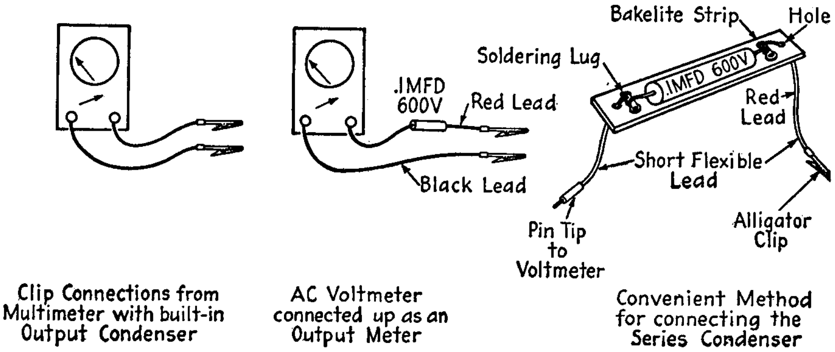
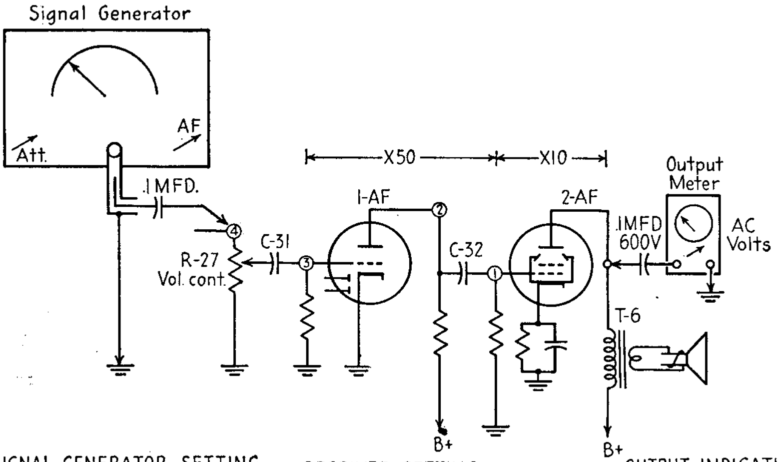


FIG. 11-7.—Test leads for the output meter.

terminating in alligator clips will be all that is needed. If the output condenser is not built in, one test lead is provided with a series 0.1-mfd/600-volt condenser, as shown in Fig. 11-7.

Stage-gain Measurements.—Now, having established standard output, let us make some gain checks on a receiver known to be perfect to determine how this information may be used in later servicing. Figure 11–8 shows the audio amplifier of the standard receiver. The output meter and the AF output of the signal generator are connected to make gain checks. The condenser in the hot lead of the signal generator (which may be connected internally) serves to keep DC plate potentials out of the signal generator circuit when the hot lead is connected to a plate terminal in the radio. The receiver volume control is set for maximum output (full ON) and the tone control, if any, is set for the minimum bass position.



SIGNAL GENERATOR SETTING
Approximately .04 Volt input signal at test point ③ to give standard output, and to show gain values indicated.

RECEIVER SETTING
Volume control - Maximum.

OUTPUT INDICATION
For stage gain measurement: 16 Volts or manufacturer's specification.

FIG. 11–8.—Audio stage-gain measurements.

The gain per stage is approximately 50 for the first AF stage and 10 for the second AF stage, as is indicated in Fig. 11–8. Now let us assume our test bench works to a reference level of 20 volts as standard output indication. Then when the hot lead of the signal generator is connected to point ①, the second AF grid, a 2-volt signal will be needed to give standard output from this point, since 2 volts input times 10, the amplification of the stage, equals 20 volts output. It is not necessary to measure the input signal voltage. Accurate stage-gain measurements would call for expensive test equipment and, although this would be of advantage in design engineering, service work to find a poorly operating stage does not require anything more than comparative data. For an idea of 2 volts input, simply note the position of the attenuator on the AF signal generator to obtain standard output on this perfect receiver.

When the test signal is connected to point ②, the first AF plate, the signal-generator attenuator will have to be advanced slightly to maintain 20 volts on the output meter, to compensate for the loss caused by coupling condenser *C*-32.

When the test signal is connected to point ③, which is the grid of the first AF tube, only 0.04 volt will be needed to give standard output, since

Input volts	×	gain of first AF stage	×	gain of second AF stage	=	output volts
0.04	×	50	×	10	=	20

The signal-generator attentuator position is again noted for the 0.04-volt position.

Moving the test signal to point ④, the hot end of the volume control, will again require a slight increase in signal input voltage to compensate for the loss caused by coupling condenser *C*-31.

Having established comparative reference points on his signal generator and output meter, by trying the above procedure on a number of perfect receivers, the serviceman is in a position to determine the normal gain to be expected from any audio stage of a receiver brought in for servicing.

Normal First AF Voltage Data.—Voltages are measured from chassis or common negative to tube terminal indicated. In some AC/DC receivers where the circuit insulates *B* minus from the chassis, the negative terminal of the voltmeter is connected to the common negative. This is most easily found at the line switch. Normal data are given in the accompanying table.

Tube terminal	12SQ7 and 6SQ7 pin No.	AC receivers, volts	AC/DC receivers, volts
Plate	6	100–170	40–60
Grid	2	0	0
Cathode	3	0	0

Voltages vary with different receivers and also with the ohms-per-volt rating of the multimeter. Since the plate-load resistor *R*-32 has an average value of 250,000 ohms, the plate circuit is a high-resistance circuit, and the plate voltage as read by a meter will depend on the extent to which the meter loads the circuit. In general, a

1,000-ohms-per-volt meter will read considerably less in this circuit than a 20,000-ohms-per-volt or vacuum-tube voltmeter.

Normal First AF Resistance Data.—These data are given in the following table:

Chassis to cathode (pin 3)	0 ohms
Chassis to grid (pin 2)	10 megohms
B plus to plate (pin 6)	250,000 ohms

COMMON TROUBLES IN THE FIRST AF STAGE

Troubles Common to the Volume Control.—Volume controls sometimes open. Since a signal check may give normal response even with an open volume control, this difficulty may not be found until the detector stage is checked, the volume control being also an important component of the detector stage.

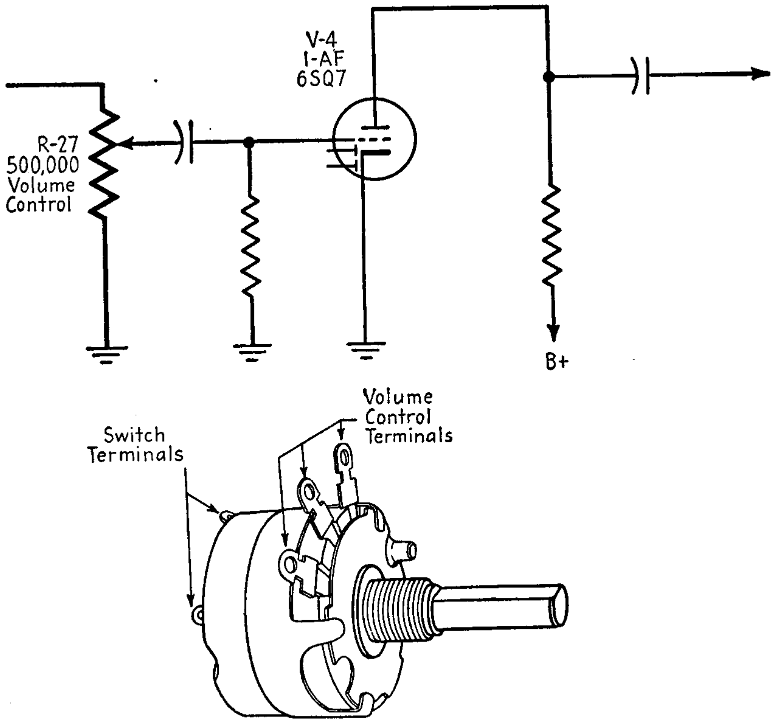


FIG. 11-9.—Typical volume control and its position in the first AF circuit.

More often, volume controls are noisy in operation, usually because of dirt between the sliding arm and its contact ring. Although a temporary repair is often possible by a cleaning, such procedure is questionable, since a noisy control is also a possible cause of intermittent operation or fading. Debit the control to normal wear and tear of a moving part and replace it with a new one.

In replacing the volume control for electric and mechanical defects, it is best to obtain an exact replacement. When this is not possible, a replacement control as similar to the original as possible must be selected. When choosing the replacement control, the serviceman must keep several factors in mind:

1. *Space Requirement.*—The replacement must not be physically larger than the original unless there is room for it.

2. *Length of Shaft.*—The shaft of the replacement control may be longer but not shorter than the original. The excess can be cut off. If the original has an unusually long shaft, an extension shaft (see Fig. 11–10) may be used.

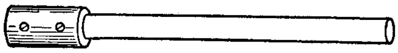


FIG. 11-10.—A volume-control extension shaft.

3. *Flat Side of Shaft.*—The volume-control knob should be examined. If it fastens with a setscrew, any shape of shaft may be used. If it is a spring push-on type of knob, the knob must fit the shaft snugly with spring tension. Too small a shaft will not do, since the knob will be loose. A round shaft or one with a small flat section will do, since it can be filed to shape.

4. *Resistance and Taper.*—The total resistance and taper of the replacement control should be the same as the original. The wrong taper will cause the control to bunch all its action in a small segment of the control rotation, while the rest of the turn has very little effect. The serviceman need not concern himself too much about the taper, however, since the replacement-control manufacturers have gone into the matter thoroughly and specify the proper taper to use in accordance with the circuit arrangement of the control.

5. *Switch.*—Volume (or tone) controls are usually combined with the line ON-OFF switch in one unit. When this is the case, if the volume control is defective, the switch is replaced at the same time. Similarly, if the switch is defective, the volume control is replaced at the same time.

How to Replace a Volume Control.

1. Choose a proper replacement control as described above.

2. Do not remove the wiring from the old control. Loosen the mounting nut, slip the shaft through the hole, and let the old control dangle from its leads.

3. If necessary to cut the shaft of the replacement control, proceed as follows:
   a. Measure it against the original as shown in Fig. 11-11 and mark the proper length.

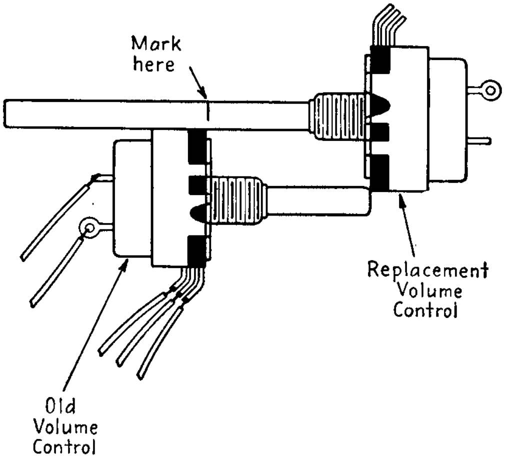


Fig. 11-11.—Measuring the replacement volume control for length.

   b. Clamp excess portion in vise with mark showing and cut to the mark with a hack saw, as shown in Fig. 11-12.
   c. Remove saw burr with a file.

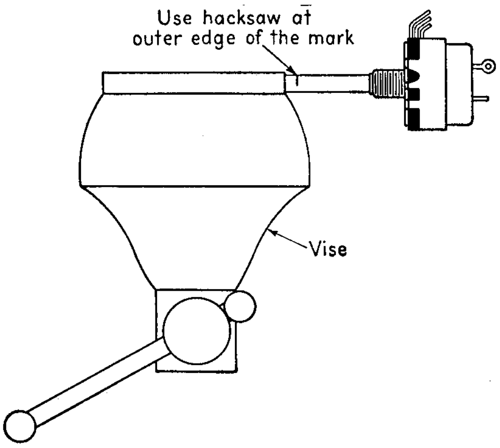


Fig. 11-12.—Cutting the volume-control shaft to size.

4. If shaft is to be filed for a push-on type of knob, proceed as follows:

a. Measure against the original, as shown in Fig. 11–13, and indicate with a mark the amount of shaft to be removed.

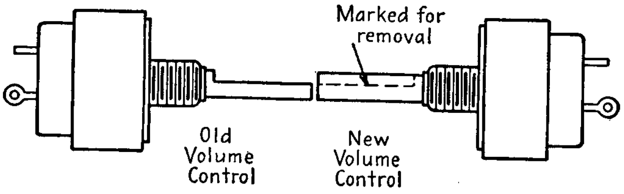


FIG. 11–13.—Marking the volume-control shaft for a push-on knob.

b. Clamp in vise with mark showing. Cut vertically at *A* with a hack saw, as shown in Fig. 11–14. Stop cutting before reaching the horizontal line. File the material away, almost down to the line with the file held horizontally.

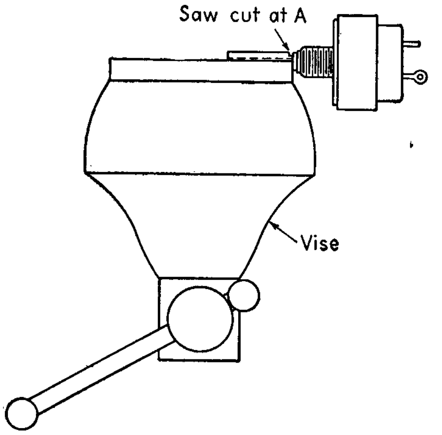


FIG. 11–14.—Cutting the volume-control shaft for a push-on knob.

c. Try the push-on knob. If too tight, one or two file strokes will bring the shaft down to the line where the knob spring should fit just right.

5. Slip the replacement control through the chassis hole, using a lock washer or locating pin, as shown in Fig. 11–15. If there is no

hole for the locating pin, bend it down if it is metal or snap it off if it is bakelite. If this is not done, the locating pin will force the control at an angle when the nut is tightened up, either damaging it or giving the control erratic action. Tighten the mounting nut with an open-end wrench. An open-end wrench marked ½ in. on one end and 9/16 in. on the other will handle most volume-control mounting nuts.

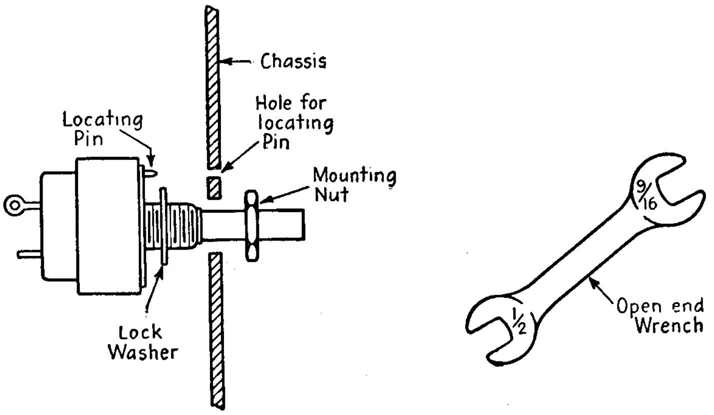


FIG. 11-15.—Mounting the volume control.

6. Remove the wires from the old control, one at a time. Each wire is to be soldered to the corresponding terminal lug on the replacement control.

If the wiring has been disturbed before the new control is in place, it will be necessary to trace the leads before soldering them into place. First the switch leads are traced, one to the line cord and the other to the power-transformer primary. Next the wire to the first AF control grid through condenser C-31 is found and soldered to the center terminal of the potentiometer. The last two leads go to ground and the detector circuit, and the serviceman must be careful not to reverse them or the control will work backward. The easiest way to be sure is to turn the control to the full ON position and imagine the position of the arm inside the control. At the full ON position the arm is stopped at the detector circuit end of the control, and the detector lead is soldered to the lug that stopped the arm. The final soldering lug connects to the chassis. These connections are illustrated in Fig. 11-16.

To check the volume-control action, tune the receiver to a strong local station. Turn the volume control to the position just before the switch shuts off power. The sound from the speaker should be just a whisper or completely off. As the volume control is rotated in a clockwise direction, the volume should gradually increase. At the halfway point, the volume should be just about right to fill the average home living room. As the rotation is continued, the volume should increase. Beyond the three-quarter point there will probably be distortion, rattling of the speaker, and microphonics.

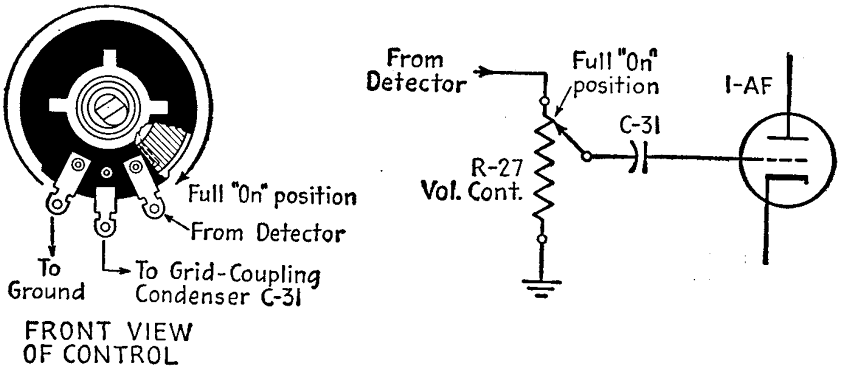


FIG. 11-16.—Volume-control connections.

To check the volume control for noisy action, the RF section of the receiver is made inoperative by removing the IF tube and rotating the volume control while listening for noise. In the case of an AC/DC receiver, where a tube cannot be removed without stopping all operation, the RF section of the receiver may be made inoperative by grounding the IF grid or the oscillator condenser stator. Grounding the oscillator condenser stator is a standard servicing procedure. A description of how the oscillator section of the gang tuning condenser may be easily recognized is given on page 159.

Troubles Common to the Input Coupling Condenser.—Coupling condenser *C*-31 rarely causes any service difficulties. It may open, in which case the condition would be found by a signal check: normal response from the grid of the first AF tube and no response from the arm of the volume control.

When replacing the condenser, be sure to use one with the same capacity as the original. Place the condenser in the same position as the original and dress the leads in the same manner. The positioning of the condenser and leads is stressed because any hum picked up at this point is amplified by the entire audio amplifier that follows. Also follow the original for the placement of the outside foil lead, although this procedure may be unimportant, since either end of the condenser is equally "hot."

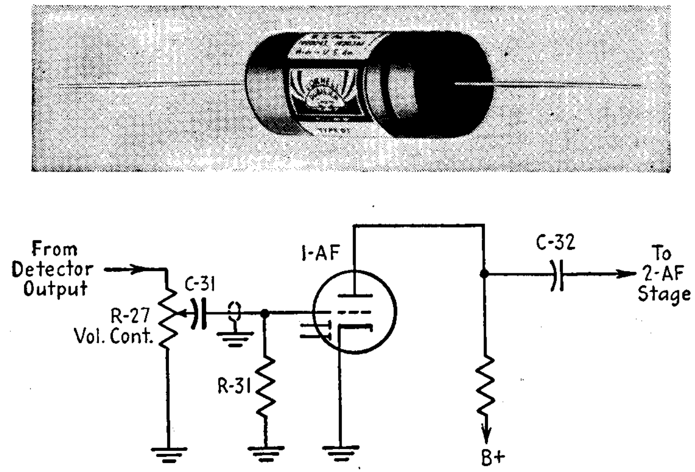


FIG. 11-17.—The input coupling condenser and its position in the input circuit of the first AF stage.

Control-grid Wiring—Any of the wiring from the detector output to the first AF grid is likely to pick up hum and, as a result, should be either carefully routed or shielded. Where shielding is not used, the wiring is usually kept close to the chassis and away from filament leads that carry 60-cycle current. Often, when a top grid contact tube like the 75 or 6Q7-G is used, the wire goes up to the grid, *inside* the tube shield. In replacing tubes, people sometimes leave the grid lead off, replace the shield, and bring the grid wire up outside of the shield. Besides increasing the possibility of hum, the shield also may cut through the insulation of the grid wire grounding the signal. When a shielded wire is used, an end of the shielding may work its way through the wire insulation and likewise ground the signal.

In either case, the trouble would be found by means of a signal check: normal response from the first AF plate and no response from the first AF grid. An ohmmeter check from grid to ground will confirm the trouble.

In repairing the radio where the tube shield has cut through the insulation, it would be safest to replace the entire lead, since any repair job so close to the chassis is likely to work away and ground the grid wire again.

When a radio with a defective shielded lead is repaired, replacement of the entire lead is also necessary.

How to Prepare Shielded Wire for Use.

1. Cut off the proper length. Include allowance for connections.
2. Push back the shielding to loosen the weave, as shown in Fig. 11–18*A*.

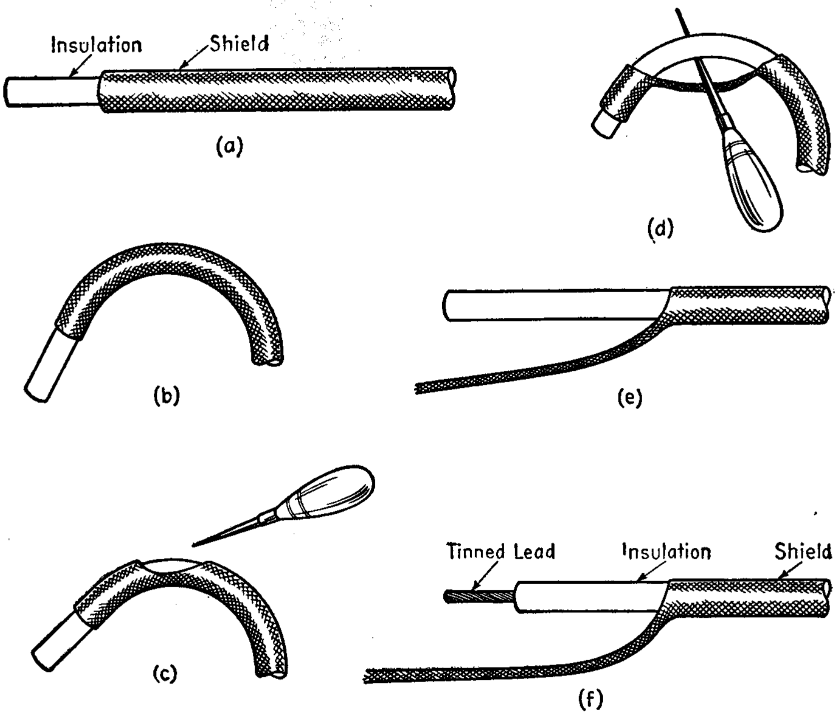


Fig. 11-18.—How to prepare shielded wire for use.

3. Bend a loop in the lead, as shown in Fig. 11–18*B*.
4. Work the weave back and forth with a pointed instrument at the top of the loop, until the hole made is large enough to pull the wire through. See Fig. 11–18*C*.
5. Slide the scriber under the wire and pull the end through the hole, as shown in Fig. 11–18*D*.
6. Pull out the empty piece of sleeving, as shown in Fig. 11–18*E*.
7. Repeat steps 1 to 6 at the other end of the shielded wire.
8. Strip and tin the ends of the lead ready for connecting, as shown in Fig. 11–18*F*.

When a shielded cable is replaced, use the prepared ends of the sleeving for the connection to the chassis. Do not attempt to solder the shielding in the middle of the lead to the chassis. The heat of the iron will probably ruin the insulation inside the shield.

Troubles Common to the Grid-load Resistor.—Grid-load resistor *R*-31 may open, resulting in motorboating as was described for *R*-12, the grid-load resistor of the second AF stage on page 106. This would be found by the standard check for motorboating, which is to check the filter condensers in the power supply and then to look for an open grid circuit.

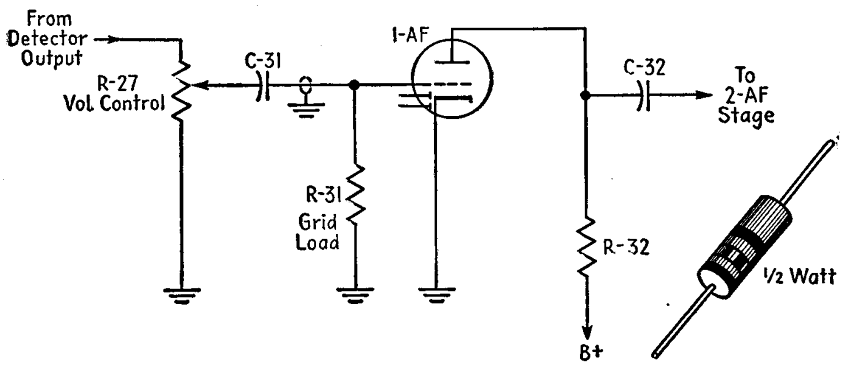


FIG. 11-19.—The first AF grid-load resistor and its position in the circuit.

When replacing *R*-31, be sure to use the same ohmic value as is called for in the receiver diagram. A wrong value here would change the contact bias (see page 127) and result in poor tone.

Troubles Common to the First AF Amplifier Tube.—The first AF amplifier tube *V*-4 is the most likely source of trouble in the stage. Hum, no reception, weak reception, noisy reception, and intermittent reception might all be due to the tube. The best check is to substitute a similar tube known to be good. When the signal check shows normal response from the first AF plate and weak or no response from the first AF grid, the tube is a likely suspect.

Troubles Common to the Plate-load Resistor.—Plate-load resistor *R*-32 sometimes opens. The signal check would show normal response from the first AF plate and no response from the first AF grid. A voltage check would then show no voltage at the first AF plate.

Troubles Common to the Output Coupling Condenser.—Coupling condenser *C*-32 is subject to many ills that impair performance of the receiver. It opens, shorts, becomes leaky, and opens intermittently.

An open condenser would result in a dead receiver and is found by a signal check. There would be a normal response from the second AF grid and no response from the first AF plate. Such a response could also be caused by a plate-to-ground short or an open plate-load resistor. These last two possibilities would be eliminated by a normal plate-voltage reading. The open condenser would then be confirmed by substituting a test condenser.

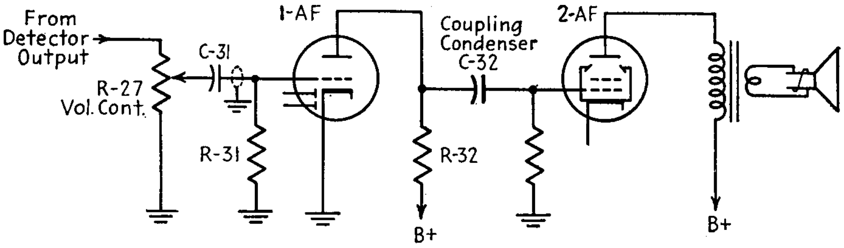


Fig. 11-20.—Coupling condenser C-32 between the first AF and second AF stages.

If *C*-32 is shorted or has low leakage resistance, the tone quality would be badly affected. Positive voltage from the first AF plate would leak over the defective coupling condenser to the second AF grid, disturbing the bias voltage on the second AF tube, with distortion as a result. The condition would be found in a voltage check of the second AF stage. Insufficient or positive bias on the second AF tube grid would cause heavier than normal plate current and result in an abnormally large potential across the output transformer primary and an unusually large potential difference between plate and screen voltages. This check is more reliable than a positive indication on the second AF grid, which may be small and therefore missed in the case of high leakage resistance. In the latter case, even though a small positive voltage leaks across the coupling condenser, it will still decrease the applied bias voltage, with consequent increased plate current and reduced signal handling capabilities. Since a leakage resistance of several megohms would be hard to measure on the average ohmmeter but would still cause distortion, a good confirmation check would be the following: Open the coupling condenser from its grid connection, and check for voltage to ground, as shown in Fig. 11-21. With a good condenser, the voltmeter needle will swing up as the condenser charges and return to the zero position, when the condenser is fully charged. Leakage resistance in the condenser will cause the voltmeter needle to remain at some position higher than zero. Owing to the high activating voltage at the first AF plate, a leakage resistance of several megohms will cause a readable deflection on even a 1,000-ohms-per-volt voltmeter.

If the coupling condenser is intermittently open, fading will result; the receiver will not operate when it is open and will resume operation when it is closed. This condition is due to a poor contact between one of the condenser leads and the tin foil of the condenser plates. Usually the condition can be confirmed by yanking gently on the condenser leads, thereby starting and stopping reception. Parenthetically, it may be added that, when a receiver is serviced for fading, all coupling condensers should be replaced as a matter of course.

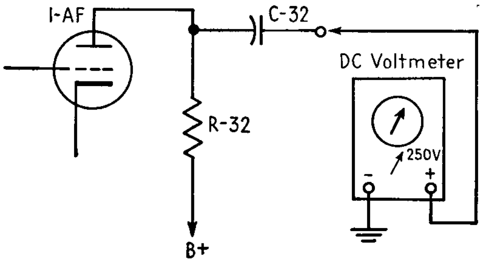


FIG. 11-21.—How to check an audio coupling condenser for leakage.

When coupling condenser *C*-32 is replaced, a good-quality condenser should be used. The condenser should have a rating of 600 volts. Although a 400-volt condenser is sufficient for the voltages normally found in this circuit, the thicker dielectric of the 600-volt size makes for less likelihood of leakage. The capacity used should be the one called for in the receiver diagram. If a different capacity is used, the serviceman should remember that a higher capacity will give a better low-frequency audio response.

CIRCUIT VARIATIONS IN THE FIRST AF STAGE

Bass Compensation Circuit.—It is characteristic of the human ear to be less sensitive to low audio frequencies than to high ones at reduced volume levels. To compensate for this deficiency, the circuit of Fig. 11-22 is found in many receivers.

Potentiometer *R*-27 is a tapped volume control with the tap located in the low-volume area. When the arm is in the high-volume position near the ungrounded end of the volume control, *C*-127 has little effect. As the volume is reduced and the arm approaches the tap, *C*-127 by-passes some of the high AF signal from the amplifier, thereby making the low audio frequencies seem stronger. The effect is greatest at the tap which will be at the low-volume position for the particular receiver. Resistor *R*-127, which may be omitted from some circuits, is to keep the by-passing effect from being too pronounced at the tap and to broaden the region around the tap where the bass compensation circuit is effective.

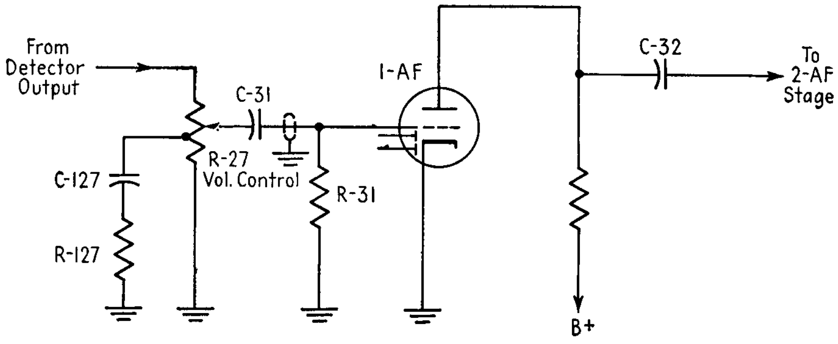


Fig. 11-22.—Bass compensation in the first AF stage.

Some receivers carry out the tone compensation at two points on the volume control, as shown in Fig. 11-23. The volume control is tapped at two points. Again, at the high-volume position the high-frequency by-pass circuits have little effect. As the volume is reduced, a slight amount of bass compensation is attained through *C*-127 and *R*-127. As the volume is reduced further, more bass compensation is attained through condenser *C*-131. All checks and operations are the same as for the standard circuit.

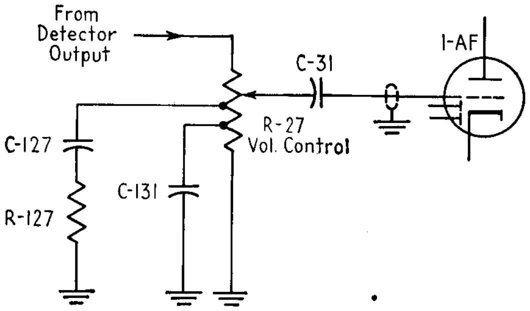
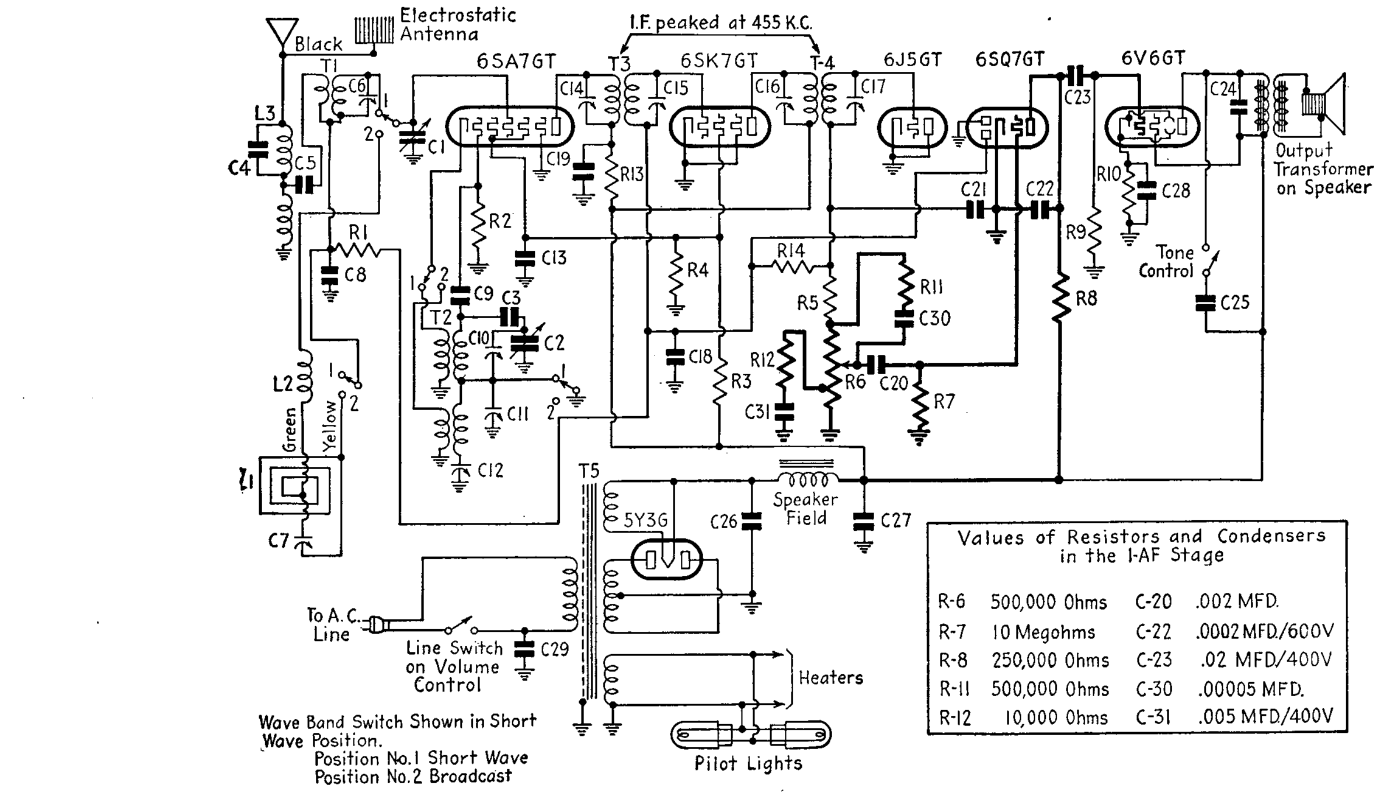


Fig. 11-23.—Bass compensation at two points in the volume range.

Condensers *C*-127, *C*-131, and resistor *R*-127 rarely if ever give any service difficulty. Volume control *R*-27, however, is subject to all the ills of volume controls. In replacing *R*-27, the serviceman must find an exact replacement for proper operation of the bass compensation circuit.

Figure 11–24 illustrates some of the points taken up in this chapter on the first AF stage. Note the tone-compensation circuit connected to the volume control *R*-6. At high-volume levels the filter is ineffective. When the potentiometer arm is in a low-volume position near the tap, condenser *C*-31 and resistor *R*-12 by-pass high audio frequencies to ground. Since the attenuation of very high audio frequencies will be excessive, the circuit composed of *R*-11 and *C*-30 restores some of these frequencies to the arm of the volume control. The net result is an increase in low AF response at low-volume levels without entirely removing the high audio frequencies.

Note also the use of a separate detector tube, the 6J5-GT, with the plate tied to the cathode as one diode element while the grid functions as the other. The rest of the first AF circuit follows the standard circuit closely except for the use of condenser *C*-22 across the plate circuit of the tube. This limits the high-frequency response. Note that *C*-22 is a 600-volt condenser and will therefore give little service difficulty. If condenser *C*-22 were shorted, the trouble would be narrowed down to the first AF stage by signal check, since there would be normal response from the second AF grid and no response from the first AF grid. A voltage check would show no plate voltage at the first AF plate. Since this condition could also be caused by an open plate-load resistor *R*-8, an ohmmeter check would finally confirm *R*-8 open or *C*-22 shorted.



Values of Resistors and Condensers in the 1-AF Stage

R-6	500,000 Ohms	C-20	.002 MFD.
R-7	10 Megohms	C-22	.0002 MFD./600V
R-8	250,000 Ohms	C-23	.02 MFD/400V
R-11	500,000 Ohms	C-30	.00005 MFD.
R-12	10,000 Ohms	C-31	.005 MFD./400V

FIG. 11-24.—Emerson Model EQ-368 receiver. The first AF circuit is shown in heavy lines.

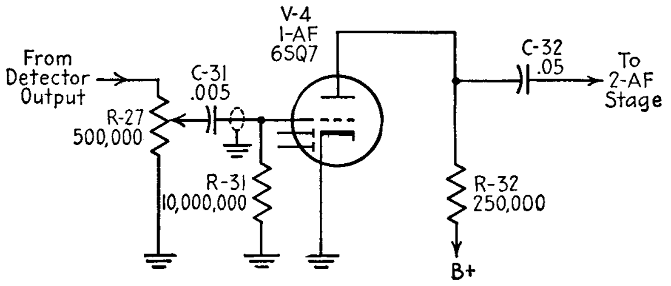
SUMMARY

Quick check for normal operation of the first AF stage.

A wet finger or a plugged-in soldering-iron tip applied to the ungrounded end of the volume control causes a very strong growl to be heard in the speaker.

Standard first AF diagram.

The accompanying figure shows the standard first AF diagram.



Normal first AF voltage data.

Voltage is measured from chassis or the common negative in an AC/DC receiver. Data given in the accompanying table.

Tube terminal	12SQ7 and 6SQ7 pin No.	AC receivers, volts	AC/DC receivers, volts
Plate	6	100–170	40–60
Grid	2	0	0
Cathode	3	0	0

Normal first AF resistance data.

Chassis or common negative to cathode	**0 ohm**
Chassis or common negative to grid	**10 megohms**
Plate to *B* plus	**250,000 ohms**

SERVICE DATA CHART FOR AN INOPERATIVE FIRST AF STAGE

Assume an inoperative first AF stage as shown by normal response when an AF test signal is applied to the second AF grid, and no response when the test signal is applied to the ungrounded end of the volume control. The following service procedure is recommended.

Step	Signal check	Response	Trouble
1	Apply AF test signal to first AF plate	None or weak	Look for open coupling condenser *C*-32 or first AF plate short-circuiting to chassis
		Normal	Proceed to step 2
2	Apply AF test signal to first AF grid	None or weak	Look for plate voltage on first AF plate (open *R*-32). Substitute a good first AF tube. Look for a shorted grid lead (shielding)
		Normal	Proceed to step 3
3	Apply AF test signal to volume control arm	None or weak	Look for open coupling condenser *C*-31. Look for grounded volume-control arm (shielding)
		Normal	Open volume control. Grounded "hot" end of volume control

SERVICE DATA CHART FOR OTHER SYMPTOMS

Symptom	Abnormal reading	Look for
Poor tone quality	First AF plate voltage low	Short-circuited or leaking coupling condenser *C*-32
	Voltages normal	Short-circuited or leaking coupling condenser *C*-31. Incorrect value of grid load *R*-31
Motorboating		Open grid load *R*-31
Hum	Voltages normal	Defective first AF tube. Incorrectly dressed grid leads. Positioning of coupling condenser
Intermittent reception (fading)		Coupling condensers *C*-31 and *C*-32 may open intermittently. Defective first AF tube. Defective volume control

QUESTIONS

1. A receiver is being serviced for weak reception. A signal check shows no gain for the first AF stage. Outline a test procedure for determining the cause of the trouble.

2. The receiver of Fig. 11–24 has poor tone quality. A voltage check shows 50 volts on the first AF plate. What is likely to be wrong and how would you confirm your assumption?

3. The receiver of Fig. 11–24 has a noisy volume control. After the volume control is replaced with an exact replacement, the volume remains at one level regardless of the position of the control arm. What is wrong? How would you check to prove it?

4. A receiver very much like the standard superheterodyne motorboats. How would you check to find the cause in the power supply? In the second AF stage? In the first AF stage?

5. An AC receiver hums excessively. When the first AF tube is removed from its socket, the hum level drops to normal. How would you check the various possibilities for hum in the first AF stage?

6. What are the possible causes of intermittent reception in the first AF stage? How would you check for each?

7. A receiver gives normal response when an AF test signal is applied to the first AF grid and a very weak response when the test signal is shifted to the hot end of the volume control. What are the possible causes of the defect and how would you check for each?

8. A receiver gives normal response when an AF test signal is applied to the second AF grid and no response when the test signal is shifted to the first AF grid. What are the possible causes of the trouble and how would you check for each?

9. What is a good test for high leakage resistance in a coupling condenser between a first AF plate and a second AF grid?

10. The receiver of Fig. 10–14 has been completely overhauled and reconditioned. As part of the servicing procedure the first AF grid-load resistor *R*-11 had been found to be open and replaced. However, it had been replaced with a 1-megohm resistor in error. The customer later complains that his radio does not sound so clear as before. Could the incorrect first AF grid-load resistor be the cause of this condition? Explain your answer.

CHAPTER 12

DETECTOR STAGE—AVC

Quick Check for Operation of the Detector Stage.—A modulated signal at the intermediate frequency of the receiver being checked is applied to the IF control grid. If the signal-generator modulation note is heard in the speaker, the detector stage is probably functioning properly, and the serviceman moves forward to the next stage.

Since the AVC (automatic volume control) action is dependent on the operation of the RF converter and IF stages, there is no quick check for AVC operation at this point.

Function of the Detector and AVC Stage.—In modern receivers, detection and automatic volume control are accomplished in one circuit and, although they are two separate functions, must be treated together.

The input signal, normally fed to the detector stage, is an alternating voltage at the intermediate frequency of the receiver and modulated by the audio component of the original signal picked up by the antenna. The signal that appears across the output of the detector stage is the audio component only. One function of the detector and AVC stage, therefore, is to demodulate the signal; that is, to remove the audio component and pass it on to the audio amplifier.

The detector stage or tube is sometimes called the "demodulator," the reason for which is obvious from its function. It is also sometimes called the "second detector" to distinguish it from the mixer tube, an old name for which was "first detector."

AVC action can be described as follows: A strong local station delivers a strong signal to a receiver. A station at some distance away will deliver a much weaker signal to it. Yet it is desirable for each of these stations to produce approximately the same volume from the speaker. This effect could be performed manually by means of a volume control, but it is far superior if this effect is performed automatically. That is the function of the AVC system.

The upper limit of sensitivity of a receiver is set by the design characteristics of the receiver itself. However, the AVC circuit reduces the sensitivity of the receiver more or less below the upper limit—more for a strong signal and less for a weaker signal. This effect is produced by the use of supercontrol (variable-mu) tubes in the RF and IF stages of the receiver. The gain of these tubes changes with different control grid-bias voltages: at greater negative bias, the gain is lower; at lower negative grid bias, the gain is greater. In an AVC circuit, the station signal itself develops negative bias voltage for the control grids of the supercontrol tubes. A strong signal develops a large negative bias voltage which reduces the gain of the controlled tubes. A weak signal develops a smaller negative bias voltage which does not reduce the gain of the controlled tubes so much. As a result, a fairly constant volume is obtained from the speaker, regardless of the original strength of the received signal within the limits of the sensitivity of the receiver.

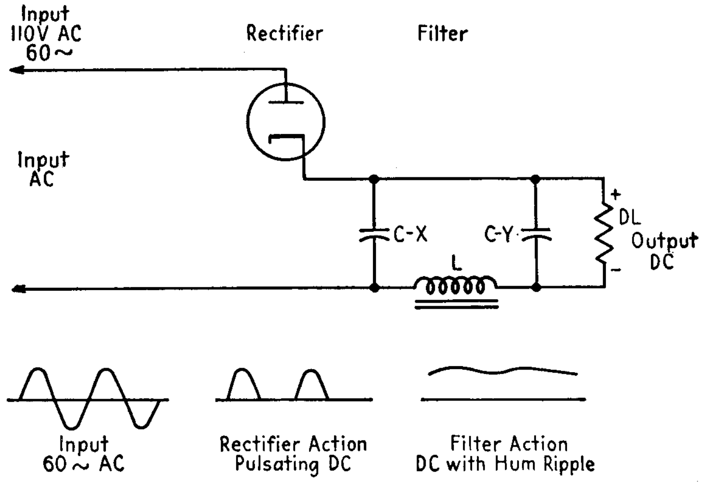


FIG. 12-1.—Half-wave *B* power supply.

Theory of Operation.—The detector and AVC stage in modern receivers performs its functions in a circuit arrangement very similar to that of a power supply; that is, it also employs a diode rectifier and filter circuit. Since power-supply circuits are generally understood, a parallel will be drawn to explain the operation of the detector and AVC stage.

Consider the half-wave rectifier circuit shown in Fig. 12–1, common in AC/DC receivers. The input is 110 volts AC. Only when the positive phase of the input voltage is impressed on the plate will current flow through the tube. The circuit is completed through load resistor *DL*. Condensers C_x and C_y and choke *L* make up the smoothing filter. The wave forms of Fig. 12–1 show the complete action of the circuit. Note the polarity of the voltage across load resistor *DL* and the hum ripple that is present. If it is desired to eliminate the hum ripple, a second section *L-C* filter would be added, as in Fig. 12–2.

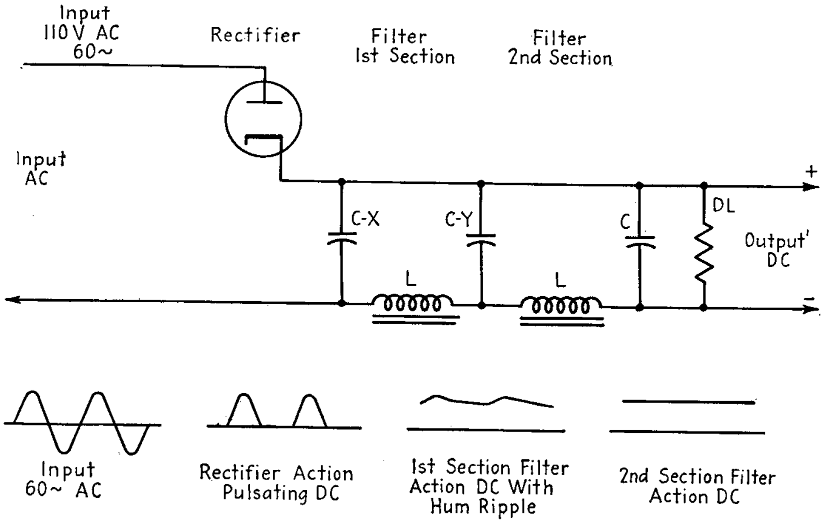


FIG. 12–2.—Eliminating hum ripple by means of a second section filter.

In the detector stage, to draw a parallel, the input voltage is across the tuned secondary of the IF transformer *T*-5, as shown in Fig. 12–3. The graph below *T*-5 represents the input voltage at the intermediate frequency and modulated by its audio component. Similar to the action in the power supply, the rectifier chops off the negative half of the input voltage, as represented in the graph under the rectifier tube V-4A. Now let us examine the filter circuit. A filtering resistor *R*-26 has been substituted for the choke. It serves a similar function. In the power supply, the filter condensers are usually 20 mfd each. In the detector filter circuit, *C*-26 and *C*-27 are usually 0.0001 mfd apiece. This filter circuit will not give unvarying direct current as its output but will make an effective filter at the intermediate frequency (455 kc). The output at this point will be the audio component of the signal which is impressed across the resistor *DL*, since the audio signal cannot be by-passed across the low-capacity condensers *C*-26 and *C*-27. Resistor *DL* is called the "diode load" and is usually the manual volume control of the receiver. With the audio signal across the volume control, the position of its arm determines the strength of the signal fed to the audio amplifier.

The audio signal, owing to its strong pulsations, is not suitable for use as an automatic bias voltage, since any bias voltage should be pure direct current. Therefore a second section filter, *R*-28 and *C*-28, is added after the audio circuit to smooth it to direct current, as shown in Fig. 12–4. The capacity of *C*-28 is 0.05 mfd to make it effective at audio frequency.

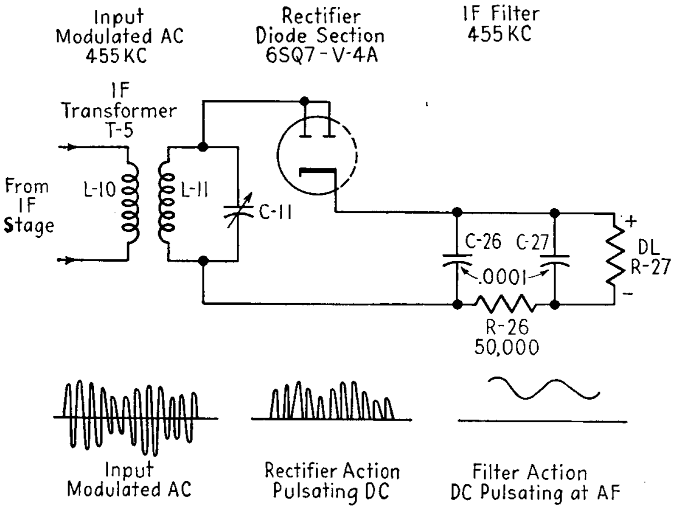


FIG. 12–3.—Diode detector operation—developing the audio output signal from the modulated IF input signal.

Now note again the polarity of the voltage across the diode load. If the diode cathode is grounded, the voltage at *R*-28 will be negative with respect to ground, and therefore suitable for use as bias voltage. The amount of voltage available at *R*-28 will depend on the voltage of the signal impressed across the secondary of the IF transformer *T*-5, since it is the rectified and filtered output of the signal voltage. For strong signals, the signal voltage across *T*-5 is high, the AVC bias voltage is high, and the amplification of the controlled RF and IF tubes is reduced. For weak signals, the signal voltage across *T*-5 is low, the AVC bias voltage is low, and the amplification of the controlled tubes is greater.

Figure 12–5 shows the detector and AVC system, including the control-grid circuits of the controlled tubes, and the coupling to the first AF stage. The wire that feeds the AVC voltage to the controlled tubes is known as the "AVC bus."

Resistor *R*-30 and its associated condenser *C*-30 in the RF grid return lead isolate the RF stage from the other stages. This is called a "decoupling" filter, which will be described in a later section.

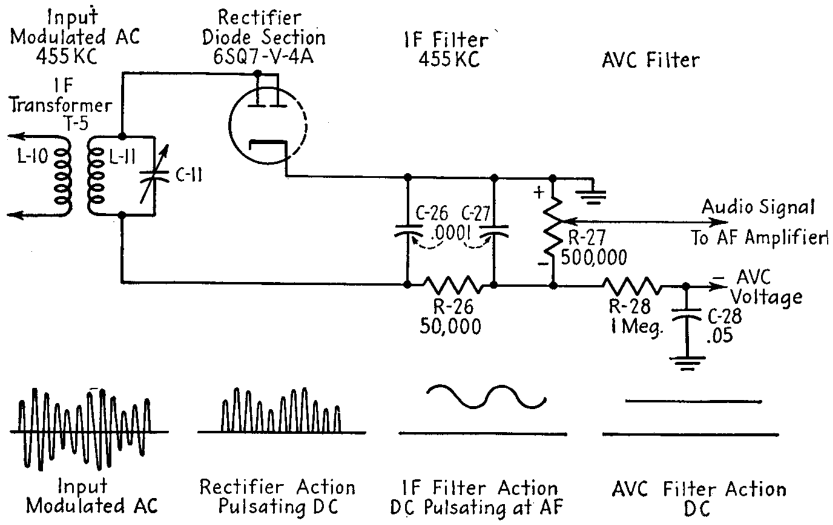


FIG. 12-4.—Developing audio signal and AVC voltage from the modulated intermediate-frequency signal.

Resistor *R*-29 and condenser *C*-29 serve a similar function for the converter stage.

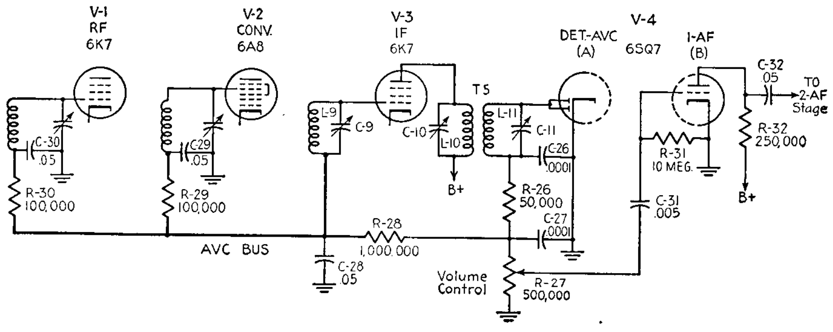


FIG. 12-5.—Typical detector and AVC circuit.

Functions and Values of Component Parts.—Potentiometer *R*-27 is the manually operated volume control for the receiver. In the detector stage, it acts as the diode load resistor, and the audio component of the signal voltage is developed across it. A portion of this voltage is taken off at the volume-control arm and is amplified as was described in Chap. 11. The ohmic value of *R*-27 is usually 500,000 ohms, although higher values are sometimes found in circuits where, at the increased load resistance, a higher value of audio output voltage is possible.

Condensers *C*-26 and *C*-27 and resistor *R*-26 make up the IF filter circuit. In this circuit, the IF pulsations are removed, leaving the audio envelope. Resistor *R*-26 is usually 50,000 ohms, and condensers *C*-26 and *C*-27 are usually 0.0001 mfd for an intermediate frequency of 450 to 480 kc. Sometimes these capacities are a little higher, not so much for more efficient filtering as for attenuation of high audio frequencies with resultant improvement of the apparent low AF response.

Resistor *R*-28 and condenser *C*-28 form the additional filter for the AVC voltage. In this circuit, audio pulsations are removed. Since the controlled grid circuits do not require current, *R*-28 can have a high value of resistance for efficient filtering of the AF pulsations, and *C*-28 by-passes the remainder to ground. In receivers containing an RF stage, *R*-28 is usually 1 megohm. In receivers that do not employ an RF stage, *R*-28 is usually higher, 2 megohms being the average size. *C*-28 is almost always 0.05 mfd.

The diode employed in the detector and AVC stage is the duo-diode section of the 6SQ7 tube, with the diode plates connected together, and the triode section functioning as the first AF amplifier tube. Some receivers use a 6Q7 duo-diode high-mu triode which is very similar to the 6SQ7, the difference being in the location of the audio grid pin. Receivers that use the loctal type of tubes employ the 7C6. When a separate tube is used for the detector, it is the 6H6 twin diode.

Occasionally, the detector diode is combined with the IF amplifier in one tube, as is the case with the 6B8 duplex-diode pentode. In these receivers, the following AF tube is usually a twin triode like the 6SC7 which combines the first AF and inverter functions in one tube.

Older varieties of the circuit combined the detector, AVC, and first AF functions in the 75 tube. Older circuits, using a separate tube, use the 37 triode with cathode and plate tied together to form one diode electrode while the grid functions as the other. An early issue of the 6B8 is the 6B7 duplex-diode pentode, where the detector, AVC, and IF amplifier functions are combined in one tube.

In AC/DC receivers employing 0.3-amp heaters, the 6Q7 and 6SQ7 are widely used. Where the 0.15-amp heater tubes are used, the 12Q7, 12SQ7, and 14B6 duplex-diode, high-mu triodes are found.

IF transformer *T*-5 couples the IF stage output signal to the detector stage. Usually both primary and secondary are tuned to the intermediate frequency by trimmer condensers *C*-10 and *C*-11. The latter are usually part of the transformer assembly. Sometimes condensers *C*-10 and *C*-11 are fixed, and tuning is accomplished by varying the position of powdered-iron core plugs inserted in the coils of the transformer. The latter method is known as "permeability tuning."

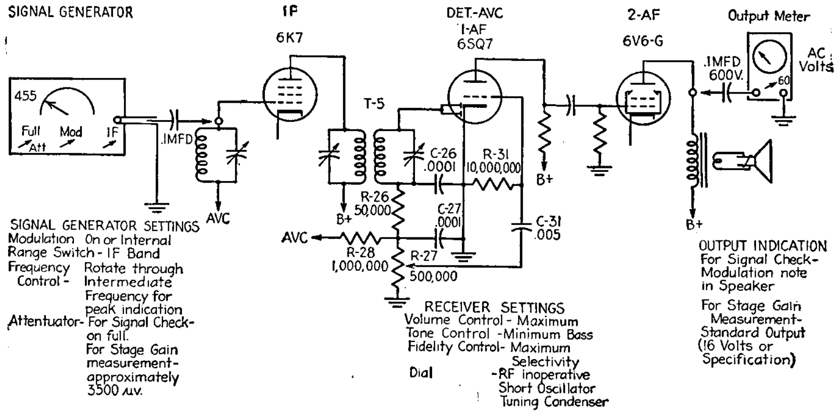


FIG. 12–6.—Signal check and stage-gain measurement connections for the detector and AVC stage.

NORMAL TEST DATA FOR THE DETECTOR AND AVC STAGE

Signal Check.—The input of the detector stage is the IF transformer *T*-5. However, when the stage is checked, the signal generator is connected to the grid of the IF tube, as shown in Fig. 12–6. There are several reasons for this connection:

1. The IF tube is generally a 6K7 with the control-grid connection at the top of the tube and therefore readily available for connection to the signal generator.
2. Since the detector input is the last step in the RF chain, the signal voltage at this point is high, higher than the RF output of most signal generators, and the amplification of the IF tube may be needed to make the signal more easily heard in the speaker.
3. If the added capacity of the signal-generator leads were connected to the IF plate, the normal input of the detector stage, it would seriously detune the primary circuit of *T*-5, making the response broad and possibly at an off-frequency setting.

The 0.1-mfd condenser in the hot lead of the signal generator acts to isolate the signal generator from DC receiver potentials in case the signal input is connected to a plate lead. It is also the standard dummy antenna capacity (coupling device) between the signal generator and the receiver for IF measurements. The output indication is the signal-generator modulation note in the speaker. This can be measured by connecting the output meter (35- to 60-volt AC range of the multimeter with a 0.1-mfd/600-volt condenser in series) from the second AF plate to ground, as was discussed on page 132.

When the signal check is made, it is also wise to check the intermediate frequency of the receiver, which is always listed in the manufacturer's service notes. In modern receivers it is usually 455 kc. For several years, the intermediate frequency chosen by the receiver manufacturers has varied between 450 and 480 kc. In very old receivers intermediate frequencies of 260, 175, and 130 kc have been used. In checking the alignment and operation of the stage, the previous stages of the receiver should be made inoperative. This is done by shorting the oscillator section of the tuning condenser. To determine which of the sections of the gang tuning condenser is the oscillator, the serviceman should trace the circuit; or it is sometimes possible to locate the oscillator section by faster methods. In some receivers, the oscillator rotor plates are smaller than the other rotor plates in the gang condenser. Another method that can be used when the receiver is operating on a station is to touch only the stator plates of the various sections. When the RF and converter sections are touched, there will be little difference observed. When the oscillator section is touched, the added capacity of the body will cause the station to disappear. A short piece of flexible wire with a clip at each end will serve as the short. One end is clipped to either stator terminal lug; the other is clipped to the condenser frame.

To check alignment, the signal-generator dial is rotated through the intermediate frequency, while the output meter reading is observed. The presence of two peaks, broad tuning, too low an output, or the peak at a considerable difference from the specified frequency —all indicate misalignment.

Stage-gain Measurements for the Detector Stage.—When making sensitivity and stage-gain measurements, since it is unlikely that the test oscillator has a calibrated output, the serviceman should run checks on several receivers in perfect condition, as was done for the audio amplifier (see Chap. 11), until he has a basis of comparative data for normal gain to be expected from the stage.

The signal generator, receiver, and output meter are hooked up, as shown in Fig. 12–6. The receiver is adjusted for maximum output as follows: The volume control is set at maximum; the tone control is set at the minimum bass position; the fidelity control (if present) is set for maximum selectivity. The RF portion of the receiver is made inoperative by shorting the oscillator section of the gang variable condenser.

The signal generator is adjusted to give a modulated signal at the intermediate frequency of the receiver. The signal-generator dial is rotated back and forth through the intermediate frequency while the output meter is being watched, and is carefully adjusted for peak deflection. If the output meter deflection goes off scale, the signal input is reduced by adjusting the signal-generator attenuator. After the peak deflection has been obtained, the signal-generator attenuator is further adjusted to give the standard output of 50 mw in the speaker. Standard output corresponds to an output meter reading of 16 volts (see page 131).

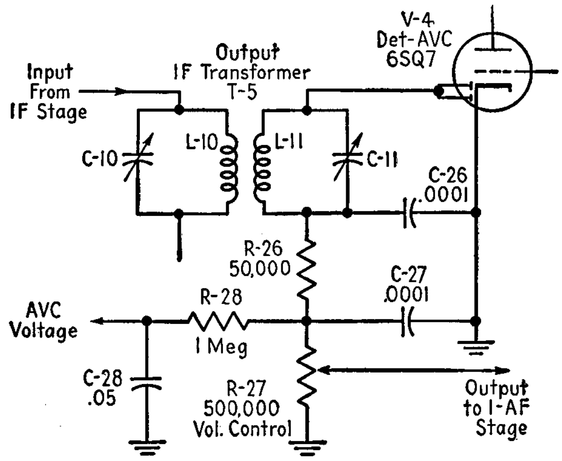


FIG. 12–7.—Typical detector and AVC stage.

The average signal input at the IF grid necessary to give standard output is 3,500 microvolts. The attenuator setting just obtained, therefore, corresponds to 3,500 microvolts. After several perfect receivers have been checked by the above procedure, a reference point corresponding to 3,500 microvolts has been duly established. It would be more important for the serviceman to remember this average attentuator setting for his signal generator rather than the corresponding 3,500 microvolts. For example, if his average attenuator setting turns out to be 50 × 100, or 5,000, he knows that a setting of approximately 5,000 on the attenuator of his signal generator should produce standard output when connected to the IF grid of any receiver. Any substantial variation from his average or normal attentuator setting indicates trouble in the stage.

Normal Voltage Data for the Detector Stage.—The voltages normally present in the detector and AVC stage are the signal voltage and the developed AVC voltage. Normal-voltage data are usually given as an aid in determining the cause of defective operation. Since measurements of these voltages would require expensive equipment and are therefore not easily obtained, normal voltages will not be given, and defects for this stage will be localized by means of resistance measurements.

Standard Circuit for the Detector and AVC Stage.—This is best illustrated by Fig. 12–7.

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

Primary (*L*-10) of output IF transformer (*T*-5)	Iron core Air core	5–15 ohms 30–50 ohms
Secondary (*L*-11) of output IF transformer (*T*-5)	Iron core Air core	5–15 ohms 30–50 ohms
Chassis to diode plates (pin Nos. 4 and 5)		550,000 ohms
Across entire volume control		500,000 ohms
Chassis to AVC bus		1,500,000 ohms

COMMON TROUBLES IN THE DETECTOR AND AVC STAGE

Troubles Common to the Output IF Transformer Assembly.—The trimmer condensers *C*-10 and *C*-11 are parts of the transformer assembly and will be considered with it. From a service standpoint, the trimmer condensers do not often cause difficulty, except in relation to alignment. At worst, they collect dust or a trimmer screw is lost because of careless alignment. The cures for these conditions are obvious. In permeability-tuned transformers, the alignment screws and fixed mica condensers cause even less trouble.

For ease in recognition, the symbol of a permeability-tuned transformer and the illustration of a typical unit are given in Fig. 12–9.

In operation, IF transformers open and cause noisy reception. Should either winding of the transformer open, the receiver would become inoperative. A signal check would locate the stage; a resistance check would show the open winding. Noisy reception, when it is caused by the transformer, is due to corrosion of the fine wire in the windings. A resistance check discloses this condition also, since the resistance of a corroded winding is several hundred ohms instead of the 5 to 50 ohms that the winding should read.

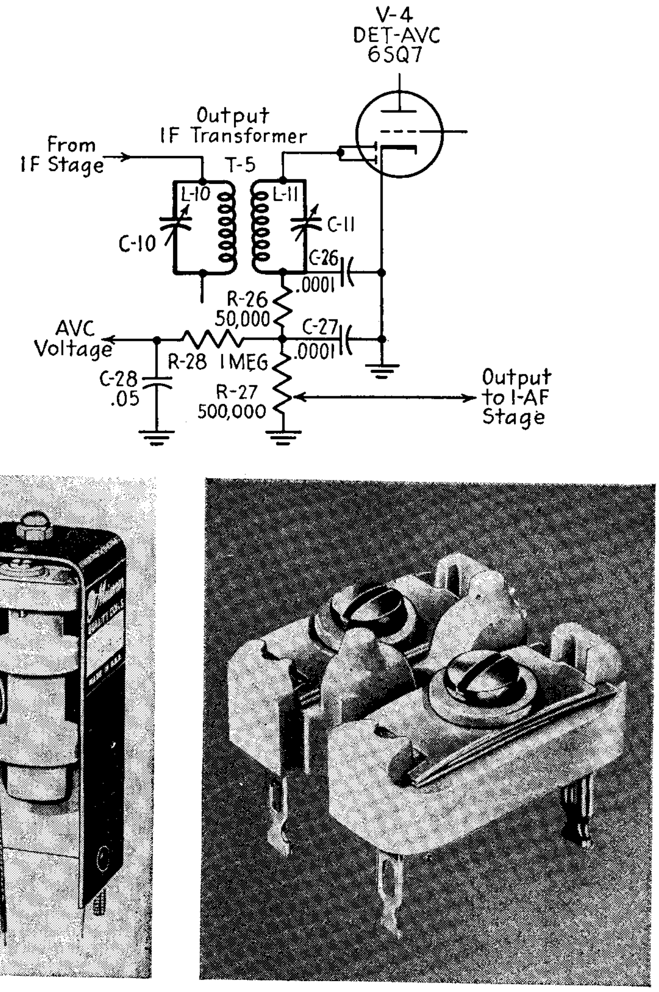
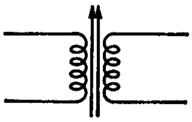


FIG. 12-8.—Typical output IF transformer assembly and its position in the detector stage. Enlarged view of trimmers is shown at lower right.

There is a rather wide divergence in the design of individual IF transformers, and the serviceman should make every effort to secure an original replacement. Where this is impossible, coil manufacturers offer a rather large variety of universal replacement IF transformers. These are listed by the following factors:



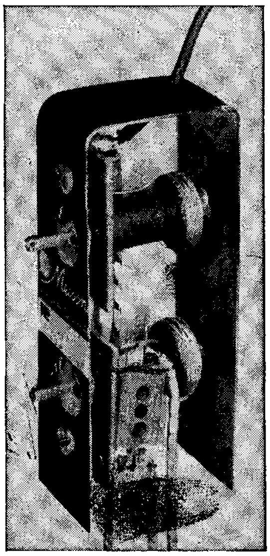


FIG. 12-9.—A permeability-tuned IF transformer.

1. Size of the shield can.
2. Type of core (air or iron).
3. Type of aligning adjustment (trimmer or permeability tuning).
4. IF range of the transformer (scope of trimmer).
5. Type of transformer (input, interstage, output). These are the factors that the serviceman should have in mind when replacing an IF transformer.

Sometimes the IF filter circuit composed of *R*-26, *C*-26, and *C*-27, or part of it, is mounted with the transformer and trimmer assembly inside the shield can. When this is the case and an exact replacement is unobtainable, provision should be made to include the filter circuit in the replacement-transformer shield can.

Replacement IF output transformers are usually color-coded in accordance with the R.M.A. specifications as follows:

Blue	Plate lead
Red	*B* plus lead
Green	Diode plate lead
Black	Diode return

Before removing an IF output transformer for replacement, the serviceman should study the wire dress of the leads, since oscillation can result from incorrectly dressed wiring. If the leads have already been disturbed, the following general notes should be observed. The leads are usually well separated as they come out of the shield can. In the case of a square shield can, the leads come out of the four corners. Before the replacement transformer is mounted, it should be so turned that the blue plate lead points toward the IF tube socket and the green diode plate lead points toward the detector-tube socket. These are the "hot" leads. They should not cross, and they should be dressed close to the chassis and routed directly to their connection terminals.

When the transformer has been replaced, the trimmers should be aligned in accordance with the receiver manufacturer's service notes or the general alignment instructions given in Chap. 22.

Troubles Common to the IF Filter Circuit.—The voltages and currents encountered in this circuit are so small that there is no danger of burned-out resistors and condensers. In addition, condensers *C*-26 and *C*-27 are the molded bakelite type with mica as the dielectric. This type of condenser does not give any trouble from leakage resistance.

Troubles Common to the Volume Control.—The volume control sometimes opens. When this occurs, the receiver becomes inoperative. A signal check will show that the audio amplifier is working but the detector stage is not. A resistance check of the components in the detector stage will confirm the open control.

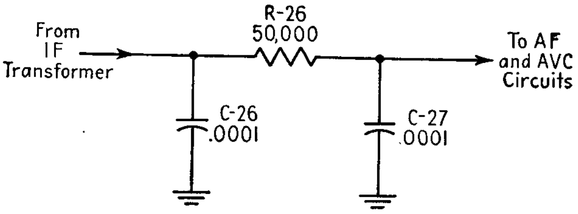


Fig. 12-10.—The IF filter circuit.

The volume control is also part of the audio amplifier. Replacement notes on the volume control are found on page 136.

Troubles Common to the Detector Tube.—The tube is the most likely source of trouble in the stage. A defective tube may cause hum, no signal, weak signal, or distortion. When checking for these symptoms, substitute a similar tube known to be good. In the case of a multiunit tube like the 6SQ7, which combines both the detector and the first AF functions, there is a possibility that the AF portion operates normally but that the detector does not. The serviceman should not assume that the tube is good because it shows normal operation as an audio amplifier.

Troubles Common to the AVC Filter and Decouplers.—Figure 12-11 illustrates the AVC circuit and shows it connected to the RF, converter, and IF stages. Resistor *R*-28 and condenser *C*-28 make up the AVC filter described previously.

Strictly speaking, the purpose of the AVC circuit is to develop a biasing voltage, and it would seem best to test it by means of a voltage test. However, such a measurement would require a vacuum-tube voltmeter, since the instrument would be across a low-voltage high-impedance circuit. It would also require an accurately calibrated attenuator on the signal generator, and too often it is not accurate. Therefore, analysis of troubles in the AVC circuit will be made from the symptoms encountered.

Resistor *R*-28, being one of high resistance, may have a tendency to open. If it does so, the receiver will become inoperative and may develop hum because the grid returns to ground of the associated tubes will be open. Replace the resistor with one of similar value.

The AVC filter condenser *C*-28 may open or become leaky. If it opens, the signal will become weak and oscillation may result. This condition would be found in a signal check of the IF stage. The gain of this stage would be abnormally low. Also, the IF tuning would be very broad and possibly off true frequency, with adjustments of trimmer condenser *C*-9 ineffective.

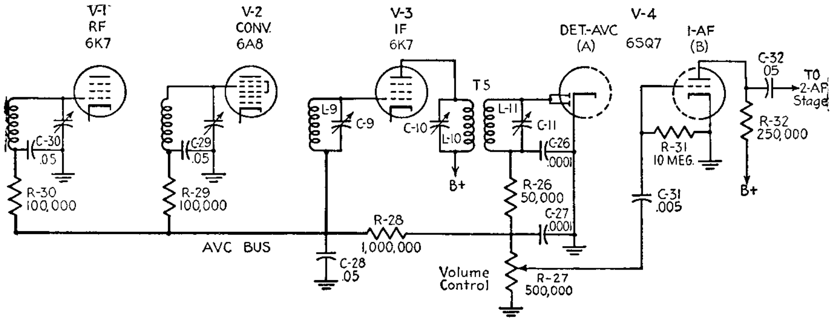


FIG. 12-11.—The AVC circuit.

If condenser *C*-28 becomes leaky, the AVC voltage would drop to an extent dependent on the resistance of the leak. This would result in insufficient bias to handle a strong signal. As a result, the receiver would overload and distort on strong local stations. Reducing the setting of the manual volume control would have little effect on this distortion. Whether the condenser is open or leaky, confirmation of the condition would be obtained by substituting a similar condenser that is known to be good. If the trouble disappears, the condenser was defective. In replacing *C*-28, the serviceman should be careful to use the same capacity value as the original condenser. Even though the voltage across it is quite low, it is advisable to use a condenser of high voltage rating so that the leakage resistance will be quite large.

Associated with the AVC circuit are the decouplers, *C*-29 and *R*-29 for the converter and *C*-30 and *R*-30 for the RF stage. As a rule, the resistors cause little trouble and are therefore of little consequence to the serviceman. However, condensers *C*-29 and *C*-30 can cause trouble. If either one opens, reception would be very weak. This condition would be confirmed with a signal check when their respective trimmer condensers would not produce a peak. Condenser *C*-30 is a particularly odd one. When it opens, the tuning circuit in the RF stage becomes inoperative, with a resulting drop in signal output. At the same time the loss of signal in the RF stage causes the AVC voltage to drop, resulting in high sensitivity so that the noise level goes up. The receiver sounds exceptionally lively even though strong local stations come in as weak ones do when the receiver is normal.

Condensers *C*-29 and *C*-30 may become leaky. When this is the condition, the developed AVC voltage will be low and the receiver will overload and distort. If the external antenna (when used) is disconnected and the sound of the receiver improves, the serviceman should hunt for leaky condensers.

VARIATIONS IN DETECTOR AND AVC STAGE

Use of Electron-ray Tuning Indicator.—Unless the superheterodyne receiver is tuned exactly to a station, serious distortion due to side-band cutting may result. Many receivers use some form of tuning indicator as an aid in tuning correctly, so as to avoid this distortion. The tuning indicator in most general use in modern receivers is an electron-ray (often called a "magic eye") tube like the 6U5/6G5. This is a cathode-ray tube which shows a wide deflection when a low voltage is applied to its grid. The deflection narrows as the applied grid voltage is increased. The magic-eye grid is connected to the AVC bus as shown in Fig. 12–12. At no signal, the AVC voltage is zero and the deflection is wide; as a signal is tuned in, the AVC voltage increases and the deflection narrows. When the signal is tuned accurately, the AVC voltage is at a maximum and the deflection is at its narrowest. To tune any station accurately, simply tune the receiver for the narrowest deflection of the magic-eye tube.

Since this tube must be located on the front panel of the receiver, its socket is not on the chassis. The tube is usually supported in position by a clamp, with a cable of connecting leads running down to the chassis.

Resistor *R*-128 is a 1-megohm/¼-watt resistor. In an AC/DC receiver, it is a ½-megohm/¼-watt resistor. In either case, it is usually located inside of the tube socket.

From a service point of view, the magic-eye tube adds few complications. All checks and tests are the same as for the standard receiver. If the tube does not glow, a new tube is needed; if the tube glows but the deflection does not change as stations are tuned in, and if the receiver operation is normal in all other respects, *R*-128 is probably open. To change *R*-128, the tube socket must be opened.

A receiver equipped with an electron-ray tube has a virtual vacuum-tube voltmeter already connected to the output of the RF and IF stages. It can be used as an indication of the AVC voltage and as an output meter for alignment purposes.

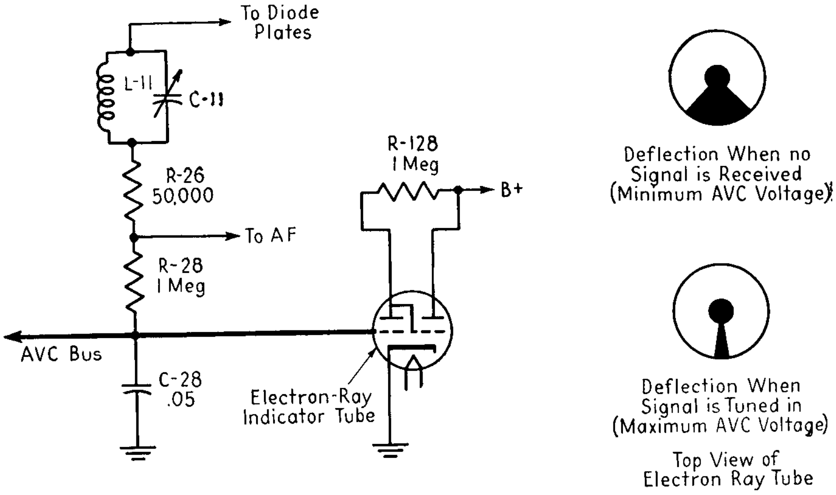


FIG. 12-12.—Electron-ray tube connected to the AVC bus as a tuning indicator.

Delayed AVC.—The standard circuit of the detector and AVC stage furnishes a type of control known as "simple AVC." Some receivers use a modified circuit known as "delayed AVC," shown in Fig. 12-13.

The diode plates are separated, and one is used for the detector function while the other develops the AVC voltage. In simple AVC circuits, all signals—even weak ones—will develop AVC bias voltage. As a result, all signals will reduce the gain of the RF and IF stages. Since weak signals require all available gain, the reduction of gain for weak signals is undesirable. In delayed AVC (DAVC), a negative delay voltage of about 2 to 3 volts is fed through resistor *R*-128 to the AVC diode plate of the tube. This fixed voltage is obtained from a tap at the proper point on the *C* voltage divider *R*-115/*R*-116 (see Fig. 8-21).

Part of the signal energy from the secondary of the IF transformer is coupled through condenser *C*-110 to the AVC plate. This plate is maintained at a small negative voltage, referred to above, which prevents it from rectifying and developing the AVC voltage until the peak voltage coupled to it through *C*-110 overbalances the negative voltage of this diode. When the signal is weak, enough voltage is not developed on the AVC diode plate to overcome the existing negative potential. No AVC voltage is developed, and the gain of the RF

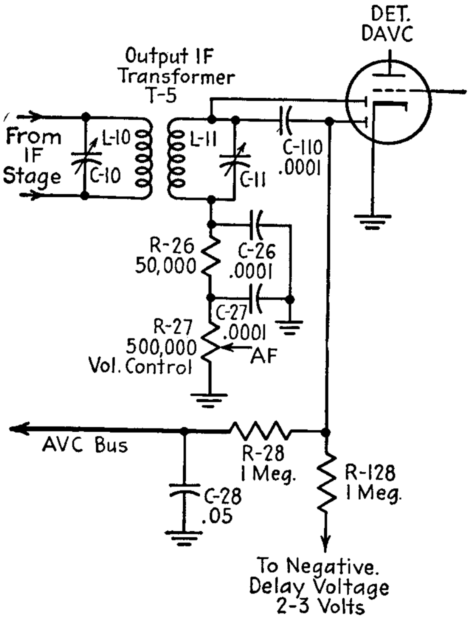


FIG. 12-13.—Delayed AVC circuit.

and IF stages remains the same as if AVC were not being used. But when strong signals are received, enough voltage will be coupled to the AVC diode to overcome the small negative plate potential and produce an AVC voltage drop across resistor *R*-128.

From the serviceman's point of view, operation of the DAVC stage and testing of components is the same as for the simple AVC circuit of the standard receiver.

Figure 12-14 is the schematic diagram of a receiver with a DAVC circuit. Note the following conditions. The delay voltage is developed across resistor (52) in the *C* voltage divider in the power supply and is applied through resistors (36) and (34) to the AVC diode plate of the 7C6 detector tube. Resistor (35) and condenser (20) form the filter circuit and carry the AVC voltage to the first

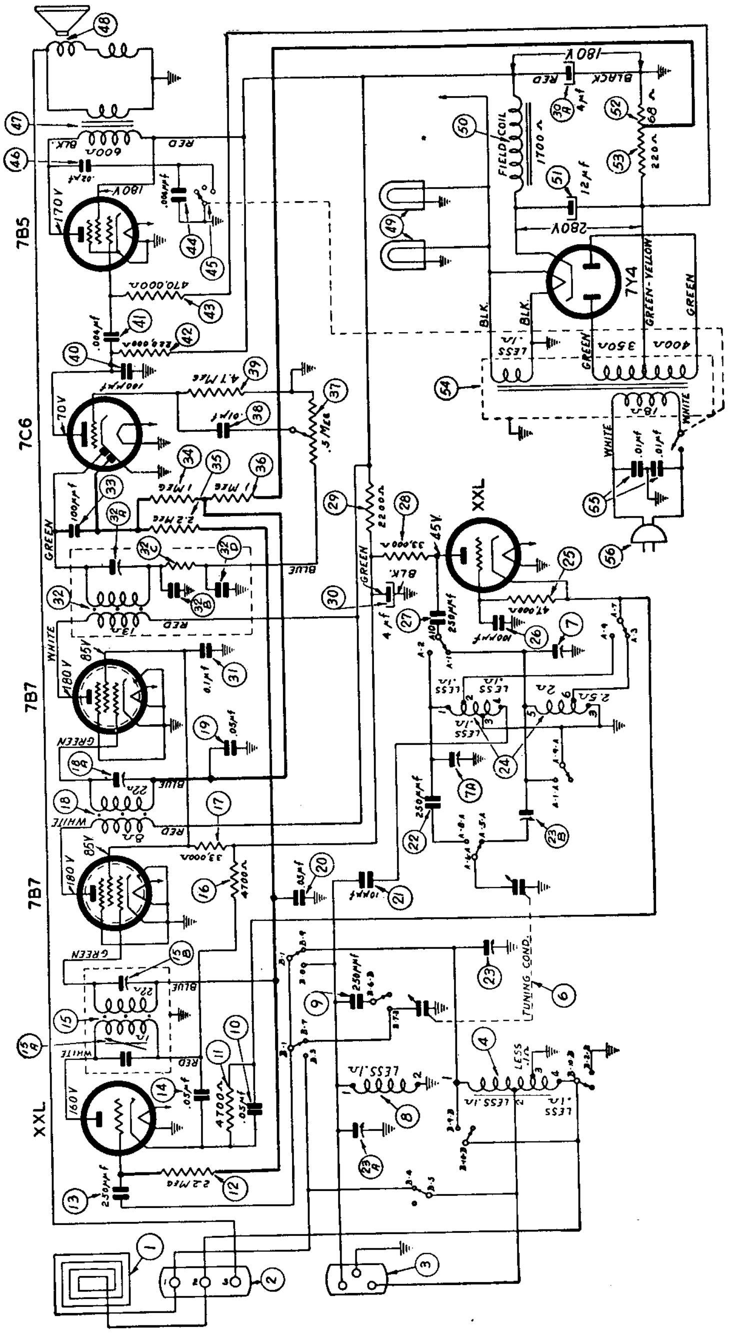


FIG. 12-14.—Philco Model 42-340 receiver. The DAVC circuit is shown in heavy lines.

IF and mixer stages. The second IF stage is fed a lower AVC voltage from the center tap of resistors (34) and (36). Condenser (19) filters this circuit. The 455-kc filter (part numbers 32B, 32C, and 32D) in the conventional detector circuit is enclosed in the IF transformer assembly (32).

Radio-phonograph Operation.—Many receivers are equipped with a phonograph in a radio-phonograph combination. Or the receiver may come equipped with a phonograph switch and input jack so that the phonograph turntable and pickup unit may be added when desired. The phonograph will utilize only an audio amplifier and therefore will use only the audio stages and speaker of the receiver. At such time, it would be undesirable to have the RF portion of the receiver in an operating condition. Therefore, a switch is used to block the radio signals from entering the audio stages. Likewise, when radio signals are being received, it is desirable that the phonograph pickup be disconnected from the audio stages. The setup is shown in the block diagram of Fig. 12–15, together with a simplified switching arrangement. The switch is shown in the RADIO (*R*) position used for the reception of radio signals.

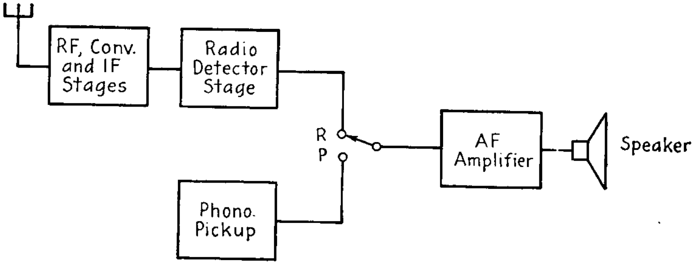


FIG. 12–15.—Block diagram of radio-phonograph operation.

The switching is usually arranged in the coupling between the detector and AF stages before the volume control so that the latter is operative for either the radio or the phonograph. A typical radio-phonograph switch hookup is shown in Fig. 12–16.

The switch is shown in the RADIO (*R*) position which is normal operation for the receiver. When the switch is changed to the PHONOGRAPH (*P*) position, the pickup feeds the audio amplifier through the volume control. Since some radio signals may leak through the switch and spoil the phonograph reception, provision is made to kill the radio when the switch is in the phonograph position. This is accomplished by opening the cathode, screen, or plate circuits of one or more of the tubes in the RF section of the receiver. The lower half of the double-pole switch in Fig. 12–16 opens the plate circuit of the IF tube when the switch is adjusted for phonograph operation.

The radio-phonograph switch is sometimes combined with other functions, making the switching arrangement somewhat complicated. As radiomen must service, replace, and sometimes design switching circuits, an example of a rather elaborate switching arrangement is chosen for detailed study.

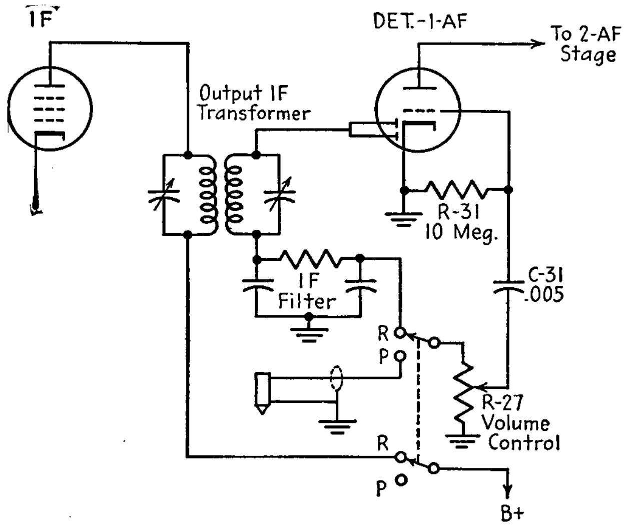


FIG. 12–16.—Typical radio-phonograph switching circuit.

The radio-phonograph combination of Fig. 12–17 combines the on-off switch, the phonograph-motor switch, and the tone control with the radio-phonograph switch. The switch used is of the 5-point, 2-gang wafer type. The front-panel view of the switch is shown below the wafers in the schematic diagram. The operation of the switch can be analyzed by a study of the diagram and the following table.

Switch positions as marked on the front panel:

1. OFF
2. RADIO MINIMUM HIGH (bass)
3. RADIO MAXIMUM HIGH (treble)
4. PHONOGRAPH MINIMUM HIGH
5. PHONOGRAPH MAXIMUM HIGH

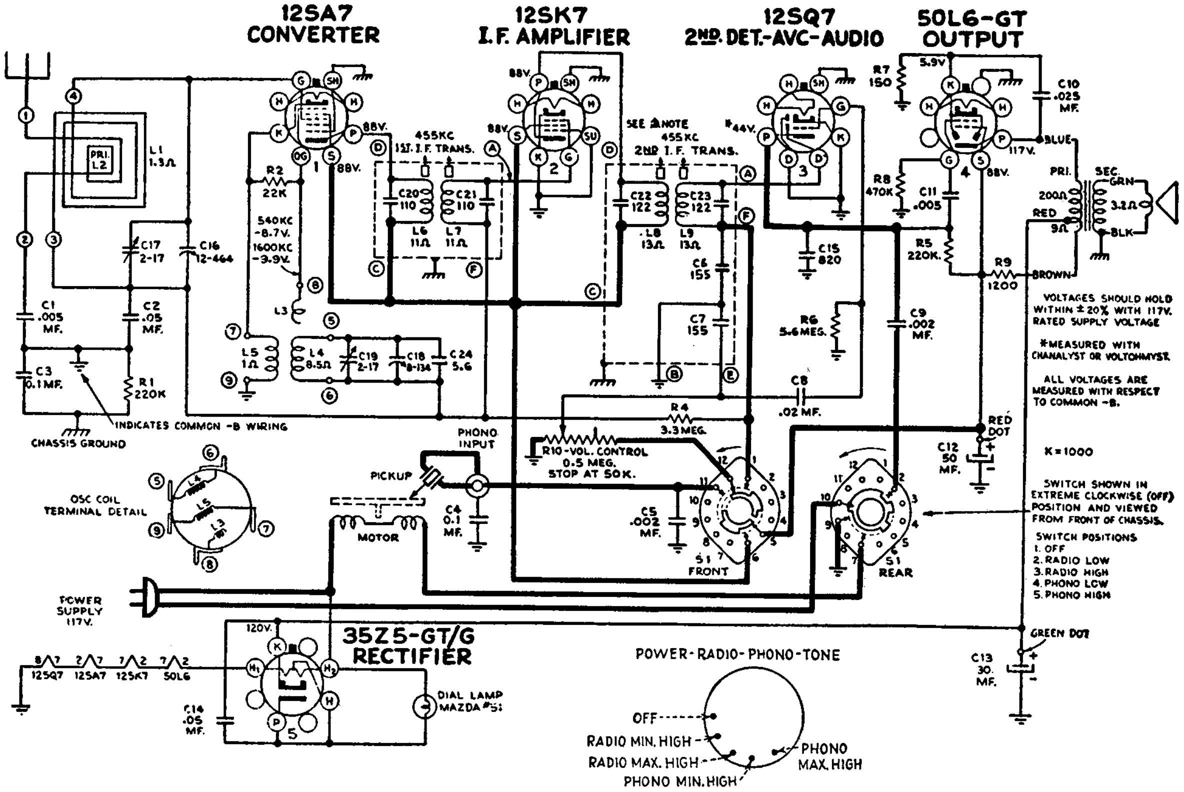


FIG. 12-17.—RCA Victor 55U radio-phonograph combination. The radio-phonograph switching is shownin heavy lines.

Rear wafer terminal connections:

Terminal 10 is connected to the line cord.
Terminal 9 is connected to the common negative.
Terminal 7 is connected to the phonograph motor.
Terminal 2 is connected through the tone-control condenser *C*-9 to the first AF plate.

Front wafer terminal connections:

Terminal 12 is connected to the volume control (input of the audio amplifier).
Terminal 1 is connected to the audio output of the detector diode.
Terminal 11 is connected to the phonograph input jack.
Terminal 5 is connected to *B* plus.
Terminal 6 is connected to the plate and screen circuits of the IF and converter tubes.

The switch is shown in the OFF position. When it is turned to the next position, the rotating arms move one position in the direction of the arrows on the diagram.

Position 1. OFF.

Position 2. RADIO MINIMUM HIGH (bass).

Rear wafer:

Terminal 10 contacts 9.	Power is fed into the radio.
Terminal 2 contacts 9.	Tone condenser *C*-9 is shunted across the output of the first AF tube.

Front wafer:

Terminal 12 contacts 1.	Receiver RF section is connected to the audio amplifier.
Terminal 5 contacts 6.	*B* plus is connected to the IF and converter tubes.

Position 3. RADIO MAXIMUM HIGH (treble).

Rear wafer:

Terminal 10 still contacts 9.	Power connected to radio.
Terminal 2 is open.	Tone condenser *C*-9 is open.

Front wafer:

Terminal 1 still contacts 12.	Radio remains connected to audio amplifier.
Terminal 5 still contacts 6.	*B* plus remains connected to converter and IF tubes.

Position 4. PHONOGRAPH MINIMUM HIGH.

Rear wafer:

Terminal 10 still contacts 9.	Power connected to radio.
Terminal 10 also contacts 7.	Power connected to phonograph motor.
Terminal 2 contacts 9.	Tone condenser *C*-9 is shunted across the first AF output.

Front wafer:

Terminal 1 is open	Receiver RF section is disconnected from the audio amplifier.
Terminal 12 contacts 11.	The audio amplifier is connected to the phonograph input jack.
Terminal 5 is open.	*B* plus is disconnected from the IF and converter tubes.

Position 5. PHONOGRAPH MAXIMUM HIGH.

Rear wafer:	
Terminals 10, 9, and 7 in contact.	Power is connected to the radio and phonograph motor.
Terminal 2 is open.	Tone condenser C-9 is open.
Front wafer:	
Terminal 12 still contacts 11.	The audio amplifier remains connected to the phonograph input jack.
Terminal 5 is still open.	B plus remains disconnected from the IF and converter tubes.

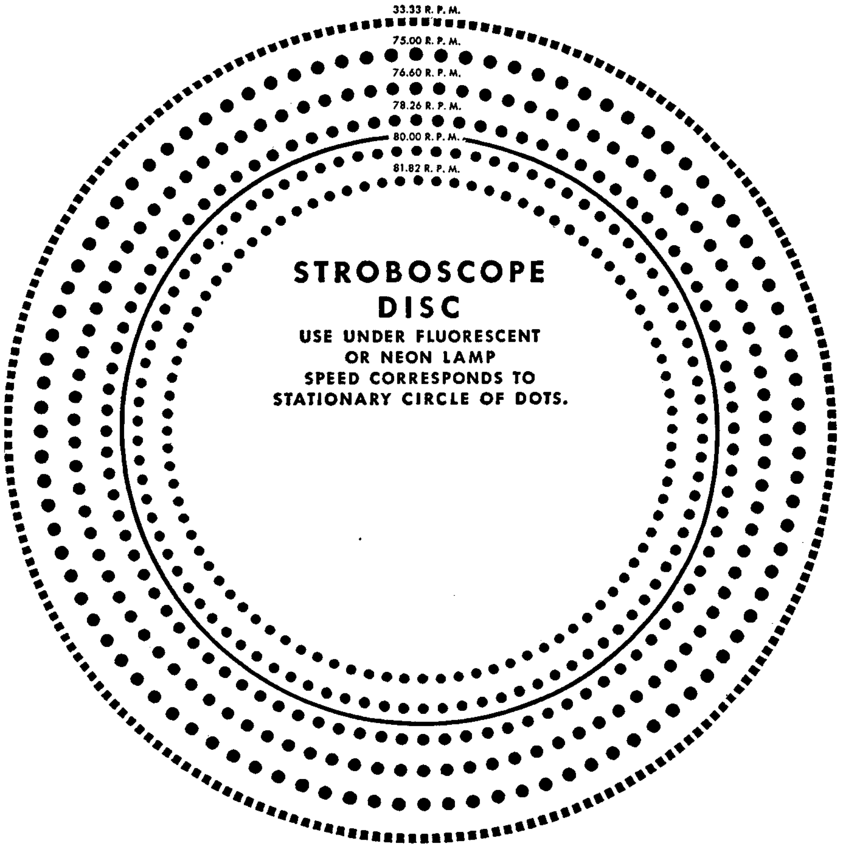


FIG. 12-18.—Stroboscope disk used in regulating speed of phonograph motors.

Troubles Common to Radio-phonograph Combinations.—Radio-phonograph considerations present two main problems to the serviceman: the servicing of radio-phonograph combinations, and the rewiring of existing straight radios so that they may be used to play records through the radio loudspeaker. In the servicing category are troubles with the motor, the pickup, the wiring, and the switches.

The servicing of phonograph motors and record changers is a field in itself and lies outside the scope of this book. The radio serviceman, however, should be able to check a motor for proper operation and to make a proper installation of a replacement unit, as well as minor repairs.

Phonograph-motor Maintenance Notes.—When a phonograph motor fails to operate, the line switch and wiring should be checked before condemning the motor. If the turntable speed is incorrect, the tone quality of the recording will suffer. The speed can be checked by means of a stroboscope disk, such as the one shown in Fig. 12–18. The turntable is operated under a single fluorescent or neon lamp. One of the circles of dots will appear to stand still. Reference to the number above the stationary circle of dots will give the number of revolutions per minute (rpm) of the turntable. Most recordings are designed to operate at a turntable speed of 78.26 rpm. The stroboscope disk of Fig. 12–18 has a solid line under the row of dots which corresponds to 78.26 rpm for easy identification. If the turntable has a speed adjustment, it may be properly set with the aid of the disk.

If the proper circle of dots remains stationary for the most part but shows a periodic jump for some of the dots, erratic action of the motor or drive mechanism is indicated. A worn spot on a rubber-rim friction-drive wheel could cause such an effect.

When the phonograph motor is supplied with oil cups, they should be filled with light machine oil. In lubricating a motor, the serviceman should be careful that oil is not smeared on the motor spindle or the rubber-tired drive wheel of a rim-drive motor (see Fig. 12–19). These should be washed with carbon tetrachloride to remove any oil or grease. The same applies to the inner rim of the turntable.

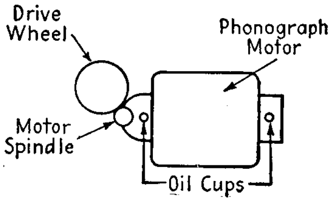


FIG. 12-19.—Rim-drive phonograph motor, showing location of oil cups.

The phonograph motor and turntable should float freely on rubber or springs. In some cases the motor mounting is floating; in others, it is solid and the entire motor board is floated. Figure 12–20 shows the mounting details for a typical phonograph motor.

In case the spring or rubber suspension is inadequate, rumble might ensue. This is particularly important in combinations where the phonograph motor and speaker are housed in the same cabinet.

The rumble is caused by a sort of mechanical feedback between the speaker and the pickup. Speaker vibrations cause the turntable and the pickup to vibrate. The vibration is in turn amplified and builds up the rumble.

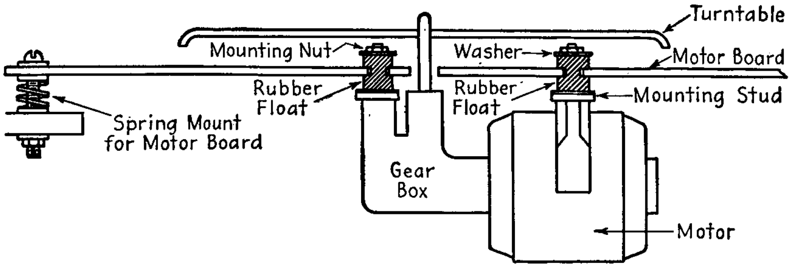


FIG. 12-20.—Phonograph-motor board assembly, showing rubber suspension mounting for the motor and spring mounting for the motor board.

Troubles Common to Radio-phonograph Switches.—Radio-phonograph switches are subject to erratic action due to dirt between the contacts. This is almost always the case when it is necessary to flip the switch two or three times before positive contact takes place.

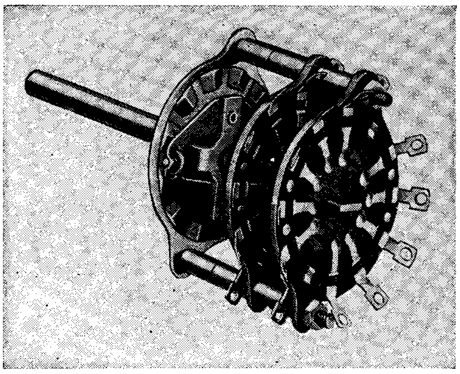


FIG. 12-21.—Typical wafer-type switch used for radio-phonograph switching.

A cleaning with carbon tetrachloride usually takes care of this difficulty. The usual procedure is to wet the switch arms and contacts with the carbon tetrachloride and then rotate the switch quickly. The procedure may be repeated if necessary.

Sometimes a switch contact or the entire assembly becomes broken with use. When this happens, the switch must be replaced. Owing to the large variety in radio-phonograph switches, it is essential that one similar to the original switch be obtained. In replacing the switch, considerable care must be exercised to make sure that the wiring is correct and that the heat of the soldering iron does not draw the temper from the spring contacts. For correct wiring on an identical switch, it would be best to remove the old switch with its wiring intact, install the new one, and then change the wires, one at a time.

In soldering the switch terminals, it would be best to solder "uphill" where possible, so that the solder or resin does not roll down to the switch contact. Production speed soldering will not draw the temper from the spring contacts. In this method of soldering, the resin-core solder is applied to the joint first, as shown in Fig. 12–22. Then the iron tip is pressed to both the joint and the solder. This makes a fast, clean joint that will not heat the contact unduly.

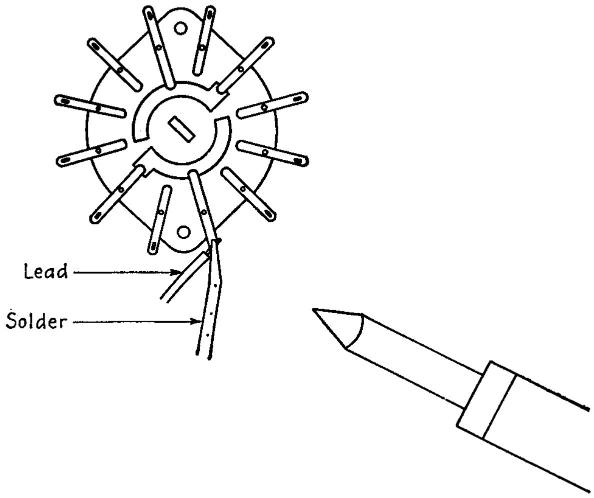


FIG. 12–22.—Method of applying solder when speed-soldering wafer-type switch connections.

When an original replacement switch is unobtainable, the serviceman must exercise his ingenuity to perform the operations of the original radio-phonograph switch with whatever standard switch is available and will fit the space requirement. For an extreme example, assume a defective radio-phonograph switch in the receiver of Fig. 12–17 and that an original replacement is unobtainable. A two-deck, four-arm, five-position switch could be substituted in accordance with the diagram of Fig. 12–23.

The front wafer takes care of the radio-phonograph switching. The top half of the rear wafer takes care of the tone-control circuit. The bottom half of the rear wafer is the on-off switch for the radio. Switching the phonograph motor on and off cannot be done with the same switch. An auxiliary switch mounted on the motor board of the phonograph takes care of this function.

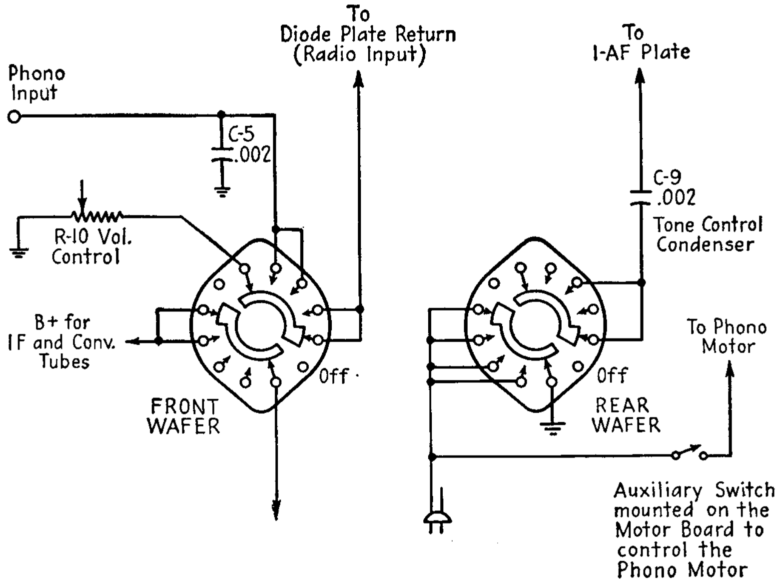


FIG. 12-23.—Alternate radio-phonograph switching circuit for the receiver of Fig. 12-17.

Troubles Common to the Pickup Unit.—Most pickups in common use are of the crystal type. These develop troubles of no output, weak output, and distorted output. A good indication as to whether the pickup is at fault is to check the operation of the radio. If the tone quality and volume of the radio half of the combination are normal, the trouble lies in the phonograph unit, since the audio amplifier and speaker operate on both.

No output from the pickup might also be caused by a defect in the radio-phonograph switch or phonograph wiring. The switch operation may be checked by reference to the schematic diagram, visual inspection, and an ohmmeter. The wiring usually consists of shielded flexible leads, which may break, or the shielding may short through the insulation to the wire. In either case a visual inspection and an ohmmeter will check the wiring. The wiring is particularly vulnerable to defects near the point where it goes through the swivel of the pickup arm. A procedure for replacing shielded wiring is given in Fig. 11–18.

The best check to determine whether the pickup is operating properly is to substitute another crystal unit known to be in good condition. The test pickup should be temporarily connected to the handiest soldering lugs on the pickup line, and its operation should be tried on a record.

When a pickup unit is replaced, a replacement crystal cartridge is often obtainable. This should be the same as the original in weight, mounting details, and output. Where a new cartridge cannot be obtained, the entire pickup unit must be replaced. Again it is preferable to replace with one similar to the original unit. In cases where a different pickup unit must be used, an important detail in making the replacement is to place the arm so that the needle will describe approximately the same arc across the record as was done by the original. For example, when replacing the pickup of Fig. 12–25, a replacement with a longer arm will describe a different needle arc than the original, if the replacement is mounted in the same hole. Moving the replacement pickup farther back will allow the needle to describe more nearly the same arc across the record. Readjusting the rest to accommodate the new pickup is also a matter of importance, since carelessness in this item may result in the new crystal being jarred and ruined.

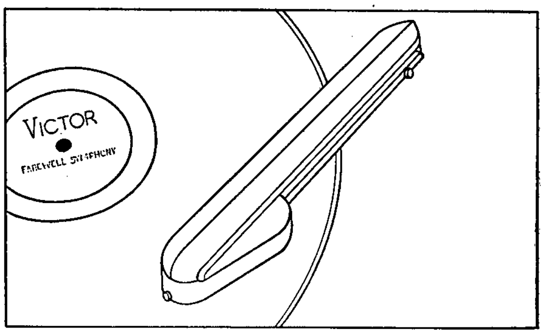


FIG. 12–24.—Typical phonograph pickup unit.

Rewiring Radios for Phonograph Operation.—The serviceman is often called upon to rewire an existing radio so that it may be used to reproduce recordings. When this is done, it would be wise to refer to the appropriate diagram manuals to see if the manufacturer also made a radio-phonograph combination similar to the radio being rewired. If such a diagram can be found, there will be several distinct advantages. In the first place, a diagram known to be satisfactory is available. Then also, the exact switches and outlets are often procurable as replacement parts. Finally, since the chassis are often stamped alike for both models, there may be unused chassis holes or knockouts to accommodate the parts that must be added. Such a procedure may mean drilling a hole in the front panel of the cabinet to accommodate the radio-phonograph switch, but this is best in any case. The switch should be readily accessible, and a workmanlike job on the front panel with a knob to match the others is far more desirable to the owner of the radio than the makeshift arrangement of a switch screwed to the back of the cabinet or dangling from wires.

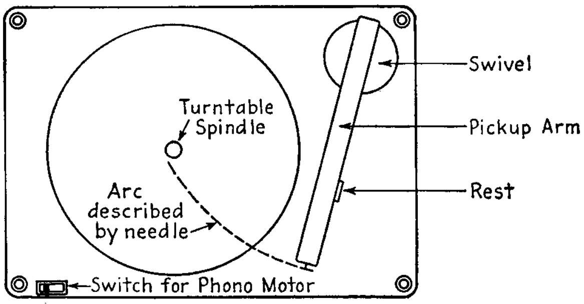


FIG. 12-25.—Top view of phonograph-motor board.

The radio-phonograph service notes may even include a picture diagram, which would solve the problem of correct lead dress. Where this is not the case, the serviceman should remember that the pickup wiring is in the input circuit of the audio amplifier and that any coupling with other wiring may cause hum and oscillation. The wiring should be shielded and dressed close to the chassis and away from all other wiring.

In cases where a diagram of a radio-phonograph combination similar to the radio being rewired cannot be found, the serviceman must make up his own. This is not very difficult for modern superheterodyne receivers, since audio amplifiers usually follow a similar pattern of two stages of AF amplification with varying amounts of undistorted power output. The serviceman simply follows general principles; that is, he incorporates a switch that connects either the detector output or the pickup output to the input circuit of the audio amplifier. At the same time, the phonograph position of the switch breaks the plate, screen, or cathode circuit of the converter or IF tubes, so that the radio is completely inoperative when recordings are being reproduced. If possible, the switch will be mounted on the front panel of the radio, and the general instructions regarding lead dress and working with shielded wire will be followed.

As a concrete example, if the receiver of Fig. 12–14 were to be rewired for phonograph operation, the serviceman might make up a circuit similar to Fig. 12–26. The phonograph motor is operated from a switch on the motor board, as shown in Fig. 12–25.

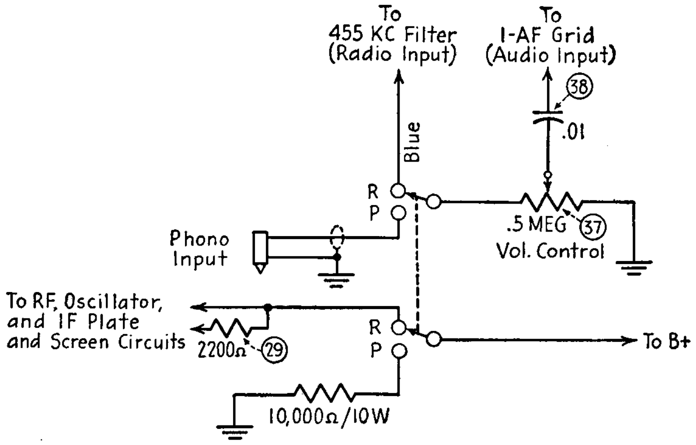


Fig. 12–26.—Adding a radio-phonograph switching circuit to the receiver of Fig. 12–14.

Since this is a fixed-bias circuit, opening the plate circuits of the RF tubes will cause the total *B* current to drop, changing the voltage across resistors (52) and (53) in the fixed-bias circuit. This may seriously affect the tone quality in the phonograph position. The resistor marked 10,000 OHMS/10 WATTS has been added to replace the load of the tubes in the RF portion of the receiver. The serviceman should try several values for this resistor, using the one that shows no change in the bias voltage across resistors (52) and (53) in either position of the phonograph switch.

The above precaution need not be taken in the case of a circuit using self-bias circuits, unless it is felt that the decreased *B* loading on phonograph operation will reduce the magnetizing current through the speaker field.

Sometimes the rewiring job includes mounting the phonograph unit in an existing cabinet. In this case, the serviceman makes up a motor board similar to the typical mounting shown in Fig. 12–25. In laying out the motor board, he should remember to center the turntable spindle so that 12-in. records can be accommodated without chopping holes in the cabinet. The pickup often includes mounting instructions relating to the proper arc that the needle should describe on the record. If no instructions are included, the arc shown in Fig. 12-25, where the needle extends just beyond the turntable spindle, is about average for most installations. The motor or motor-board suspension is important for the reduction of rumble. Lining the phonograph compartment with felt may also help in this regard.

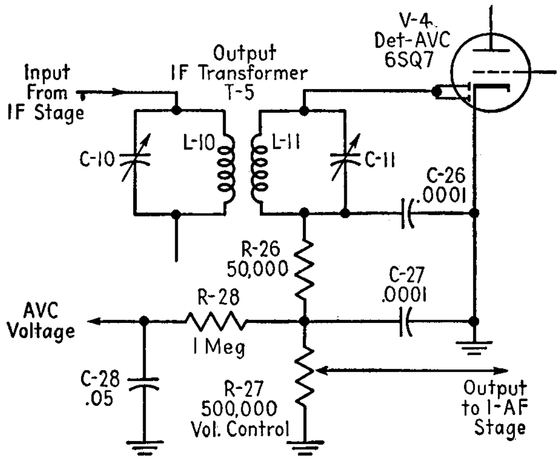
SUMMARY

Quick check for normal operation of the detector and AVC stage.

The signal generator is adjusted for a modulated output at the receiver intermediate frequency and its output is applied to the grid of the IF tube. When the stage is functioning properly, the modulation note will be heard in the speaker.

Diagram of standard detector and AVC stage.

A diagram of standard detector and AVC stages is given in the accompanying figure.



Resistance data.

These data are given in the accompanying table.

Primary of output IF transformer	Iron core	5–15 ohms
	Air core	30–50 ohms
Secondary of output IF transformer	Iron core	5–15 ohms
	Air core	30–50 ohms
Chassis to diode plates	....	550,000 ohms
Across entire volume control	....	500,000 ohms
Chassis to AVC bus	....	1,500,000 ohms

SERVICE DATA CHART

Assume an inoperative detector stage, as shown by normal response when an AF test signal is applied to the ungrounded end of the volume control, and no response when a modulated test signal at the intermediate frequency is applied to the IF grid.

Step	Check	Response	Trouble
1	Advance the signal-generator attenuator and rotate the dial through the intermediate frequency	The modulation note is heard at an off-frequency setting	The IF transformer is out of alignment
		The modulation note is not heard	Proceed to step 2
2	Apply the IF test signal to the IF plate. Rotate the signal-generator dial and advance the attenuator to full output	The modulation note is heard in the speaker	The trouble is in the IF tube or its supply voltages. See Chap. 13 on the IF stage
		The modulation note is not heard	Defective tube. Substitute a detector tube known to be good. The trouble may be an open IF transformer winding, a shorted trimmer condenser, etc. Make a resistance check of all components in the stage

SERVICE DATA CHART FOR OTHER SYMPTOMS

Symptom	Abnormal reading	Look for
Hum		Defective detector tube. Substitute a good one. Poorly dressed leads in the diode plate and plate return circuits. Open wiring or shielding in the phonograph section
Weak reception and oscillation	If equipped with an electron-ray tuning-indicator tube, the eye will not close fully	Incorrect alignment. Open AVC by-pass condensers *C*-28, *C*-29, and *C*-30
Distortion on strong signals		Leaky AVC by-pass condensers *C*-28, *C*-29, and *C*-30

QUESTIONS

1. A dead AC receiver gives a normal response when checking the AF stages but gives no response when a test signal at the proper intermediate frequency is applied to the IF grid. Outline a service procedure to be followed in finding the cause of the trouble.

2. List the likely sources of trouble that will cause a receiver to give no response when an IF test signal is applied to the IF plate and normal response when an AF test signal is applied to the "hot" end of the volume control.

3. A radio-phonograph combination has a distorted output when it is tuned to local stations. The tone quality is normal when it plays phonograph recordings. Would you check the audio stages for the trouble? Why? What is likely to be wrong? How would you prove it?

4. When a receiver with weak reception is checked, it is noted that the trimmer across the input IF secondary has no effect on the output. What circumstances can cause this condition? How would you check for each?

5. Which components in the detector stage may cause hum? How would you check each?

6. The receiver of Fig. 12–7 has a defective phonograph-radio switch. An exact replacement is not obtainable. The customer indicates a desire to have the phonograph motor operated from the phonograph-radio switch and, since he always uses his radio in the position of maximum high, he is not interested in the tone control. Redraw the diagram of Fig. 12–23 to meet these conditions.

7. It is desired to rewire the receiver of Fig. 10–13 for phonograph operation. Design a circuit for the necessary rewiring. Include provision for the radio-phonograph switch to make the radio inoperative in the phonograph position.

8. After the rewiring of the receiver of question 7, it is found that the tone on phonograph operation is poor. Radio operation is normal, and the pickup is not at fault since the test pickup gives the same results. When the receiver is checked with the bench (P-M) test speaker, operation is normal for both the radio and phonograph. This indicates insufficient magnetizing current through the field coil of the radio loudspeaker. What circuit rearrangement would you advise to overcome this condition?

9. What precautions in regard to lead dress should be taken when replacing an output IF transformer? What conditions might result from improper lead dress?

10. A receiver equipped with an electron-ray tuning-indicator tube operates normally, but the magic-eye tube deflection does not change as stations are tuned in. What is likely to be wrong and how can it be checked?

11. A radio-phonograph combination has poor tone on phonograph and normal tone on radio operation. What factors can cause this condition? How can you check for each?

12. A radio is brought in with a complaint that reception is weak. The serviceman also notices that the noise level is high. What is likely to be wrong? How can this condition be checked?

CHAPTER 13

IF AMPLIFIER STAGE

Quick Check.—If a modulated signal at the intermediate frequency is applied to the signal grid of the converter tube and the modulation note is heard in the speaker, the IF stage is probably functioning, and the serviceman proceeds to check the next stage.

Function of the IF Stage—The input IF transformer couples the IF stage to the previous converter. The output IF transformer couples the IF stage to the succeeding detector stage. The signal at the input of the stage contains components at the oscillator frequency, the received signal frequency with its modulation, and sum and difference values of these two frequencies with the same modulation as the signal. The signal at the output of the stage should be at the difference or intermediate frequency and will also contain the modulation component of the original signal. The function of the IF stage, therefore, is to tune and amplify at the intermediate frequency.

THEORY OF OPERATION

Standard Circuit.—This is illustrated by Fig. 13–1.

Functions and Values of Component Parts.—The tuning function of the IF amplifier is accomplished by the action of the four tuned circuits of the input and output transformers: *L*-8 and *C*-8, *L*-9 and *C*-9, *L*-10 and *C*-10, and *L*-11 and *C*-11. All are tuned sharply to the intermediate frequency, and the four tuned circuits make possible the well-known selectivity of the superheterodyne receiver.

The amplification function of the IF amplifier is dependent on two factors: the design of the transformers *T*-4 and *T*-5, and the amplification of the tube. In a circuit of this type, the transformers are usually designed for high gain, and the voltage amplification of the 6K7 tube is roughly 100. A discussion of stage-gain measurements will be given in the section on the signal check.

Input IF Transformer.—Input IF transformer assembly *T*-4 includes the primary coil *L*-8 with its associated trimmer *C*-8, and the secondary coil *L*-9 with its trimmer *C*-9. This transformer is the coupling device between the converter and the IF stages. It is very similar to the output IF transformer *T*-5 and, although there may be some design differences between them, the input and output transformers are usually a matched pair. Both transformers are tuned to the intermediate frequency of the receiver. The tuning arrangement is usually by means of trimmer condensers on either air or iron-core coils. In some cases, condensers *C*-8 and *C*-9 are of the fixed mica type, and tuning is accomplished by varying the permeability of the cores by a screw arrangement that withdraws or inserts the core plug.

We might at this time refer to the intermediate frequencies in common use. Older receivers operate at an intermediate frequency of 130 or 175 kc. Later receivers operate at some frequency between 450 and 480 kc, to minimize image-frequency interference (see Chap. 16 on the RF stage). An intermediate frequency often encountered is 260 kc. The trend in modern receivers is to standardize at 455 kc. In almost all cases, the intermediate frequency used in a particular receiver is indicated on the schematic wiring diagram of that receiver.

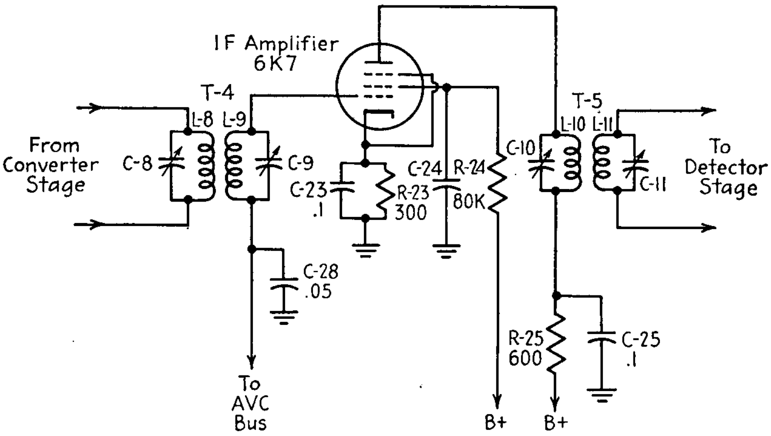


FIG. 13-1.—Typical circuit of an IF amplifier stage.

IF Tube.—The tube employed in the IF stage is usually the metal 6K7 supercontrol pentode. Sometimes the single-ended 6SK7 type of tube is used, the characteristics of which are quite similar to those of the 6K7. When glass tubes like the 6K7-G or 6K7-GT are used, they are almost always enclosed in a shield. Older receivers use the 6D6 or 78 type of tubes that have similar characteristics.

Where the IF amplifier tube is combined with a diode for detection purposes, the tube employed is the 6B8.

AC/DC receivers may use any of the above tubes in circuits where all the tubes draw 0.3 amp of filament circuit. Where the 0.15-amp filament tubes are used, the 12K7, 12K7-G or -GT, or 12SK7 tubes are found.

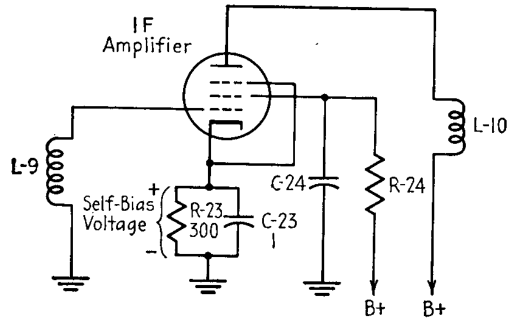


FIG. 13-2.—Self-bias in an IF amplifier without automatic volume control.

Minimum-bias Circuit: R-23, C-23.—Components *R*-23 and *C*-23 form a self-bias circuit, similar to that of *R*-13 and *C*-13 in the second AF stage (see page 101). To see the similarity more clearly, assume for the moment that the grid return goes to ground instead of the AVC bus, as in Fig. 13-2. Plate and screen currents flow through the cathode resistor *R*-23, making the cathode 3 volts positive with respect to ground. Since the grid is at ground potential, it is 3 volts negative with respect to cathode. This is the grid-bias voltage.

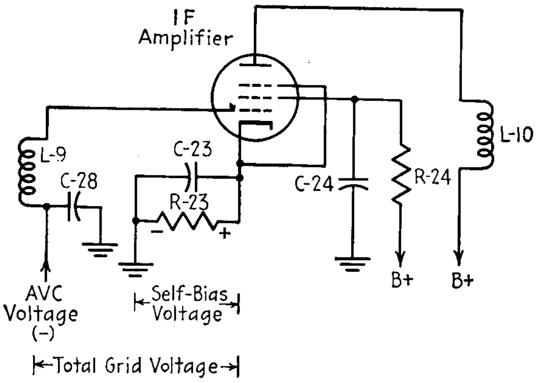


FIG. 13-3.—The grid bias applied to the IF tube is the sum of the self-bias and AVC voltages.

When the grid is returned to the AVC bus, as in Fig. 13-3, there is no AVC voltage when no signal is present, and the grid is therefore at zero or ground potential. This makes the condition similar to that of a grounded grid return; that is, the grid is at ground potential, the cathode is at a potential of plus 3 volts due to the self-bias resistor *R*-23, and the grid is therefore 3 volts more negative than the cathode. When a signal is tuned in, it develops an AVC voltage, which is negative with respect to chassis, thereby making the grid negative with respect to chassis by an amount equal to the AVC voltage. The cathode is still positive with respect to chassis because of self-bias, and therefore the actual bias on the grid of the tube is the sum of the AVC and the cathode voltages. The weaker the signal, the lower the AVC voltage will be, and the less it will add to the minimum grid bias. However the grid-bias voltage cannot fall below the self-bias voltage, even when no signal is received. Since the self-bias circuit of *R*-23 and *C*-23 sets a minimum limit to the grid-bias voltage, it is called the "minimum-bias" circuit.

Cathode resistor *R*-23 is usually a ½-watt resistor, and its ohmic value is usually 300 to 400 ohms. A higher value would mean a higher minimum-bias voltage and less possible amplification for the stage.

Cathode condenser *C*-23 by-passes the signal from the self-bias resistor in the same way that *C*-13 by-passes the audio signal from *R*-13. However, in this case the signal is at the intermediate frequency, and a much smaller capacity will be effective. The usual capacity for *C*-23 is 0.1 mfd. The type of condenser most often used is the paper tubular type. Voltage rating is not important. A 200-volt value is satisfactory.

The AVC voltage is by-passed by condenser *C*-28, which is usually a 0.05-mfd/200-volt paper tubular condenser.

Screen Voltage Supply: C-24 and R-24.—Resistor *R*-24 drops the *B* voltage, from the usual 250 volts available at *B* plus, to approximately 100 volts at which the tube screen operates. It is usually a ½-watt, 80,000-ohm resistor. There is considerable variation in this value in different models of receivers. In general, a higher resistance will make for a lower screen voltage, and a lower value of resistance makes possible a higher screen voltage.

Screen resistor *R*-24 is sometimes omitted and the screen voltage is taken from the mid-point of the voltage divider *R*-15 and *R*-16 (see Fig. 8–14).

Condenser *C*-24, the by-pass for the screen voltage, helps to filter the screen supply. Its usual value is 0.1 mfd/400 volts. Its most important function, however, is to keep the screen of the tube at ground potential as far as the signal is concerned, since *C*-24 offers little impedance to IF signals. This effectively shields the control grid from the plate, internally in the tube, and allows for stable amplification.

Sometimes screen condenser *C*-24 is not readily located in the receiver schematic diagram. This may be the case where the screens of other tubes are tied together with the IF screen for a common voltage supply. The screen by-pass condenser will then be found at one of the other screens. As a matter of fact, in some circuits, where an electrolytic filter condenser is used on the screen voltage supply, an additional paper screen by-pass condenser is often found in the RF or IF screen circuit, in parallel with the electrolytic condenser. This is to take advantage of the more effective RF filtering by the paper tubular condenser.

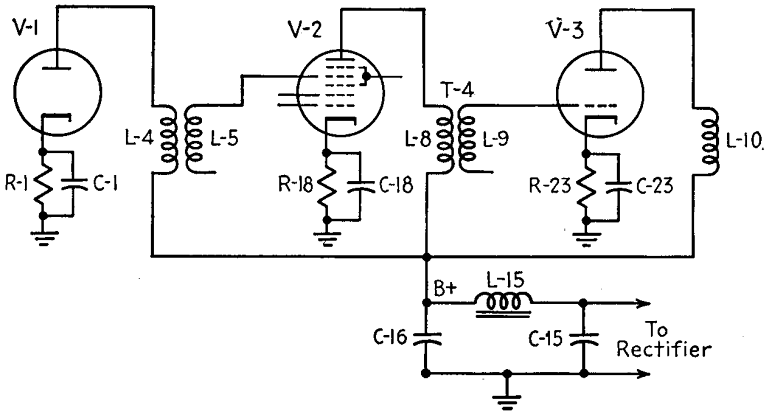


FIG. 13-4.—Coupling in the plate circuit due to a common *B* power-supply component.

In AC/DC receivers, operating potentials for the IF tube are approximately 90 volts for both the plate and the screen. In this case, the dropping resistor *R*-24 is omitted and the screen is connected directly to *B* plus. Screen by-pass condenser *C*-24 may also be omitted, in which case its by-pass function is taken over by the output filter condenser *C*-16 in the power supply.

Output IF Transformer T-5.—Output IF transformer *T*-5 couples the output of the IF stage to the detector stage. Replacement notes for *T*-5 are found in Chap. 12, which describes the detector and AVC stage (see page 161).

Decoupling Filters.—Whenever two or more stages are operated from the same voltage supply, there is a possibility of coupling between the stages through the common power supply. This is illustrated in Fig. 13-4.

If we consider the signal voltage in the plate circuit as being from plate to cathode, the signal voltage of tube *V*-1 is across *L*-4, *C*-16 in the power supply, and *C*-1. The signal voltage of *V*-2 is across *L*-8, *C*-16 in the power supply, and *C*-18. The signal voltage of *V*-3 is across *L*-10, *C*-16 in the power supply, and *C*-23.

Let us consider the plate circuit of tube *V*-1. The greater part of the signal voltage will be where it is wanted—across the high impedance of *L*-4, where it will be transferred to *L*-5 and the grid circuit of the following tube. There will also be some signal voltage drop across the low impedance of *C*-16 in the power supply and *C*-1 in the cathode circuit.

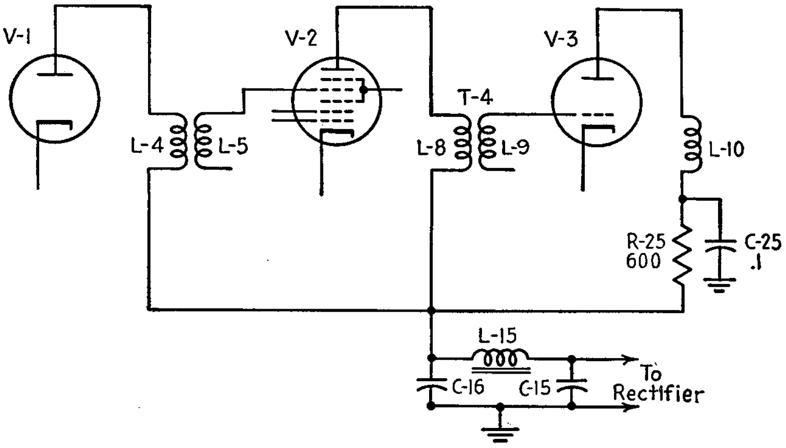


Fig. 13-5.—Decoupling filter in the plate circuit of tube *V*-3.

Now let us consider the plate circuit of *V*-2. Again, the signal voltage will be mainly across *L*-8, but there will be some across *C*-16 and *C*-18. Note that the signal voltages of tubes *V*-1 and *V*-2 have a common circuit in *C*-16 in the power supply.

When we consider the plate circuit of *V*-3, again, most of the signal is across *L*-10, but a small part will be across *C*-16, which is common to all three plate circuits.

If the signals from any of the tubes are in phase, oscillation may result owing to regenerative feedback through the common coupling, *C*-16.

The coupling through the common power supply is usually avoided by the addition of a resistor and condenser known as a "decoupling filter" or isolation circuit, as shown in Fig. 13-5.

The decoupling filter consists of *R*-25 and *C*-25. Condenser *C*-25 offers a low opposition path to ground for the signal, and *R*-25 offers a high opposition path to the signal. The net result is to keep the signal voltage of *V*-3 out of the power supply, so that it cannot mix with the signal from any other tube. An RF choke is sometimes used instead of *R*-25. This also offers high opposition to the signal.

The decoupling filter may be applied in the plate circuit of tube *V*-1 instead of tube *V*-3, as shown in Fig. 13-6. The result would be the same, since in this case the signal voltage of *V*-1 would be kept out of the power supply and therefore would not react with the signal from any other tube.

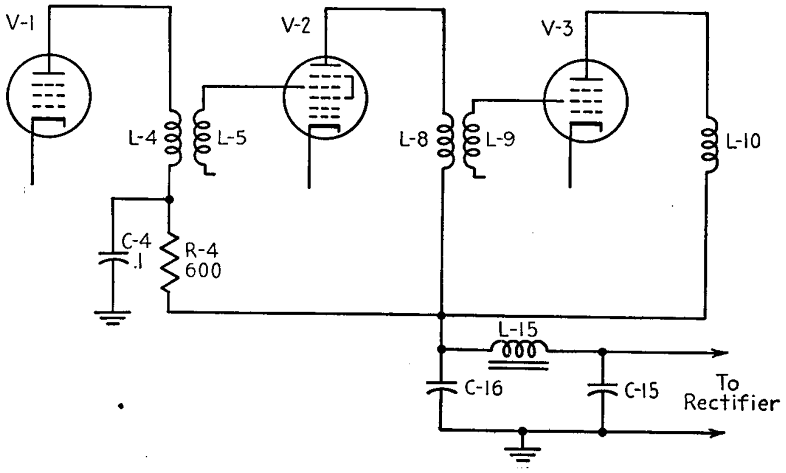


FIG. 13-6.—Decoupling filter in the plate circuit of tube *V*-1.

In different receivers, there is considerable variation as to the placement of the decoupling filter. Sometimes it is in the plate circuit of *V*-1, sometimes in the plate circuit of *V*-3, sometimes in both. Also, the plate circuit of *V*-2 may be tied to either that of *V*-1 or *V*-3, or have its own filter. Since there is no standardization in the placement of the decoupling filters, a decision as to the placement in the standard receiver circuit (Fig. 1-1), which attempts to show the most commonly used practices, has to be reached. In the standard receiver circuit, a decoupling filter is placed in the plate circuit of each tube, and servicing procedures are dealt with so as to include the filter. From the above discussion, it is to be hoped that the serviceman will expect an individual receiver to differ somewhat from the standard in that one or more decoupling filters may be omitted.

By a similar line of reasoning, there could be undesirable regenerative coupling, if the cathodes of three stages were connected together and fed from a common cathode to ground resistor for equal self-bias voltages. The same thing could happen with the screen-voltage supply, or the grid returns through the AVC bus. Where we have three stages operating at similar frequencies through a common coupling, decoupling filters will be found in at least one of these circuits.

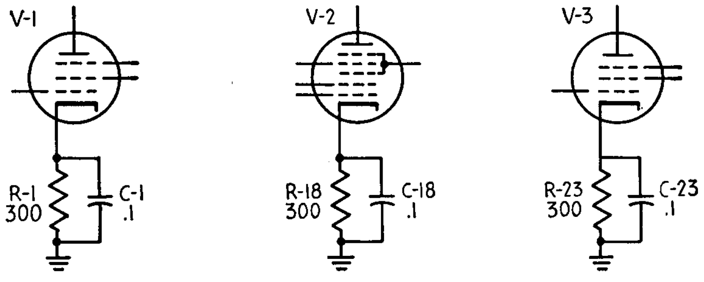


FIG. 13-7.—Cathode circuits with individual self-bias resistors to avoid interstage coupling.

In the standard circuit, the cathodes of the RF, converter, and IF tubes have individual self-bias resistors to avoid coupling, as shown in Fig. 13–7. It is fairly common practice, however, to find the cathode of *V*-2 joined to *V*-1, and *R*-18 and *C*-18 omitted.

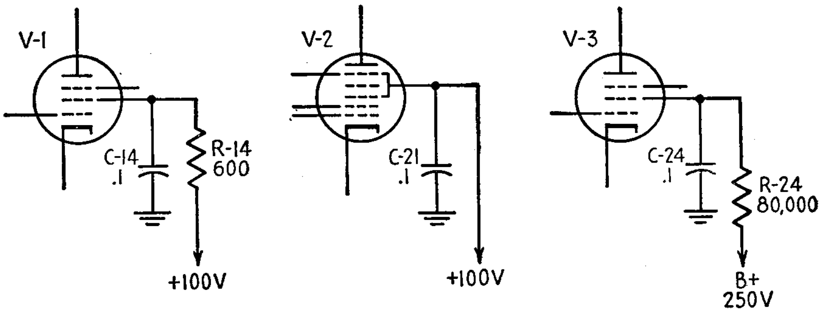


FIG. 13-8.—Decoupling filters in the screen circuit to avoid coupling in the common power supply.

In the screen circuit, coupling is avoided, as shown in Fig. 13–8, where screen by-pass condensers, in conjunction with screen resistors, are used. It is most common practice to obtain screen voltage for the IF tube *V*-3 from a separate dropping resistor *R*-24 connected to *B* plus. The screens of *V*-1 and *V*-2 may be tied together, with *R*-14 and *C*-14 omitted. Or all three screens may be tied together and fed from a common voltage source.

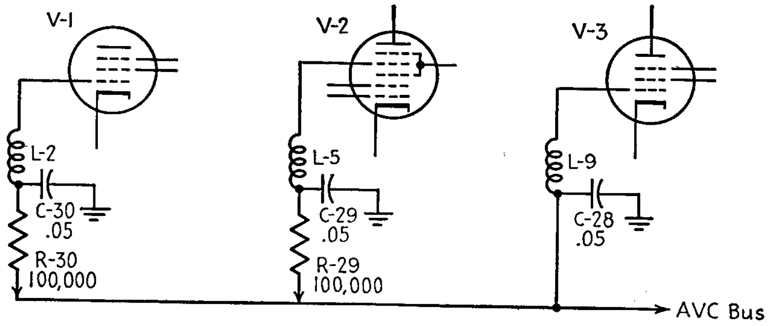


FIG. 13-9.—Decoupling filters in the grid return circuit to avoid coupling in the common AVC voltage supply.

Decoupling filters in the grid returns of the RF and converter tubes are rarely omitted. In this case, the standard circuit is indeed standard. In Fig. 13–9, resistor *R*-30 and condenser *C*-30 make up

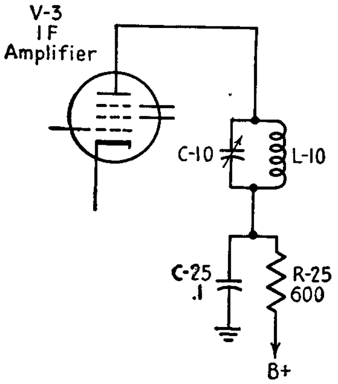


FIG. 13-10.—Plate-circuit decoupling filter in the IF amplifier stage.

such a decoupling filter for tube *V*-1, while *R*-29 and *C*-29 make up a similar filter for tube *V*-2.

A great many receivers do not use an RF stage. In this case, since there are fewer stages with a common coupling component, the probability of regenerative feedback is lessened, and there is little necessity for decoupling filters.

To get back to the IF stage, the plate decoupling filter consists of

R-25 and *C*-25, as shown in Fig. 13–10. Resistor *R*-25 varies from 400 to 1,000 ohms in different receivers, and *C*-25 varies from 0.05 to 0.25 mfd. These values are not critical.

NORMAL TEST DATA FOR THE IF STAGE

Signal Check.—The test point for the signal check of the IF stage is the converter signal grid, as shown in Fig. 13–11. As was the case in the signal check for the detector stage, the input signal is applied to a previous tube, to avoid the detuning effect of the capacity in the signal generator. The converter-grid test point is readily available, either at the top contact of the 6A8 converter tube or at the stator-plates terminal of the converter tuning condenser, *C*-5. The output indication is the modulation note of the signal generator in the speaker, or its amplitude, as shown by the output meter. The output meter should be adjusted for a high-voltage range at the start of the signal check, since, from this test point, the amplification of the receiver is considerable. Until the signal generator's attenuator is adjusted, the output signal may be high enough to harm the meter, if it is at its usual 25- to 60-volt range for output measurements. The RF portion of the receiver is made inoperative by shorting the oscillator section of the gang tuning condenser, as explained on page 159.

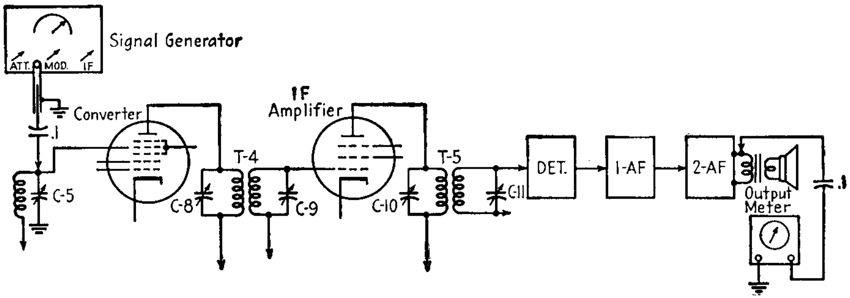


Fig. 13–11.—Connections for the signal check and gain measurements of the IF stage.

The signal check consists in rotating the frequency control of the signal generator through the receiver's intermediate frequency, while listening for its modulation note in the speaker or observing the output meter reading. Unless the response is considerably stronger than that heard from the IF grid (quick check for the detector stage), the IF stage bears investigation for trouble. This is the quick check for the IF stage.

At the same time, the signal check may be used to check alignment, operation at the proper intermediate frequency, and the presence of oscillation. The presence of two peaks close together is not necessarily an indication of misalignment. This may be the normal response from an overcoupled IF transformer. This is explained in the variations section dealing with broad-band IF amplifiers.

When the modulated IF signal is applied to the converter grid and there is no response or abnormally low response, the trouble may be in the converter tube or its operating potentials. This can be checked by shifting the signal generator test lead to the converter plate. In this case, normal response is a somewhat stronger signal from the converter plate than was obtained from the IF grid (quick check of the detector stage). Trouble in the converter tube or its operating potentials is handled in Chap. 14, which deals with the converter. If there is no signal response from the converter plate, the trouble is definitely in the IF stage.

Normal Voltage Data.—Readings are taken from the chassis or common negative terminal to tube elements. The data are given in the accompanying table.

Tube elements	AC receivers, volts	6K7 pin No.	AC/DC receivers, volts
Plate	250	3	90
Screen	100	4	90
Cathode	3	8	3

Normal Resistance Data.—These data are presented below.

	Resistance, ohms	
	Air core	Iron core
Across *L*-8, primary of *T*-4	30–50	5–15
Across *L*-9, secondary of *T*-4	30–50	5–15
Across *L*-10, primary of *T*-5	30–50	5–15
Across *L*-11, secondary of *T*-5	30–50	5–15
Cathode to chassis	300–400	
Control grid to chassis	1,500,000	
Screen grid to chassis	140,000*	
Screen grid to *B* plus	80,000*	
Plate to *B* plus	640†	

* These values are for the standard circuit. Owing to the wide divergence in methods of obtaining screen supply, these readings should be checked against the receiver schematic diagram.

† If there is no decoupling filter, this reading will be simply the DC resistance of *L*-10, the primary of the output IF transformer *T*-5.

A wide divergence is given for the coils *L*-8, *L*-9, *L*-10, and *L*-11, to allow for differences between receivers. In any one receiver, however, owing to the common use of matched transformers, these coils should all check very close to the same value within the limits given,

IF Stage-gain Measurements.—As was done for the previous stages, the serviceman should run some checks on receivers known to be good, so as to have a bas s of comparative data as to the operation of his test equipment and the normal gain to be expected from the IF stage.

The receiver, test oscillator, and output meter are connected, as shown in Fig. 13–11. The receiver's RF section is made inoperative by shorting the oscillator section of the gang tuning condenser. The receiver is set to the full volume and minimum bass positions. A selectivity control, if any, is set for the maximum selectivity position. The test oscillator is adjusted for modulated output on the IF band. The output meter is set at a high AC voltage range for safety's sake, although the range will be reduced for the final check of the standard output voltage.

The signal generator is connected to the converter grid, and the frequency-control dial is rotated carefully through the receiver's intermediate frequency for peak deflection on the output meter. At peak, the attenuator of the signal generator is adjusted to give the standard output of 50 mw in the speaker. Standard output corresponds to an output meter reading of 16 volts (see page 131).

The average IF signal input at the converter grid, necessary to give standard output, is 50 microvolts for a modern high-gain receiver. The attenuator setting just obtained, therefore, corresponds to 50 microvolts. After several good receivers have been checked by the above procedure and the results have been compared, a reference point, corresponding to 50 microvolts, has thus been established on the signal-generator attenuator dial.

In the detector stage, it was seen that the average IF signal input necessary to give standard output from the IF grid was 3,500 microvolts. From the converter signal grid, the average IF signal input necessary to give standard output is 50 microvolts. The average gain of a receiver between the two grids, therefore, is $3{,}500/50 = 70$. Having established comparative data on good receivers, the serviceman is in a position to judge the gain characteristics of any IF amplifier.

COMMON TROUBLES IN THE IF STAGE

Troubles Common to the Input IF Transformer.—Replacement notes and troubles of the input IF transformer *T*-4 will be outlined briefly here. For a more detailed discussion, the replacement notes on the similar output IF transformer are equally applicable (see page 161).

The IF transformers sometimes open. When this is the case, the receiver will not operate, and a signal check will indicate the defective stage. An ohmmeter check then shows the open transformer.

The IF transformers also cause noise. This condition is usually due to corrosion of the windings. It will be found by an ohmmeter check, since a corroded winding will check several hundred ohms instead of its normal value of 15 to 50 ohms.

If an exact replacement transformer is not available, the suggestions on page 163 should be helpful.

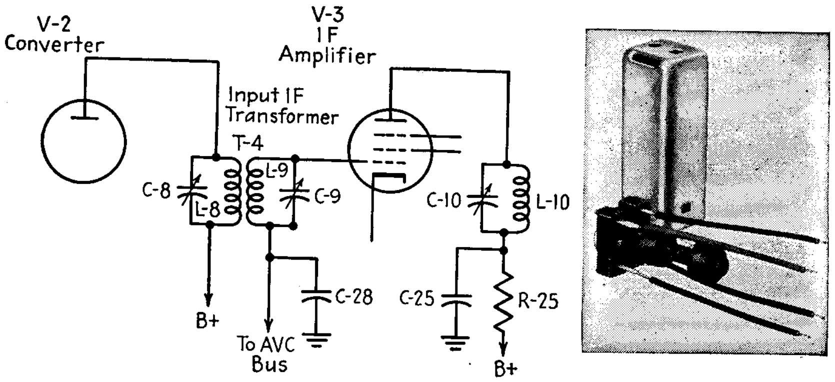


FIG. 13-12.—The input IF transformer and its position in the circuit.

Input IF Transformer Color Code.—The R.M.A. color code given below will help to identify the leads.

Blue	Plate lead
Red	*B* plus lead
Green	Grid lead
Black	Grid return

When a new transformer is installed, grid and plate leads should be short and direct and away from each other and all other wiring.

Troubles Common to the AVC By-pass Condenser.—Replacement notes on the AVC by-pass condenser *C*-28 are found in the detector and AVC stage on page 165.

Troubles Common to the Minimum-bias Resistor.—The voltages and currents encountered in the cathode circuit of the IF tube are such that there is no overload on minimum-bias resistor *R*-23, and the resistor rarely gives trouble. If it should open, the stage will not operate and the condition would be found in a voltage check.

The cathode-to-ground voltage would check abnormally high, since the test voltmeter, with its high resistance, would bridge the open resistor in the circuit.

The original should be duplicated as to ohmage and wattage. If the exact ohmage value is not available, a considerable tolerance may be allowed, since the value is not critical and will cause little effect on the over-all performance of the receiver.

Troubles Common to Minimum-bias By-pass Condenser.—As with its associated resistor *R*-23, the low voltage encountered will rarely harm minimum-bias by-pass condenser *C*-23. Nor will leakage be overly important, since the condenser is in parallel with a low-ohmage resistor. Should the condenser open, however, there will be degeneration with a consequent loss in gain for the stage. If the open is intermittent, there will be intermittent loss in volume or fading. In either case, substituting a condenser known to be good and observing results is the best check. Sometimes wiggling the condenser leads will show up the intermittent open. When condenser *C*-23 is replaced, a large tolerance in capacity is allowable.

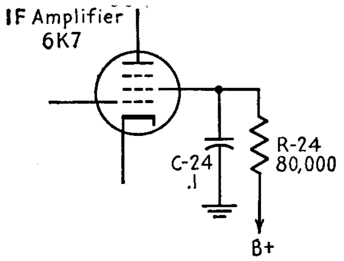


FIG. 13-13.—The screen circuit of the IF amplifier stage.

Troubles Common to the Screen By-pass Condenser.—In service, screen by-pass condenser *C*-24 sometimes opens and sometimes shorts. If it is open, the receiver will oscillate. Standard procedure for an oscillating receiver includes checking for open-screen by-pass condensers. Bridging the various screens to ground with a good 0.1-mfd condenser is the regular test.

If condenser *C*-24 is short-circuited, there will be no screen voltage and the receiver will not operate. The condition would be found in a voltage check and confirmed by a resistance check.

When a short-circuited *C*-24 is replaced, it would also be wise to replace the screen dropping resistor *R*-24, which may have been harmed by feeding heavy current to the short-circuited screen by-pass condenser.

The replacement condenser should not be smaller than the original as to the capacity and voltage rating. A higher capacity will do no harm. Although the screen operates at about 100 volts, the voltage rating of the condenser should be considerably higher. This is because the condenser is at the full *B* plus voltage when the receiver is first turned on, owing to the dropping resistor circuit of *R*-24.

Troubles Common to the Screen-dropping Resistor.—Screen-dropping resistor *R*-24 may change in value or open. A change in value might not be noticed until checking the screen voltage, since the over-all operation of the receiver would not be affected too much, unless the change is very great. If the resistor is open, screen voltage is zero and the stage is inoperative.

Before resistor *R*-24 is replaced, screen by-pass condenser *C*-24 should be checked, since a shorted screen by-pass may have originally caused the resistor to open.

The ohmic value of *R*-24 is not critical, and a fairly wide tolerance may be allowed. The replacement, however, should be at least a ½-watt size.

Troubles Common to the Plate Decoupling Filter.—If present, the decoupling filter may be a source of trouble. Condenser *C*-25 may short, with the result that there will be no plate voltage, the receiver will be inoperative, and resistor *R*-25 will probably burn. This condition would be found very early in the trouble-shooting procedure, since the *B* plus voltage will be very low. To find the short, however, might be more difficult, since there are several circuits in parallel with the condenser. An overheating *R*-25 would be one indication. Another helpful device is to make a resistance check from all plates to ground. If condenser *C*-25 were shorted, the IF plate would check approximately 40 ohms to ground (the resistance of *L*-10), while all other plates would check their normal plate load plus the resistance of their decoupling filter, if any, plus the resistance of *R*-25.

It is not unusual to find only a by-pass condenser connected at *B* plus of an RF or IF tube, even though no other form of decoupling filter is used. This condenser therefore is connected from *B* plus to chassis and is in parallel with the power-supply filter condenser *C*-16. When this is the case, the ohmmeter check from each plate to ground would give no definite clue, since, with no decoupling resistors, all plate-to-ground readings would show their normal plate load. It would be necessary then to open the *B* plus wiring, one circuit at a time, to find the short.

A decoupling filter condenser may also open. In this case, all voltages would show normal readings, but the receiver would have a tendency toward oscillation. Since it is common practice, in trouble shooting for oscillation, to bridge all by-pass condensers with a good condenser, the open decoupling condenser would be found in this manner.

When replacing condenser *C-25*, voltage rating is important. A 600-volt rating is recommended for all replacements. The capacity is not critical, so that a wide tolerance may be allowed. If a shorted *C-25* is being replaced, the resistor *R-25* in the decoupling filter should also be replaced, since it has been damaged by feeding heavy current to the short. Unless *C-25* has been shorted, *R-25* will, of itself, cause no service trouble.

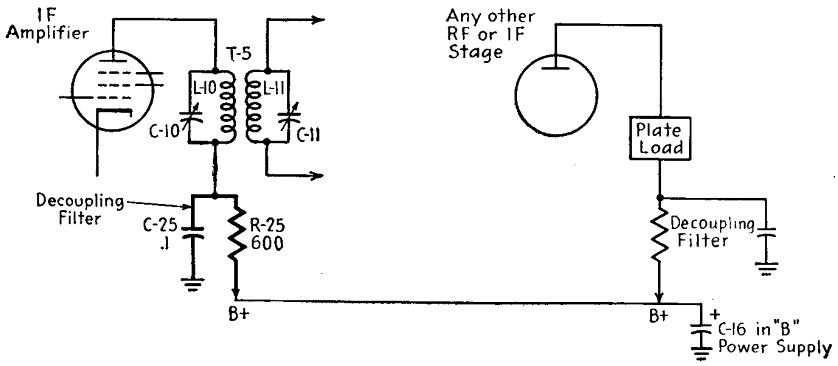


FIG. 13-14.—The IF amplifier plate-decoupling filter.

Troubles Common to the IF Amplifier Tube.—The amplifier tube is the most common cause of trouble in the stage. The best check, of course, is to compare operation with a similar tube known to be good.

Since there are many similar tubes that will operate in the IF stage, a previous tube replacement may have put a different tube in the IF socket, and the serviceman would do well to check the tube type for which the receiver was originally designed. For example, 6K7-G, 6K7-GT, and 6K7 are all pretty much alike, and any one of them might work in some circuits. They cannot be interchanged in all circuits, however, since they differ as to shielding and interelectrode capacities. A receiver designed for a 6K7-G may not ground pin 1, and a 6K7 or 6K7-GT would show a tendency to oscillate in this receiver. Similarly, a 6K7-GT may oscillate in a receiver designed for a 6K7, unless equipped with a close-fitting shield in contact with the metal tube base. A 6K7-G would have to be shielded and the shield grounded.

CIRCUIT VARIATIONS OF THE IF STAGE

Minimum Bias from Delayed AVC.—The IF stage in a receiver, using fixed bias and receiving AVC voltage from a delayed AVC circuit, is similar to the standard circuit. It differs primarily in the manner of obtaining minimum bias for the IF tube. The cathode is grounded. Normal fixed-bias voltage for the IF tube, with no signal input, is obtained from the voltage drop across the *C* voltage divider *R*-116, through the grid return. This minimum bias is also the delay voltage, since the same end of *R*-116 is connected to the IF grid return and the delayed AVC diode plate, through resistor *R*-128.

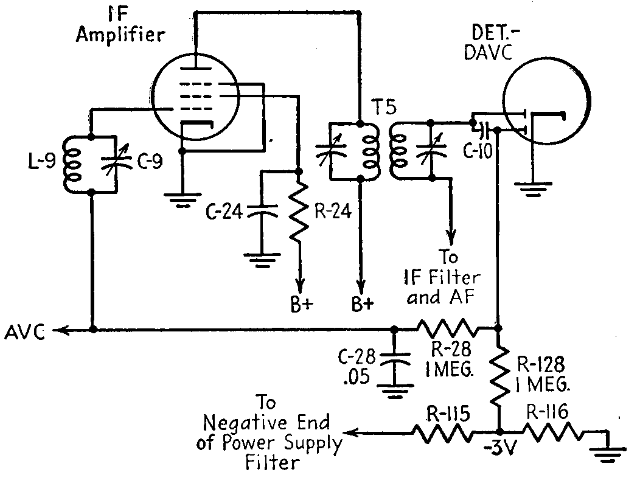


FIG. 13-15.—The IF amplifier stage in a receiver using a DAVC circuit.

When a strong station signal is received on the diode plate and it overrides the delay voltage, a voltage drop takes place across *R*-128, which adds to the fixed minimum bias delivered to the IF grid. In this manner, station signals may increase the IF grid bias, but under no condition will the bias drop below the minimum bias furnished by the *C* voltage divider.

All service notes and tests for the standard IF stage apply here also, except for cathode-to-ground voltage. Owing to the high resistance of *R*-28, a voltage check from grid to chassis may not show any indication with the usual voltmeter. This voltage, however, can be measured across *R*-116.

Broad-band IF Amplifiers.—The IF transformers of receivers, lik that of the standard, are designed for great selectivity and gain Figure 13-16 shows the frequency-response curve for such transformers. However, such a circuit has a defect in that it is too selective and attenuates the high-frequency audio signals. This defect is known as "side-band cutting." In high-fidelity reproduction, where the high-frequency audio notes are desired, it is necessary to broaden the response curve of the IF transformers to that shown in Fig. 13–17.

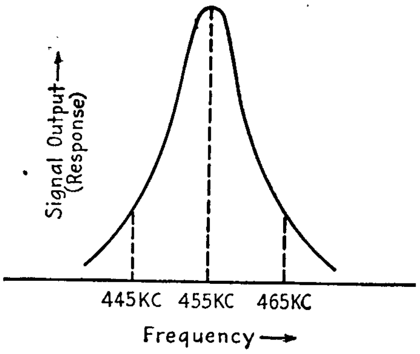


Fig. 13–16.—Frequency-response curve of the usual IF transformer.

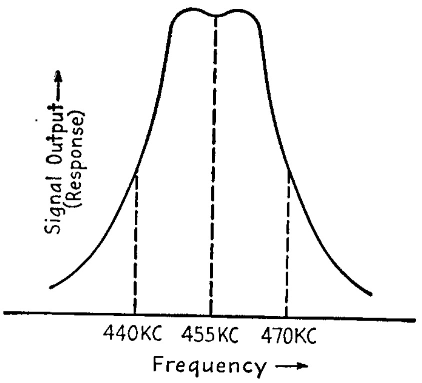


Fig. 13–17.—Frequency-response curve of a high-fidelity IF transformer.

In high-fidelity receivers, where the response curve of the IF amplifier is broadened, the amplification of the stage is reduced. Usually, a second broadly tuned stage is therefore added to make up for this loss. The over-all gain of the two-stage IF amplifier is somewhat greater than the gain of a single-stage amplifier, and the over-all selectivity is equally good owing to the extra tuning circuits of the added stage. Figure 13–18 is a graphic representation of the response curve of each stage of a two-stage IF amplifier and the over-all response of the amplifier.

Several methods are in common use to obtain the desired broadband response. One method is known as "overcoupled" transformers. In any IF transformer, the relative position of the primary and secondary windings to each other is called the "coupling." When the two windings are far apart, the energy transfer from primary to secondary is small, and the transformer will give low gain and good selectivity. As the two windings are brought closer together, the gain of the transformer increases and the selectivity becomes somewhat broader up to a critical point, after which the gain is reduced and the selectivity becomes considerably broader, owing to the appearance of two peaks, one on each side of the resonant frequency. When the primary and secondary windings are closer than this critical point, the transformer is said to be "overcoupled." Figure 13–19 illustrates the effects of the coupling on the gain and selectivity of a transformer.

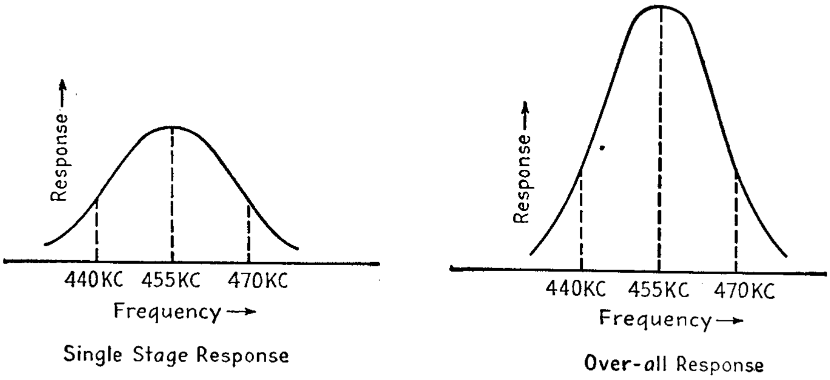


FIG. 13–18.—Frequency-response curve of a high-fidelity IF amplifier.

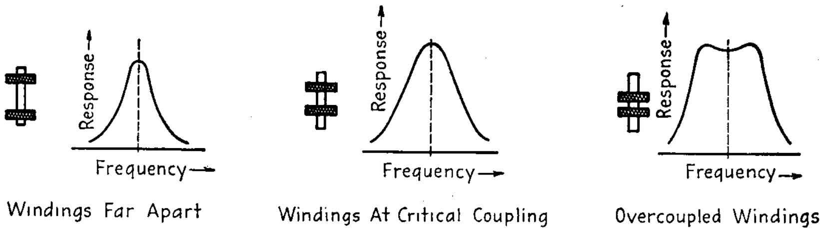
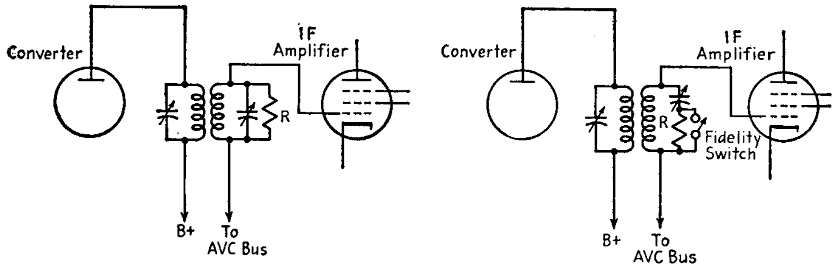


FIG. 13–19.—Effect of coupling on the frequency-response curve of an IF transformer.

The design of the usual single-stage transformer makes some compromise as to coupling between the low and the critical points, so as to give high gain with good selectivity. Some receivers that feature broad-band IF amplifiers make use of overcoupled IF transformers. Often the coupling is made variable by a mechanical arrangement that raises and lowers one winding by turning a knob on the front panel of the receiver. The position of minimum coupling is labeled SELECTIVITY or SENSITIVITY, whereas the position of maximum coupling is labeled FIDELITY or TREBLE. This control is called a "fidelity" control.

Another method of broadening the response of the IF amplifier is to load the tuned circuits with resistors, as shown in Fig. 13–20. The resistors may be placed across the primary winding, the secondary, or both; or they may be placed in series with the trimmer condenser. In any case, the introduction of resistance loads the tuned circuit and results in a decreased gain and a broader response curve. The amount of broadening is determined by the amount of loading; that is, the ohmic value of the resistor. The single-stage curve of Fig. 13–18 is typical for a resistance-loaded transformer.



A. SHUNT LOADING B. SERIES LOADING

FIG. 13–20.—Resistance loading to broaden response characteristic of an IF amplifier.

A third method of broadening the response of the IF transformer is to use loosely coupled primary and secondary windings, and to introduce a third winding, known as a "tertiary" coil, closely coupled to the secondary winding. The tertiary is also tuned to the intermediate frequency and absorbs energy from the secondary winding, thereby acting as a load and broadening the response. A resistor, if used in the tertiary winding, increases the effect. Figure 13–21 shows a circuit for an IF transformer with a tertiary winding.

From the serviceman's point of view, a two-stage IF amplifier presents few complications. The signal check is about the same as for a single-stage IF amplifier, since the gain per stage is considerably lower. It merely adds another grid from which to check. The presence of two peaks close together is to be expected, especially where overcoupling is employed. The IF transformers are subject to the same ills as with a single stage. They open and become noisy because of corrosion; the same checks are applicable. However, when an IF transformer is replaced in a two-stage IF amplifier, it becomes more necessary to employ an exact replacement.

Because of an added stage, more decoupling filters will be used. However, the treatment of them will not vary from that given for our standard circuit.

The alignment of broad-band IF amplifiers can best be performed with an oscilloscope, but satisfactory alignment can be obtained with a standard signal generator and output meter. It is extremely important to follow the manufacturer's service instruction. Where such instructions are not obtainable, a generalized procedure may be followed. Set the receiver for maximum gain position (not high-fidelity); that is, minimum coupling where a coupling control is used (shunt resistors switched out where this is the method), and align for maximum response, as usual. Then switch to the high-fidelity position and rotate the signal generator about 10 kc on each side of the intermediate frequency, noting the output-meter deflection. If it remains fairly constant for about 5 kc on each side of the intermediate frequency, the alignment may be considered good. If the output meter fails to remain constant, alignment adjustments should be repeated.

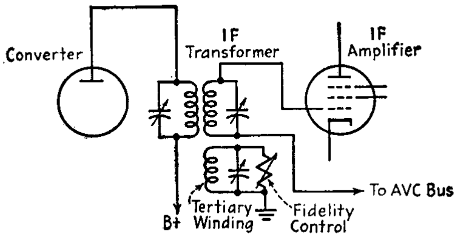


FIG. 13-21.—Tertiary winding to broaden response characteristic of an IF amplifier.

Overcoupling and use of a tertiary coil may sometimes be used in a single-stage IF amplifier, where gain is sacrificed for fidelity of reproduction. The tertiary coil may be switched out here for greater gain at the expense of fidelity.

Broad-band IF amplifiers are not usually employed in AC/DC receivers, where emphasis is on simplicity, low cost, and maximum gain from the fewest tubes.

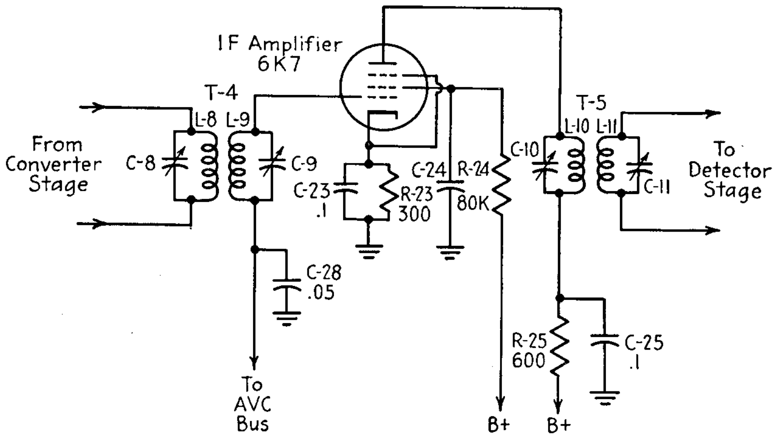
SUMMARY

Quick check.

Introduce a modulated signal at the intermediate frequency to the signal grid of the converter tube. When the IF stage is functioning properly, the modulation note will be heard in the speaker. The response will be much stronger than that heard when the detector stage is checked; that is, when the signal is applied to the IF grid.

Diagram of typical IF amplifier stage.

A diagram of the typical IF amplifier stage is given in the accompanying figure.



Voltage check.

Readings are taken from chassis or common negative terminal. Normal voltage data are given in the accompanying tables.

Tube elements	AC receivers, volts	6K7 pin No.	AC/DC receivers, volts
Plate	250	3	90
Screen	100	4	90
Cathode	3	8	3

Normal resistance data.

Normal resistance data are given in the accompanying table.

	Resistance, ohms	
	Air core	Iron core
Across *L*-8, primary of *T*-4	30–50	5–15
Across *L*-9, secondary of *T*-4	30–50	5–15
Across *L*-10, primary of *T*-5	30–50	5–15
Across *L*-11, secondary of *T*-5	30–50	5–15
Cathode to chassis	300–400	
Control grid to chassis	1,500,000	
Screen grid to chassis	140,000*	
Screen grid to *B* plus	80,000*	
Plate to *B* plus	640†	

* These values are for the standard circuit. Owing to the wide divergence in methods of obtaining screen supply, these readings should be checked against the receiver schematic diagram.

† If there is no decoupling filter, this reading will be simply the DC resistance of *L*-10, the primary of the output IF transformer *T*-5.

A wide divergence is given for the coils *L*-8, *L*-9, *L*-10, and *L*-11, to allow for differences between receivers. In any one receiver, owing to the common use of matched transformers, these coils should all check very close to the same value within the limits given.

Signal-substitution test procedure for an inoperative IF amplifier.

The test oscillator, receiver, and output meter are connected as shown in Fig. 13–22. The signal generator is adjusted for modulated output on the IF band. The receiver is adjusted for maximum volume, minimum bass response, and maximum selectivity (if there is such a control); the RF portion is made inoperative by shorting the oscillator section of the gang tuning condenser. Let us assume normal operation of the audio amplifier, as proved by a normal response when an audio test signal is applied to point ⑤, the input of the AF amplifier, and no response or weak response when a modulated signal at the intermediate frequency is applied to point ①, the converter signal grid.

STEP 1. The test lead from the signal generator is moved to point ②, the converter plate.

1. If a normal response results, the trouble may be
    - *a.* A shorted converted signal grid (most likely a short in the gang tuning condenser).
    - *b.* A defective converter tube (substitute a good one).
    - *c.* Open or shorted plate, screen, or cathode circuit in the converter tube (detected by voltmeter check).
2. If the signal does not come through or remains very weak, move on to step 2.

STEP 2. The test lead from the signal generator is moved to point ③, the IF grid.

1. If a normal response (3,500 microvolts input for standard output) results, the trouble may be
    - *a.* A defective input IF transformer (detected by ohmmeter check).
    - *b.* An open AVC by-pass condenser *C*-28. (Bridge it with a good one and recheck from point ①.)
    - *c.* Input IF transformer *T*-4 badly misaligned (check alignment).
2. If the signal does not come through or remains very weak, move on to step 3.

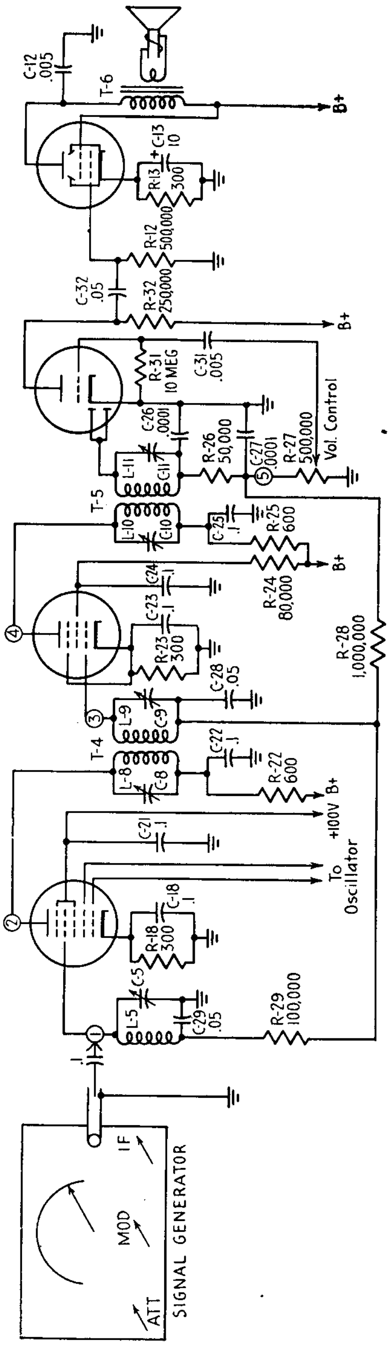


FIG. 13-22.—Signal check for locating trouble in an IF amplifier.

STEP 3. The test lead from the signal generator is moved to point ④, the IF plate. The attenuator is advanced, and the frequency control is wobbled through the intermediate frequency.

1. If the signal comes through, the trouble may be
   a. A shorted IF grid. (Detected by ohmmeter check. The short would most likely be between the grid wire or trimmer and the IF shield can.)
   b. A defective IF tube (substitute a good one).
   c. Open or short in the plate, screen, or cathode circuits of the IF tube (detected by voltmeter check).
2. If the signal does not come through, check the detector stage (see Chap. 12).

SERVICE DATA CHART

Symptom	Abnormal reading	Look for
No reception	Plate voltage = 0	Open IF output transformer. Shorted plate by-pass condenser *C*-25. Open plate circuit decoupling resistor *R*-25. Plate-to-ground short in IF can
	Screen voltage = 0	Shorted screen by-pass condenser *C*-24. Open screen voltage-dropping resistor *R*-24
	High cathode voltage	Open minimum-bias resistor *R*-23
	All voltage checks are normal	Dead IF tube *V*-3. Shorted trimmers in the IF cans. Open IF transformer secondaries. Open AVC by-pass condenser *C*-28
Weak signal	All voltage checks are normal	Weak IF tube *V*-3. Open AVC by-pass condenser *C*-28. Open cathode by-pass condenser *C*-23. Open plate circuit by-pass condenser *C*-25. Misalignment
Noise	All checks are normal	Noisy IF tube *V*-3. Corrosion in the IF transformer windings
Squeal or oscillation	All checks are normal	Open screen by-pass condenser *C*-24. Open ground connection to shielding. Incorrect IF tube *V*-3. Open AVC by-pass condenser *C*-28. Open plate circuit by-pass condenser *C*-25. Incorrect wire dress

QUESTIONS

1. A receiver does not play. Signal check shows normal operation when a test signal is applied to the IF plate; no response when the test signal is shifted to the IF grid. List the likely sources of trouble, and explain how you would check for each.

2. A receiver does not play. Signal check shows normal operation when the proper test signal is applied to the IF grid; no response when the test signal is shifted to the converter plate. List the likely sources of trouble, and explain how you would check for each.

3. The receiver of Fig. 12–17 is inoperative. A signal check shows that the trouble is in the IF stage. A voltage check gives normal readings for the stage. List the likely causes of the trouble, and explain how you would check for each.

4. A receiver gives the following voltage readings for the IF stage:

Plate	250 volts
Screen	130 volts
Cathode	50 volts

What is the probable trouble, and how would you check for it?

5. A receiver gives the following voltage readings for the IF stage:

Plate	0 volt
Screen	95 volts
Cathode	1 volt

What are the probable troubles? What should the next checks be?

6. An AC superheterodyne receiver oscillates badly. The oscillation continues when the converter tube is removed but stops when the IF tube is removed. This indicates that the cause of the trouble is probably in the IF stage. What checks and adjustments should be made to track down the trouble?

7. What factors in the IF stage can cause noisy reception? How would you check for each?

CHAPTER 14

CONVERTER: MIXER AND OSCILLATOR STAGES

After the IF check, the next area for investigation is the converter, which consists of two distinct stages: the mixer and the oscillator. Their functions are so closely interrelated that they are best handled as one unit—the converter. In most receivers, the two stages are combined in one pentagrid converter tube. Although some receivers use separate mixer and oscillator tubes, service analysis is similar for both types of receivers.

The modulated RF signal from the stage before the converter is fed to the mixer grid of the converter tube, where it is mixed with the unmodulated RF signal from the local oscillator stage. The signal on the mixer grid, regardless of frequency, is changed by the converter to a signal with the same frequency, the intermediate frequency of the receiver. The signal at the intermediate frequency retains the same audio modulation that is present in the RF signal fed to the mixer grid. The IF signal is then fed to the input of the IF amplifier.

Many superheterodyne receivers do not incorporate an RF stage. In receivers of this type, the antenna is coupled to the converter mixer grid. In the signal-substitution method of servicing, where the trouble shooter works from the speaker back to the antenna, the converter will be the last area of investigation for receivers of this type.

Quick Check for the Operation of the Oscillator Stage.—Tune the receiver to 600 kc. Connect the signal-generator output to the converter signal grid through a 0.1 mfd condenser, and rotate the signal-generator dial through 600 kc. If the signal-generator modulation note is heard in the speaker at or near 600 kc, the oscillator is functioning.

Quick Check for the Operation of the Mixer Stage.—Tune the receiver to 1,400 kc. Connect the signal-generator output to the RF grid (antenna if there is no RF stage) through a 0.00025-mfd condenser, and rotate the signal-generator dial through 1,400 kc. If the signal-generator modulation note is heard in the speaker at or near 1,400 kc, the mixer stage is functioning.

Function of the Converter.—The function of the converter is fourfold:

1. It tunes and amplifies the received signal.
2. It generates an unmodulated RF signal of its own at a frequency different from the received signal.
3. It mixes the locally generated signal with the received signal.
4. It maintains a constant frequency difference (the intermediate frequency) between the locally generated signal and any signal to which the receiver is tuned.

Standard Circuit of a Converter.—This circuit is shown in Fig. 14–1.

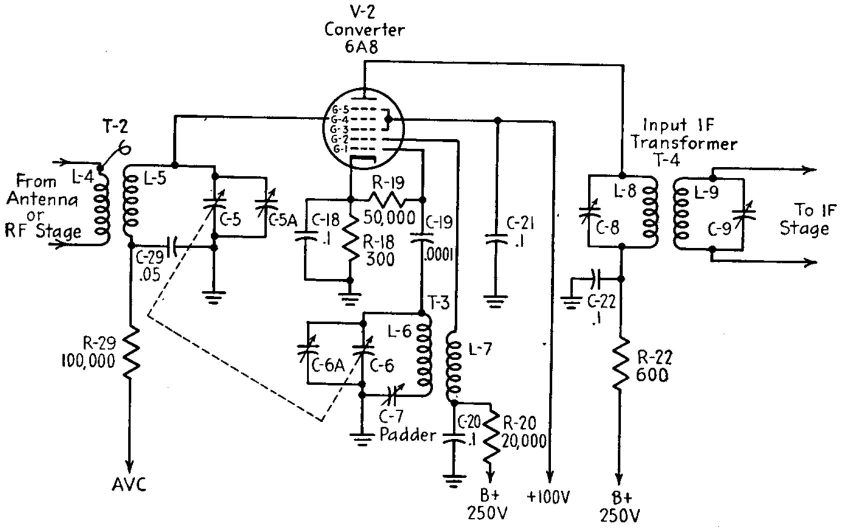


FIG. 14–1.—Typical pentagrid converter circuit.

Theory of Operation of the Converter.—The theory of operation of the converter can be explained by elaborating the four functions listed above.

1. *It tunes and amplifies the received signal.* The input of the stage is RF transformer *T-2*, which couples the preceding RF stage or antenna to the converter tube. Tuning is accomplished by the circuit composed of *L-5* and *C-5*, which feeds the signal to *G-4*, the signal grid of the converter tube. Grids *G-3* and *G-5* are tied together and act as a screen, so that this section of the converter tube plus cathode and plate is a tetrode amplifier. Condenser *C-5* is one section of the ganged tuning condenser.

2. *It generates an unmodulated RF signal of its own at a frequency different from the received signal.* The cathode and grids *G*-1 and *G*-2 act as a triode oscillator. This can be more easily seen by redrawing the oscillator stage of the converter, as shown in Fig. 14–2. Grid *G*-1 acts as the oscillator grid while grid *G*-2 acts as the oscillator plate or anode. Coil *L*-6 and its associated condenser *C*-6 are located in the oscillator grid circuit and make up the tuning section for the oscillator. Condenser *C*-6 is the oscillator section of the gang tuning condenser. Feedback from the plate circuit is obtained by coupling between *L*-6 and *L*-7, the latter coil being in the oscillator anode circuit. The feedback is in proper phase and of sufficient strength to maintain oscillation, the frequency of which is controlled by *L*-6, *C*-6, *C*-6*A*, and *C*-7. The function of condenser *C*-7 will be explained in more detail in the section on tracking.

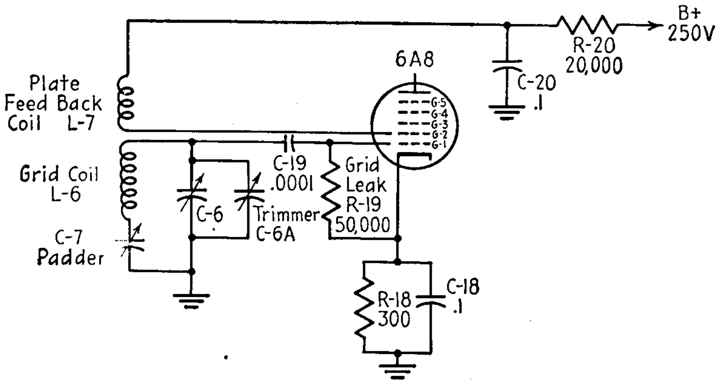


Fig. 14–2.—Oscillator circuit in the 6A8 pentagrid converter.

3. *The converter mixes the locally generated signal with the received signal.* The electron stream coming from the cathode is caused to pulse by the oscillator action of grids *G*-1 and *G*-2, at a rate determined by the values of *L*-6, *C*-6, *C*-6*A*, and *C*-7. Since the oscillator anode is not a solid plate but a pair of rods, most of the pulsing electron stream will go right through the oscillator anode *G*-2 to the rest of the converter tube. The received signal is applied at *G*-4, where it contributes its own effect on the pulsing electron stream, thereby mixing the signal and oscillator output in the converter tube. Grid *G*-4 in the converter tube is sometimes called the "converter signal" grid, and sometimes called the "mixer" grid. The plate output circuit of the converter tube, therefore, will contain a signal with components at the received signal frequency, the oscilla-

tor frequency, the sum of these two frequencies and the difference of these frequencies. This type of mixing of two signals is known as "electron" mixing.

4. *The locally generated signal must maintain a constant frequency difference (the intermediate frequency) with any signal to which the receiver may be tuned.* Of all the signals present in the converter plate circuit, the IF amplifier accepts only the one to which it is tuned. This is the signal that is at the difference frequency between the received signal and the locally generated signal. The oscillator frequency is usually higher than the frequency of the received signal. A few examples may clear this up. The most commonly used intermediate frequency is 455 kc. This will be used in the examples. Let us assume that the wanted station signal is 1,000 kc, approximately in the center of the broadcast band. Then the signal tuning circuit (*L*-5, *C*-5) will be at 1,000 kc. The frequency of the oscillator section, controlled by *L*-6, *C*-6, *C*-6*A*, and *C*-7, will be 455 kc higher, or 1,455 kc.

The converter plate circuit will contain various frequency components:

1,000 kc	Received signal
1,455 kc	Oscillator signal
2,455 kc	Sum of the above
455 kc	Difference between the first two

The sharply tuned IF amplifier will accept the signal at 455 kc, amplify it, and pass it on to the detector.

If the desired signal is near the low-frequency end of the broadcast band at 600 kc, the signal input circuit (*L*-5, *C*-5) will be tuned to 600 kc, and the oscillator tuning circuit composed of *L*-6, *C*-6, *C*-6*A*, and *C*-7 will be tuned to 1,055 kc, making the difference frequency 455 kc.

At the high-frequency end of the broadcast band, the oscillator must be adjusted to 1,955 kc to receive a signal at 1,500 kc. The two signals are mixed in the converter tube, giving, among others, the same difference frequency of 455 kc.

From the above examples, it can be seen that the prime function of the converter is to change any received signal to a signal at 455 kc, the intermediate frequency. It follows as a corollary that the oscillator frequency must be greater by 455 kc, the intermediate frequency, than the desired station signal frequency.

An oscillator frequency 455 kc lower than the desired signal frequency could also be used. This is sometimes done in reception on the short-wave bands.

Tracking.—In a receiver operating on the broadcast band, condenser *C*-5 tunes coil *L*-5 from 550 to 1,600 kc in the received signal circuit (the mixer grid circuit). In the oscillator tuning circuit, condenser *C*-6 tunes coil *L*-6 from 550 plus 455, or 1,005 kc to 1,600 plus 455, or 2,055 kc, where the IF amplifier is tuned to 455 kc. Since condensers *C*-5 and *C*-6 are parts of the same tuning gang, there is considerable design work needed to make these two tuning circuits always 455 kc (or the intermediate frequency) apart. The ability of a receiver to perform equally well on all parts of the tuning range is dependent on this factor, which is known as "tracking." Alignment instructions often include tracking adjustments on both ends of the tuning range and a tracking check in the center. The usual check points on the broadcast band are 600 kc for the low-frequency end, 1,000 kc for the middle, and 1,400 or 1,500 kc for the high-frequency end.

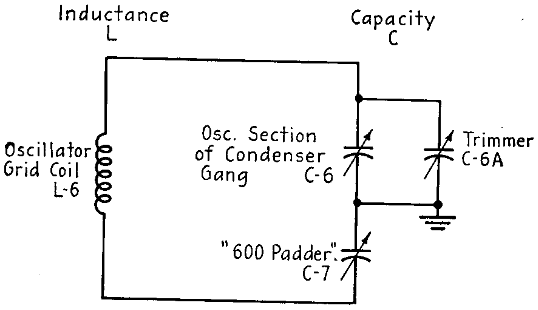


FIG. 14-3.—Oscillator tuning circuit.

Oscillator Tuning Circuit.—The RF tuning circuits have a tuning range for the broadcast band of 550 to 1,600 kc. The oscillator tuning circuit for the same band must have a tuning range of 1,005 to 2,055 kc. The two tuning circuits must, therefore, be considerably different.

The oscillator tuning circuit can perhaps be better understood if it is redrawn, as in Fig. 14-3. It can now be recognized as an *L-C* circuit, the *L* being the oscillator coil. The *C* of the *L-C* circuit is composed of the main tuning condenser *C*-6 with its shunt trimmer *C*-6*A*, both of which are in series with condenser *C*-7. The latter is an adjustable condenser of comparatively high capacity. Trimmer *C*-6*A* is a low-capacity unit. Now we need only remember that the capacity of condensers in series is lower than the individual condensers, whereas the capacity of condensers in parallel is additive.

When tuning condenser *C*-6 is in a low-capacity position, the lumped *C* in the tuning circuit is small (series condensers). Trimmer condenser *C*-6*A* is an important cog at this position since its small capacity is added to the small capacity of the tuning condenser. The setting of trimmer condenser *C*-6*A*, therefore, controls the low-capacity (high-frequency) end of the tuning range. This trimmer is often called the "high-frequency oscillator aligner."

When tuning condenser *C*-6 is in a high-capacity position, the lumped *C* in the tuning circuit is high since it is composed of two comparatively large condensers in series. Trimmer condenser *C*-6*A* has little effect in this position since its small capacity is added to the large capacity of the tuning condenser. At this time, the setting of adjustable condenser *C*-7 becomes of greater importance, since its capacity, now of about the same order as that of the tuning condenser, will have a greater effect on the lumped *C* in the circuit. The setting of adjustable condenser *C*-7, therefore, controls the high-capacity (low-frequency) end of the tuning range. Since this adjustment is usually performed at 600 kc, condenser *C*-7 is often called the "600 padder."

Cut-plate Oscillator Tuning Condensers.—In some receivers oscillator tuning condenser *C*-6 has been designed to maintain the 455-kc difference without a low-frequency padder adjustment. In this case, the rotor plates of condenser *C*-6 are smaller and differently shaped than the rotor plates of the other condensers in the tuning gang, as shown in Fig. 14–4. When the oscillator rotor plates are shaped in this manner, the gang condenser is known as one having a "cut-plate oscillator" section. The shape of the cut plates is so designed that tracking is automatic, in that the capacity in the oscillator circuit maintains its frequency at a value 455 kc higher than the frequency of the received signal.

Functions and Values of Parts in the Converter.—From the above discussion, it can be seen that the values of the component parts in the tuning section of the receiver are an important part of the design of any receiver. The serviceman rarely, if ever, changes the values of any of these parts, since any such changes will seriously affect the operation of the receiver in selectivity, sensitivity, and dial calibration. Defective components in the tuning circuit usually require the serviceman to obtain the original manufacturer's replacement parts. As a result, values of parts need not be given, and it merely remains to state the functions of parts not yet mentioned.

The oscillator grid leak and condenser, *R*-19 and *C*-19, develop the oscillator grid-bias voltage. When a tube is in an oscillating condition, there is considerable grid current. This flows through *R*-19 and causes a voltage drop across it. The grid end of the resistor is negative, giving the bias voltage for the oscillator section of the tube.

The voltage developed across *R*-19 is also important from a service point of view, since it makes a good check as to whether the oscillator is operating.

Oscillator grid-leak resistor *R*-19 is usually a 50,000-ohm/½-watt resistor. Oscillator grid condenser *C*-19 is usually a 0.0001-mfd mica condenser. Occasionally, a paper tubular condenser is used for *C*-19.

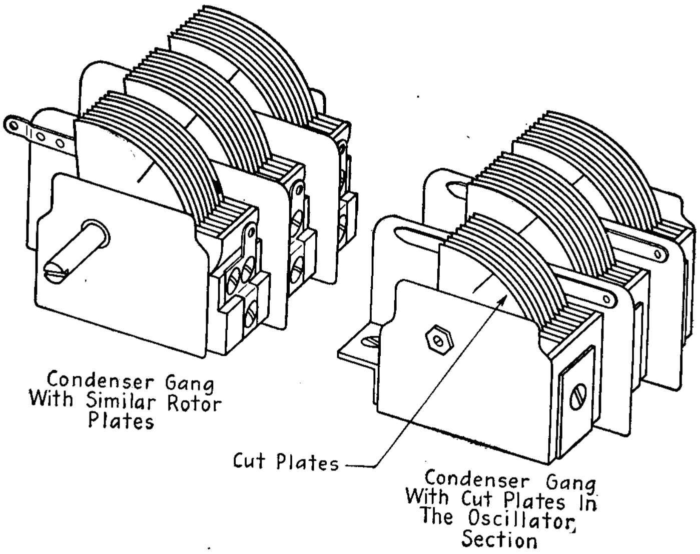


FIG. 14-4.—Comparison between condenser gangs with similar rotor plates and with a cut-plate oscillator section.

Minimum-bias circuits were described in some detail in connection with *R*-23 and *C*-23 in the chapter dealing with the IF stage. Resistor *R*-18 and condenser *C*-18 form a similar circuit for establishing a minimum-bias voltage to be applied to the signal grid of the pentagrid converter, where AVC operation is used.

Resistor *R*-18 is usually a 300-ohm/½-watt resistor. In some circuits, *R*-18 is made somewhat larger, 500 to 600 ohms. In these circuits the tube is being operated at a higher minimum-bias voltage. The by-pass condenser *C*-18 is usually 0.05 to 0.1 mfd. The voltage rating of this condenser is unimportant since it is a low-voltage circuit. In some circuits, *C*-18 may be omitted to provide some degeneration in the converter.

Finally, both *R*-18 and *C*-18 may be omitted, and the cathode of the converter tube is tied to the cathode of either the RF or IF tube, resulting in a common minimum-bias voltage for both tubes.

The AVC decoupling filter (*R*-29 and *C*-29) has been described in the detector and AVC stage. Typical values are 100,000 ohms/½-watt for *R*-29, and 0.05 mfd/400 volts for *C*-29. When there is no RF stage, *R*-29 and *C*-29 are usually omitted, and the signal grid return of coil *L*-5 is connected directly to the AVC bus.

The tube used is the metal 6A8 pentagrid converter. The 6A8-G or 6A8-GT are also used in similar circuits. In the latter case, the tube is usually covered by a closely fitting metal shield. Receivers using loctal-type tubes use the 7B8 or 7B8-LM. An older variety of the same tube is the 6A7.

Another tube very commonly employed is the 6SA7 pentagrid converter. In this case the circuit is somewhat different. A circuit using the 6SA7 will be described in Chap. 15.

AC/DC receivers may use any of the above tubes in circuits where the filament drain is 0.3 amp. In circuits utilizing a 0.15-amp filament line, 12-volt/0.15-amp tubes like the 12A8, 12SA7, and 14Q7 pentagrid converters are used.

The oscillator anode filter circuit, *R*-20 and *C*-20, also acts as a voltage-dropping device for the oscillator anode. *R*-20 is usually a 20,000-ohm/½-watt resistor and *C*-20 is a 0.1-mfd/400-volt condenser. Where the total *B* voltage of the receiver is 200 volts or less, *R*-20 and *C*-20 may be omitted.

The converter-plate-circuit decoupling filter consists of *R*-22 and *C*-22. Resistor *R*-22 is usually 400 to 1,000 ohms, while condenser *C*-22 is 0.05 to 0.1 mfd. Like all decoupling or isolating circuits, *R*-22 and *C*-22 may be omitted.

The input to the mixer stage of the converter is the RF transformer *T*-2. The primary *L*-4 is in the plate circuit of the RF tube, or antenna circuit where no RF stage is used. The secondary *L*-5, which is tuned by *C*-5 of the ganged variable condenser, feeds the signal to the signal grid of the pentagrid converter tube. In some receiver circuits, RF transformer *T*-2 is replaced by an untuned resistance-coupled stage.

In receivers that do not use an RF stage, RF transformer *T*-2 couples the antenna to the signal grid of the pentagrid converter tube. In this case, *L*-4 the primary of the transformer is connected to the antenna and ground. In loop-operated receivers that do not use an RF stage, RF transformer *T*-2 is replaced by the loop antenna. Coil *L*-5 is the main part of the loop, which is still tuned by condenser *C*-5 in the usual way. Primary coil *L*-4 consists of two or three turns on the loop, which may be connected to an external antenna and ground when it is desired to obtain greater signal pickup. Figure 15–2 shows a loop-operated receiver of this type.

NORMAL TEST DATA FOR THE CONVERTER

Signal Check for Normal Operation of the Oscillator.—When the operation of the oscillator is checked, the test signal is applied to the converter mixer grid (sometimes called the "signal" grid). This is the same point that was used in checking the IF amplifier. Before the oscillator check is made, any short that had been placed on the oscillator tuning condenser for previous tests is removed. The receiver is tuned to 600 kc. The signal-generator dial had been set at 455 kc for checking the IF amplifier. At this position, the modulation note will still be heard in the speaker. The signal-generator dial is then rotated past 600 kc. As the dial leaves 455 kc, the modulation note should die out, and it should be heard again, at about the same volume as before, when the signal-generator dial pointer passes 600 kc. This is the signal check for normal operation of the oscillator portion of the converter.

If the modulation note is not heard, the oscillator section is inoperative. If the note is considerably weaker than the note at 455 kc, the converter tube is probably weak. If the note is heard when the signal-generator frequency control is at a considerable distance from 600 kc, the oscillator circuit is probably out of alignment.

This check could be performed at any position in the tuning range. However, it is recommended that the check be performed at 600 kc, since oscillator action is normally weaker at the low-frequency end of the tuning range.

Signal Check for Normal Operation of the Mixer.—When normal operation of the oscillator section has been found, the next step is to check for normal operation of the mixer portion of the converter. The test signal is applied through a 0.00025-mfd condenser to the control grid of the RF tube. Where there is no RF tube, the test signal is applied to the antenna lead of the receiver. The antenna lead is, of course, readily available. The same applies to the control grid of the RF tube in the case of a 6K7 where it is the top contact. Where a single-ended RF tube is employed, the test point is most easily available at the stator connection of the RF section of the gang tuning condenser.

The receiver dial is set to 1,400 kc. If an output meter is connected to the receiver, it should be switched to a high-voltage range. This is important since the amplification from the RF grid is very high and even a moderate test-signal input may furnish sufficient output voltage to bend the output meter pointer.

The signal generator frequency control is rotated a few points each side of 1,400 kc. When the receiver is functioning normally, the signal generator modulation note should be heard in the speaker as its dial pointer passes 1,400 kc. It should be considerably louder than the last check (the oscillator section), where the test signal was applied to the mixer grid.

If the signal-generator note is not heard, the mixer section must be checked. The same applies if the check shows no gain over the check from the mixer grid. If the note appears at a considerable distance from 1,400 kc on the signal-generator dial, alignment is indicated.

Normal Voltage Data for the Converter.—Readings taken from indicated terminals to the chassis or common negative terminal of the receiver are given in the accompanying table.

	6A8 pin No.	AC receiver, volts	AC/DC receiver, volts
Plate	3	250	90
Screen	4	100	50
Oscillator anode	6	200	90
Oscillator grid	5	—15	—10
Cathode	8	3	3

Normal Resistance Data for the Converter.—Resistance data are given in the following table.

Across *L*-4, primary of the signal input transformer *T*-2	40 ohms
Across *L*-5, secondary of the signal input transformer	.5 ohms
Across *L*-6, grid coil of the oscillator transformer *T*-3	.5 ohms
Across *L*-7, feedback coil of the oscillator transformer	.3 ohms
Cathode to chassis	300 ohms*
Signal grid (*G*-4) to chassis	1,600,000 ohms
Screen grid (*G*-3 and *G*-5) to chassis	30,000 ohms*
Plate to *B* plus	640 ohms*
Oscillator grid (*G*-1) to chassis	50,000 ohms
Oscillator anode (*G*-2) to *B* plus	20,000 ohms

*These readings are for the standard circuit and should be checked against service notes for any particular receiver.

In receivers where the signal input transformer *T*-2 is a loop antenna, the grid coil of the loop will measure 1 to 3 ohms. The antenna winding will measure less than 1 ohm.

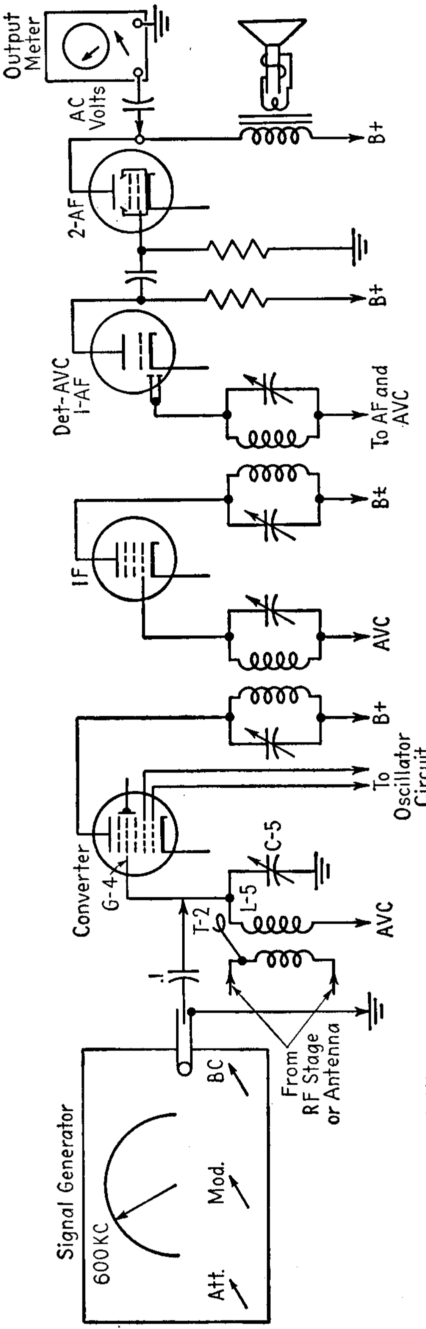
Stage-gain Measurements for the Converter from the Converter Signal Grid.—The serviceman should run some checks on receivers known to be in perfect operating condition, so that he has a basis of comparative data on his bench test equipment, and normal gain data to be expected from the converter. In addition, he should tabulate his experience with each of the various types of converters.

There are two check points for the converter: the converter signal grid *G*-4, and the RF grid or antenna, if the receiver does not use an RF stage. The receiver, signal generator, and the output meter are connected, as shown in Fig. 14–5 to check from the converter signal grid. The receiver is adjusted as follows: The volume control is set to the maximum-volume position; the tone control to the minimum bass position; the selectivity control is set for the position of maximum selectivity; and the receiver dial is adjusted to 600 kc. Any short placed across the oscillator section of the tuning condenser gang for previous tests should be removed. The output meter is switched to a high-voltage range. The signal-generator output leads are connected shield to chassis, and the "hot" lead through a 0.1-mfd condenser to the converter signal grid. The signal generator is adjusted to give a modulated signal on the broadcast band. The attenuator setting is kept comparatively low, since approximately 50 microvolts will give standard output from the receiver.

The frequency-control dial on the signal generator is rotated through 600 kc for peak output from the receiver. When the peak position is found, the attenuator on the signal generator is adjusted to give the standard output of 50 mw from the receiver. When the output voltage is low enough, the range switch of the output meter is reduced so that the 16 volts which correspond to 50 mw can be read more accurately.

The average 600-kc signal strength necessary to give standard output from the converter signal grid is 50 microvolts. In making stage-gain checks for the IF amplifier (see page 197), it was seen that the average IF signal strength necessary to give standard output from the converter signal grid was also 50 microvolts. From the above it may be seen that the gain of the receiver from the converter signal grid should be approximately the same for a signal at the intermediate frequency as for the RF signal to which the receiver is tuned. Any great difference in signal input for standard output would indicate a defective converter tube.

Stage-gain Measurements for the Converter, Including the Tuned Signal Grid Input.—Since the capacity of the signal generator will detune the converter signal grid circuit, measurements to include the tuned circuit must be made, as was done in all other checks,



Signal Generator Setting

Modulation	On or Internal
Range Switch	To Cover 600KC
Frequency Control	Rotate through 600KC for peak indication
Attenuator	Adjust for standard output. Average setting=50μv

Receiver Settings

Volume Control	Maximum
Tone Control	Maximum Highs
Fidelity Control	Maximum Selectivity
Dial	600 KC

Output Indication

Standard output-16 Volts or Specification

Fig. 14-5.—Stage-gain measurements from the mixer grid.

from a previous point in the receiver. Figure 14-6 shows the connections for a receiver with an RF stage. Note that the condenser in the "hot" lead of the signal generator is 0.00025 mfd. When the receiver has no RF stage, measurements are made from the antenna terminal, as shown in Fig. 14-7. When the receiver has no RF stage and is loop-operated and there is no antenna terminal on the receiver, the signal generator is fed into a loop made up of a few turns of wire. This loop is then placed near the loop antenna of the receiver, as shown in Fig. 14-8. In all cases, the receiver is adjusted for maximum gain; that is, the volume control is set to the full ON position, tone control to the minimum bass, and the selectivity-

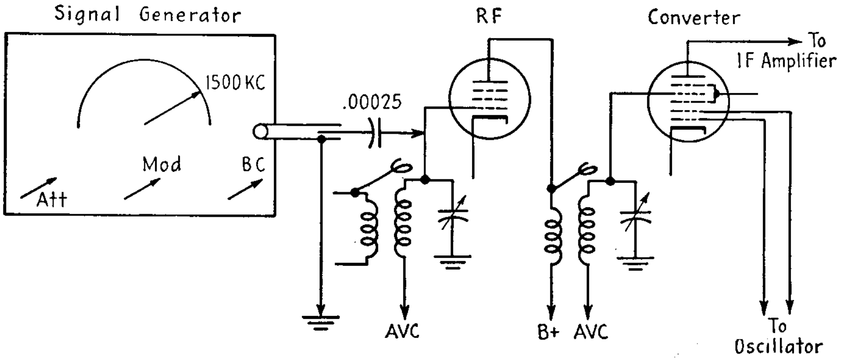


FIG. 14-6.—Signal-generator connections for stage-gain measurements of the converter when the receiver incorporates an RF stage.

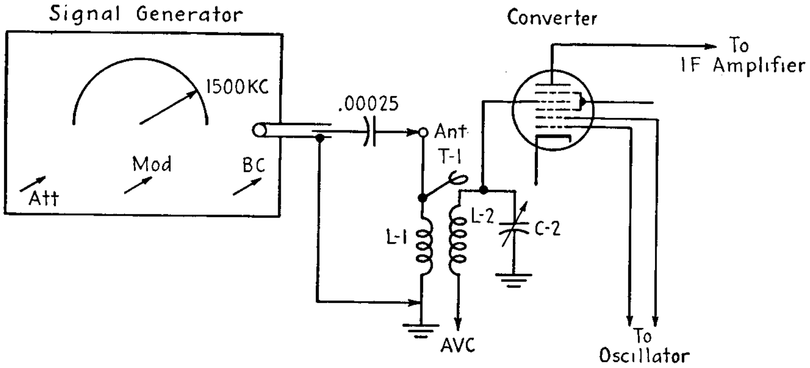


FIG. 14-7.—Signal-generator connections for measurement of converter gain when the receiver does not include an RF stage.

fidelity control to the position of maximum selectivity. The receiver dial is turned to 1,500 kc. (If a station is received at this frequency, it will interfere with the check. When this is the case, the receiver is tuned to a quiet part of the dial between 1,400 and 1,600 kc.) The output meter is set for a high-voltage AC range. The signal generator is adjusted for a modulated output on the broadcast band.

The frequency-control dial on the signal generator is then carefully rotated through 1,400 to 1,600 kc for peak response from the receiver. When the peak position is found, the attenuator is adjusted to give the standard output of 50 mw in the speaker. When the standard output has been obtained, the signal-generator frequency control is again adjusted for peak response on the output meter, and the attenuator readjusted if a response greater than 50 mw was obtained. This repetition is necessary because a high-level signal input would bring AVC action into play with a consequent broadening of the peak.

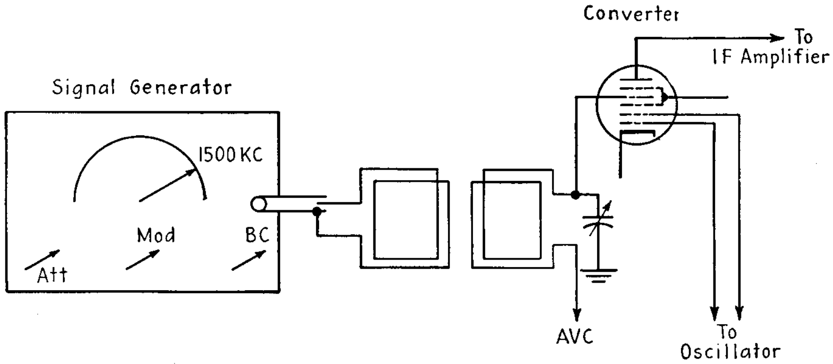


FIG. 14-8.—Method of connecting a signal generator to a loop-operated receiver.

The average signal strength at 1,500 kc needed to give the standard output of 50 mw from the antenna of a receiver that does not use an RF stage is 20 microvolts. Since an average of 50 microvolts is required to produce the same effect from the converter signal grid, the apparent approximate gain between the antenna and the converter signal grid is 50/20 = 2.5.

When a receiver uses an RF tube, the average input signal (at 1,500 kc) applied to the RF grid is 5 microvolts for standard output from the receiver. In this case the apparent gain between the converter signal grid and the RF grid is 50/5 = 10. The added gain is due to the amplification of the RF tube.

Having established comparative gain data with several good receivers, the serviceman is in a position to judge the gain characteristics of any converter stage. He should remember, however, that these checks are approximate and that there will be considerable variation shown when different receivers are checked.

A signal of 5 microvolts is about the lower limit that can be expected from the average signal generator. Leakage in the attenuator circuits, insufficient shielding, and the increased noise level when working at lower signal levels make it extremely difficult to carry out even approximate stage-gain measurements. For this reason, gain data for the antenna circuit of a receiver that uses a tuned RF stage will not be given.

COMMON TROUBLES IN THE CONVERTER

Troubles Common to the RF Input Transformer.—The RF input transformer, *T-2*, is likely to be an interstage RF transformer coupling the RF stage to the converter, or an antenna coil coupling the antenna to the converter, or a coil loop acting as the antenna for the receiver, depending on the type of receiver. The three types of coupling units all have one common trouble—that is, the windings open—but they present different service problems and will be handled separately.

Service Notes for an Interstage RF Transformer.—An open secondary winding of an interstage RF transformer will be found on signal check. At such time, when a test signal, either at RF or IF, is fed into the converter signal grid, the signal will come through to the speaker, but the gain will probably be low. In addition, the modulation note of the signal generator will have a rough tone due to the open grid circuit. When the test signal is applied to the RF grid, the response will be very low. The condition is then confirmed with an ohmmeter check.

When the primary of the interstage RF transformer is open, the receiver will operate normally when the test signal is applied to the converter signal grid but will not operate at all when the test signal is shifted to the RF grid. A voltage check will then show no voltage at the RF plate, and a continuity check will confirm the trouble.

Before a defective interstage RF transformer is replaced, it would be wise to examine the coil, since the break is often at or near a terminal lug and is easily repaired. Even removing a turn to effect a repair is permissible.

An exact replacement of the RF interstage transformer is necessary, since tuning circuits will not bear wide tolerances. However, at times, the coil is beyond repair, an original replacement cannot be obtained, and a general replacement transformer is the only alternative. In this case, the serviceman should choose the replacement transformer carefully, so that it matches the original as closely as possible in physical characteristics. The important points to keep in mind are the size of the shield, length and diameter of the coil form, and size and location of the windings.

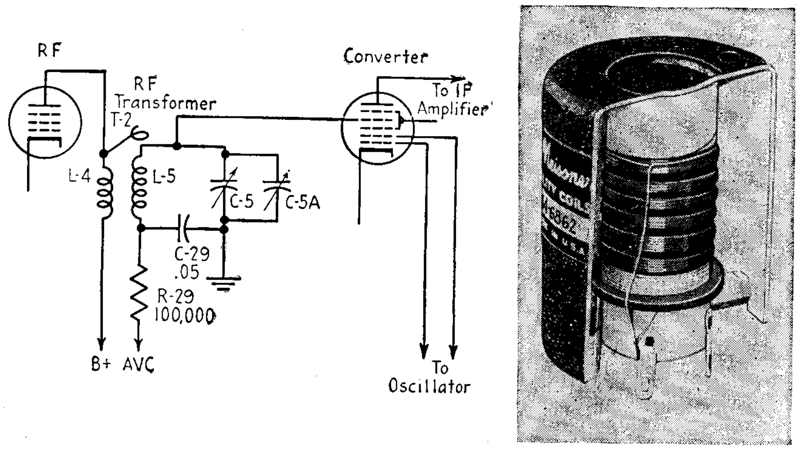


FIG. 14-9.—A typical interstage RF transformer and its position in the circuit.

When the replacement transformer has coded leads, the color coding is the same as for an IF transformer.

Blue wire	Plate
Red wire	*B* plus
Green wire	Grid
Black wire	Grid return

The placing of the green grid lead can easily be altered to conform to the placing in the original transformer. For example, if, in the replacement, the green wire comes through the shield can for connection to a top cap on the converter tube, whereas, in the original, the grid wire was brought through the bottom to a 6SA7 converter, it takes only a few minutes to remove the coil from the shield can and reroute the wire.

When the replacement-transformer coil leads are brought to unmarked soldering terminals, the terminals can be identified as described in the next section.

How to Identify RF Transformer Coil Leads.—For the identification of RF transformer coil leads, see Fig. 14–10 and the following notes.

Plate Lead.—Look for the gimmick loop. Trace it to the coil terminal lug. This is the plate lead, which connects to the RF plate.

B Plus Lead.—Look for the leads on the primary coil. One goes to the plate lead. Trace the other lead to its terminal lug. This is the *B* plus lead.

Grid Lead.—Look for the secondary coil leads. Trace the top end of the secondary winding (near the gimmick loop) to its terminal lug. This is the grid lead, which connects to the tuning condenser stator and converter signal grid.

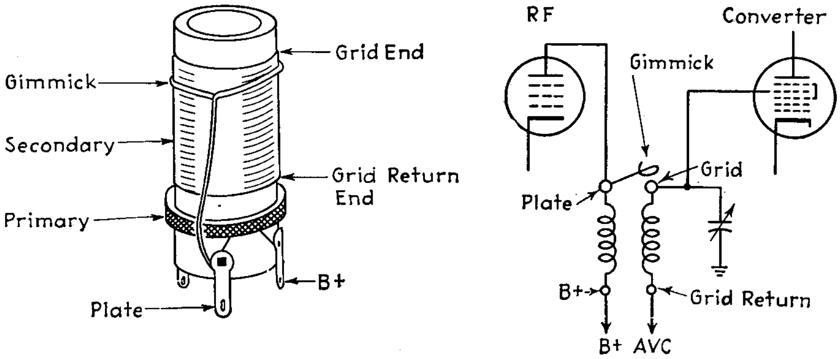


Fig. 14–10.—Interstage RF transformer leads.

Grid Return Lead.—Check to see that the remaining terminal lug goes to the bottom end of the secondary winding. This is the grid return lead, which connects to the AVC circuit.

Service Notes for an Antenna RF Transformer.—An open secondary of an antenna RF transformer will be found by a signal check. The radio will operate at reduced gain and possible hum, when a test signal, either RF or IF, is applied to the converter signal grid, and at greatly reduced gain when the test signal is applied to the antenna terminal. An ohmmeter check then confirms the condition.

An open primary winding may or may not cause any appreciable difference in operation. The capacity of the gimmick loop may transfer sufficient energy from the antenna to the secondary winding, so that operation is apparently normal for local reception, and the trouble would not be found unless stage-gain measurements or routine ohmmeter checks are made. In receivers where the open primary winding causes a large difference in reception, even a rough signal check will show a loss in gain between the antenna and the converter signal grid.

All the service notes pertaining to the RF transformer can be applied to the antenna transformer, by making allowance for the fact that the primary connects to antenna and ground, instead of RF plate and *B* plus.

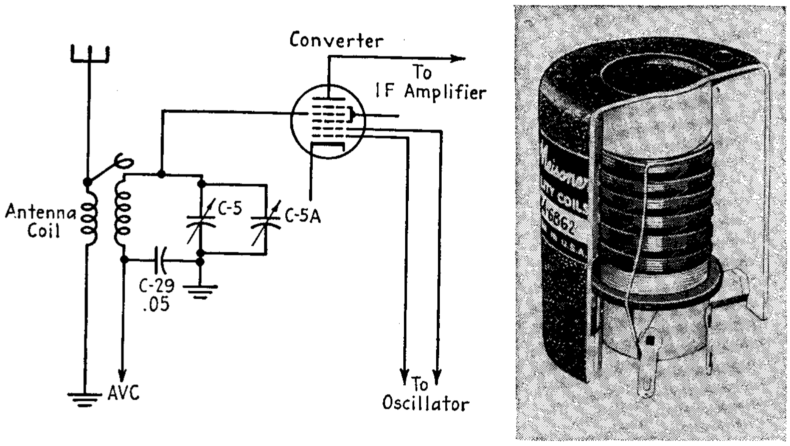


FIG. 14–11.—A typical antenna coil and a circuit showing antenna input to the converter tube

Antenna Transformer Color Code.—The R.M.A. color code for the antenna transformer follows:

Blue lead	antenna
Red lead	ground
Green lead	grid
Black lead	grid return

How to Identify Antenna Transformer Leads.—For the identification of antenna transformer leads, see Fig. 14–12 and the following notes.

Antenna Lead.—Look for the gimmick loop. Trace it to the coil terminal lug. This is the antenna lead, which connects to the antenna terminal of the receiver.

Ground Lead.—Look for the leads on the primary coil. One goes to the antenna terminal. Trace the other lead to its terminal lug. This is the ground lead.

Grid Lead.—Look for the secondary coil leads. Trace the top end of the secondary winding (near the gimmick loop) to its terminal lug. This is the grid lead, which connects to the tuning condenser stator and converter signal grid.

Grid Return Lead.—Check to see that the remaining terminal lug goes to the bottom end of the secondary winding. This is the grid return lead, which connects to the AVC circuit.

Replacement Notes for Antenna and RF Transformers.—When replacing an antenna or RF transformer, the serviceman should be careful of the placement of the leads. Improper lead dress may cause oscillation. The leads should be routed as they were in the original transformer of the receiver. If the wiring has been disturbed, the following general rules should be observed. The blue (plate or antenna) and the green (grid) leads are the "hot" wires. The transformer should be so mounted that the green lead or grid terminal points to its connection point on the tuning condenser stator or signal grid terminal of the converter tube. At the same time the blue lead (RF plate or antenna terminal) points to its connection point, the plate terminal of the RF tube socket or the antenna terminal. The leads are dressed close to the chassis and away from each other and all other wiring. The dress of the other two leads is not quite so important, but they should also be routed close to the chassis and directly to their connection points.

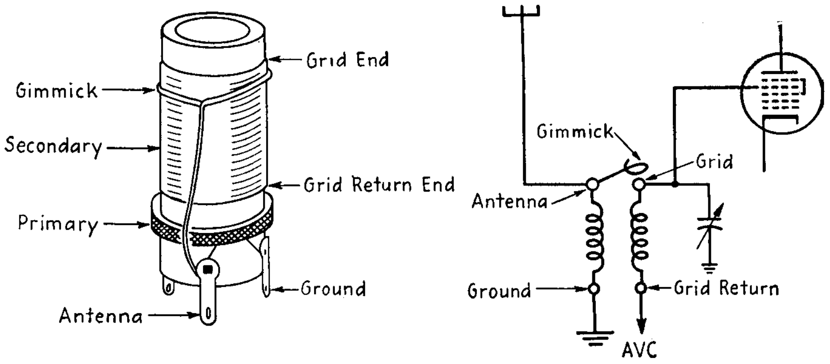


FIG. 14-12.—Antenna coil leads.

When an antenna transformer is being replaced in an AC/DC type of receiver, the transformer antenna terminal connects to the hank of wire that acts as the antenna or leadin of the receiver through a condenser. The purpose of this condenser is to insulate the receiver from accidental grounds through the antenna wire. The condenser is usually a paper tubular type that almost never gives any service difficulties. However, the moving of leads, coincidental with the replacement of the antenna transformer, may have caused one of the condenser terminal leads to break away from the tin foil of the plates, causing an intermittent or fading condition. It is a good idea, therefore, when replacing an antenna transformer in an AC/DC receiver to examine carefully the associated condenser terminal leads. If they appear to move under the wax, or if a gentle pull causes the receiver to fade, the condenser should be replaced. The capacity of the condenser is unimportant. Any capacity over 0.002 mfd will be satisfactory.

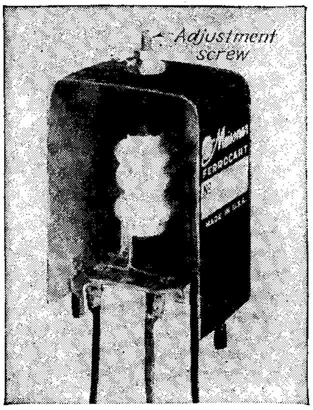


FIG. 14–13.—Universal adjustable replacement RF or antenna coil.

When the antenna or RF transformer is replaced, the circuit will have to be realigned as must be done when any component in any tuned circuit is changed. It is usual practice to realign the entire receiver.

When universal adjustable replacement antenna and RF transformers are employed, it is necessary to alter the standard alignment procedure somewhat, so that the replacement transformer may be adjusted to work properly in the circuit in which it is being placed. The adjustable feature of these coils is permeability tuning with a screw adjustment similar to that used in IF transformers, so that the inductance of the coil may be varied to suit the receiver. An adjustable replacement coil of this type is shown in Fig. 14–13.

The alignment procedure specified for the receiver being serviced, or the standard alignment procedure given on page 427, is followed down to the adjustment of the oscillator trimmer and padder condensers. At this point, the receiver dial is correctly calibrated. The hot lead of the signal generator is connected through a 0.00025-mfd condenser to the antenna terminal of the receiver, the signal generator and receiver dials are both turned to 600 kc, and the permeability adjustment screw of the replacement transformer is tuned for maximum response on the output meter. The receiver and signal-generator dials are then turned to 1,400 kc, and the RF or antenna trimmers on the gang condenser are aligned for maximum output in the usual way. The permeability adjustment-screw setting is then checked at 600 kc and, if readjustment is required, the procedure at 1,400 kc is repeated.

Service Notes Pertinent to a Loop Antenna.—Loop antennas used with receivers are of many types, but they develop troubles that may be catalogued together. Loops are usually wound with heavy wire and, as a result, are rarely troubled with corrosion, which is the main cause of trouble in all other coils in the receiver. However, the position of the loop in the back of the receiver makes it vulnerable to troubles of a mechanical nature. The leads connecting the loop to the receiver chassis become frayed and broken, various types of plug-in connectors lose contact, and sometimes the loop becomes partly unwound.

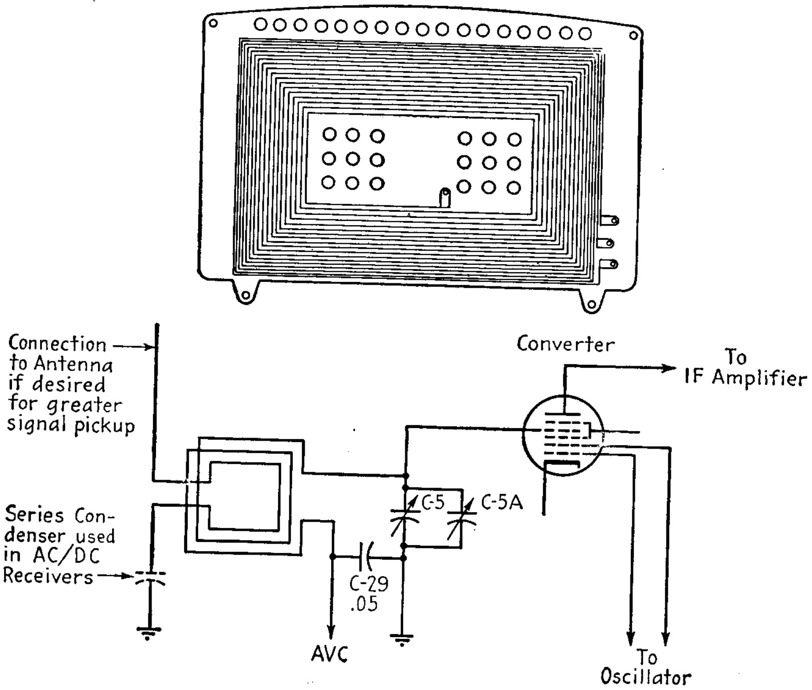


FIG. 14-14.—A loop antenna and the schematic diagram of a loop providing signal input to the converter tube.

An open loop will be found on signal check. The radio will operate at reduced gain and possible hum when a test signal, either at modulated radio frequency or at modulated intermediate frequency, is applied to the converter signal grid. When the test signal is shifted to the antenna lead, the radio may operate at greatly reduced gain or not at all. An ohmmeter check then confirms the condition.

It is rarely necessary to replace the loop. The broken lead or loose contact is found by inspection and repaired. A partly unwound loop is rewound, and the wire is held in place with coil dope.

If several leads have broken away, there is likely to be some confusion as to where they should be replaced. The manufacturer's service notes are helpful in this regard, since they often include a wiring diagram of the loop connections. When this information is not available, the serviceman should examine the loop antenna to determine whether the primary antenna winding (one or two turns) is on the outside or the inside of the loop winding. After that, the conventional connections for both types are shown in Fig. 14–15.

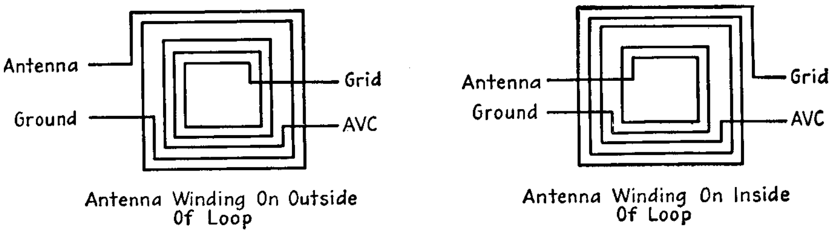


FIG. 14–15.—Identifying loop antenna leads.

The outside and inside leads are always easily located. The two inner leads may not be so readily distinguished by visual inspection. A continuity check with the ohmmeter, however, will positively identify the inner leads. In the case of the AC/DC type of receiver, the serviceman should remember to check the insulating condenser, which should be in the antenna or ground lead.

Troubles Common to the Tuning-condenser Gang Assembly.—Tuning condensers usually develop troubles of a mechanical nature which may be repaired by the serviceman. Replacement of a tuning gang with anything but the original part would be extremely difficult, since the replacement would have to match the condenser drive mechanism, and the dial and pointer. Also the plates would have to be so shaped that the dial calibrations would be reasonably accurate; in addition there are the usual considerations of size, capacity, etc. For this reason, maintenance notes on tuning-condenser gangs will be in considerable detail.

A very common trouble is slipping or failure of the condenser and dial drive mechanism. Since there are such a large number of different types of drive assemblies in common use, the information under this heading will be generalized.

Sometimes the drive mechanism operates the dial pointer but the condenser rotor plates do not turn, resulting in no stations or one station all over the dial scale, depending on the position of the rotor plates. This is usually due to loose setscrews between the condenser drive and the rotor shaft. The cure is obvious—tightening the setscrew. Before doing so, however, the serviceman should refer to the receiver service notes to see if there are definite instructions about the positioning of the dial pointer. This information is usually given as part of the alignment instructions. If no reference can be found, the usual procedure is to rotate the gang tuning condenser until the plates are fully engaged, set the dial pointer to the last calibration mark on the low-frequency end of the dial scale, and tighten the setscrew in this position (see Fig. 14–16).

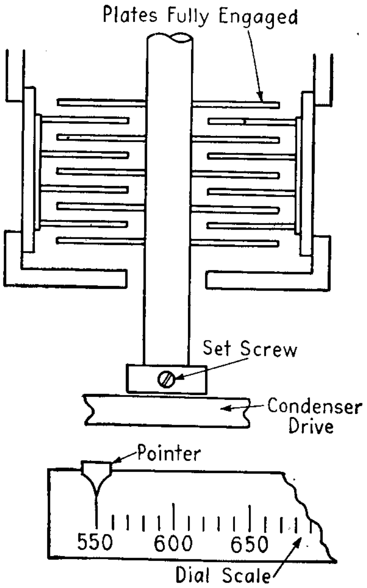


FIG. 14–16.—Position of condenser drive, setscrew, and dial pointer.

The trend in modern receivers is to use silk fish cord for the dial drive mechanism. Fortunately, receiver manufacturers are now issuing instructions for restringing the dial drive cords, as part of their service literature (see Fig. 15–2). Where this is not available, the serviceman must work out the mechanical details for himself. After some experience, a man with average mechanical ingenuity will have little difficulty with any of the multiplicity of dial drives in common use.

Servicing Condenser Contact Springs.—Another common trouble with tuning condenser gangs develops in the contact springs, often called "wipers." Figure 14–17 shows the location of this item. The wiper makes contact between the rotor plates and the condenser shields that ~~are~~ grounded. Sometimes a ground wire is soldered to the contact spring, and sometimes no wire is connected. In either case, when dirt gets between the contact spring and the rotor, there will be resistance between the rotor plates and the ground. This may cause noisy reception, and even no reception over parts of the tuning range. In TRF receivers, poor contact at this point is a cause of oscillation. The cure is to remove the wipers, clean them, readjust the spring tension, and return them to their positions. When the wipers are riveted in place, the spring can be pried back at the point of contact with a screw driver that has been dipped in carbon tetrachloride. The screw driver is then removed, and the drop of cleaning solution is worked back and forth by rotating the condenser gang quickly. When this procedure is repeated a couple of times for each wiper, the contact between the rotor plates and ground is reestablished.

At this time, it might be well to add a word about the general use of cleaning solutions, lubricants, and abrasives in radio service work.

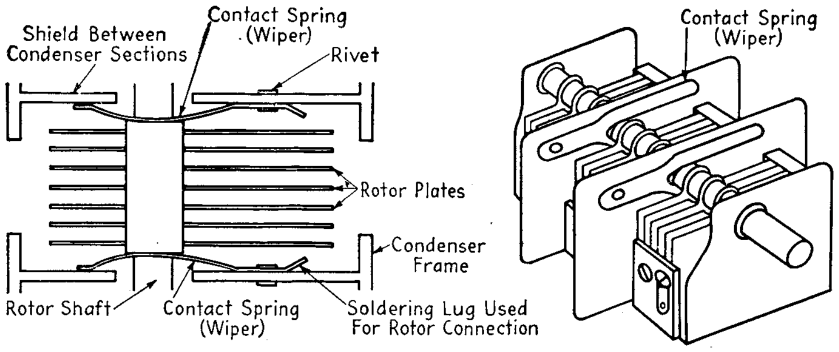


FIG. 14-17.—Location of contact springs (wipers) for the rotor plate connection on a variable condenser.

Carbon tetrachloride makes a good general-purpose cleaning solution, since it dissolves grease, loosens dirt, dries quickly, is noninflammable, and is not harmful to radio parts. A light machine oil should be used for lubricating bearings, pulleys, shafts, etc. Tuning-condenser bearings should not be lubricated, since they are self-lubricating, and any oil at this point may work its way into the condenser contact springs and insulate the rotor from the ground. Where an abrasive is needed, sandpaper should be used. Steel wool and emery cloth should not be used on or near a receiver. Although steel wool will do a good cleaning job on a condenser contact spring, particles of it getting into the tuning gang or into the speaker will cause considerable trouble. The abrasive material in emery cloth is also a conductor and will cause similar troubles.

Shunt Resistance and Shorts in Variable Gang Condensers.—Condensers, especially when not covered by shielding, collect a considerable amount of dust and dirt. When a bakelite stator-plate support or a trimmer condenser is dusty, the dust will act as a shunt resistor between the stator and the ground. The shunt resistance may cause very little effect on the operation of the antenna and RF stages, but it can seriously impair the operation of the oscillator. Dusting with a soft brush usually takes care of the trimmer condenser, and a wash with carbon tetrachloride cleans the stator insulator.

A short between the stator and the rotor plates of any condenser in the tuning gang will cause noisy reception and dead spots in the tuning range. The short may be due to a number of causes: one or more bent plates (usually in the rotor), shifted stator plate, dirt and dust between the plates, and, in the case of plated condenser plates, slivers of plating sometimes peel, causing shorts as the condenser is rotated. A detailed procedure for locating and removing these shorts is given as part of the general overhaul procedure that follows.

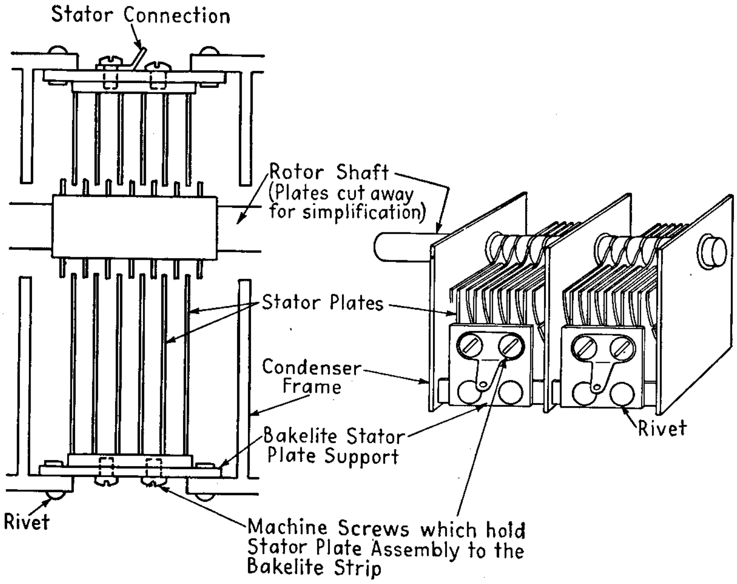


FIG. 14-18.—Method of fastening stator plates in a variable condenser.

General Reconditioning Procedure for Variable Gang Condenser.

1. *Clean.* Blow out the dust by applying a gentle air pressure, as from a bicycle pump, to all parts of the variable gang condenser. Go over the trimmer condensers and stator supports with a soft brush. Wash the stator supports with carbon tetrachloride. Clean

the condenser contact spring as described on page 235. Clean and lubricate the dial drive mechanism.

2. *Tighten and align the stator plates.* Examine the insulators that hold the stator plates in position. Figure 14–18 shows a common method of supporting the stator plates. Most condensers have a similar arrangement. The machine screws that hold the assembly together may loosen, making for poor contact with the stator soldering lug and also allowing the stator plates to slip out of parallel alignment. Figure 14–19 represents a condenser where this has happened. To repair this condition, pry the stator plates back into parallel alignment with the rotor plates, making sure at the same time of equal spacing between the plates, and then tighten the screws. Even if the plates have not slipped out of position, the screws usually require retightening. In condensers where the spacing between plates is very small and parallel alignment and equal spacing cannot be judged by eye, spacing shims can be made by cutting stiff paper into strips. An ordinary business card is of about the right thickness. The shims are inserted between the plates on both sides of the rotor shaft, the screws are tightened, and the shims removed.

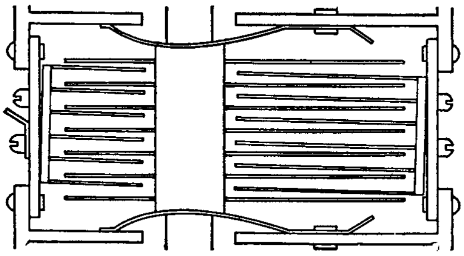


FIG. 14–19.—Stator plates out of parallel alignment because of loosened holding screws.

3. *Check the tension on the rotor.* The friction bearing on the rear of the rotor shaft should be tight enough to hold the rotor in any position, even if the radio is jarred, and should be loose enough so that the condenser rotor shaft can be turned easily by hand. If the tension is wrong, it should be adjusted. Most variable gang condensers have a tension adjustment screw similar to that shown in Fig. 14–20. The lock nut is loosened and the adjusting screw is turned. Tightening the screw tightens the tension. The screw should be turned about a quarter turn in the correct direction, while the rotor is held stationary. The lock nut is then tightened and the tension checked. If further adjustment is required, the procedure

is repeated. The front bearing of the rotor rarely requires any attention.

4. *Locate and remove any shorts.* The cleaning of the trimmer condensers and stator insulators, and the correct aligning of the stator plates, removed some of the possibilities for shorts and shunt resistance in the variable gang condenser. There are still dust between plates, bent rotor plates, and slivers of plating to be considered. To find these, remove the wiring from the condenser stator soldering lugs, and then apply high voltage between the stator connection and the chassis while turning the rotor. The high voltage will show an arc at any shorting position. The arc will probably burn up any dust or sliver of plating that caused the short (thereby automatically removing it) and will show the position of a bent plate. The high voltage is most easily obtained from the rectifier plate terminal. Use a test lead with an alligator clip on one end and an insulated test prod on the other. Clip the alligator to one of the plate leads of the full-wave rectifier (socket terminal 4 or 6 for a 5Y3-G rectifier) and keep the test prod where it can reach the condenser stator terminals. Switch the set on, touch the test prod to one of the stator lugs momentarily while watching for an arc either in the condenser or at the stator terminal. Turn the rotor plates in and out of mesh while the prod is connected. If a bent plate is discovered, turn the current off, straighten the plate, and then resume the procedure until all signs of shorts have disappeared. The procedure is then repeated for the other condensers in the tuning gang.

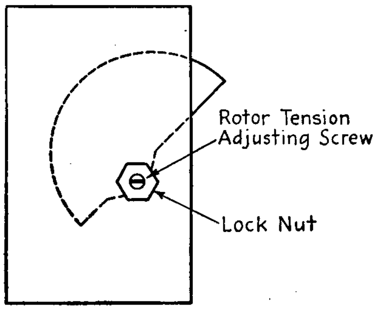


FIG. 14-20.—Rear view of tuning condenser, showing rotor tension adjustment.

In this procedure, it must be emphasized that the serviceman is working with a live lead at 300 or more volts, which is quite dangerous. He should have the current on only when needed, the test lead should be well insulated, and he should exercise care and alertness in his movements. He should also remember that shorting the high-voltage winding may ruin the transformer. That is why the test prod is touched to the condenser stator *momentarily* for checking the location of a short. It should not be left on a shorted condenser for any length of time.

When an AC/DC receiver is serviced, the transformer high-voltage winding is not available right on the same chassis. In this case, a separate transformer may be used, connecting one high-voltage lead to the chassis, and the other to the test lead. The same procedure is then followed.

When all shorts have been removed, the stator leads are then resoldered.

5. *Check the dial drive.* The dial drive mechanism is then checked. If it is the cord or belt type and shows signs of wear, replace it. If it is the type that uses a friction rim drive, it will usually respond to a thorough cleaning. Finally check the position of the pointer, as described on page 234.

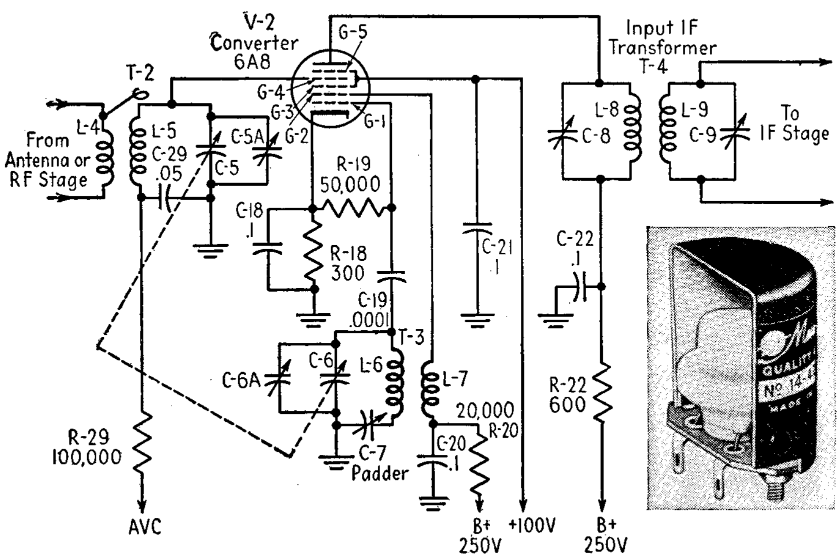


FIG 14–21.—A typical oscillator coil and its position in the converter circuit.

Troubles Common to the Oscillator Coil.—As with all other coils in the receiver, the main difficulty encountered with oscillator coils is open windings. If either winding opens, the oscillator will not function and the receiver will not pick up any stations. Signal check will isolate the oscillator stage as the field of trouble, since when a modulated test signal is applied to the converter signal grid at the intermediate frequency, there will be normal response from the receiver, whereas when the signal generator test frequency is shifted to radio frequency, there will be no response. An open feedback winding will be indicated in a voltage check, when no voltage appears at the oscillator anode. Since an open *R*-20 or a shorted *C*-20 can also cause no voltage at the oscillator anode, an ohmmeter is used for the final check. The ohmmeter check will also show up an open grid winding on the oscillator coil.

If the oscillator coil proves defective, it is usually necessary to obtain an exact replacement of the original, since the oscillator circuit controls the calibration of the dial scale. When an exact replacement is used, it is necessary only to connect the wiring to the new coil without disturbing the lead dress and to realign. It is, of course, necessary to connect the leads correctly, since a reversal of the connections to either winding will reverse the phase of the feedback coil, and the circuit will not oscillate. A good way to make sure that the rewiring is correctly done is to follow the procedure suggested for replacing volume controls. The old coil is loosened with the wiring intact, the new coil is mounted, and the wiring is shifted one wire at a time to its corresponding soldering lug.

When an exact replacement oscillator coil is not obtainable, it is possible to use a universal adjustable replacement coil, where the inductance of the coil may be varied by means of a permeability adjustment screw. When this is done, it is necessary to follow the instruction sheet with reference to identifying the coil terminals, since oscillator coils are rarely color-coded. It is also difficult to determine the ends of the windings, since the windings are usually wax-impregnated and closely coupled.

The replacement coil is mounted in such a way that the oscillator grid and anode leads are short. The replacement coil is then wired and the receiver is realigned. However, it is necessary to alter the alignment procedure, so that the universal replacement oscillator coil may be adjusted to work properly in the receiver in which it is placed.

Aligning a Universal Replacement Oscillator Coil.—When the receiver is of the type that uses cut plates in the oscillator section of the variable gang condenser and there is no 600 padder, the alignment procedure is as follows: First, the IF transformers are aligned in the usual way. Then the "hot" lead of the signal generator is connected through a 0.00025-mfd condenser to the antenna, and the generator is adjusted to give a modulated signal at 600 kc. The receiver dial is turned to 600 kc, and the permeability adjustment screw on the replacement oscillator coil is aligned to give maximum response. The signal generator and the receiver dials are shifted to 1,500 kc, and the high-frequency trimmer on the oscillator section of the gang condenser is adjusted for maximum response. The procedure is repeated at 600 and 1,500 kc for optimum results. The RF and antenna trimmers are then aligned in accordance with the standard alignment procedure.

When a universal adjustable replacement oscillator coil is placed in a receiver that uses a 600 padder, the alignment procedure is somewhat more involved.

Possibly, it would be best to review the function of each of the adjustments in the oscillator tuning circuit, in the hope that the procedure may become more understandable and usable. This is done in Fig. 14–22. Condenser C-6 is the main tuning condenser, which is the oscillator section of the gang. The condenser T is the high-frequency trimmer. The condenser labeled P is the series 600 padder. The adjustment screw on the universal replacement oscillator coil controls its inductance and is labeled L. It will be remembered that the high-frequency trimmer T controls the frequency of the oscillator tuning circuit at the high-frequency end of the dial, and the series padder controls the low-frequency setting of the oscillator tuning circuit. The actions of these controls are not entirely independent, since each will have some effect on the opposite end of the tuning range. This explains why alignment procedures always recommend repeating the setting of these adjustments until they are at their correct positions, as proved by no further need for readjustment.

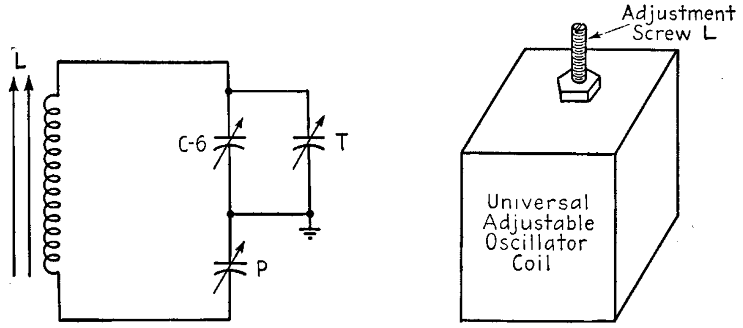


FIG. 14–22.—Oscillator tuning-circuit adjustments when a universal adjustable replacement oscillator coil is used.

When the inductance of the oscillator coil is also variable, as is the case when a universal replacement is used, its adjustment will control the frequency of the oscillator circuit all over the tuning range, since this depends on the inductance as well as the lumped capacity of the circuit. As a corollary, any adjustment of the inductance by means of its permeability screw L will necessitate readjustment of the series padder and shunt trimmer. With all three controls variable and dependent upon each other, proper alignment will be extremely difficult, unless a planned procedure is followed closely.

If the 600 padder has been undisturbed, one of these variables will be eliminated, since the padder will be close to its correct setting. In this case, the 600 padder is neglected entirely, and the receiver realigned by the procedure just given for a circuit that uses cut plates in the oscillator section of the gang condenser, and no 600 padding adjustment.

If the serviceman is not sure of the setting of the 600 padder, two alignment procedures may be used. In the first, the settings of the three adjustments are first made roughly and, then by repeated readjustments, are brought to their final positions. This procedure, although simple, is not always operative, owing to varying circuit constants and limited trimmer ranges in many receivers. The second procedure is more difficult, but it is always successful. In it, the alignment of the receiver is carried out at several prefixed positions of the 600 padder, each one is checked, and finally the position of best tracking is chosen.

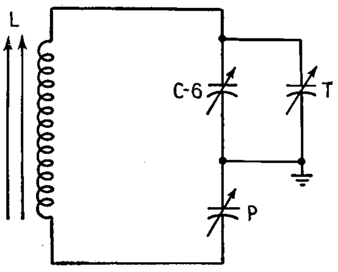


Fig. 14-23.—Oscillator tuning-circuit adjustments.

Alignment Procedure No. 1 for an Oscillator Circuit with Variable Trimmer, Padder, and Inductance.

1. *Check IF alignment.*

2. *Connect the "hot" lead of the signal generator to the antenna terminal of the receiver through a 0.00025-mfd condenser.* Adjust the signal generator for a modulated output on the broadcast band.

3. *Set the trimmer and padder to center-capacity range.* The average trimmer and padder condensers require three full turns of the adjustment screw from full to low capacity. For approximate center-capacity setting, tighten the screws fully, then loosen one complete turn.

4. *Adjust L at 1,000 kc.* Tune the signal generator and receiver to 1,000 kc, and adjust the permeability screw *L* on the oscillator coil for maximum output.[1]

5. *Adjust P at 600 kc.* Tune the signal generator and receiver to 600 kc, and adjust the 600 padder *P* for maximum output.[1]

6. *Adjust T at 1,500 kc.* Tune the signal generator and receiver to 1,500 kc, and adjust the high-frequency trimmer *T* for maximum output.[1]

---

[1] If the signal cannot be tuned in, the adjustment range is not large enough, or the first rough setting for center capacity is too far from the correct setting. Try the second alignment procedure.

7. *Repeat steps* 4, 5, *and* 6 *in sequence until each screw requires no further readjustment.*

8. *Align the RF and antenna trimmers in the usual way.*

Alignment Procedure No. 2 for an Oscillator Circuit with Variable Trimmer, Padder, and Inductance.

1. *Check IF alignment.*

2. *Connect the "hot" lead of the signal generator to the antenna terminal of the receiver through a* 0.00025-*mfd condenser.* Adjust the signal generator for a modulated output on the broadcast band.

3. *Set P for minimum capacity.* Examine the 600 padder and the action of its adjustment screw. Set the adjustment screw in the position where the plates begin to move together. This is the low-capacity setting of the 600 padder.

4. *Adjust L at* 600 *kc.* Tune the receiver and signal generator to 600 kc, and adjust the permeability screw on the oscillator coil for maximum response. If the signal cannot be heard over the range of this adjustment, increase the capacity setting of the 600 padder by a quarter turn and try again. Repeat this until the signal-generator note can be heard.

If the receiver does not have an RF stage, and the signal-generator attenuator is well advanced, there is a possibility of tuning the oscillator stage to the second harmonic of the 600-kc signal. To make sure that this error does not spoil the alignment when the 600-kc note is first heard, tune the signal generator to 1,200 kc. If the signal is not heard at this point, *L* is correctly adjusted for 600 kc. If the signal is heard and with a stronger note, *L* has been adjusted for 1,200 kc. More inductance and probably more capacity are needed in the circuit.

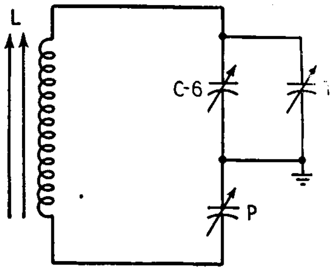


FIG. 14-24.—Oscillator tuning-circuit adjustments.

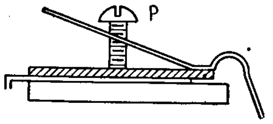


FIG. 14-25.—Low-capacity setting for padder *P*.

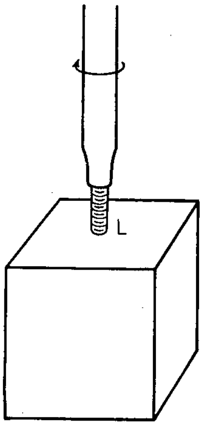


FIG. 14-26.—Adjust *L* at 600 KC.

5. *Adjust T at* 1,500 *kc.* Tune the receiver and signal generator to 1,500 kc, and adjust the high-frequency trimmer on the oscillator section of the gang condenser for maximum response. If the test signal cannot be heard, increase

the capacity of the padder P by an eighth turn of its adjustment screw. Then readjust L at 600 kc and try again to adjust T at 1,500 kc. Repeat this until the signal-generator note can be heard. The receiver is now tracking at 600 and 1,500 kc.

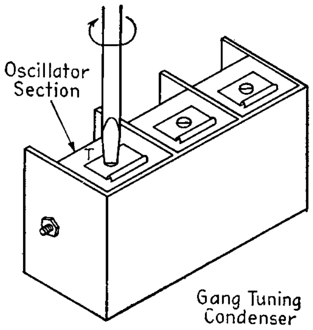


FIG. 14-27.—Adjusting the high-frequency trimmer T.

6. *Measure sensitivity at* 1,000 *kc.* Tune the receiver to 1,000 kc. Rotate the signal generator through 1,000 kc, while watching the output meter for maximum deflection. At peak response adjust the attenuator for standard output. Note the attenuator setting. This gives the sensitivity of the receiver at 1,000 kc.

7. *Adjust for maximum sensitivity at* 1,000 *kc.* Tighten the padder another eighth turn. Adjust L for maximum response at 600 kc. Adjust T for maximum response at 1,500 kc. Measure sensitivity at 1,000 kc. Note the reading. The receiver should show an improvement over the reading taken in step 6.

Repeat with another eighth turn on P. Readjust L at 600 kc, T at 1,500 kc, and measure sensitivity at 1,000 kc. Continue until the sensitivity decreases. The previous adjustment of the 600 padder was the correct one. Loosen P an eighth turn and complete the alignment.

Troubles Common to the Pentagrid Converter Tube.—The converter tube is a common cause of trouble in the stage. Tube checkers are not very reliable in indicating an inoperative tube, since the tube may show adequate emission but still not oscillate. If the signal check shows normal response when a test signal at the intermediate frequency is applied to the converter signal grid, but no response or weak response when the test signal is shifted to 600 kc, there is a sure indication that the oscillator is not functioning. The most probable reason is the tube. The best check is to substitute another similar tube that is known to be good.

Another trouble often experienced with pentagrid converters is modulation hum, caused by cathode-to-heater leakage. Again the best check is substituting a similar tube known to be good.

Sometimes a receiver is encountered where conditions for maintaining oscillations are critical, and the oscillator circuit will not operate over the entire tuning range. Substituting another pentagrid converter tube usually clears this up. The original tube may not be defective and may operate perfectly in another receiver. This matter is treated in greater detail in the next section.

Critical Oscillator Conditions.—Superheterodyne receivers sometimes develop a peculiar trouble. Reception is normal on the high-frequency end of the tuning range, erratic at the middle frequencies, and dead on the low-frequency end. Such a condition could be caused by shorts in the gang tuning condenser; more often it is due to failure of the oscillator at the low-frequency end of the tuning range. Which of the two possibilities is responsible can be quickly determined by the following procedure: Start at the low-frequency end of the tuning range, and tune toward the high-frequency end, noting the frequency of the first station received. Let us assume that it is at 1,100 kc. Then starting at the high 1,600-kc end, tune toward the 540-kc end, noting the stations as they are passed. If the 1,100-kc station comes in, followed by stations at 1,000 and 900 kc, and no stations after that, the trouble is sure to be in the oscillator circuit. The stations at 1,000 and 900 kc cannot be tuned in unless the radio is being tuned from high to low frequencies.

It is normal for oscillator operation to be more efficient at high frequencies than at low. Then if we assume, for example, an oscillator tube with weak electron emission, it may oscillate at the high-frequency end of the tuning range, but not at the low. Also, when the circuit is in an oscillating condition, the oscillation may continue as the operating frequency is reduced beyond the point of a normally nonoscillating position. Such operation might be called "critical oscillating conditions."

A condition of critical oscillator operation may be caused by other factors than a weak tube. The tube, however, is the most easily checked, since we can substitute another that is known to be good. If the new tube does not entirely clear up the trouble but causes the oscillation to stop at a lower frequency than before, it may be advisable to try still another tube, with the hope of finding one that will continue to oscillate all over the tuning range.

At this point, it might be well to add that a condition of oscillation is easily determined by a check of the voltage between the oscillator grid and the chassis. When the circuit is oscillating, the oscillator grid voltage will be negative with respect to chassis. When oscillation stops, the oscillator grid will check zero or slightly positive.

When replacement of the tube fails to clear up the trouble, all components of the oscillator circuit should be carefully checked.

This includes cleaning the oscillator section of the gang tuning condenser, since a dusty shunt across the oscillator tank may be the cause of the condition.

If all components seem to be in good condition, refer to the receiver manufacturer's service notes, to see if later changes incorporated in the receiver include any change in the oscillator circuit. Often the condition is widespread for a particular receiver, and later changes include remedial measures. The change may be a different value for the cathode resistor or for the oscillator grid resistor; or, the oscillator coil may have been changed, as indicated by a new part number. If any such alterations can be found, incorporating this same change in the receiver being serviced will clear up the difficulty.

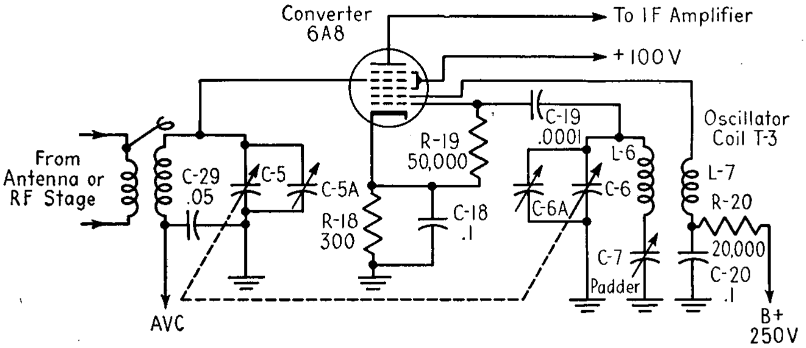


FIG. 14-28.—The oscillator circuit in a 6A8 pentagrid converter.

Where the receiver service notes do not indicate any such changes, the serviceman should experiment with the ohmic value of the cathode self-bias resistor. When this is reduced, a stronger electron flow in the tube is assured, with consequent better chance for maintaining oscillations at the low-frequency end of the tuning range.

Miscellaneous Oscillator Troubles.—When the signal check indicates trouble in the oscillator section, any of the component parts might be at fault. The tube, oscillator coil, and tuning condensers, which are the most common offenders, have been covered in previous sections. The resistors and condensers in the cathode, oscillator grid, and anode circuits remain as possible sources of faulty operation.

Trouble in the cathode circuit would appear before the oscillator circuit is suspected, since it would interfere with the operation of the pentagrid converter as an amplifier and would therefore cause trouble when the IF amplifier is checked from the converter signal grid. The usual trouble is an open bias resistor *R*-18. This would be found on voltage check, since the cathode voltage would be abnormally high, 50 volts or thereabouts, depending on the sensitivity of the voltmeter, instead of the normal value of approximately 3 volts. Self-bias by-pass condenser *C*-18 rarely gives any trouble.

In the oscillator grid circuit, resistor *R*-19 and condenser *C*-19 rarely give any trouble. Occasionally, a paper tubular condenser for *C*-19 may cause oscillator trouble owing to leakage. When replacing condenser *C*-19, use a mica condenser of the proper capacity.

In the oscillator anode circuit, resistor *R*-20 and condenser *C*-20 are in high-voltage circuits, where troubles and breakdown are more common. If condenser *C*-20 should short, the oscillator would not function owing to the absence of anode voltage. Signal check would show the inoperative oscillator, voltage check would show no voltage at the oscillator anode, and a resistance check would show a shorted *C*-20. Since no voltage at the oscillator anode might also be caused by an open *R*-20 or an open feedback winding, the resistance check would also disclose these defects. If the trouble is a short in condenser *C*-20, resistor *R*-20 should also be replaced, since it has been forced to feed heavier than normal current to the shorted condenser.

An open anode by-pass condenser *C*-20 would also cause the oscillator stage to be inoperative. Voltage check would show low voltage on the oscillator anode, and no or little voltage on the oscillator grid, the exact voltages depending on the stray capacity in the circuit. In addition, checking the oscillator anode voltage may cause the radio to play, since the capacity of the meter leads is added to the stray capacity in the circuit.

SUMMARY

Quick check for normal operation of the oscillator.

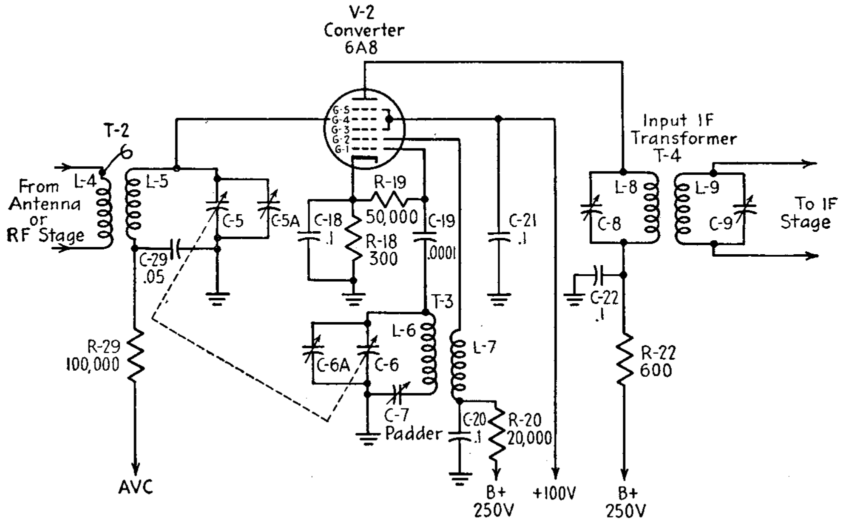
Tune the receiver to 600 kc. Connect the signal-generator output to the converter signal grid (mixer grid) through a 0.1-mfd condenser, and rotate the signal-generator dial through 600 kc. If the signal-generator modulation note is heard in the speaker at or near 600 kc, the oscillator is functioning.

Quick check for normal operation of the mixer.

Tune the receiver to 1,400 kc. Connect the signal-generator output to the RF grid (antenna if there is no RF stage) through a 0.00025-mfd condenser. Rotate the signal generator dial through 1,400 kc. If the signal-generator modulation note is heard in the speaker, at or near 1,400 kc, the mixer stage of the converter is functioning.

Standard diagram.

This circuit is shown in the accompanying figure.



Normal resistance data for the converter.

Across *L*-4, primary of the signal input transformer *T*-2	40 ohms
Across *L*-5, secondary of the signal input transformer	5 ohms
Across *L*-6, grid coil of the oscillator transformer *T*-3	5 ohms
Across *L*-7, feedback coil of the oscillator transformer	3 ohms
Cathode to chassis	300 ohms*
Signal grid (*G*-4) to chassis	1,600,000 ohms
Screen grid (*G*-3 and *G*-5) to chassis	30,000 ohms*
Plate to *B* plus	640 ohms*
Oscillator grid (*G*-1) to chassis	50,000 ohms
Oscillator anode (*G*-2) to *B* plus	20,000 ohms

* These readings are for the standard circuit and should be checked against service notes for any particular receiver.

In receivers where the signal input transformer *T*-2 is a loop antenna, the grid coil of the loop will measure 1 to 3 ohms. The antenna winding will measure less than 1 ohm.

Normal voltage data for the converter.

Readings taken from the indicated terminals to the chassis or common negative terminal of the receiver are given in the accompanying table.

	6A8 pin No.	AC receiver, volts	AC/DC receiver volts
Plate	3	250	90
Screen	4	100	50
Oscillator grid	5	—15	—10
Oscillator anode	6	200	90
Cathode	8	3	3

SERVICE DATA CHART FOR AN INOPERATIVE OSCILLATOR STAGE

Assume an inoperative oscillator section in a dead receiver, as shown by normal response when an IF test signal is applied to the mixer grid, and no response when the test signal frequency is changed to RF. The following test procedure is recommended.

Procedure	Reading	Trouble and subsequent check
Make a voltage check	Oscillator grid reads zero or positive	Confirms the inoperative oscillator
	Oscillator anode reads zero	Feedback coil is open. Oscillator anode dropping resistor *R*-20 is open. Oscillator anode by-pass condenser *C*-20 is short circuited. Confirm with a resistance check
	Oscillator anode reads low	Oscillator anode by-pass condenser is open
	Voltages normal except for oscillator grid	Nonoscillating converter tube. Substitute one that is known to be good. If the trouble still persists, it is in the oscillator grid circuit. Make ohmmeter check as shown below

Make a resistance check. Check for the following conditions:

Open oscillator coil grid winding *L*-6.
Shorted oscillator section of the gang tuning condensor *C*-6.
Leakage across the oscillator tuning condenser *C*-6 or the shunt trimmer *C*-6*A*.
Open padder condenser *C*-7.
Open or leaking oscillator grid condenser *C*-19.
Open or wrong resistance value for oscillator grid leak *R*-19.

SERVICE DATA CHART FOR AN INOPERATIVE MIXER STAGE

Assume an inoperative mixer in a dead or weak receiver, as shown by normal response when an RF test signal is fed to the mixer grid, and no or weak response when the RF test signal is fed to the RF grid.

Procedure	Reading	Trouble and subsequent check
Apply the test signal to the RF plate.	Normal response	Trouble is in the RF tube or its associated circuit. Substitute an RF tube known to be good. Make a voltage check and a resistance check of the RF stage to find the defective component.
	No or weak response	Trouble is in the mixer grid circuit. Check the mixer input transformer *T*-2 for opens. Check the AVC decoupling filter *R*-29 and *C*-29 for opens.

SERVICE DATA CHART FOR THE CONVERTER

Symptom	Look for
Hum	Open mixer grid coil *L*-5
Modulation hum	Defective converter tube. (Cathode-to-heater short or leakage)
No reception on LF end of the tuning range	Weak converter tube. Check oscillator circuit for critical oscillator conditions
Distortion	Short-circuited AVC condenser *C*-29
Weak reception	Open cathode by-pass *C*-18. Open plate by-pass *C*-22. Misalignment
Weak reception—high noise level	Open AVC condenser *C*-29
Squeal	Open screen by-pass *C*-21. Open plate by-pass *C*-22. Shielding improperly grounded. Leads improperly dressed
Squeals or birdies when tuning certain stations	Image frequency interference. See Chap. 16
Noisy, intermittent operation	Defective converter tube. Corrosion in input transformer *T*-2 and oscillator transformer *T*-3. Check gang tuning condenser for shorts and poor wiper contacts. Check wiring for loose connections and rosin joints
One station all over the tuning range	Condenser gang not turning. IF amplifier tuned to the wrong frequency
Receiver will not track on alignment	Tuning-condenser stator plates incorrectly spaced

CHAPTER 15

FURTHER NOTES ON THE CONVERTER—VARIATIONS

There are probably more variations in the converter than in any other stage in the receiver. Some receivers use separate mixer and oscillator tubes. Others use different converter tubes. In addition, there are a large number of oscillator circuits other than the anode feedback type, shown in the standard circuit for the 6A8 pentagrid converter tube. And finally, the mixing of the received signal and the locally generated signal can be accomplished in other ways than the electronic mixing described for the 6A8 tube. However, in all cases, the functions of the components remain the same, the signal check remains the same, and the service notes, applying to the main component parts of the stage, can be equally well applied to identical or similar components, regardless of the type of mixer and oscillator stage employed.

The variations chosen for this section will be those commonly found, or those requiring a special service procedure. They will include the popular 6SA7 or 12SA7 converter tubes, multiband receivers, push-button tuning, and permeability tuning.

Receivers Using the 6SA7 or 12SA7 Pentagrid Converter.—Many receivers employ a 6SA7 instead of a 6A8 for the converter tube. The signal input circuit and the IF output circuit are the same for either tube. There are some important differences in the oscillator circuit. The oscillator circuit employed is the Hartley type, using a tapped coil with the feedback winding in the cathode circuit. The oscillator anode and the screen are combined in the second and fourth grids.

From the serviceman's point of view, the following differences should be kept in mind. The signal input grid is pin No. 8 rather than the top cap. Signal-generator test signals, therefore, are most conveniently applied to the stator terminal of the tuning condenser *C*-5. Since the oscillator anode and screen are combined, one voltage measurement suffices for both and is usually called "screen" voltage. In AC/DC receivers, the screen voltage of the 6A8 averages 50 volts, whereas the 6SA7 or 12SA7 averages 90 volts. The oscillator grid-leak *R*-19 is approximately 20,000 ohms in circuits using a 6SA7, whereas grid-leak values approximating 50,000 ohms are found in circuits designed around the 6A8 tube. Adjustments of the 600 padder condenser *C*-7 must be performed with a special aligning screw driver made of insulating material, since both sets of plates are at high RF potential and, as a result, any adjustment will be affected by hand capacity.

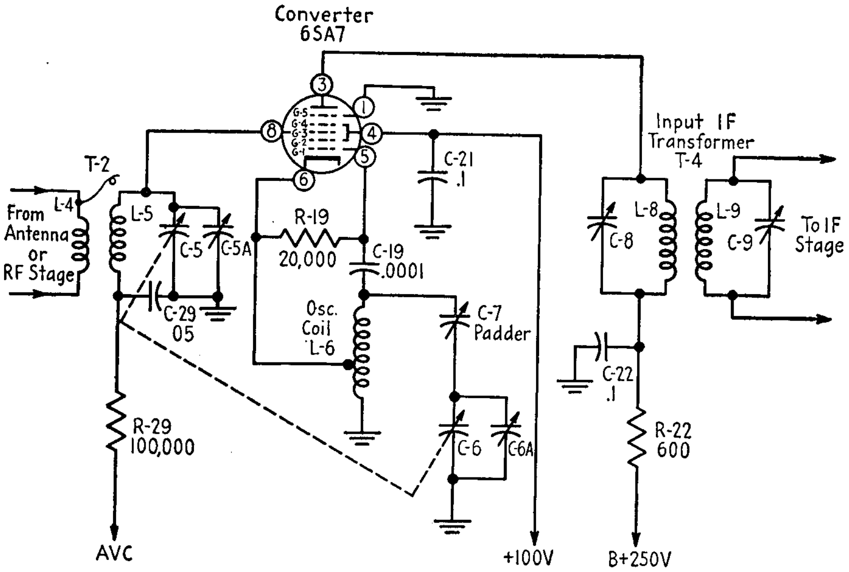


FIG. 15-1.—Schematic diagram of a 6SA7-type pentagrid converter.

Normal Voltage Data for a 6SA7 Converter.—Readings are taken from the indicated terminal to the chassis or common negative terminal. Data are given in the accompanying table.

Test terminal	6SA7 or 12SA7 pin No.	AC receivers, volts	AC/DC receivers, volts
Plate	3	250	90
Screen	4	100	90
Oscillator grid	5	—15	—10
Cathode	6	0	0

The signal check and the approximate stage-gain measurements are the same as those given for the standard circuit.

Figure 15-2 shows the service data wiring diagram of the RCA 45 X 18 receiver which uses a 12SA7 pentagrid converter. Note the following points in the converter stage. The tube is labeled 1ST DET. OSC. Condenser *C*-21, between the oscillator coil and the

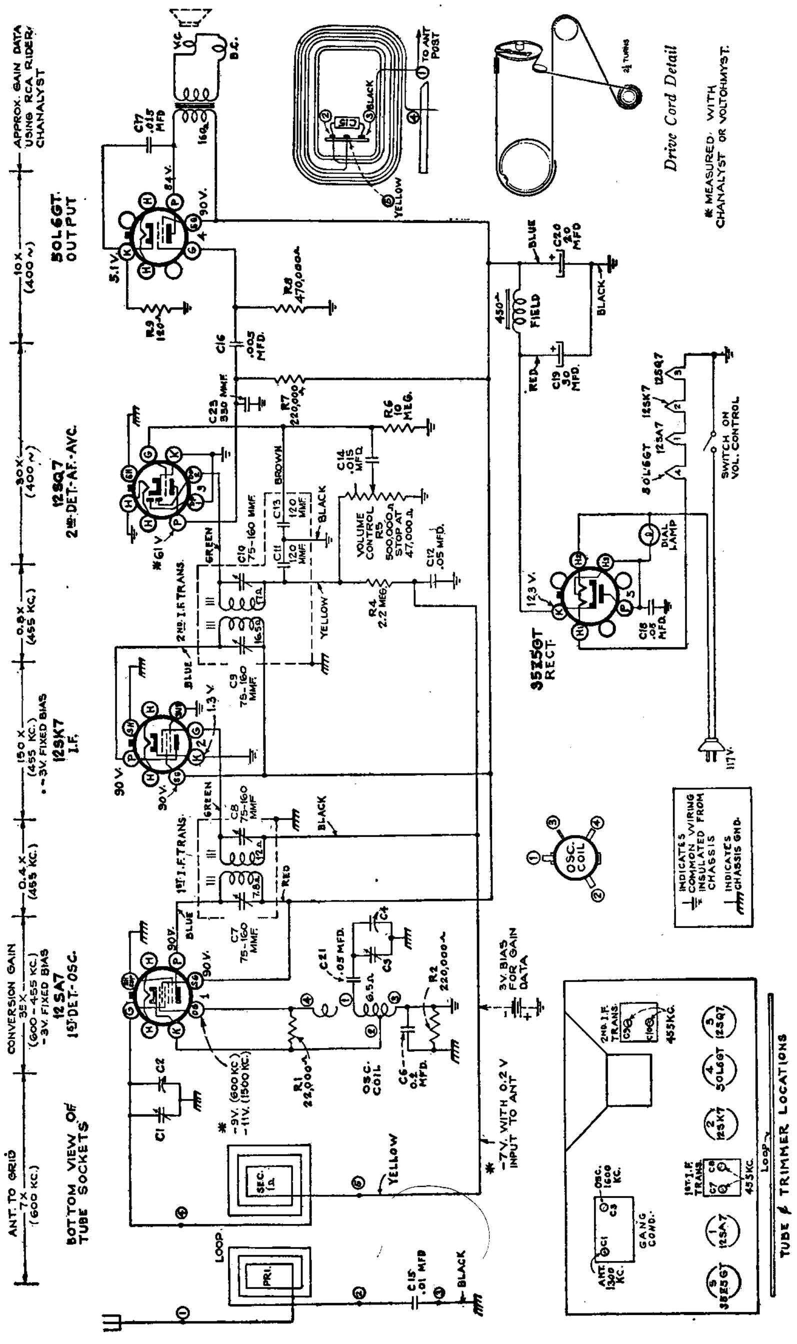


FIG. 15-2.—The RCA 45 X 18 receiver diagram.

tuning condenser, is a fixed condenser, which means that there is no 600 padder, and the oscillator section of the gang-tuning condenser has cut plates. The oscillator grid condenser is replaced by a capacity winding on the oscillator coil, connected to terminal ④ of the oscillator coil. The oscillator grid voltage is minus 11 volts at 1,500 kc and minus 9 volts at 600 kc, indicating greater oscillator output at the high-frequency end of the tuning range. The signal input transformer is a loop so that the receiver may be operated without an antenna for local reception. For reception of weak signals, an antenna may be connected as indicated to the primary winding of the loop. Condenser *C*-15, connected between the primary loop winding and the chassis, insulates the receiver against accidental short circuits in the power line, if the antenna should become grounded.

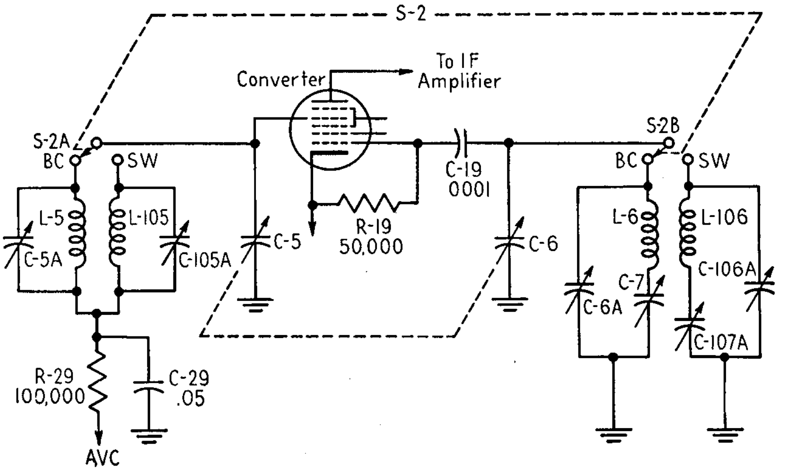


FIG. 15-3.—Simplified switching circuits for a multiband receiver.

Note also the following points of general interest in this diagram. The arrangement of the tube elements may make the diagram more difficult to read, but it facilitates the finding of tube pins for voltage checking. The voltages are marked for easy reference right at the socket terminal. Gain data are included above the diagram and, although the figures given are for the RCA Rider Chanalyst, they may be interpolated for any system of measuring gain.

Multiband Receivers.—In multiband receivers, the inductances in the tunable circuits are switched, so that the receiver may operate over more than one band of frequencies. A simplified circuit indicating how this may be accomplished is shown in Fig. 15-3.

The gang tuning condensers *C*-5 and *C*-6 are permanently connected across the signal grid and oscillator grid circuits. Switch *S*-2 is the wave-band switch. In the broadcast (*BC*) position shown, coil *L*-5 with its trimmer *C*-5*A* is connected in the signal grid circuit. In the oscillator grid circuit, for broadcast, the *B* section of the switch throws coil *L*-6 with its low-frequency padder *C*-7 and its high-frequency trimmer *C*-6*A* across the main oscillator tuning condenser *C*-6.

When the switch is thrown to the short-wave (*SW*) position, coil *L*-105 with its associated trimmer *C*-105*A* is connected in the signal grid circuit, while coil *L*-106 with its associated low-frequency padder *C*-107*A* and high-frequency trimmer *C*-106*A* is connected across the oscillator tuning condenser *C*-6. An arrangement such as the above makes it possible to align each wave-band position individually.

By using more positions on the wave-band switch, each one throwing in a different set of coils with their associated trimmers, it is possible to have a multiband or all-wave receiver. The common bands used for radio receivers are as given in the accompanying table.

Band	Approximate frequency range	Type of program
X or *LF*	150—400 kc	Maritime and aircraft
A or *BC*	540—1,600 kc	Standard broadcast
B or police	1.5—4.6 mc 2—6.2 mc	Police, amateur
C or *SW*	5.8—18 mc	U.S. and foreign short wave

The *B* or police band has either of the two frequency ranges shown, depending on whether it is desired to include state police at 1,600 to 1,800 kc or the United States and foreign broadcast stations at 6 to 6.2 megacycles. When the latter range is chosen, the broadcast band is usually extended to 1,750 kc to include the state police broadcasts.

Multiband receivers usually include two or three of the frequency ranges listed above. All-wave receivers include all bands, and sometimes add a fifth which extends the high-frequency range to approximately 40 megacycles.

The circuit of Fig. 15-3 is simplified in that it makes no provision for shorting the unused coils (a usual procedure), and does not show the primary of the coil in the signal grid circuit or the feedback winding of the oscillator coils, either or both of which may also require switching.

Practical multiband receivers use a variety of switching and coil arrangements. In addition to changing coils, the switch may include extra sections which accommodate auxiliary functions. For example, pilot lights may be switched on and off so that the proper frequency range on the dial scale is illuminated. Another common practice is to increase sensitivity and to alter the tone response, when the receiver is switched to short-wave reception.

Figure 15–4 is a three-band superheterodyne receiver. *C*-1 and *C*-2 are the gang tuning condenser. The antenna coil assembly includes the antenna transformer *T*-1, the broadcast loading coil *L*-2, and the three trimmer condensers, *C*-3, *C*-4, and *C*-5. The proper coil, with its associated trimmer, is switched to the tuning condenser *C*-1 and the signal grid of the 6SA7-GT converter by the *A* section of the band switch. The oscillator coil assembly includes the oscillator coils, all labeled *T*-2, with their associated high-frequency trimmers, *C*-6, *C*-7, and *C*-8. Note the low-frequency padder *C*-21 for the broadcast coil, the fixed condenser for the police coil, and no condenser for the short-wave coil. The *B* section of the wave-band switch connects the proper coil with its trimmer and padder to the main oscillator tuning condenser *C*-2 and the oscillator grid circuit. The *C* section of the band switch connects the proper feedback coil to the cathode circuit of the 6SA7-GT converter tube. Note the shorting arm on all three sections of the wave-band switch.

Figure 15–5 is a two-band superheterodyne receiver. The range switch has four decks or wafers, labeled *A*-1 to *A*-4. The switch has three positions: broadcast band (antenna), broadcast band (loop), and short-wave band. In the position shown, broadcast band (antenna), range switch sections *A*-1 and *A*-2 connect the antenna to the center tap of antenna coil *L*-3; antenna tuning condenser *C*-4 is connected across *L*-3 with its trimmer *C*-1; and the tuning circuit, composed of *L*-3 and *C*-4, is connected in the grid circuit of the RF amplifier tube, which is a 6SK7 type. Oscillator tuning condenser *C*-5 is connected through switch sections *A*-3 and *A*-4 to broadcast oscillator coil *L*-6 and the oscillator grid circuit of the 6SA7 tube. The cathode of the 6SA7 tube connects through the tap on short-wave oscillator coil *L*-7 to the tap on broadcast oscillator coil *L*-6. Terminals 6 and 7 on switch deck *A*-3 throw a short across condenser *C*-28*A* in the grid circuit of the lower 6V6-GT tube through the wires labeled *Y*-*Y*. This is a tone-compensation circuit which will be open on short-wave reception.

When the range switch is moved one position to broadcast (loop), switch section *A*-2 opens the antenna circuit, and *A*-4 shorts out the minimum-bias resistor in the cathode circuit of the RF 6SK7 tube. The other connections remain the same as in the broadcast (antenna) section.

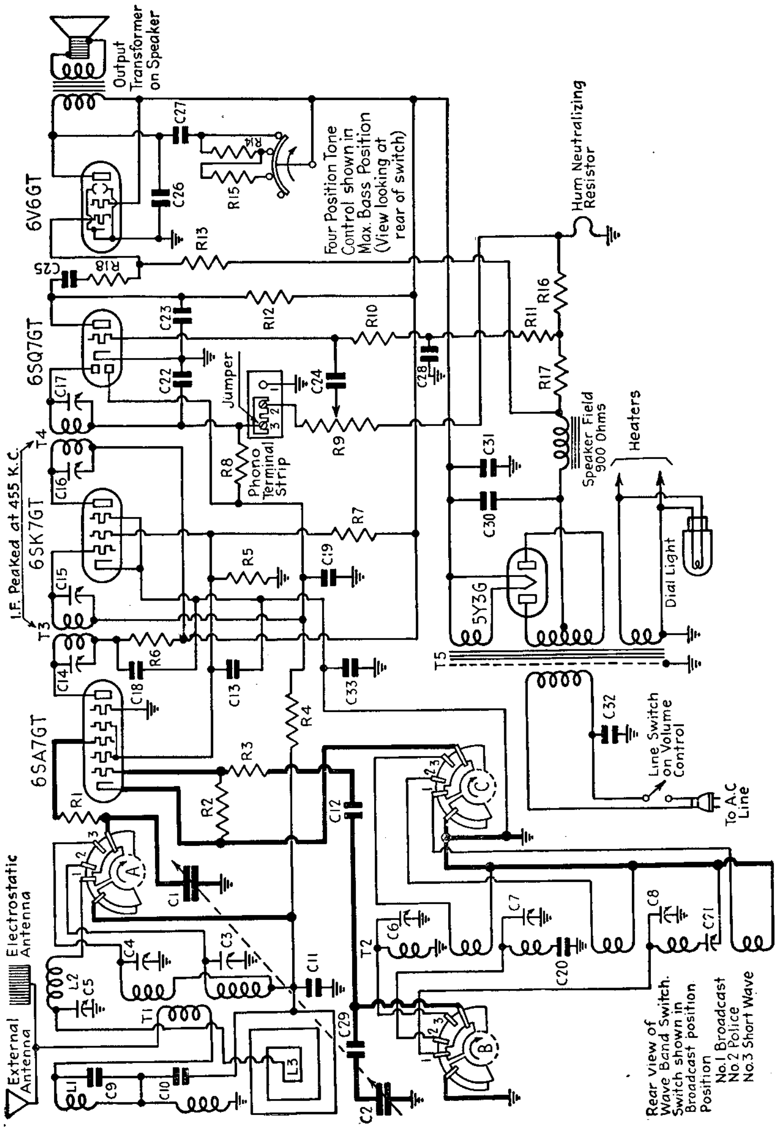


FIG. 15-4.— Schematic diagram of the Emerson DX-356 three-band receiver.

When the range switch is moved to the short-wave position, the following changes take place: The antenna is connected to the center tap of short-wave antenna coil *L*-4 through terminals 9 and 10 on range-switch section *A*-2. Terminals 1 and 2 on the same section connect short-wave antenna coil *L*-4 to the 6SK7 grid circuit. Terminals 7, 6. and 5 on the *A*-1 section of the range switch short the lower halves of the loop and broadcast antenna coil. Terminals 2 and 3 on the same section connect antenna tuning condenser *C*-4 through *C*-6 to the grid circuit of the 6SK7 tube. Condenser *C*-6 is for band-spread purposes. In the oscillator section, terminals 8, 9, and 10 of section *A*-4 keep the RF tube in the sensitive position by shorting out the cathode resistor, and by grounding the bottom lead of the short-wave oscillator coil *L*-7 as well as the bottom half of the broadcast oscillator coil *L*-6. Oscillator tuning condenser *C*-5 is connected through band-spread condenser *C*-11 to the top lead of short-wave oscillator coil *L*-7 and the oscillator grid circuit of the 6SA7 tube. Switch terminals 6 and 7 of section *A*-3 connect the condenser in the grid circuit of the 6V6-GT tube for tone compensation.

Servicing Multiband Receivers.—Although multiband receivers look more complicated than a single-band unit and may take a little longer to service, they are no more difficult. As a matter of fact, the range switch opens a possibility of faster diagnosis in some ways. When a receiver is dead on the broadcast band but operates normally on other bands, the defective condition is more quickly narrowed down to defective coils in the RF or oscillator portions of the receiver.

Servicing procedures for the multiband receiver are the same as for any other, until the RF portion of the receiver is reached. At this point the serviceman need only make sure that the range switch is in the broadcast position in order to continue in the usual way.

There are, of course, some service problems connected with multiband receivers that will not be present in single-band radios. These include the short-wave coils, the range switch, and alignment.

Short-wave coils are usually wound as a single-layer inductance using heavy wire. This type of winding rarely gives any service trouble. The serviceman, however, should be able to check the windings with an ohmmeter. This may not be so easy as it sounds, since it is sometimes difficult to determine which lead is which on a multiunit coil assembly. Also, the serviceman may not be sure as to whether the winding is being shorted by the range switch.

A better method would be to work with the schematic diagram and check the coils and switch at the same time. For example, in

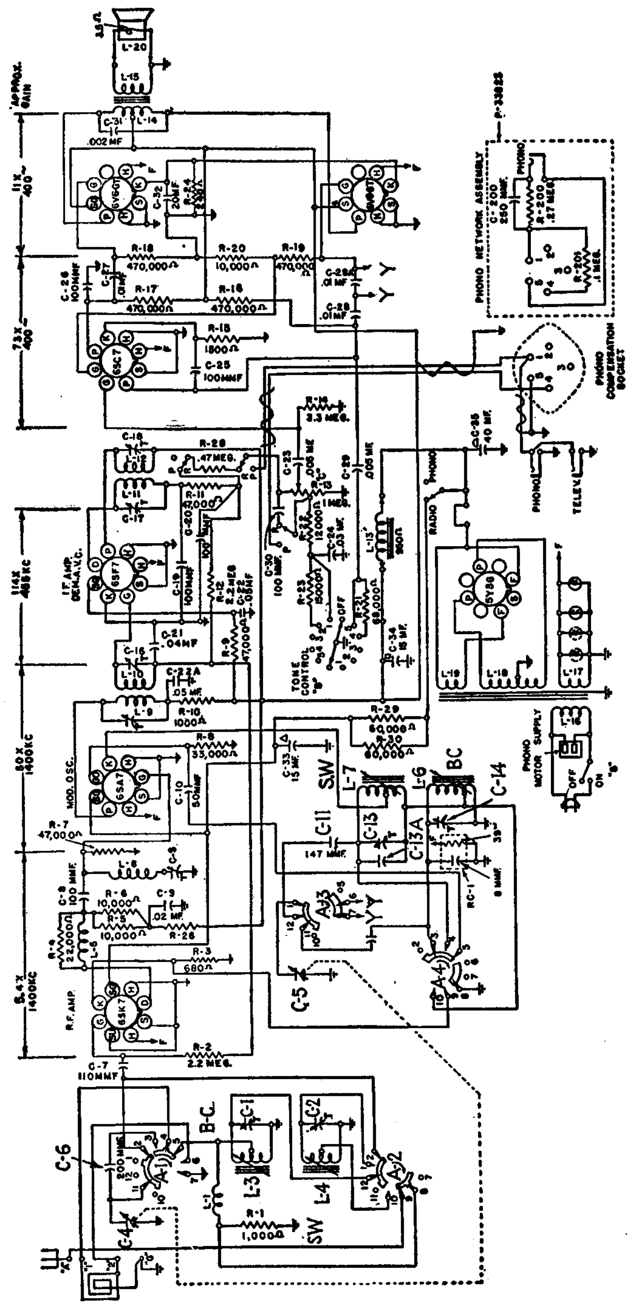


FIG. 15-5.—Schematic diagram of the Stromberg-Carlson No. 1020-1120 receiver.

checking the receiver of Fig. 15–4, the feedback winding of the oscillator coils could be checked as follows: Connect one ohmmeter terminal to chassis, the other to the cathode of the 6SA7 tube, and rotate the range switch. The ohmmeter would read the resistance of each winding, which would be approximately 2 ohms for the broadcast position, ½ ohm for the police band, and "short" for the short-wave band. The other coils could be checked in a similar manner. To check the oscillator grid coils, one ohmmeter terminal would connect to the junction of condensers *C*-29 and *C*-12, while the other ohmmeter prod would be moved with the band switch. It would connect to the 600 padder when checking the broadcast band, *C*-20 when checking police, and ground when checking the short-wave range. Because of the diversity of range switches, no standardized procedure can be arranged for checking coils and switches. However, the examples given will help to clarify the method of procedure.

When an open coil is found, the serviceman should first make sure that the defect is not due to a broken lead wire. If the coil must be replaced, it is necessary to obtain an exact duplicate from the manufacturer of the receiver. Even if it is necessary to replace an entire coil assembly for one open winding, this must be done since the chances of finding a usable section are very slim.

The lead dress between the range switch and the short-wave coils is very important. In high-frequency circuits, stray capacity of the wiring represents a considerable portion of the total capacity of the circuit. Very often, the wiring in these circuits makes use of heavy bus bar, so that the positioning will be maintained. Any replacement of switch or coils should be accomplished with a minimum of bending or rearranging of the wiring, so as to avoid undesirable coupling or changes in the stray capacity.

Range switches become covered with a layer of dust and dirt, resulting in poor contact and sometimes leakage between terminals. Dusting with a soft brush and then cleaning with carbon tetrachloride comprise the usual service procedure. A good way to clean the contacts is to wet them and the contact arms with carbon tetrachloride and then rotate the switch rapidly.

If a switch contact or wafer becomes broken, it is necessary to replace the entire switch. Again, an exact duplicate must be obtained from the manufacturer. Service notes on the replacing of switches were given in connection with radio-phonograph switches (see page 176).

Aligning Multiband Receivers.—In realigning a multiband receiver, the manufacturer's instructions should be followed to the last detail. This advice is given whenever the word "alignment" is mentioned. However, in the case of multiband receivers, it is of more than usual importance for two reasons. One is that the alignment on one wave band may affect the alignment on the other ranges, and the proper alignment sequence should be followed. The other is the fact that some receivers are so designed that the oscillator frequency should be 455 kc lower than the signal frequency on the short-wave band, while the conventional 455 kc higher signal on the other bands is maintained. Often both frequencies are within the scope of the trimmer adjustment, and it is important to use the peak at the lower or higher capacity setting, as instructed, in order to maintain proper tracking. If alignment instructions are not obtainable, the following suggestions may be of value.

IF Alignment.—First turn the range switch to the broadcast position, short the oscillator section of the gang tuning condenser, and align the IF trimmers in accordance with the general alignment instructions given in Chap. 22. Then remove the short from the oscillator section of the tuning condenser and check the position of the dial pointer, by turning the gang tuning condenser to full capacity (full mesh). The dial pointer should be in line with the last calibration mark on the low-frequency end of the dial scale.

As for the sequence of range alignment, when trimmer settings of one band affect another, it is suggested that the broadcast band be aligned last, because the cumulative effect will be most noticeable on the lowest frequency band. In addition, the owner of a receiver is usually most concerned about the operation of the broadcast band. For these reasons, when more exact instructions are not available, it is advisable to align the broadcast band last.

Short-wave Alignment.—Connect the signal generator through a dummy antenna of 400 ohms to the antenna and ground of the receiver. Turn the range switch to the highest frequency band on the receiver, and set the dial at a convenient mark near the high-frequency end of the scale. Adjust the signal generator to a modulated output at the same frequency as shown on the receiver dial. Adjust the short-wave oscillator coil trimmer for maximum response. If only one peak is obtained, the oscillator is adjusted to the proper frequency. If two peaks are obtained, choose the peak at minimum capacity. This sets the oscillator to a higher frequency than the signal.

If the receiver has an RF stage, the interstage coil trimmer is next to be aligned. If there is no RF stage, the antenna-coil trimmer follows the oscillator adjustment. In either case, the trimmer is adjusted for maximum response. If two peaks are obtained, the one that maintains the oscillator at the higher frequency is the peak that is nearer the maximum capacity setting of the trimmer. If the peak is unobtainable or if the receiver does not track at the low-frequency end of the dial, the alignment should be tried with the oscillator set for a lower frequency than the signal. This is done by choosing the maximum capacity peak for the oscillator trimmer and the minimum capacity peak for the antenna trimmer.

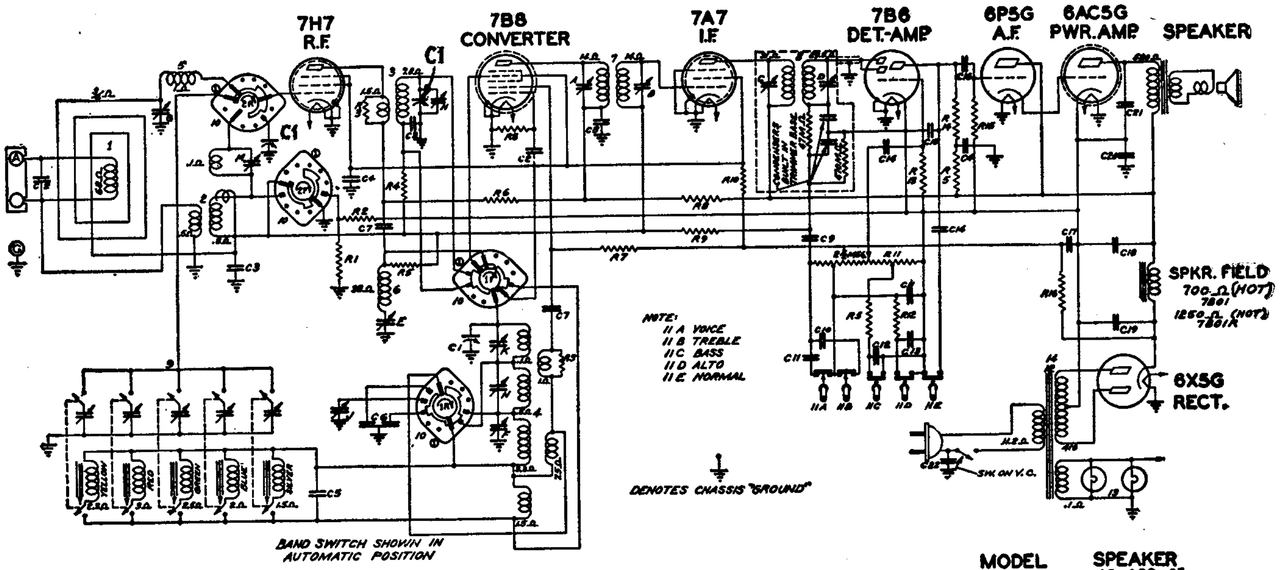
If the receiver has more than one short-wave band, the next lower frequency range should be aligned. The same procedure is followed as for the highest frequency band except that the oscillator circuit should be adjusted for a higher frequency than the signal. However, it is doubtful if two peaks are obtainable on any but the highest frequency band. This band may or may not include a low-frequency padder.

Broadcast Alignment.—Set the range switch at the broadcast position and adjust the tuning condenser until the dial reads 600 kc. Connect the signal generator to the antenna and ground, using a 0.00025-mfd condenser as the dummy antenna. Adjust the signal generator for a modulated signal at 600 kc. Adjust the 600 padder for maximum response. Then set the receiver dial to 1,500 kc and adjust first the oscillator-coil high-frequency trimmer, then the RF coil trimmer (if present), and finally the antenna-coil trimmer for maximum response. Return both dial and signal generator to 600 kc and readjust the 600 padder, if necessary. Then return to 1,500 kc and check alignment. If readjustment is necessary, repeat the alignment at 600 kc and check at 1,500 kc until further readjustment is unnecessary.

Receivers with Push-button Tuning.—Receivers that employ push buttons for tuning favorite stations use either mechanical or switching arrangements. In the mechanical method, the tuning-condenser gang is turned to predetermined positions by means of an electric motor, or by the actual push on the button. In the switching method, the tuning condensers or the entire tuning circuits are switched out, and trimmers or tuning circuits preset to the favorite station are switched in.

There are a large number of types of each of these arrangements. A typical example of each type will be described, together with applicable service notes.

Switched Push-button Tuning Circuits.—Figure 15–6 shows the schematic diagram of the Zenith Model 7S633R receiver. Push-button tuning is inaugurated by turning the range switch to the automatic tuning position. This disconnects the gang tuning condenser, all three sections of which are labeled *C*-1, throws a row of



DIAG. No	PART No	DESCRIPTION		DIAG. No	PART No	DESCRIPTION		DIAG. No	PART No	DESCRIPTION		DIAG. No	PART No	DESCRIPTION
C1	22-1205	THREE GANG VARIABLE		C20	22-827	.1 MFD.	200 V.	R15	63-271	1 MEGOHM	¼ W.	14	95-882	PWR. TRANS. 115V. 50-60~
C2	22-289	50 MMFD.	600 K	C21	22-1119	.005 MFD.	1000 V.	R16	63-1191	8200 OHM	2 W.			(7801 R)
C3	22-829	.05 MFD.	200 K	C22	22-1041	.005 MFD.	600 K					A		1ST I. F. TRANS. PRI.
C4	22-828	.05 MFD.	400 K									B		1ST I. F. " SEC.
C5	22-868	COMPENSATING COND.										C		2ND I. F. " PRI.
C6	22-1087	DUAL PADDER		R1	63-1100	52 OHM WIREWOUND	½ W.	1		WAVE MAGNET ASSEMBLY		D		2ND I. F. " SEC.
C7	22-182	.00025 MFD.	600 V.	R2	63-733	33 OHM	¼ W.	2	S9657	ANTENNA COIL "		E	22-1016	WAVE TRAP
C8	22-825	.1 MFD.	400 K	R3	63-590	15 M OHM	¼ W.	3	S9585	DETECTOR COIL "		F		BROADCAST OSC. (NOTE 1)
C9	22-327	.02 MFD.	200 V.	R4	63-715	100 M OHM	¼ W.	4	S9658	OSCILLATOR COIL "		G		BROADCAST ANT. (NOTE 2)
C10	22-954	.00035 MFD.	600 V.	R5	63-593	47 M OHM	¼ W.	5	S9589	LOOP LOADING COIL		H		BROADCAST DET. (ON GANG)
C11	22-470	.00015 MFD.	600 V.	R6	63-587	4700 OHM	½ W.	6	S8326	WAVE TRAP COIL ASSEMBLY		J		BROADCAST PADDER (NOTE 2)
C12	22-229	.005 MFD.	600 V.	R7	63-150	10 M OHM	½ W.	7	95-708	1ST I.F. TRANSFORMER		K		SHORT WAVE OSC. (NOTE 1)
C13	22-887	.001 MFD.	600 V.	R8	63-605	1000 OHM	½ W.	8	95-709	2ND I.F. "		M		SHORT WAVE ANT. (NOTE 2)
C14	22-448	.004 MFD.	600 V.	R9	63-599	1.5 MEGOHM	¼ W.	9	S9808	AUTOMATIC TUNING		N		POLICE BAND OSC. (NOTE 1)
C15	22-854	.0005 MFD.	600 K	R10	63-1192	27 M OHM	1 W.	10	85-290	BAND SELECTOR SWITCH			NOTES	(1) TRIMMERS F, K & N ARE
C16	22-890	.02 MFD.	600 K	R11	63-1122	VOLUME CONTROL		11	S9805	TONE CONTROL SWITCH ASSEM.				MOUNTED ON STRIP #22-1051
C17		15 MFD. ELECTROLYTIC	450 V.	R12	63-5?4	68 M OHM	¼ W.	12	95-710	PWR. TRANS. 115V. 50-60~				(2) TRIMMERS G, J & M ARE
C18	22-1085	15 MFD. "	350 V.	R13	63-976	15 MEGOHM	¼ W.			(7801)				MOUNTED ON STRIP #22-1?7?
C19		15 MFD. "	450 V.	R14	63-296	220 M OHM	¼ W.	13	100-36	DIAL LIGHT 6.3K .25A.				

MODEL	SPEAKER
7S633	49-460 6"
7S634	49-460 6"
7S657	49-457 12"
7S633R	49-505 6"
7S634R	49-505 6"
7S657R	49-397 12"

I.F. FREQUENCY 455KC.
7 TUBE SUPERHETERODYNE
CHASSIS No 7B01 & 7B01R 3BAND A.C.
ZENITH RADIO CORPORATION
CHICAGO, ILL.

Fig. 15-6.—Schematic diagram of the Zenith model 7S633R push-button receiver.

preset trimmers across the antenna tuning circuit, eliminates the converter signal-grid tuning circuit by converting it into an untuned resistance-coupled circuit, and throws any one of a row of permeability-tuned coils in the oscillator grid circuit.

The predetermined station is then tuned in by depressing the proper push button. The buttons are sprung so that they are normally in the OFF position. Then as any button is depressed, a catch holds this button in place while automatically releasing any button previously depressed. Each button controls a double-pole switch, one pole of which connects one of the permeability-tuned coils in the oscillator grid circuit, while the other pole connects the proper associated trimmer in the RF grid circuit.

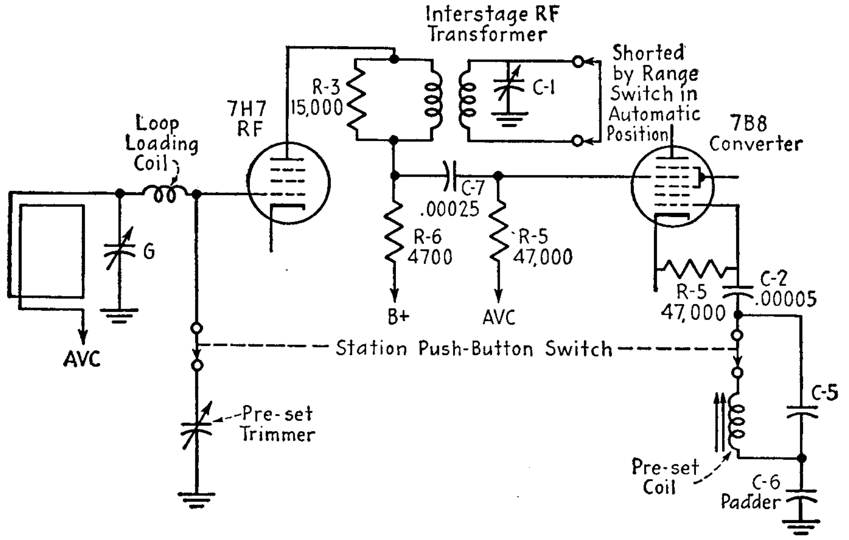


FIG. 15-7.—Simplified diagram of the tuning circuit of the receiver of Fig. 15-6.

The trimmers and coils in the automatic tuner have a limited range (approximately 400 kc), so that each button cannot tune many desired stations in the broadcast band. However, the values of coils and condensers are staggered, so that any station can be tuned in on some one button. The tuning range of each button is usually marked near the adjustment screws.

Figure 15-7 shows a simplified drawing of the tuning circuit of the Zenith receiver of Fig. 15-6, when the range switch is in the automatic position. One push button is depressed, showing one preset trimmer connected across the RF tuning circuit and one preadjusted permeability coil in the oscillator tuning circuit. The coupling between the RF and converter tubes is of the resistance-capacity type. This coupling also remains the same for the short-wave position of the range switch. The circuit is tuned only in the manually operated broadcast position of the range switch.

The system just described is typical for push-button tuners of the switching type. These systems differ mainly in the number of preset stations available. In some cases, switching from manual to automatic tuning is taken care of by an extra similar push button, rather than a position on the range switch. Often the radio-phonograph switch is also an extra similar push button. In addition, some types provide two sets of trimmer condensers, instead of one set of trimmers and one set of permeability-tuned coils. In these types, the regular broadcast oscillator coil is used, the oscillator tuning condenser is switched out of the circuit, and one of the preset trimmer condensers is substituted for it.

Servicing Push-button Tuners of the Switching Type.—Push-button systems of the switched tuning-circuit type give very little service difficulty. Occasionally, the switches do not make good contact. When this happens, the following cleaning procedure is effective: Dust the entire switch assembly with a soft brush. Depress the first switch, and apply carbon tetrachloride to its contacts and also the arm and contacts of the next switch. Then depress the two switches alternately: first the second, then the first. Repeat the procedure for the first and second switches, this time depressing the second button before applying the carbon tetrachloride to it. Repeat on the next pair, making sure that each switch has been washed in both the open and the closed position.

Another service problem is resetting the adjustment screws, which may change their position with time. When doing this, the receiver should be allowed a warm-up period of about 15 min, to allow all components to reach normal operating temperature. The oscillator control is adjusted first, followed by the antenna adjustment. If the adjusting screws are not marked, the serviceman can identify them by checking the wiring diagram or by the operation of the adjustments. The oscillator adjustment is critical—a fraction of a turn will bring the station in or out. The antenna adjustment is broad in comparison. If the receiver is equipped with a magic eye, it should be used to indicate exact resonance. An output meter cannot be used for this purpose, since the reading will vary with the modulation of the program. A vacuum-tube voltmeter, if available, connected to the AVC bus, can also be used as the resonance indicator. If neither the magic eye nor a vacuum-tube voltmeter is available, the adjustments are set for best volume and tone by ear. A good check for correct settings is to tune to the same station with the switch set for manual operation, and then switch from manual to push button and note any difference. Operation should be the same, except in the case of a receiver like that of Fig. 15–6, where the manual switch throws in an extra tuning circuit.

When push buttons are set up or when the adjustment screws are far from their correct alignment positions, it would be timesaving to use the signal generator for finding the desired stations.

Figure 15–8 shows the method of connecting the signal generator to the receiver. Adjust the signal generator for a modulated output at the frequency of the first desired station. Depress the first push button, and adjust the associated oscillator control until the signal-generator note is heard. It will be accompanied by a squeal, caused by the beating action between the generator signal and the signal from the desired station. Disconnect the signal-generator "hot" lead. If the squeal does not stop because of leakage, detune the signal generator. Then readjust the oscillator control for maximum response from the station. Finally, adjust the antenna trimmer. Repeat the procedure for the other buttons.

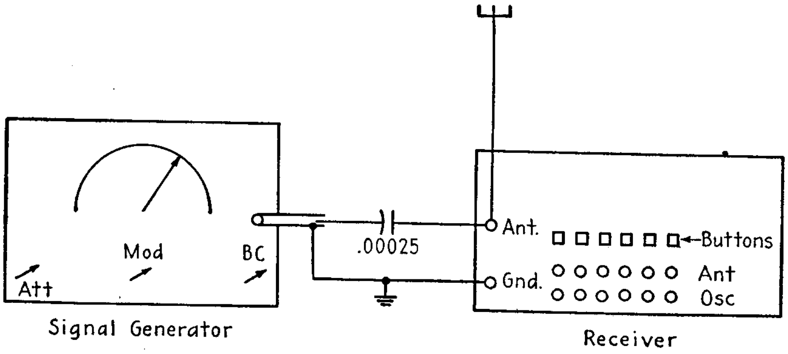


FIG. 15–8.—Using a signal generator as an aid in quickly presetting push buttons.

Mechanically Operated Push-button Tuners.—Figure 15–9 shows two views of a typical mechanically operated push-button tuning system. This type is known as a "rocker-bar" mechanism and is probably the most popular of all push-button tuners. Each button depresses a preset pawl, which turns the rocker bar as far as the pawl setting will allow. A gear connected to the rocker bar rotates the gang tuning condenser. The tuning knob and dial pointer rotate with the condenser gang. The return spring maintains the push button in its normal out position and, at the same time, keeps the pawl away from the rocker bar.

When a button is set up, the locking screw is loosened. A screw driver is kept pressed against the loosened locking screw, thereby depressing the push bar and pushing the pawl against the rocker bar. The desired station for each button is tuned in manually, thereby pushing the pawl to its proper setting. The locking screw is then tightened, fixing the pawl firmly between the shoe and push rod. Subsequently, when the button is depressed, the pawl pushes the rocker bar to its set position, thereby bringing in the desired station.

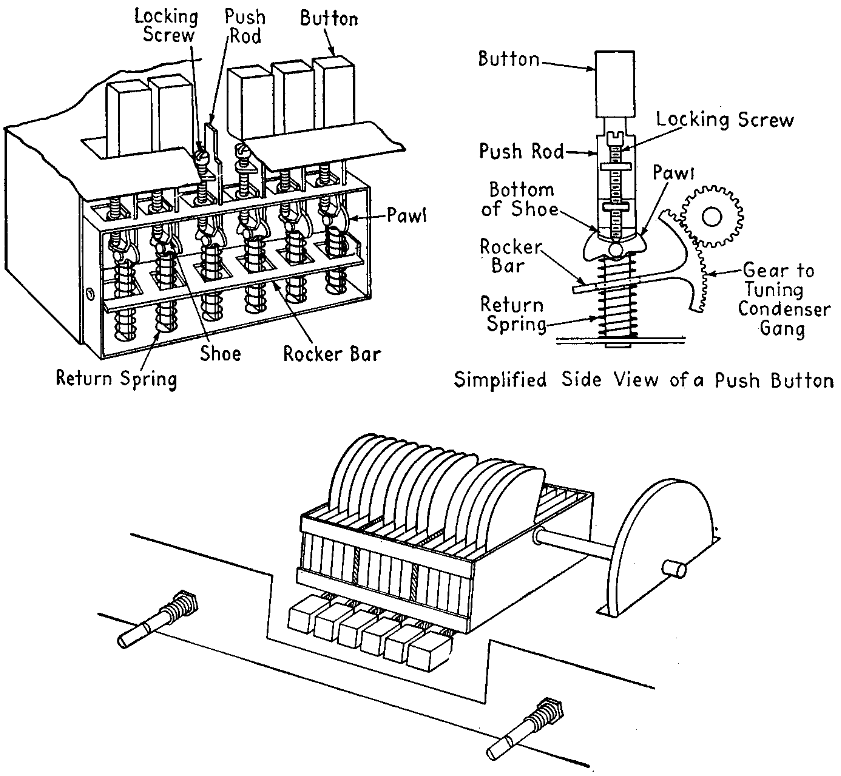


Fig. 15-9.—Mechanically operated push-button tuner.

From the servicing point of view, loosened adjustments are about the only difficulty experienced with mechanical buttons of this type. A complete adjustment procedure follows.

Adjustment of Push Buttons for Mechanical Automatic Tuners.—Rotate the range switch to the broadcast position. Select the stations desired for automatic tuning. Choose one of these stations and any button to be adjusted for it. Follow the procedure outlined below:

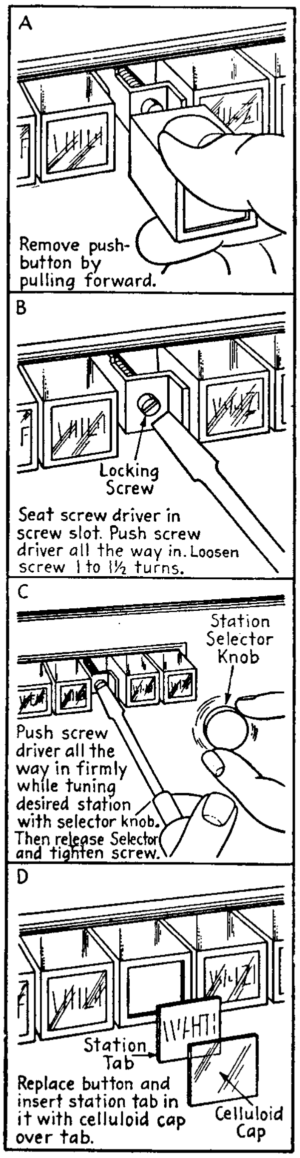


FIG. 15-10.—Adjustment of push button for mechanical automatic tuners.

1. Grasp the button firmly and remove it from its shaft by pulling straight out (see Fig. 15-10*A*).
2. Insert a screw driver into the slot of the locking screw. Press in and loosen the screw 1 to 1½ turns (see Fig. 15-10*B*).
3. With the screw driver seated in the screw slot, press the screw in as far as possible. Hold it in firmly with one hand, and tune in the desired station with the other hand by pressing in and rotating the selector knob (see Fig. 15-10*C*).
4. Release the selector knob and tighten the screw firmly.
5. Check the adjustment by tuning well past the station, using the selector knob and then pushing in the button shaft. The station should come back in again clearly and with maximum volume. After the adjustment is tested, check to see that the locking screw is tightened firmly. Replace the button on its shaft.
6. Adjust the remainder of the buttons in the same manner as outlined above.

Figure 15-10*D* shows a common method of inserting station tabs.

Mechanically Operated Push-button Tuners of the Motor-driven Type.—Motor-driven push-button tuners are too varied in their operation, adjustment, and service problems for any generalized treatment in a book of this nature. The serviceman is referred to the manufacturer's service notes when he experiences difficulty with any of these devices. For teaching purposes, as an example, the diagram and station-setting instructions of the Stromberg-Carlson No. 440 receiver are included in the text.

Instructions for Setting Up Push Buttons.—Before reading the instruc-

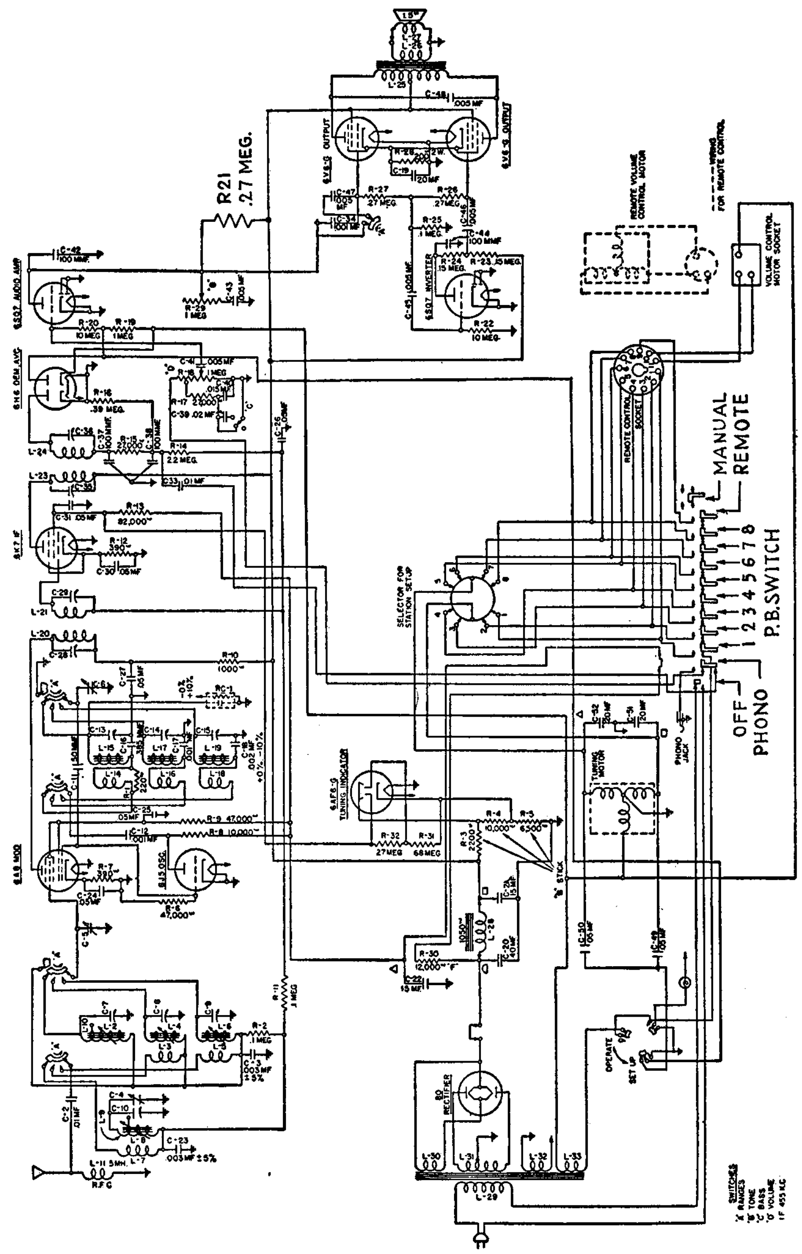


FIG. 15-11.—Schematic diagram of the Stromberg-Carlson Model No. 440 push-button receiver.

tions for setting up push buttons, note carefully the following important items.

Important.—(1) The stations selected should be the local favorite ones that give good reception at all times. (2) Set up stations in the daytime to avoid unnecessary interference. (3) Allow the set to run for about 20 min before setting up stations. (4) Always use the tuning indicator unit when setting up stations in order to determine when a station is exactly in tune.

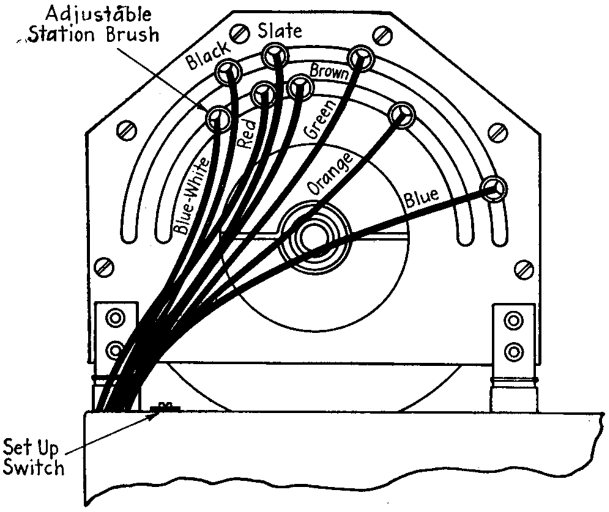


FIG. 15-12.—Brush and commutator assembly of the receiver of Fig. 15-11.

1. Put the call letters of the selected stations in place above the push buttons. The stations should be arranged according to frequency, with the highest frequency at the right and the lowest frequency at the left, just as on the dial.

2. Set the TREBLE control in normal position.

3. Turn the setup switch (located on the base just back of the brush and commutator assembly) to the setup position. (The slot in the screw should point toward SETUP.)

4. Push the button of the highest frequency station to be set up (button No. 3) and then tune in that station manually. Be sure that the station is exactly in tune by tuning carefully and watching the cathode-ray indicator.

5. Slide the brush to which the blue wire is connected until it is over the slot in the commutator. Then adjust it very carefully until the pilot light goes out. This indicates exact adjustment.

6. Repeat operations 4 and 5 for each station. Work from right to left or from the higher to the lower frequencies in accordance with the accompanying table.

Push button No.	Purpose	Color of wire on brush
1	Manual	
2	Remote	
3	Highest frequency station	Blue
4	Next lower frequency station	Orange
5	Next lower frequency station	Green
6	Next lower frequency station	Brown
7	Next lower frequency station	Slate
8	Next lower frequency station	Red
9	Next lower frequency station	Black
10	Lowest frequency station	Blue-white
11	Phonograph	
12	Off	

7. Turn the setup switch back to the OPERATE position.
8. Check the operation of all the push buttons to be sure that each has been accurately set up. If it is necessary to readjust any of the buttons, follow the procedure given above.

Permeability Tuning Systems.—In the conventional receiver, tuning is accomplished by changing the capacity of a variable condenser connected across a coil, thereby changing the resonant frequency of the combination. The same effect can be brought about by allowing the condenser capacity to remain fixed and changing the inductance of the coil. This is the basis of permeability tuning systems, where the inductance of the coil is changed by varying the position of an iron-core plug in the coil.

Coils with adjustable cores are used as IF transformers, and for the fixed-tuned antenna and oscillator coils of the circuit-switching type of push-button tuners. In these cases, the inductances of the coils are adjusted during the alignment procedure or when setting up the push buttons, and remain undisturbed thereafter. In some receivers, instead of using a variable condenser, the antenna and oscillator core plugs are ganged, and their adjustment is brought out to the front control panel as a continuously variable adjustment of the tuning range of the receiver. Such a tuning system is known as a "permeability" tuner. Figure 15–13 shows a tuner of this type, where the positions of the core plugs are varied by means of a drive cord.

The coils, drive pulley, and idler pulley are fastened to a subassembly. The coil mounts are so arranged that either coil may be shifted slightly to the right or left for tracking purposes. Ordinary dial-drive cord is used to vary the position of the core plugs. Note that when the drive shaft is rotated in the direction shown, both core plugs are pulled into their respective coils.

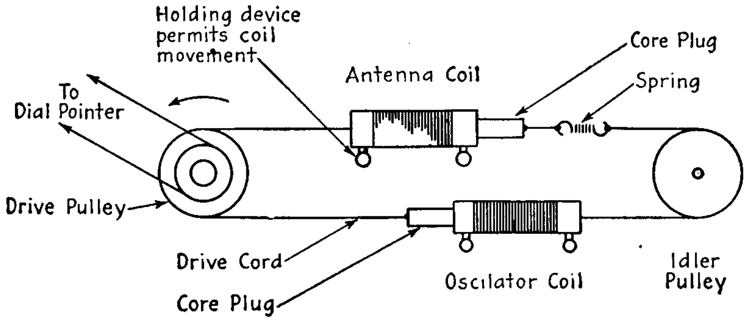


Fig. 15-13.—Drive-cord type of permeability tuner.

From the servicing point of view, any trouble in the permeability tuner would be found in the same way that a similar trouble would be found in a conventional tuner, since the circuits are alike. The alignment procedure is somewhat different, and the manufacturer's service notes should be followed closely in this regard. Another difference lies in the fact that restringing the drive cord calls for realignment, since the restringing process will slightly alter the relative positions of the tuning slugs.

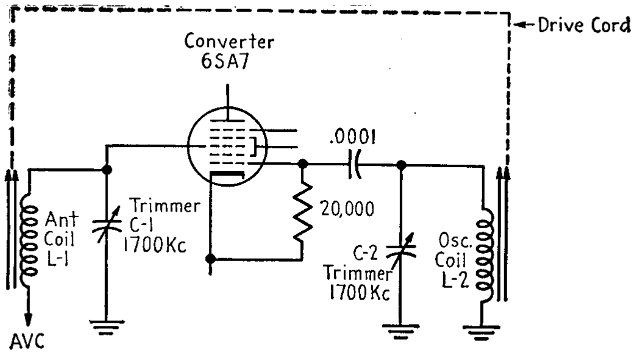


Fig. 15-14.—Skeleton diagram of drive-cord type of permeability tuner.

If specific restringing and alignment notes are not available from the receiver manufacturer, the following generalized procedure should be of help. The skeleton schematic diagram of Fig. 15–14 is included as an aid in locating and identifying the trimmers.

Restringing and Alignment Procedure for Drive-cord Permeability Tuners.

1. Restring the tuning slugs, using the frayed or torn pieces of the old drive cord as a guide, so that the relative positions of the tuning slugs are as close as possible to their original settings.
2. Set the antenna coil in the center of its positioning range, so that it may be shifted either to the right or left.
3. Rotate the drive so that the antenna core plug is completely out of the winding.
4. Set the oscillator coil so that its core plug is in the same relative position as the antenna coil and its core plug. Set the dial pointer to the highest frequency division on the dial scale.
5. Rotate the drive to make sure that the dial pointer and tuning slugs move together and cover the entire tuning range.
6. Check the alignment of the IF amplifier, and if necessary, align in the usual manner.
7. Connect the signal generator to the receiver antenna, using a 0.00025-mfd dummy antenna. Rotate the drive to the high-frequency end of the dial scale, and adjust the signal generator for a modulated output at the same frequency. Adjust the oscillator trimmer *C*-2 to a maximum response. Then adjust the antenna trimmer *C*-1 to a maximum response.
8. Rotate the drive to 1,400 kc, and adjust the signal generator frequency control to a peak. This should occur at 1,400 kc. If it is too far off, the starting position of the oscillator core plug was incorrectly adjusted. This should be corrected and steps 7 and 8 repeated.
9. When the peak at 1,400 kc in step 8 has been obtained, the antenna coil is shifted to the right or left for a maximum tracking peak.
10. Return the dial and signal generator to the highest frequency reading on the dial scale, and check the adjustment of the antenna trimmer *C*-1. If no appreciable change is needed, the antenna coil is in track. If a considerable change has been made, repeat steps 9 and 10.

Screw-drive Permeability Tuners.—Another type of permeability tuner uses a screw for driving the ganged tuning slugs. Figure 15–15 shows a tuner of this type. The proportions have been altered to permit viewing the operation of the unit.

The coils *L*-1, *L*-2, and *L*-3 are mounted on the back plate of the carriage. The bakelite strip is threaded to take screws attached to the core plugs. Adjusting these screws permits adjustment of the relative positions of the individual core plugs with respect to their coils. Rotating the drive shaft causes the bakelite strip to move in and out, carrying the core plugs with it, and thereby changing the inductance of the coils. The drive shaft is the tuning control for the radio. The gear ratio is usually chosen to allow several turns of the drive shaft for complete coverage of the tuning range, thereby giving vernier tuning. A similar ratio on a drive pulley (not shown in the diagram) operates a conventional dial pointer from the same tuning shaft.

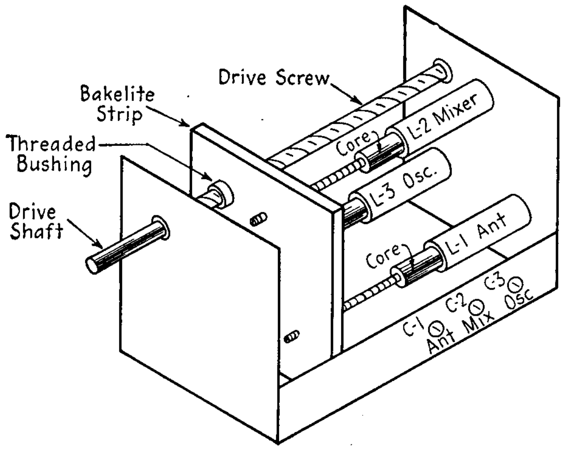


FIG. 15-15.—A permeability tuner of the screw-drive type.

A tuner of this type, employing three coils, may be used for a receiver with an RF stage. It may also be used in a receiver with a converter stage only, the antenna coil being used in a preselector circuit. Figure 15-16 shows a receiver of the latter type.

Coils *L*-1, *L*-2, and *L*-3, with their core plugs ganged in the permeability tuning unit, are identified as the antenna, mixer, and oscillator coils, respectively. Actually, coil *L*-3 is not the oscillator coil with a function similar to the one in the standard receiver. The actual oscillator coil that furnishes the feedback voltage for operation of the oscillator circuit is coil *L*-4, which is outside the permeability tuning unit. This coil, *L*-4, is referred to as the master oscillator coil. Coil *L*-3, in the tuner, is shunted across a portion of the master oscillator coil and acts to tune it. Trimmer condenser *C*-3.

is the high-frequency aligner for the oscillator circuit. The 600-kc aligner is the permeability adjustment screw on the master oscillator coil L-4.

The antenna plate is a sheet of metal, insulated from the chassis, and acting as a self-contained antenna for the receiver. It is usually mounted behind the chassis so that it also acts as the back of the cabinet. The lead for a standard antenna is capacitively coupled, as shown, by a few turns of the antenna lead around the antenna plate lead. The antenna signal is impressed across the antenna coil L-1 and condenser C-4. The condenser acts as the common coupling to feed the mixer coil L-2 in the converter signal grid circuit. Trimmer condensers C-1 and C-2 are the alignment controls for the antenna and mixer circuits.

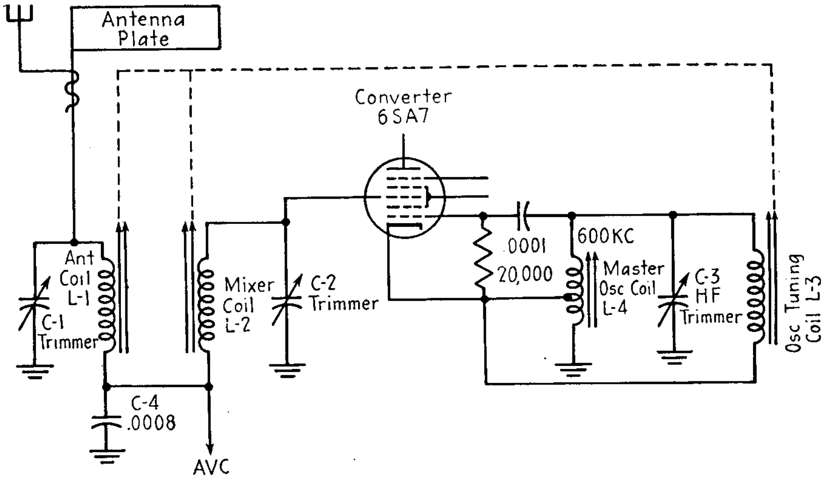


FIG. 15-16.—Three-coil permeability tuner with a preselector circuit.

Antenna plates are commonly used in receivers employing permeability tuners. However, there are some receivers that employ a loop antenna. Figure 15–17 shows a two-gang permeability tuner of the screw-drive type fed by a loop antenna.

From the servicing point of view, the screw-drive type of permeability tuner likewise offers no new problems, except from the standpoint of alignment. A generalized alignment procedure follows.

Alignment Procedure for Screw-drive Permeability Tuners.

1. Align the IF amplifier in the usual way.

2. Check the dial pointer setting and positioning of the core plugs by the following steps.
   a. Rotate the tuning shaft to the low-frequency stop.
   b. Rotate the core plugs by means of the screws in the bakelite rack until they are fully engaged in their respective coils.
   c. Set the dial pointer at the lowest frequency calibration mark on the dial scale.

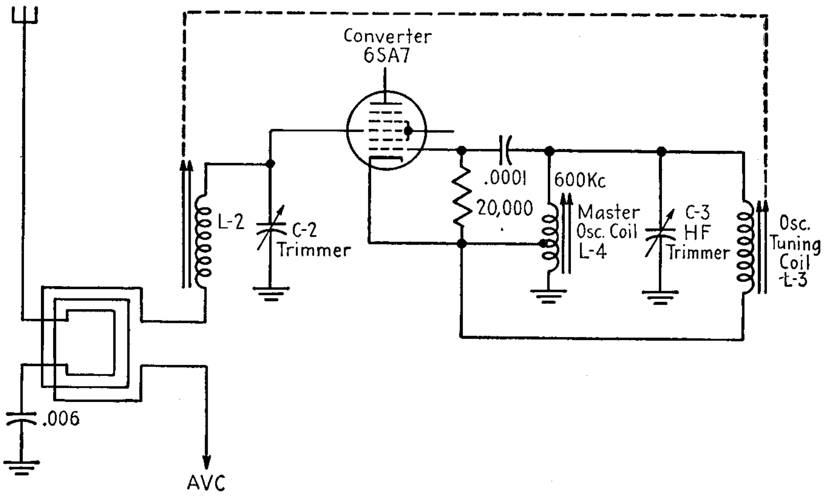


FIG. 15-17.—Two-coil permeability tuner fed by a loop antenna.

3. Connect the signal-generator output lead to the antenna connection through a 0.00025-mfd dummy antenna. Do not connect to the antenna plate.

4. Set the signal generator to feed a modulated signal at 600 kc, rotate the tuning shaft to read 600 kc on the receiver dial, and align the master oscillator-coil permeability adjustment for maximum output.

5. Tune the receiver to a quiet point near the high-frequency end of the tuning range, adjust the signal generator to feed the same frequency as that shown on the receiver dial scale, and align the oscillator high-frequency trimmer for maximum output. This trimmer is labeled *C*-3 in Figs. 15–15, 15–16, and 15–17.

6. Check the 600-kc adjustment by repeating step 4. If considerable readjustment is necessary, realign the high-frequency adjustment by repeating step 5 and then recheck at 600 kc.

7. Tune the signal generator and receiver to a peak near 1,400 kc, and align first the mixer and then the antenna trimmers for maximum output.

QUESTIONS

1. Outline a procedure for determining the cause of a defective oscillator circuit in a dead receiver.

2. Outline a procedure for determining the cause of a defective mixer circuit in a dead receiver.

3. A receiver operates on the high-frequency end of the broadcast band but not on the low-frequency end. List the probable causes and state how you would check for each.

4. The receiver of Fig. 15–2 does not operate. Signal check shows normal response when checking with an IF signal at the 12SA7 mixer grid, and no response when checking with an RF test signal from the same point. Voltage check shows no reading at the oscillator grid and normal readings for the 12SA7 plate and screen. Resistance check on the oscillator coil shows a reading of 6.5 ohms. Where is the trouble likely to be? How would you check for it? How would you remedy the condition?

5. The receiver of Fig. 15–4 operates normally on both short-wave ranges but not on the broadcast band. Outline a procedure to locate the cause of the trouble.

6. The receiver of Fig. 15–5 gives no reception. Signal check shows normal operation when a test signal, either RF or IF, is applied to the 6SA7 signal grid, and no reception when an RF test signal is applied to the RF grid. Voltage check on the RF tube shows a reading of zero at the plate terminal. What are the probable causes of the trouble? How would you check each?

7. The receiver of Fig. 15–6 operates normally on the manual and short-wave positions of the range switch, but gives no reception on any push button. What is the most likely cause of the trouble? How would you check for it? How would you remedy the condition?

8. What is the function of *L*-4 in Fig. 15–17? What is the function of *L*-3 in the same drawing?

9. What are the important points to remember when replacing an oscillator coil?

10. A receiver has a tunable hum. The line filter is checked and found to be O.K. What else is likely to cause this condition? How would you check for it?

11. A superheterodyne receiver squeals all over the tuning range. How would you check the converter stage for this complaint?

12. The receiver of Fig. 15–2 does not operate. When a test signal, either RF or IF, is applied to the converter signal grid, the response is heard weakly and with a rough note. What is likely to be wrong? How would you check for it?

13. The receiver of Fig. 18–19 operates, but reception is a little weak and the noise level is high. Stage-gain measurements show a normal response when an

RF test signal is applied to the converter signal grid, and a loss in gain when the test signal is applied to the antenna lead. What is likely to be the cause of the trouble? How would you check for confirmation?

14. The receiver of Fig. 15–4 is inoperative. Signal check shows a normal response when a 455-kc test signal is applied to the 6SK7-GT grid. There is no response when the 455-kc test signal is shifted to the 6SA7-GT grid. A resistance check of the converter tube shows the following abnormal readings:

Plate to chassis	40 ohms
Plate to *B* plus	open

What is wrong?

CHAPTER 16

RF AMPLIFIER STAGE

Many receivers incorporate a stage of RF amplification ahead of the converter. It is called the "RF" stage, or sometimes the "antenna" stage. It requires no quick check for operation. Since it is last in a line of stage checks, if all others check perfect for a defective receiver, the RF stage must be defective by a process of elimination.

Of course, the entire receiver may be normal and the trouble may lie in the antenna system, which is the first link in the signal chain. This possibility, however, should not occur on a test bench setup. Only at the customer's home will such trouble arise, and the alert serviceman will recognize the condition. Checking the antenna is usually a routine part of the home service call. Service notes relating to antennas will be included later in this text.

Function of the RF Stage.—The RF stage receives energy from the antenna, tunes the desired signal (station), amplifies the signal, and passes it on to the converter. Because of these functions—tuning and amplification—it increases the selectivity and sensitivity of the receiver. The RF stage provides other advantages. One is the reduction of the noise level when a stronger signal is fed to the converter. Another is the improvement of the AVC action, since another controlled tube is added in the RF and IF chain. A third is the elimination of image-frequency interference—peculiar to superheterodyne receivers.

Image-frequency Interference.—Examine the operation of a superheterodyne receiver. The antenna picks up station signals broadly at all frequencies. Where a receiver has no RF stage, the antenna energy is fed through a tuned circuit to the signal grid of the converter tube. For example, suppose the tuning circuit is set to receive a desired signal at 1,000 kc. The local oscillator of the receiver will then have an output at 1,455 kc if the IF amplifier of the receiver is fix-tuned to 455 kc. The station and oscillator signals are mixed in the converter tube and the output from the latter is many frequencies. The IF amplifier, usually sharply tuned by four resonant circuits, accepts only the signal that is the difference in frequency between the station and the oscillator signal—in this case 455 kc, the intermediate frequency. This IF signal is then amplified and sent on to the detector and AF amplifier.

Any signal at 455 kc in the converter plate circuit will be accepted by the IF amplifier and passed on. We have just seen how one 455-kc signal is developed at the input of the IF amplifier. Is it possible for a second one to be present at the same time?

Reexamine the converter signal grid. It is tuned to 1,000 kc by means of one tuned circuit that is somewhat broad. As a result, the grid may receive signals of widely different frequencies picked up by the antenna. Normally, these signals mix with the local oscillator signal (1,455 kc) and produce difference frequencies which are rejected by the sharply tuned IF amplifier. However, there might be one station signal at 1,910 kc on the converter grid which, after mixing with the local oscillator signal of 1,455 kc, will produce a difference frequency at 455 kc. This 455-kc signal will be accepted by the IF amplifier and result in two stations at the speaker output—1,000 and 1,910 kc.

Similarly, if the receiver is tuned to a station at 600 kc, the oscillator will be tuned to 600 + 455, or 1,055 kc, and an intermediate frequency of 455 kc will be produced at the IF amplifier grid. And a station signal at 1,510 kc at the converter signal grid will mix with the oscillator signal and again produce a difference, or IF frequency of 455 kc which will appear as an interfering station. Thus, any desired station is likely to experience interference from another station that happens to have a frequency which is higher than that of the desired station by twice the intermediate frequency (as much above the oscillator frequency as the desired station is below the oscillator frequency). This defect of superheterodyne receivers is known as "image-frequency interference."

Since the two stations are rarely exactly twice the intermediate frequency apart, they will beat with the oscillator signal to produce intermediate frequencies very close to 455 kc and to each other. These two intermediate frequencies will be accepted by the IF amplifier, where they will beat with each other to form a difference frequency which will be AF and result in a high-pitched squeal. Thus, image-frequency interference appears in the receiver in a form called "birdies" or "whistles," which mar reception on certain stations.

Early superheterodyne receivers employed an intermediate frequency of 175 kc. Here, image-frequency interference would occur from stations 350 kc from the desired ones (twice the intermediate frequency, or 2 × 175 kc). If there were only one tuned circuit before the converter, that tuned circuit would not be sufficiently sharply tuned to eliminate image frequencies 350 kc from the desired signal and interference would be troublesome. Modern practice employs an intermediate frequency of 455 kc, thereby placing the image frequency much farther away, 910 kc from the desired station. As a rule, with such a wide spread between desired and image frequency, even one RF tuning circuit is adequate to keep a station 910 kc away from affecting the converter signal grid.

A preselector circuit is an added tuning circuit between the antenna and the converter signal grid, the purpose of which is to sharpen the tuning to reduce image-frequency response. Figure 16–1 shows a typical preselector circuit together with its over-all selectivity curve.

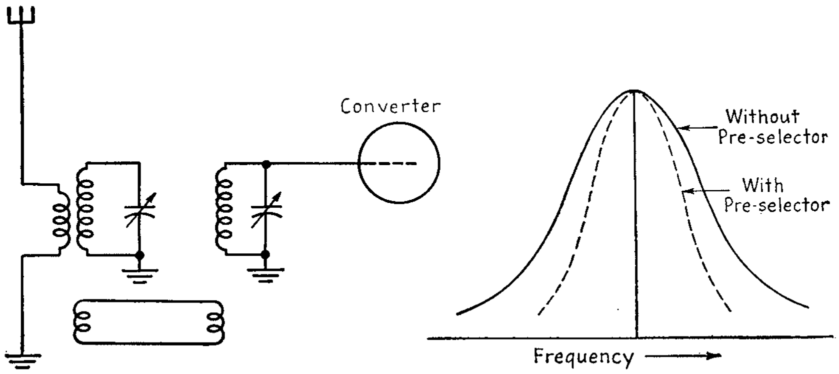


Fig. 16–1.—A preselector circuit and its effect on selectivity before the converter signal grid

Preselector circuits are rarely used in modern receivers, since they reduce the sensitivity, and the same reduction in image-frequency response is possible by increasing the intermediate frequency.

A tuned RF stage, ahead of the converter, combines the added selectivity of the preselector in reducing image-frequency response and, because of the amplification of the tube, adds to the sensitivity of the receiver.

Standard Circuit.—The standard circuit is shown in Fig. 16–2.

Functions and Values of Component Parts.—The antenna transformer *T*-1 couples the energy picked up by the antenna to the grid of the RF tube. The secondary winding *L*-2 is tuned by *C*-2, the antenna section of the gang tuning condenser. As explained before in connection with the components of the converter stage tuning system, the values of parts in any tuning system are important parts of the design of the receiver and cannot be changed without altering the calibration and tracking.

When the receiver is of the loop-operated type, antenna transformer *T*-1 is replaced by the loop antenna. In this case, the main portion of the loop winding acts as the antenna for the receiver and is tuned by condenser *C*-2. Should it be desired to connect an external antenna for greater sensitivity, the loop is equipped with a primary winding of one or two turns which is connected to the antenna and ground.

IF Wave Traps.—Any superheterodyne receiver is especially sensitive to its intermediate frequency. With an intermediate frequency adjusted to 455 kc, if a signal at or near this frequency gets to the converter grid, it will be present in the converter plate and be accepted by the IF amplifier and cause interference with the desired station. In areas near the seacoast, many powerful shore-to-ship stations operate at frequencies close to 455 kc. These cause interference that blankets the low-frequency half of the broadcast band and, in severe cases, covers the entire tuning range.

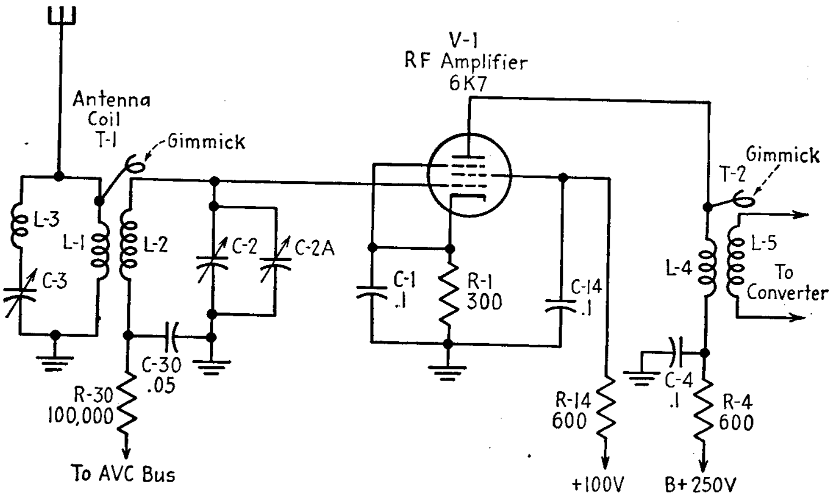


FIG. 16–2.—Schematic diagram of a typical RF stage.

A wave trap located in the antenna circuit of the receiver will minimize this effect. In the standard circuit of Fig. 16–2 a series-resonant wave trap, composed of *L*-3 and *C*-3, is shunted across the primary of the antenna coil. The trap circuit is tuned to the intermediate frequency of the receiver, and offers a low-impedance path to ground for signals of that frequency present in the antenna.

In most cases the trap is tunable by means of trimmer condenser *C*-3, as shown in the standard circuit. In some cases, the wave trap is fixed-tuned to the intermediate frequency of the receiver, and the condenser corresponding to *C*-3 is a fixed mica condenser. Sometimes, the trap is tunable by means of an adjustable permeability plug in the coil in conjunction with a fixed mica condenser.

In loop receivers, the trap is usually placed in the converter signal grid circuit, where it serves a similar purpose by providing a low-impedance path to ground for signals at the intermediate frequency, which may be present in the converter signal grid circuit. Coil *L*-12 and condenser *C*-28 make up this type of wave trap in the receiver of Fig. 16–10.

In some receivers, especially where the primary of the antenna transformer is of the low-impedance type, the wave trap is a parallel resonant circuit connected in series with the antenna transformer primary, as shown in Fig. 16–3. The wave trap is tuned to the intermediate frequency of the receiver. This trap offers a high-impedance path to signals at the intermediate frequency appearing across the antenna circuit, and tends to dampen them.

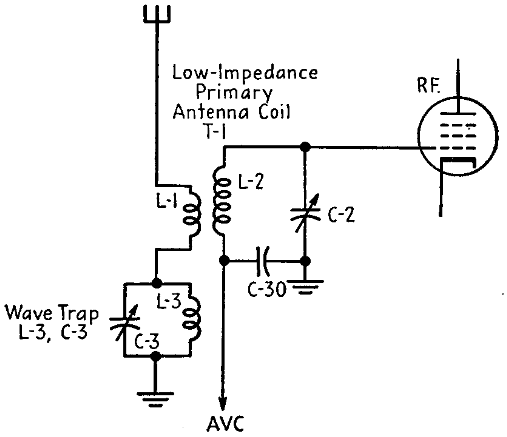


FIG. 16–3.—Wave trap in series with the antenna circuit.

Decoupling Filters in the RF Stage.—When a receiver incorporates an RF stage, there is more likelihood of undesirable coupling. As a result, there must be more decoupling filters not only in the RF stage, but also throughout the receiver. The RF cathode may be tied to the converter cathode or IF cathode, but rarely to both. In some receivers the RF cathode resistor *R*-1 is variable. This provides a variable minimum-bias resistor for the RF tube, and acts as a sensitivity control for the entire receiver. Such a sensitivity control is usually 25,000 ohms.

The screen supply voltage may also be common with that of the converter or IF tube, but again rarely to both. The most common screen supply consists of a suitably by-passed voltage-dropping resistor in series with *B* plus for the IF tube and a voltage-divider arrangement for the RF tube. The converter screen is then usually tied to the RF screen. The standard circuit connects the RF screen to the voltage divider through the decoupling resistor *R*-14. Condenser *C*-14 by-passes the screen to ground, and its usual value is 0.1 mfd/400 volts.

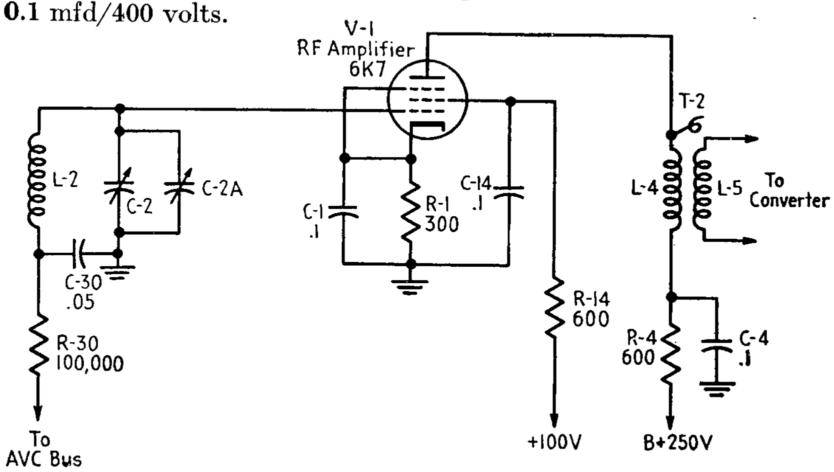


FIG. 16-4.—Decoupling filters in the RF stage.

The plate supply also usually includes decoupling filters for one or more of the RF, IF, and converter plate circuits. The decoupling resistor *R*-4 for the RF plate is usually 600 to 1,000 ohms. The plate by-pass condenser *C*-4 is usually 0.05 to 0.1 mfd/600 volts.

Tubes Commonly Used in the RF Stage.—The 6K7 supercontrol pentode is the most commonly used RF amplifier tube. When the 6K7-G or 6K7-GT tube is used in this stage, it is usually covered by a closely fitting shield. The single-ended 6SK7 supercontrol pentode is also often used. The characteristics of this tube are similar to those of the 6K7, the main difference being in the location of the grid terminal as pin No. 4 instead of the top cap. Multiband receivers generally use the 6SG7, which is also a triple-grid supercontrol pentode with a higher gain and leads brought out in such a way as to provide for wiring with minimum coupling effects. Receivers with locking-base tubes use the 7A7 or the 7G7/1232. The 7A7 is similar to the 6SK7 and the 7G7/1232 is similar to the 6SG7. Older receivers use the 6D6 and 78 tubes, which are similar except for lower gain.

AC/DC receivers use any of the above tubes in circuits designed for 0.3-amp heaters. When the circuit is designed for 0.15-amp heaters, the RF tubes used are the 12K7, the 12SK7, the 14A7, and the 6SS7.

NORMAL TEST DATA FOR THE RF STAGE

Normal Signal Check for the RF Stage.—The signal generator is connected to the antenna and ground through a 0.00025-mfd condenser, and adjusted for a modulated output at 1,500 kc, with the attenuator set for a very low output. The receiver is adjusted for maximum gain; that is, volume control full on, tone control at maximum high AF response, and fidelity control in the selective position. The receiver dial is set for a quiet point between 1,400 and 1,500 kc. If an output meter is connected to the receiver, it should be on a high-voltage range. The signal generator dial is then rotated through 1,400 to 1,500 kc.

When the receiver is operating normally, the signal generator modulation note will be heard in the speaker very strongly as the signal-generator dial passes the point at which the receiver is tuned. The RF stage is then known to be functioning. Usually, the output in the speaker will be greater than the standard output of 50 mw, even with both attenuation controls set at zero. In addition, with the receiver gain controls set at maximum, random noise pulses, picked up by the receiver, cause considerable output meter deflections, so that stage-gain measurements for the RF stage cannot be made to get the usual standard output.

However, if the signal check does not show some gain over a signal measurement from the RF grid, it may be assumed that there is trouble between the antenna and the RF grid.

Normal Voltage Data for the RF Stage.—Readings are taken from the indicated terminal to the chassis or common negative. Normal voltage data for the RF stage are given in the accompanying table.

Tube terminal	6K7 or 12K7 pin No.	AC receiver, volts	AC/DC receiver, volts
Plate	3	250	90
Screen	4	100	90
Cathode	8	3	3

Normal Resistance Data for the RF Stage.—Normal resistance data are given in the following table:

Antenna to ground, or across *L*-1 (primary)	30–50 ohms
Across *L*-2, secondary of the antenna transformer *T*-1	5 ohms
Cathode to chassis	300 ohms
Plate to *B* plus	40 ohms plus the resistance of a decoupling filter, if used
Control grid to chassis	1,600,000 ohms
Screen grid to chassis	30,600 ohms
Screen grid to *B* plus	30,600 ohms

The screen grid readings are for the standard receiver and will vary, depending on the screen grid circuit of the receiver being tested.

In receivers where the antenna transformer is replaced by a loop antenna, antenna to ground will measure less than 1 ohm and the grid coil of the loop will measure 1 to 3 ohms.

COMMON TROUBLES IN THE RF STAGE

Most of the parts used in the RF stage are similar to those used in other stages in the receiver. In this section, the common troubles and how they are found will be covered, but the reader will be referred to other parts of the text to avoid repetition of replacement notes.

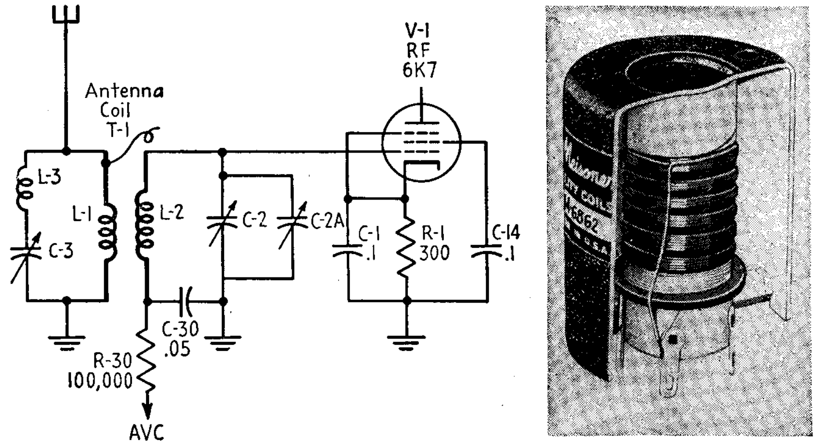


FIG. 16-5.—An antenna coil and its position in the RF circuit.

Troubles Common to the Antenna Transformer.—Either winding of the antenna transformer *T*-1 is likely to open. An open secondary would cause weak, noisy reception, possibly accompanied by hum. The trouble would be localized on a signal check since there would be no gain between the RF grid and the antenna. An ohmmeter check would then confirm the difficulty.

An open primary winding might not be so easily found, owing to the fact that the capacitive gimmick winding may transfer sufficient energy to the secondary for fair operation of the receiver. The nature of the open in the winding will affect the type of trouble experienced with the radio. Usually it will be noisy, and a noisy receiver always calls for a routine check of coils that will locate the trouble.

Replacement notes on antenna transformers will be found in Chap. 14.

Troubles Common to the Antenna Tuning Condenser.—The antenna tuning condenser develops troubles in common with any section of the gang tuning condenser. The plates may touch and cause a short and no operation or very noisy operation over parts of the tuning range. Also the plates and the associated trimmer condenser collect dust and cause noisy operation and a partial short. Sometimes the wipers make poor contact, again causing noisy operation or weak reception over parts of the tuning range.

A shorted tuning condenser or trimmer would be found on signal check. When the converter stage from the RF grid is checked, the defective condenser would short the signal-generator output and cause no signal. An ohmmeter check would then disclose the short. Since this might be in the trimmer or the plates of the tuning condenser, the serviceman must determine which unit is defective. An easy way of doing this is to rotate the tuning condenser to the full open position and check again. If the short remains, it is probably due to cracked mica in the trimmer condenser.

When the tuning condenser is causing noisy reception over part of the range, a thorough overhaul of the tuning-condenser gang will be necessary. A procedure for doing this is given in Chap. 14.

Troubles Common to the RF-stage Decoupling Filters.—The resistors in decoupling filters usually give no service troubles unless the associated condenser shorts. If *C*-14 or *C*-4 should short, there would be an overload of current through *R*-14 or *R*-4 which might damage them. When this happens, the resistors are usually replaced. Condenser *C*-30 in the AVC circuit rarely shorts and, if it should, there is insufficient voltage in this circuit to harm resistor *R*-30.

If condenser *C*-4 shorts, the stage becomes inoperative owing to lack of plate voltage. The condition would be found much earlier in the test procedure, however, since the short would reduce the total *B* voltage and affect the operation of stages previously tested. Similarly, a short in condenser *C*-14 would affect the operation of any later stage whose screen supply came from the same source. The shorted condensers would be found by voltage and resistance checking.

If condenser *C*-30 shorts, the AVC voltage applied to the stage would be shorted out. This would cause the stage to be operating at maximum volume with consequent overloading of itself or succeeding stages. The overload would cause poor tone on all but weak signals, a symptom of defective AVC operation, which would focus attention on this circuit.

If any of these condensers open, the trouble would be found by checking for the symptom that ensues. If plate condenser *C*-4 opens, the gain of the stage would be reduced with possible oscillation also resulting. Signal check and stage-gain measurements would show normal response from the converter grid and insufficient gain from the RF grid. This could be caused by a weak RF tube, improper operating potentials, a defective interstage RF transformer, or an open plate by-pass condenser *C*-4, all of which would have to be investigated. The condition would be found when a test condenser, bridged across *C*-4, restores normal operation.

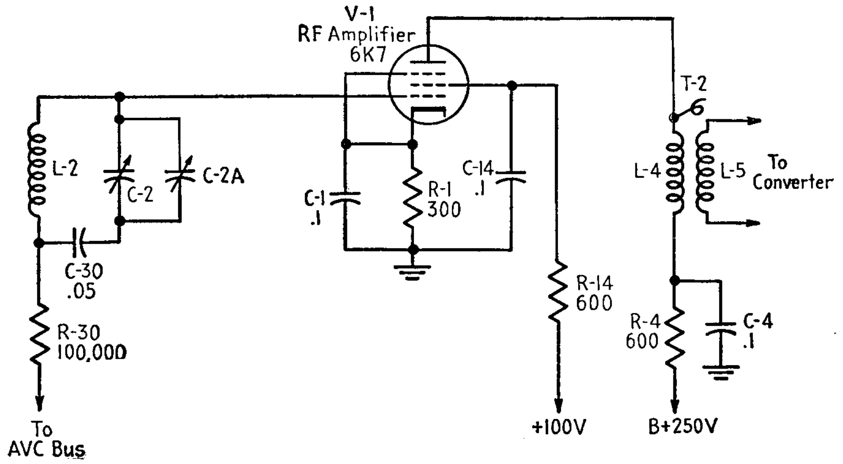


FIG. 16-6.—Decoupling filters in the RF stage.

If the screen by-pass condenser *C*-14 opens, the receiver will oscillate. The oscillation will be tunable; that is, as the receiver is tuned, each station will come in with a squeal. This should not be confused with image-frequency interference. The latter causes a whistle on only one or two stations. Standard servicing procedure for oscillation includes bridging all by-pass condensers with a test condenser. This will disclose the open screen condenser.

If AVC by-pass condenser *C*-30 opens, the tuning circuit in the RF stage becomes ineffective. This causes a weakening of the received signal, which in turn causes the AVC to step up the gain of the controlled tubes. The net result is that strong locals come in like weak stations, that is, with a high noise level, and weak ones do not come in at all. The trouble would be found on signal check, since operation would be normal from the RF grid and show no gain or a loss when checking from the antenna. An open antenna coil primary may give the same results. The trouble would be confirmed when a test condenser bridged across *C*-30 restores normal operation. A second check that may be used for confirmation is that the trimmer condenser across the antenna section of the gang tuning condenser is ineffective.

Troubles Common to the Wave-trap Circuit.—The wave-trap circuit composed of *L*-3 and *C*-3 rarely causes service difficulties. Figure 16–7 shows the two common connections for the wave trap.

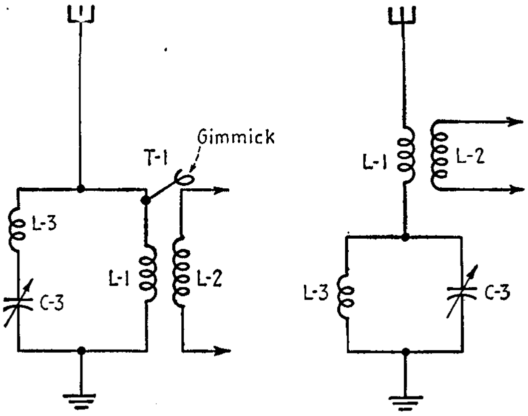


FIG. 16–7.—Common wave-trap circuits.

In either circuit, even if the wave-trap coil *L*-3 should open, the receiver would continue to operate normally. There may, of course, be a tendency for the receiver to have "code" interference, a heterodyne effect, but this would occur only if the receiver is located near a station transmitting at or near the intermediate frequency.

If the complaint is code interference all over the tuning range, the wave-trap circuit would naturally be suspected and checked. Then, when the trap is found to be defective, it is repaired or replaced. Using an exact replacement is desirable, but not essential. Any wave trap that is tunable to the intermediate frequency of the receiver will do.

Correct alignment procedure for the wave trap is first to have the receiver in perfect alignment, then to tune the receiver to 1,000 kc, feed a strong modulated signal at 455 kc (or the intermediate frequency of the receiver) into the antenna, and adjust the trap trimmer condenser or permeability-tuned coil for minimum response. In some cases, the interference is more completely eliminated if the trap is adjusted for minimum response at the frequency of the interfering signal.

Reduction of Image-frequency Interference.—Interference caused by the normal response of superheterodyne receivers to stations operating at the image frequency causes service difficulties in relatively few instances. Receivers that incorporate a tuned RF stage are not troubled. Loop-operated receivers are likewise little affected, since the tunable loop antenna is less responsive to a station 910 kc off resonance than are the ordinary antenna and antenna coil which respond to a very large band of frequencies. The usual offenders, as regards image-frequency interference, are the types of receivers that employ an antenna and no RF stage, or an RF stage followed by an untuned converter stage. Also, the trouble is a local one, since another requirement is the presence of a strong image-frequency signal at the high-frequency end of the broadcast band (twice the intermediate frequency above the frequency of the desired station).

Image-frequency interference can be recognized as a whistle, or "birdie," which mars reception on one station at the low-frequency end of the broadcast band while reception is normal for all other stations. In the metropolitan New York area the stations affected are either WMCA—570 kc, or WNBC—660 kc. In the case of station WMCA, the interference will be prevalent in the vicinity of station WHOM operating at 1,480 kc (570 + 910 = 1,480). Station WNBC may be troubled with image-frequency whistles caused by the presence of a signal from WQXR operating at 1,560 kc (660 + 910 = 1,570). In addition, reception at many points in the tuning range may on occasion experience image-frequency interference, if the receiver should be in the vicinity of police or amateur stations operating on frequencies ranging from 1,700 to 2,400 kc.

When the service job is to reduce image-frequency interference, various methods can be employed by the serviceman. A simple yet sometimes effective method is to reduce the signal input to the receiver. Modern superheterodyne receivers are usually more sensitive than needed for normal requirements of local reception, and may perform satisfactorily with very little antenna pickup. When this is the case, a reduced antenna may receive so much less signal from the interfering station that the whistle disappears. It is always worth while, therefore, to try the effect of a short indoor antenna on the interference. If it is effective, the serviceman should then check carefully to see that reception from all desired stations is satisfactory with regard to both signal strength and freedom from noise.

Another expedient is the installation of a wave trap tuned to the frequency of the interfering station. This frequency may be determined by adding twice the receiver intermediate frequency to the frequency of the station experiencing the interference. The wave trap chosen should have a range which includes the frequency of the interfering station. If such a wave trap is not obtainable, it may be made by adding a series mica condenser of approximately 0.0001-mfd capacity to a standard IF wave trap. The circuit is shown in Fig. 16–8. Several capacities from 0.00005 to 0.0002 mfd should be tried for the series condenser, in order to extend the range of the wave trap so that it covers the frequency of the interfering station.

Still another method of reducing image-frequency interference is to change the intermediate frequency of the receiver. The operation of a receiver is not greatly altered in respect to sensitivity, selectivity, tracking, etc., if the intermediate frequency is shifted about 10 kc, provided the receiver is completely realigned. The change, however, may reduce image-frequency interference. For example, assume a receiver with an IF amplifier tuned to 455 kc and experiencing an image whistle when tuned to a station at 570 kc. The whistle is caused by a station operating at 1,480 kc (1,480 − 910 = 570). Suppose now that the IF amplifier is retuned to 465 kc, and the entire receiver is realigned to operate at this intermediate frequency. The station at 1,480 kc will still be present and will cause image-frequency interference when a station at 550 kc is tuned in (1,480 − 930 = 550). But there is no local station at 550 kc and the image-frequency interference that marred reception from the station at 570 kc will be greatly reduced or entirely eliminated.

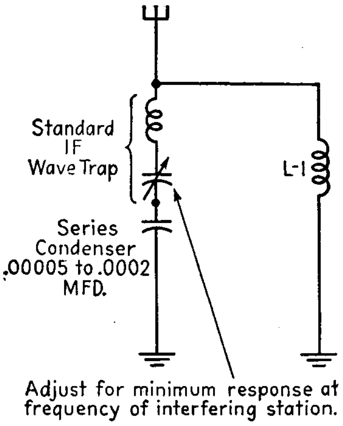


FIG. 16–8.—Using a standard IF wave trap to reduce image-frequency interference.

Variations in the RF Stage.—Multiband receivers will, of course, cause changes in the RF stage. These will be in the tuning circuit, switching arrangements, etc. The servicing of these components has been dealt with in connection with multiband circuits in the converter stage, and it is felt that the serviceman will be able to apply the same techniques to similar situations in the RF stage.

However, a few points should be mentioned. One is that the RF stage is used only on the broadcast band in some receivers. Another is that some provision must be made for a loop antenna to operate on more than one band. The Motorola 103K1 receiver of Fig. 16–9 illustrates both of these points.

The antenna winding of the loop feeds the arm of the range switch section marked "58–1." This arm is open in the broadcast position, and the grid winding of the loop feeds the control grid circuit of the RF tube. In the police and short-wave positions of the range switch, the antenna winding of the loop feeds the appropriate antenna coil through this same switch arm. The secondary of either antenna coil feeds the signal grid circuit of the converter tube through the arm of range switch section 58–2, thereby dispensing with the RF tube in these positions. In the broadcast position of switch 58–2, the converter signal grid is fed by the interstage RF transformer which is marked BC-RF COIL in the diagram.

Note also that the push-button arrangement for this receiver makes use of a motor-driven tuning condenser gang. A switching push-button system would require the removal of one of the three tuned circuits or three rows of trimmer adjustments.

RF Stage Followed by an Untuned Converter.—Many receivers employ an RF stage that is resistance-coupled to the converter signal grid. This arrangement gives the receiver some of the advantages of an RF stage while using only two tuned circuits: the RF grid and the oscillator. The Stromberg-Carlson No. 1000 receiver shown in Fig. 16–10 uses this type of circuit.

The coupling between the RF and the converter tubes consists of RF plate load *R*-14, coupling condenser *C*-5, and converter signal grid load *R*-13. The circuit composed of *L*-12 and *C*-28 in the converter signal grid is a wave trap tuned to the intermediate frequency of the receiver. Similar circuits in other receivers use different values for the components in the resistance-coupling circuit. The plate load varies from 5,000 to 10,000 ohms. The coupling condenser varies from 0.0001 to 0.0005 mfd. The grid-load resistor is often smaller than the one shown in the diagram, 25,000 to 100,000 ohms being more usual. Another circuit difference is that some receivers bring the grid-load resistor to ground or common negative rather than to the AVC bus, as shown in Fig. 16–10.

From a servicing point of view, receivers of this type are checked in the same manner as the standard receiver. There would be only two differences noted. In a voltage check, the RF plate voltage would measure lower than usual, owing to the voltage drop across the plate load resistor. And also, in stage-gain measurements, when checking from the RF grid, there would be a lower gain found than for the tuned coupling. A tuned coupling produces an average gain of 20 between the RF and converter grids. Checking between the

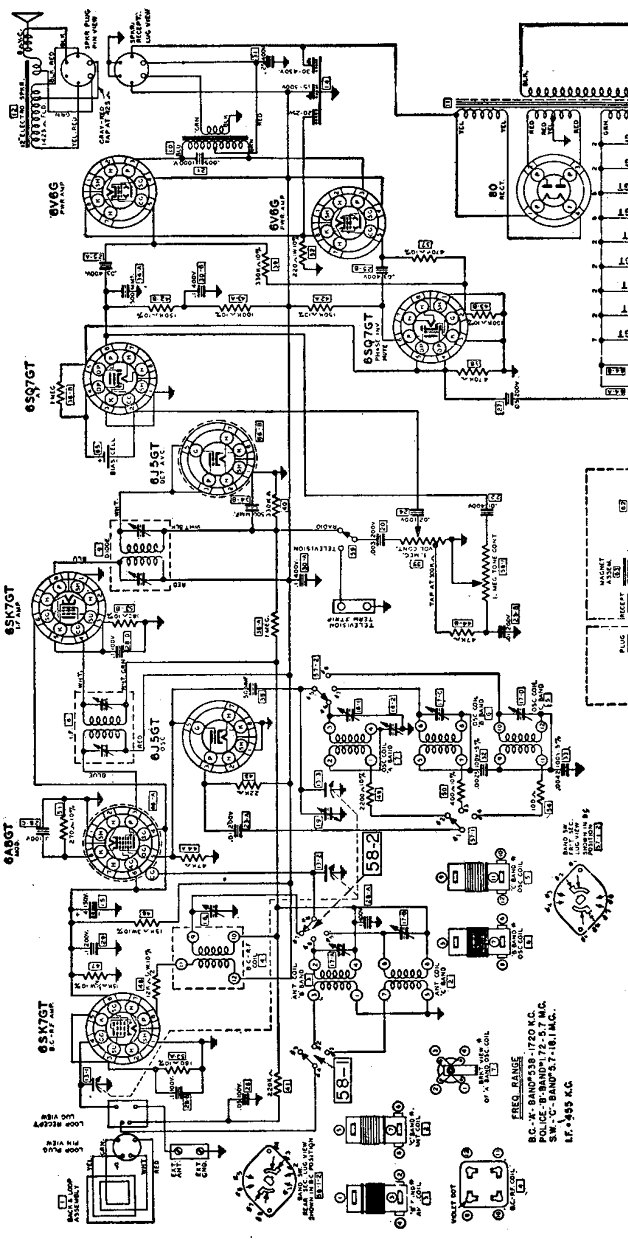


FIG. 16-9.—Schematic diagram of the Motorola 103K1 receiver.

same two points will show an average gain of approximately 7 for an untuned coupling.

The components of the resistance coupling circuit rarely give any service difficulties. The coupling condenser is usually a mica type which is comparatively trouble-free. An open plate-load resistor would be readily found on signal and voltage checks. The grid-load resistor is also trouble-free.

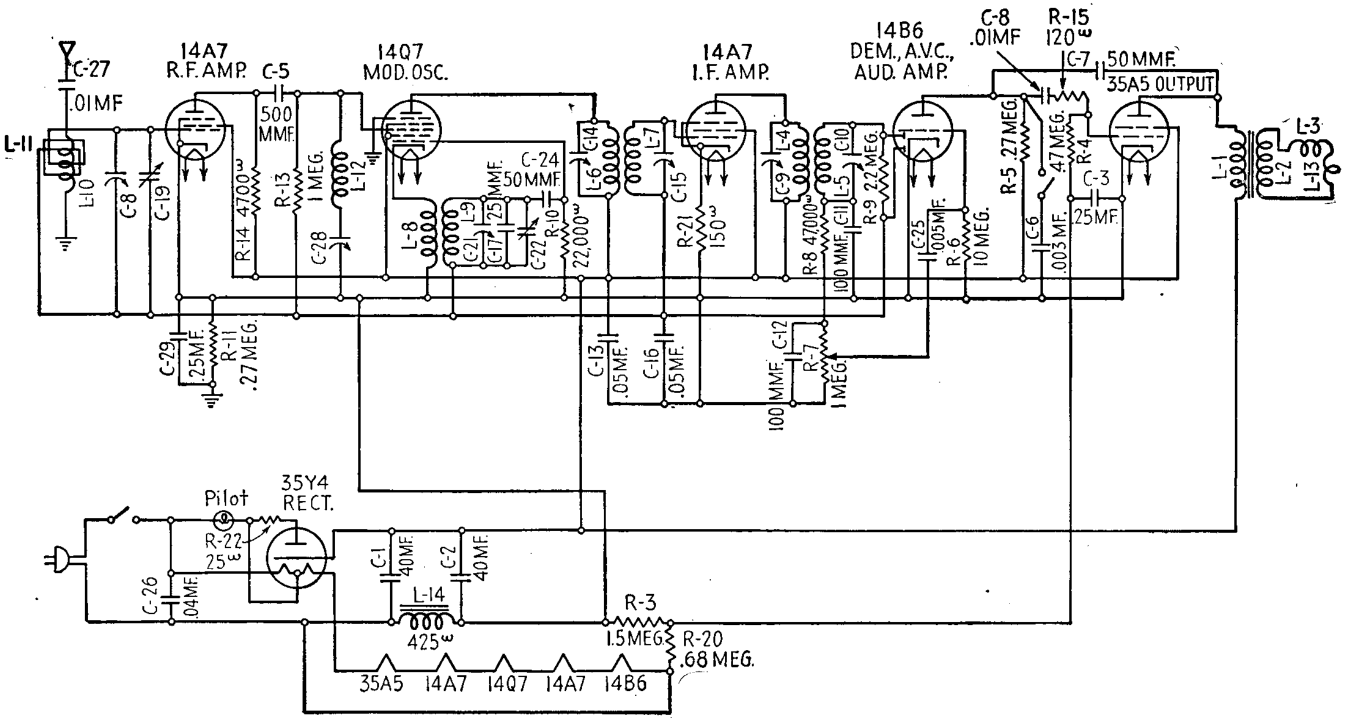


FIG. 16-10.—Schematic diagram of the Stromberg-Carlson No. 1000 receiver.

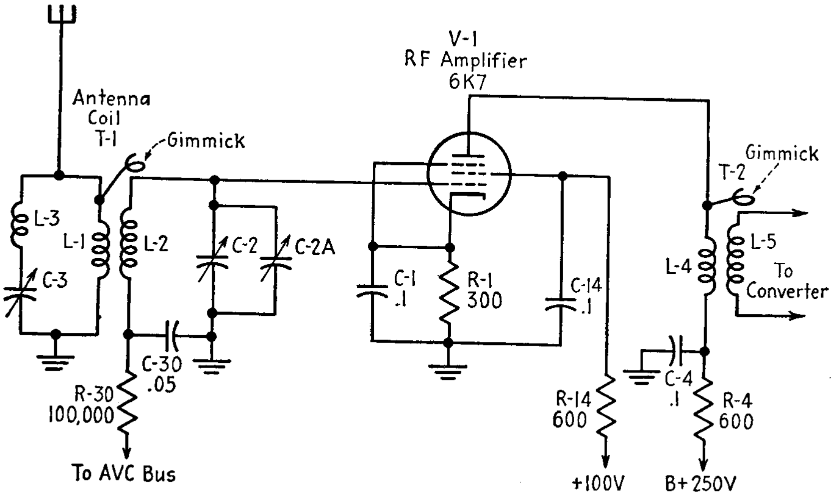
SUMMARY

Quick check for normal operation of the RF stage.

If all previous stages checked showed a normal response, the trouble must be in the RF stage.

Standard RF stage diagram.

The accompanying figure shows the standard RF stage.



Normal voltage data for the RF stage.

Readings are taken from the indicated terminal to the chassis or common negative. Normal voltage data are given in the accompanying table.

Tube terminal	6K7 and 12K7 pin No.	AC receivers, volts	AC/DC receivers, volts
Plate	3	250	90
Screen	4	100	90
Cathode	8	3	3

Normal resistance data for the RF stage.

Across *L-1*	30–50 ohms
Across secondary of the antenna transformer	5 ohms
Cathode to chassis	300 ohms
Across primary of interstage RF transformer	30–50 ohms
Control grid to chassis	1,600,000 ohms
Screen grid to chassis	30,600 ohms
Screen grid to *B* plus	30,600 ohms

SERVICE DATA CHART

Symptom	Abnormal reading	Look for
No signal from the speaker	Plate voltage = 0. Other voltages normal	Open primary of interstage RF transformer *T*-2. Open plate decoupling resistor *R*-4
	Plate voltage = 0. Other voltages low	Plate-chassis short circuit in the RF circuit. Short-circuited decoupling condenser *C*-4
	Cathode voltage high. Other voltages normal	Open cathode resistor *R*-1
	Screen voltage = 0. Other voltages normal	Short-circuited screen by-pass condenser *C*-14. Open decoupling resistor *R*-14
	Cathode voltage = 0. Other voltages normal	Dead RF tube *V*-1
	All voltages normal	Short circuit in gang tuning condenser *C*-2
Weak signal	All voltages normal	Weak RF tube *V*-1. Open antenna transformer *T*-1. Open cathode by-pass condenser *C*-1. Open plate by-pass condenser *C*-4. Open AVC by-pass condenser *C*-30. Misalignment
Oscillation	All voltages normal	Open screen by-pass condenser *C*-14. Shielding improperly grounded. Incorrect lead dress
Noisy operation	All voltages normal	Open or corroded antenna transformer *T*-1. Open AVC by-pass condenser *C*-30. Corrosion in the interstage RF transformer *T*-2. Defective RF tube *V*-1. Defective gang tuning condenser
Code interference	All voltages normal	Open wave-trap circuit. Mistuned wave trap
Poor tone quality	All voltages normal	Short-circuited AVC by-pass condenser *C*-30
Whistles on one or two stations	All voltages normal	Image-frequency interference

QUESTIONS

1. Outline a procedure for checking the source of trouble in a receiver that has a defective RF stage.

2. A weak AC superheterodyne receiver gives a normal response when the proper test signal is applied to the RF grid and a weaker response when the same test signal is applied to the antenna. What are the likely sources of the trouble, and how would you check for each?

3. A dead AC superheterodyne receiver gives a normal response when the proper RF test signal is applied to the converter signal grid and no response when the same test signal is shifted to the RF grid. Use the standard circuit of Fig. 1–1 and list the possible causes of the trouble. How would you check for each?

4. The receiver of Fig. 16–10 gives poor reception in the customer's home although it operates normally on the service bench. A long out door antenna was suggested and installed. The reception was greatly improved but the receiver is now troubled with code interference all over the tuning range. What is likely to be wrong and how should it be checked?

5. A superheterodyne receiver gets a station operating at 570 kc all over the dial. What is likely to be wrong? How can you check for this condition?

6. The receiver of Fig. 18–19 operates normally on all local stations except one at 660 kc. On this station, there is a persistent whistle that cannot be tuned out. What is the most likely cause of the difficulty? Outline a procedure to be followed in an attempt to minimize the condition.

7. The receiver of Fig. 16–9 is inoperative. Signal check shows that the trouble is in the RF stage. A voltage check of the RF stage gives the following results:

Plate	250 volts
Screen	100 volts
Cathode	50 volts

What is likely to be wrong? How would you confirm your assumption?

8. Assume the receiver of question 7 gave the following voltage readings:

Plate	250 volts
Screen	100 volts
Cathode	0 volt

What is likely to be wrong in this case? How would you confirm your assumption?

9. The receiver of Fig. 16–9 has poor tone quality on local stations. Removing the RF tube and connecting the antenna to the plate terminal of the RF tube clear up the tone. What in the RF stage can cause this trouble? How would the serviceman confirm the cause?

10. A receiver with an RF stage like the standard circuit of Fig. 1–1 picks up local stations but the reception is below normal in strength and is coupled with considerable noise. A signal check shows normal response when the proper test signal is applied to the RF grid, and a loss when the same test signal is applied to the antenna. Name the parts that may cause this condition. How would each one be tested?