PROFITABLE
Radio Troubleshooting

A PROFESSIONAL GUIDE TO THE TECHNICAL AND BUSINESS METHODS OF OPERATING A RADIO-TV SERVICE BUSINESS

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PROFITABLE RADIO TROUBLESHOOTING

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Preface

This book presents profitable short-cut procedures for servicing radio receivers that are dead, weak, noisy, humming, distorting, squealing, or intermittent. It shows how to use the signal generator, vacuum-tube voltmeter, and oscilloscope as practical instruments for cutting down labor costs in a service business so as to boost profits. It guides you in getting an auxiliary income from a profitable part-time radio servicing business. It guides you as you expand into a profitable full-time radio business. It teaches you how to handle customers profitably. It helps you to avoid mistakes that lead to low profits and failure. It gives you basic technical and business know-how if you plan to expand into the still more profitable field of black-and-white and color television servicing.

The information represents the compressed experiences of many successful servicemen presented clearly and concisely for easiest possible learning. All you need is a basic radio knowledge. The rest is here, telling exactly how to make your present knowledge pay off to give you the highest possible net income from full-time or spare-time servicing.

Nothing is taken for granted. Many simple diagrams accompany the text to help you visualize more clearly. By judicious repetition of information, learning is made easier and more lasting.

The business suggestions will be found invaluable for a radio or television servicing business. Too many good technicians never get to run their own successful shops because their business know-how is undeveloped.

William Marcus
Alex Levy

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Types of A-M Radio Receivers

Scope of This Book. The field of radio grows as fast as human imagination and engineering skill can unite in making dreams come true. Within one generation, a radio alphabet has tumbled before us with terms like tuned radio frequency, superheterodyne, a-m, f-m, TV and now color TV. New variations of console models, table radios, portable receivers, three-way portables, auto radios, a-c receivers, a-c/d-c receivers, and all-transistor radios appear constantly.

The field of radio is so large today that it is no longer possible to pack all radio knowledge into one book. Of necessity, therefore, this book specializes in one large and highly useful portion of radio knowledge, aimed at developing your professional techniques to the point where you can fix a-m radios fast enough to make a really good living from your work.

The field of this book is a-m (amplitude-modulated) radio receivers. In the rush to new things, television receivers capture the major share of newspaper advertising. But the a-m receiver is still king from the point of view of numbers in existence. It still makes up a lion's share of sales and service. The serviceman who overlooks its possibilities is losing a large area for profit.

And if the serviceman is looking forward to the complete servicing field, he must keep in mind that the a-m radio is the basic circuit for study because of its simplicity. It is generally learned first and is a good introduction for later study of television.

This Chapter. This book begins with brief descriptions of the varieties of a-m receivers. First comes the old tuned radio-frequency (trf) sets to help you get your bearings, even though this type of set is now a museum piece. Then we go on to the superheterodyne receiver, which is the most widely used. A brief description is given of receivers using two different power supplies—the a-c receiver and the a-c/d-c receiver. Finally the auto radio and the three-way portable receiver are described.

Second Chapter. Here you get a quick preview of the professional troubleshooting techniques that make it possible to put servicing on an efficient mass-production basis. Helter-skelter, hit-and-miss work habits never pay.

Remember that the time taken to develop a proper service approach at the start will appear at some future date in the form of dollars and cents.

Chapters on Various Defects. The next few chapters after the one described are concerned with receiver defects. Each will prove extremely valuable to you. After all, your business will begin with a gripe about a receiver. It hums; it is noisy; it whistles; it is dead; it doesn't sound clear; it brings in two stations at once; and many other conditions. Each chapter on defects in receivers will give you possible causes of trouble for the various types of receivers. The generalized approach will help you to narrow down all possibilities to the specific cause. Properly used, this approach will save you time. And for you, time will be money.

Chapters on Instruments. Two chapters will concentrate on specialized service instruments that help you to work more rapidly and effectively. These instruments will be described and their practical use fully explained. You will learn about vacuum-tube voltmeters, signal tracers, the cathode-ray ocilloscope, and others.

Experience-building Chapters. One entire chapter shows you how to get practical experience in the least possible time so as to build up your troubleshooting speed rapidly. Two related chapters provide quick-reference reviews and actual examples of typical service jobs, to boost further your speed and confidence.

Business-technique Chapters. The remainder of the book will carry you from the technical to the business aspects of a television and radio servicing business. Just as a doctor's bedside manner may be the secret of his success, so may your sales personality be your secret. Not having it is like entering a battle unarmed. These business-technique chapters are even more important than the technical chapters, because they show you how to get the money that you deserve for your professional servicing work.

The various types of a-m radio receivers will now be reviewed briefly, with emphasis on the differences in their power supplies.

Tuned Radio-frequency Receiver. You are not going to find many tuned radio-frequency (trf) receivers around today. Their production has just about stopped. However, you should know a little about them, just in case one of these old sets is brought in for servicing.

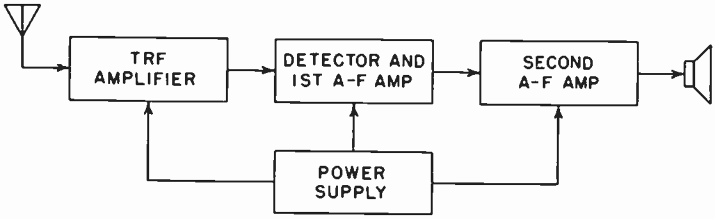


Fig. 1-1. The basic trf receiver

The trf receiver consists basically of a tuned radio-frequency amplifier, a detector, two stages of audio-frequency amplification and a power supply. A block diagram of such a receiver is shown in Fig. 1-1. Its simplicity makes it a relatively easy set to service.

In Fig. 1-2 is shown the schematic diagram of a typical trf receiver. This circuit is a bit unusual in that the input and output of the r-f amplifier are tuned by means of tuning slugs which move in and out of coils *L*-1 and *L*-2. Condensers *C*-1 and *C*-2 are simply trimmers across the coils.

At this point, little will be said about the power supply. A little later in this chapter, we will take up a study in more detail of how power is furnished to the various stages. Since these were inexpensive receivers, they usually used a-c/d-c power supplies, which are cheaper to manufacture.

Superheterodyne Receiver. The usual a-m receiver produced today uses the superheterodyne circuit, which has many advantages over the trf circuit. This is true for receivers designed to operate on 117 volts—either a-c or d-c, on 6 volts as in the auto radio, on batteries or power line as in the three-way portable receiver. All these receivers use the same basic superheterodyne circuit, with differences in the power supply.

The block diagram of a superheterodyne receiver is shown in Fig. 1-3. The modulated r-f signal from the antenna is amplified in an r-f amplifier and fed to the next tube, the converter. Here the signal is mixed with an unvarying r-f signal produced by a local oscillator within the receiver. Out of the converter comes a modulated signal at a radio frequency which is much lower than the original r-f signal. This lowered frequency is usually

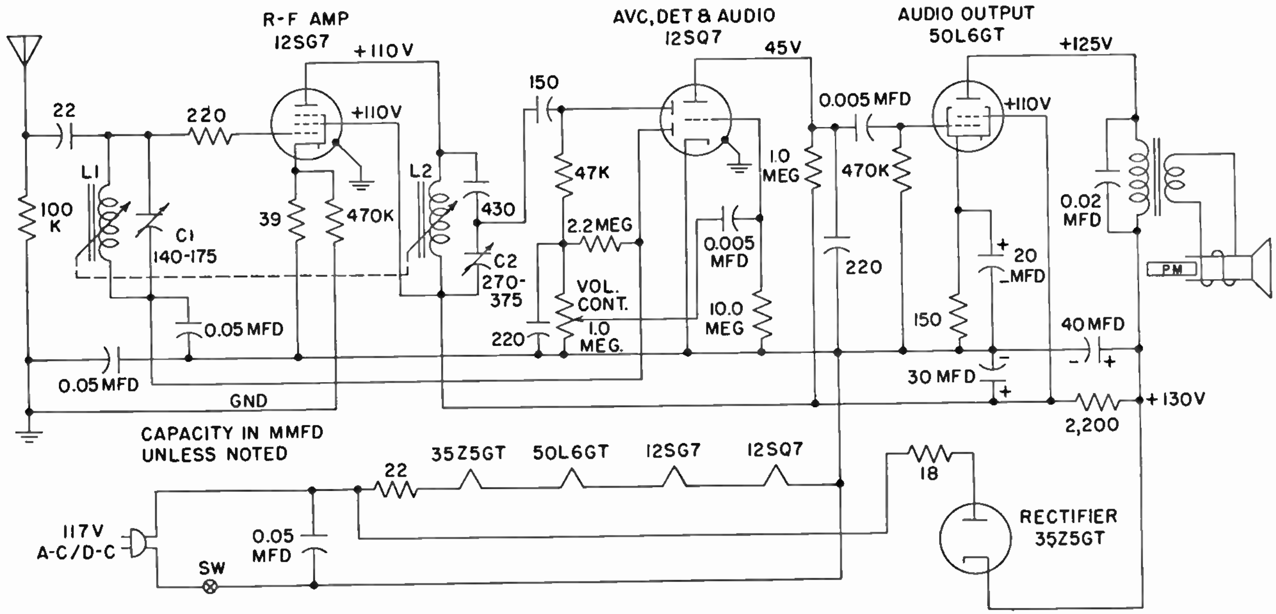


Fig. 1-2. The General Electric Model 50 trf receiver (clock omitted)

around 455 kc and is called the intermediate frequency (i-f) signal. It has the same modulations as the original incoming wave. Its frequency is always the difference between the frequencies of the original r-f and the local oscillator signals. When tuning from station to station, the oscillator is also tuned automatically by the ganged tuning mechanism, to give the same intermediate frequency at all times—455 kc.

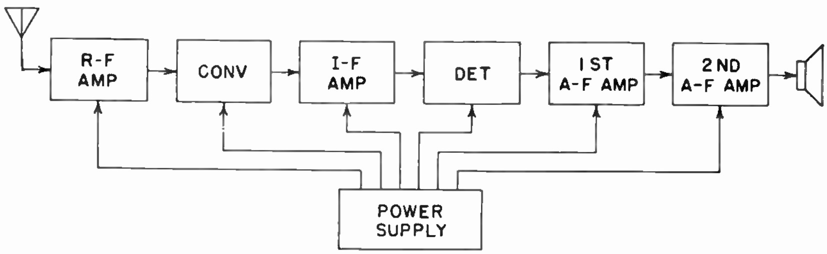


Fig. 1-3. Block diagram of a superheterodyne receiver

The i-f signal is then fed to the i-f amplifier which is sharply tuned to 455 kc for build-up. Then it is fed to the detector for demodulation. The a-f modulation is separated from the modulated r-f signal, and the former is then sent through two a-f amplifiers for increased power to drive the loudspeaker.

In Fig. 1-4 is shown the schematic diagram of a small superheterodyne receiver. Several things should be noted. In this receiver, as in many others, the first r-f amplifier is omitted and the signal is fed directly into the tuned input of a converter tube. The local oscillator is part of the same tube and coil *T*-2 is the local oscillator coil, tuned by condenser C-2.

Note how the main r-f tuning condensers C-1 and C-2 are ganged so as to give a constant intermediate frequency. Transformers *T*-3 and *T*-4 are fixed-tuned for the intermediate frequency at the input and output of the i-f amplifier.

The avc line feeds a low voltage to the converter and i-f amplifier, helping to maintain a uniform sound level from the loudspeaker regardless of the station signal strength at the antenna. Potentiometer *R*-1 is the volume control regulating the strength of signal fed to the first a-f amplifier.

The power supply shown is of the a-c/d-c type. Since many superheterodyne receivers also use the a-c type of supply, this is a good point at which to discuss these two power supplies.

A-C and A-C/D-C Power Supplies. The purpose of any power supply is primarily to furnish current of any type to heat the heaters of the tubes

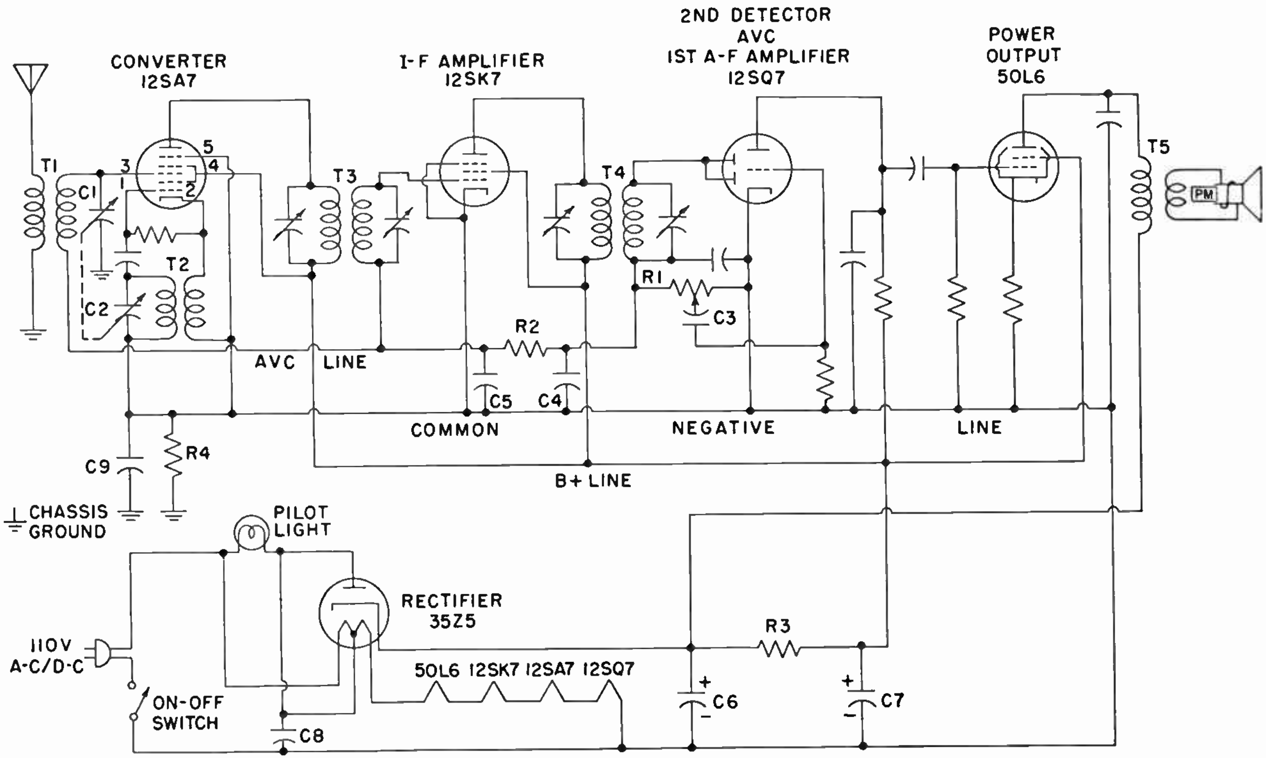


Fig. 1-4. Circuit diagram of a typical a-c/d-c superheterodyne receiver

and to supply the smooth d-c voltages required for the plates and screens of the tubes. The type of circuits used will depend mainly upon whether the power source is a-c or d-c.

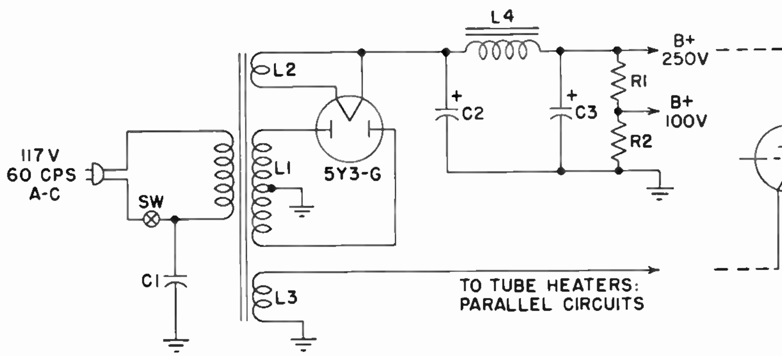


Fig. 1-5. A typical a-c power supply

In Fig. 1-5, we have the typical power supply of an a-c receiver. The 117 volts a-c are fed to the primary winding of a power transformer. There are, as you note, three secondary windings. Winding *L*-1 is part of a high-voltage step-up transformer. Across it may be as many as 700 volts. It is center-tapped, so that 350 volts on each half of it are fed to the plates of the 5Y3-G rectifier tube. This tube changes the alternating current to pulsating direct current and feeds it to the filter system, made up of electrolytic condensers C-2 and C-3 and choke *L*-4. The choke is sometimes the field coil of the loudspeaker. Emerging from the filter system comes almost smooth, unvarying direct current. Resistors *R*-1 and *R*-2 make up a voltage-dividing system to get various values of d-c voltage.

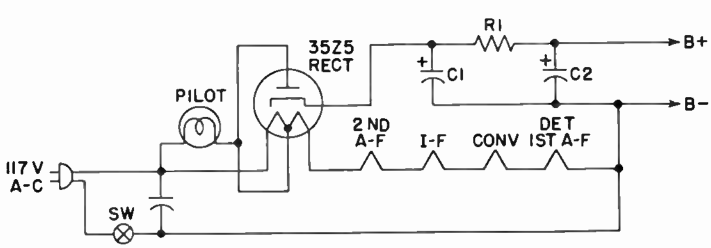


Fig. 1-6. A standard a-c/d-c power supply, in which heaters are connected in series

Coils *L*-2 and *L*-3 make up the low-voltage step-down portion of the power transformer. Coil *L*-2 feeds low-voltage alternating current to the 5Y3-G tube heater. Coil *L*-3 feeds low-voltage alternating current to the heaters of the other tubes within the receiver.

The same job must be done in the a-c/d-c receiver. In Fig. 1-6, we have a typical a-c/d-c power supply. The a-c input is rectified to pulsating d-c by the 35Z5 tube. Note that this tube is a cathode-heater type. The current is then fed to the filter (C-1, R-1, and C-2) for smoothing. Voltage dividers are usually not employed in the power supply. The 117 volts a-c are fed to the tube heaters, connected in series. Usually the heater requirements are such that 117 volts are neither too little nor too much. If 117 volts are too much, some sort of voltage-dropping resistor is inserted in series with the heaters.

Auto Radio. The auto radio is a superheterodyne receiver and has many similarities to the home receiver. However, its variations are primarily the result of unique operating conditions. These conditions are operation from a 6-volt storage battery, nearness to sources of radio noise, and use of a smaller-than-usual outdoor antenna. These conditions might be best understood by examining a typical auto receiver in Fig. 1-7. The condenser in the antenna input is designed to match the capacity of the particular antenna used in the car. This matching enables a stronger signal to be fed to the r-f amplifier.

Examination of the power supply of the receiver shows the battery as the power source. It feeds a vibrator and transformer whose purposes are to change 6-volt direct current to high-voltage alternating current. The latter current is rectified in the 6X4 tube and then receives the usual filter circuit action.

One terminal of the car battery is grounded to the chassis of the car. The other terminal, called the *hot* terminal, is connected through a 9-ampere fuse to the auto radio. The 6 volts of the battery are connected across the heaters of all the tubes connected in parallel, since they are 6-volt-type tubes. Spark-plate condenser *M*-5 and choke *L*-7 make up a filter circuit to prevent engine noise from entering the receiver through the battery wire.

Auto-radio Vibrator. Note that the battery voltage in Fig. 1-7 is applied through the switch, vibrator choke *L*-8, and one-half of the primary of transformer *T*-1 whenever the vibrator reed touches the vibrator contact points. The upper and lower halves of the transformer primary winding are thus energized in turn as the reed moves between the upper and lower contact points. The reed is kept vibrating by the action of the vibrator electromagnet. As each half of the primary winding first passes and then ceases to pass current, this action induces high a-c voltage across the sec-

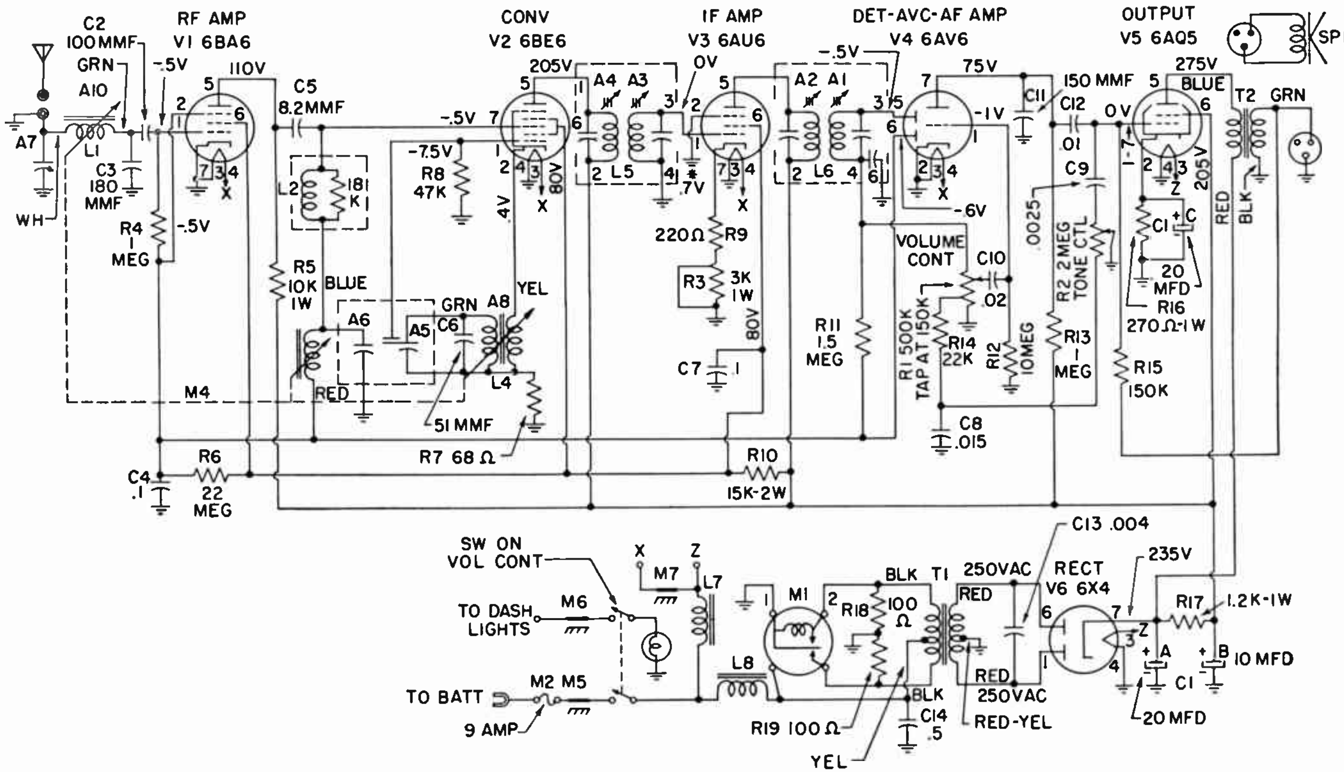


Fig. 1-7. Schematic diagram of Ford Model 5BF auto radio (Howard W. Sams Photofact illustration)

ondary winding of this step-up transformer. This is rectified by the 6X4 to give the B-supply voltage, much as in an a-c power supply.

The continual sparking at the contacts would feed into the receiver and produce a type of r-f interference known as *hash*. Filter circuits suppress the sparking and filter the undesirable r-f currents. Resistors R-18 and R-19 across the vibrator contact points also suppress sparking and hash. Vibrator choke L-8 and condenser C-14 make up one hash filter which keeps the undesirable r-f current out of the receiver heater lead, while choke L-7 and spark plate M-7 serve as another.

Auto-radio Rectifiers. The a-c output of the vibrator transformer is fed to a full-wave rectifier. The rectifier tube is usually of the heater-cathode type, as in Fig. 1-7, because the cathode must be kept at a high positive potential.

Some receivers use a cold-cathode type of rectifier tube, like the 0Z4 tube, without a heater. It passes current through a gas and glows with a purple light. Such a circuit is shown in Fig. 1-8. In this circuit, condensers C-4 and C-5 are filter condensers to reduce hash produced by the gas conduction.

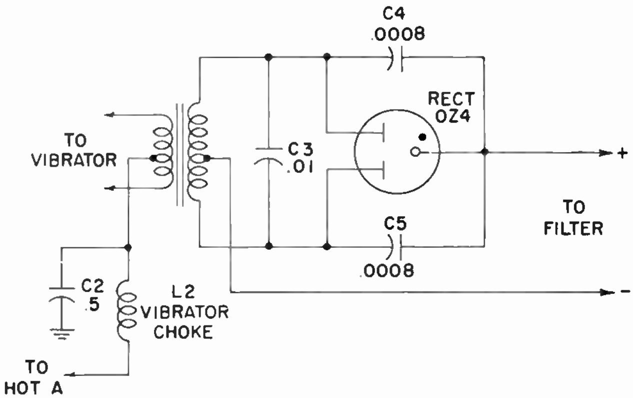


Fig. 1-8. Cold-cathode type of auto-radio rectifier circuit

The rectifier tube output is fed into a standard L-C filter circuit for smoothing. Auto receivers rarely use a voltage divider. Lower screen voltages are usually obtained by suitably bypassed dropping resistors.

Synchronous Rectifier. The type of auto-radio power supply just described is known as the nonsynchronous type of supply. There is another type known as the synchronous vibrator type of power supply. This type depends for its operation on mechanical rectification by the vibrator and therefore does not require a tube rectifier. A simplified circuit for such a power supply is shown in Fig. 1-9. Note that this vibrator has four vibrator contact points.

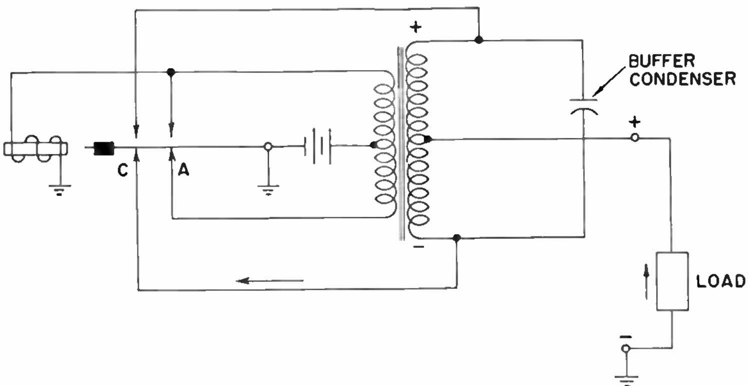


Fig. 1-9. The synchronous vibrotor of on outo rodio

Three-way Portable Receiver. The three-way portable receiver is one designed to be used on either an a-c line or d-c line, or to be self-powered by batteries. The changeover is performed by a switch. The tubes used are of the filament-heater type and require a heater voltage of 1.4 volts. Sometimes the output tube is operated at 2.8 volts, with the two halves of its heater connected in series rather than in parallel.

The filaments are usually connected in series when operated either from the batteries or the lines. When the receiver is operated from the batteries, the circuit is straightforward: B batteries furnish the plate and screen voltage supplies; the A battery furnishes the filament voltage. When the receiver is switched to a-c or d-c line supply, various interesting factors arise.

Use on the power line requires that the line furnish both the B supply and the A supply. For the B supply, the common a-c/d-c supply with its half-wave rectifier and an R-C filter is employed. For the A supply the same rectifier is used with a different R-C filter.

A typical three-way portable power supply is shown in Fig. 1-10. The 80-mfd condenser is the input filter condenser for both the A and B supply. The series of resistors in the A-supply string serves a special purpose. The audio-output tube is usually at the positive end of the series filament string in order to obtain grid bias from the drop across the remaining filaments. As a result, the plate current of the output tube must flow through the filament string. This condition would overload the filaments of the other tubes.

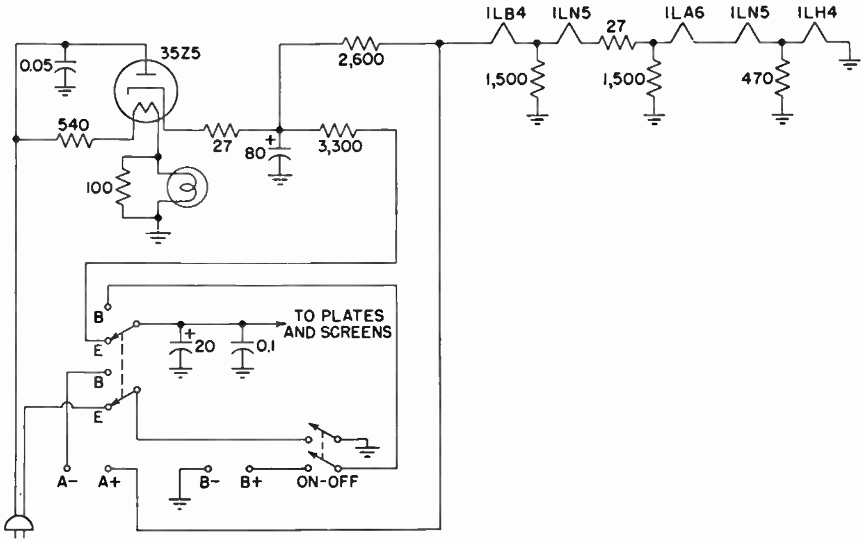


Fig. 1-10. A typical three-way portable radio power supply

The resistors in Fig. 1-10 act as equalizers to maintain proper voltages across the filaments. The voltage drop of the other tubes furnishes bias for the power tube. Bias for these tubes in turn is obtained partly from the avc line, and partly from grid-return connections going to various voltage points on the filament string.

Another variation of this basic circuit is shown in Fig. 1-11. A 117Z6-GT

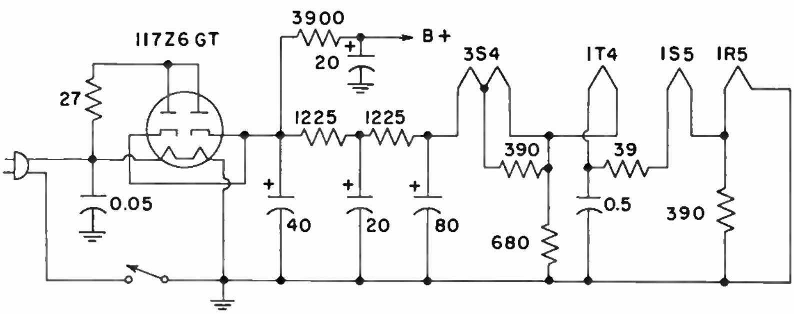


Fig. 1-11. A three-way portable radio power supply using a 117Z6-GT rectifier. Battery switching is omitted to simplify the circuit

tube replaces the 35Z5 tube. A slightly different A-supply and B-supply filter is shown, but the principle of operation is basically the same.

Still another interesting variation is the one shown in Fig. 1-12. Here, a selenium rectifier replaces a tube rectifier. The selenium rectifier should usually last a very long time in operation. Following the rectifier is a standard R-C filter to furnish the B supply. The rectified voltage past the

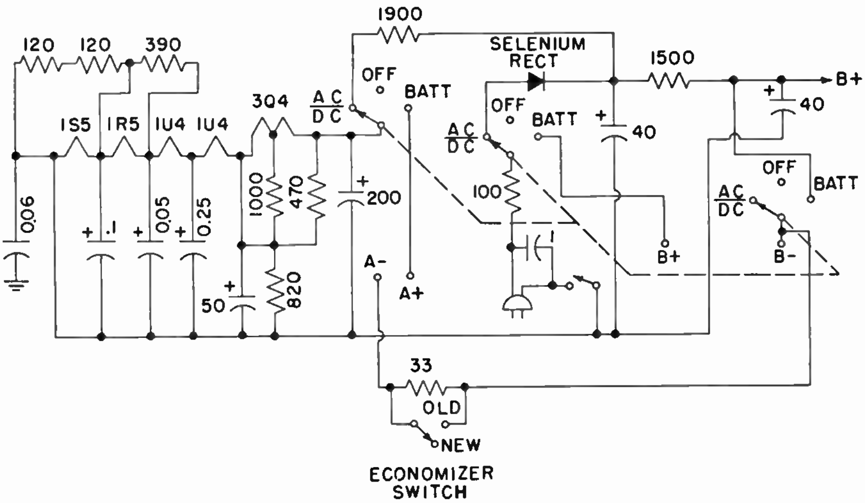


Fig. 1-12. A three-way portable radio power supply using a selenium rectifier

selenium rectifier is then filtered and sent to the series string of filaments. The resistance network around the heaters once again acts as the voltage equalizers. The economizer switch is a device to extend the life of the A battery. When batteries are new and voltage is high, current drain is dropped through the 33-ohm resistor. When batteries are old and voltage is lower, the resistor is shorted out.

2

General Servicing Procedure

The Serviceman Needs a Procedure. The fellow who enjoys the solving of a puzzle or a problem could ask for no more pleasurable challenge to his time or energy than radio servicing. If the receiver defect is a tough nut to crack, so much the better—especially if it is solved.

But do not get any ideas that the professional radio serviceman with his own business is a fellow who spends his time enjoying the solving of problems. The necessity of making his business a profitable one adds a new factor which he must never overlook. He must not only solve radio-service problems, but he must solve them efficiently. The defect must be found and repaired with the greatest possible speed. It is not that the customer wants his receiver returned to him within the hour. Rather, it is the need for time to handle the great quantity of service jobs coming into a successful shop that makes efficiency the keynote.

Did you ever see a skilled technician like an oil-burner serviceman handle a job? He seemed so sure of what he was doing and what the next step must be. You had the feeling that here was a man who knew his job. If you could look into the mind of the technician, you would see an efficient sizing up of the situation, and a definite approach procedure for solving the defect. For the skilled radio serviceman the situation is similar, except that there is an even greater need for a definite procedure because of the complexity of the problems that he tackles.

Professional Servicing Procedure. The professional radio serviceman could in many ways be compared with a doctor. The serviceman cures ailing receivers, just as the doctor cures ailing persons. The procedures of the two are very similar.

When the doctor receives his patient, he inquires as to past and present complaints. This is essential for getting the physical history of the sick man. As the patient talks, the doctor looks for outward clues. Later, the doctor will make a more thorough external examination. Then, on the basis of complaints and external clues, he performs some directed tests on the patient. Once the ailment is diagnosed, the doctor prescribes a cure. And finally, a short time later, the patient returns for a checkup to make sure that the ailment is gone.

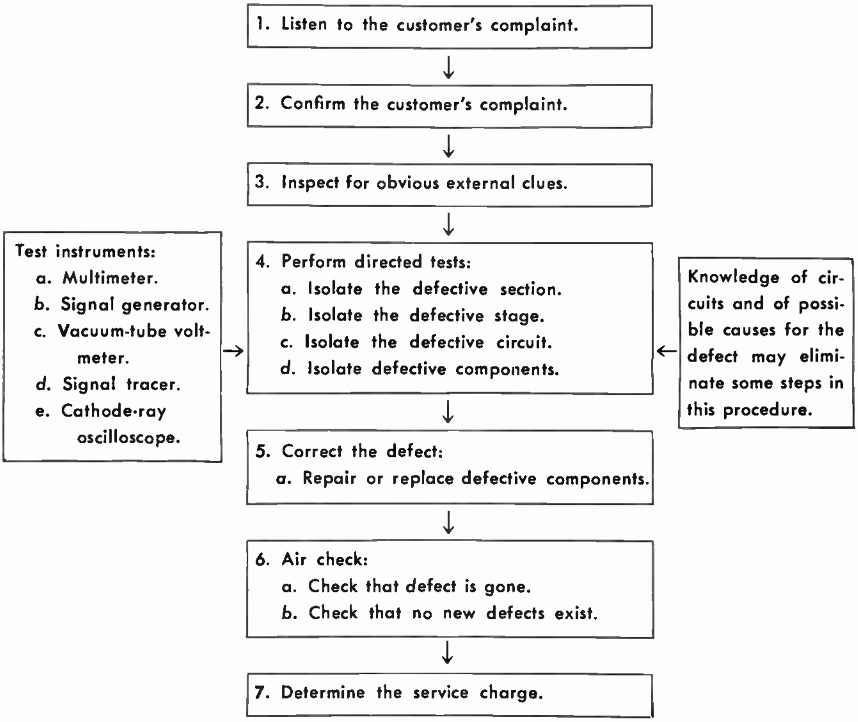


Fig. 2-1. Summary of the professional service procedure

The professional serviceman follows a similar procedure, modified by the nature of the medium that he handles. This service procedure is summarized in Fig. 2-1. The mastery of this procedure will enable the serviceman to tackle his job with efficiency and with the feeling of self-assurance. Let us analyze the various steps in more detail.

Customer's Complaint. The customer's complaint is the beginning of the servicing cycle. A receiver is referred to the serviceman because the customer is not satisfied with its performance. The complaint can be, and very often is, the first clue in the diagnosis of the defective condition. But the untrained customer must not always be considered as infallible in the description of a complaint. Often what irritates the customer may be only one condition in a group of conditions and may not be the best clue as to the defect.

Asking Questions. It becomes necessary to cross-examine the customer —politely, of course. The serviceman should first determine how long the complaint has existed and how it developed. This is part of the case history. Sometimes, the serviceman will find that the complaint always existed and was inherent in the receiver design. Since it is not wise to redesign a receiver, customer education as to the limitation of his set is all that can be done.

The serviceman should also inquire about previous service work for earlier complaints. This history may point to defects created by some inexpert technician. And finally, pointed questions should be asked about the operation of the receiver in other respects on the basis of suspected conditions.

Purpose of Questions. This questioning serves several purposes: First, it draws forth a more complete picture of the defective operation and thereby helps to localize the defect. Second, the serviceman begins in this procedure to develop a hypothesis as to the nature of the defect, so that he may go directly to what he considers to be defective. And finally, the psychological effect on the customer is to give the impression that this serviceman is approaching the problem systematically and professionally.

Confirming the Customer's Complaint. Of course, too much time cannot be consumed in this questioning. The serviceman soon proceeds to confirm the customer's complaint. To avoid later complications as to the service charge, it is wise for the serviceman to point out to the customer any other conditions of defective operation that may require servicing, in addition to those described by the customer. Both must know exactly what the complaint is that the serviceman is contracting to remedy. The serviceman is now ready for the next step—the examination of the receiver for obvious external clues.

Looking for Clues. This search for external clues becomes more systematic and efficient as the serviceman gains more and more experience. He searches with his eyes, ears, nose, and sense of touch. The odor or feel of an overheated component can be an important clue. The serviceman looks for broken connections, for components accidentally being grounded out, for leads improperly dressed so as to pick up unwanted signals, for tubes out of sockets, for disconnected tube grid caps, for tubes that do not light, for mechanically damaged components, and similar conditions that do not call for an extended search or for controlled and directed tests.

The first examination should be made on top of the chassis, because it is easier to do so and because it can often be done without removing the chassis from the cabinet. If no defective condition is found, it becomes necessary to continue the examination on the underside of the chassis. Of course, the chassis must be removed from the cabinet to get to its underside.

The purpose of this examination is to find an obvious condition that stares the serviceman in the face. If no clue as to the cause of the defective operation is found, the serviceman then resorts to a systematic isolation procedure by means of directed tests. Since these tests vary in accordance with the type of complaint, we should first classify defects with this point of view in mind.

Types of Complaints. The serviceman must have a clear picture in mind of the exact nature of the condition which makes the receiver one in need of servicing. Such a picture guides him both in his search for obvious external defects and in his directed tests. It guides him in drawing upon his service information for the solution of the problem.

A list of the most common conditions of receiver misbehavior is tabulated in Fig. 2-2. On the basis of the customer's complaint and his own

1. **Dead Receiver**—The receiver is completely inoperative, giving no signal output at the loudspeaker. Tubes may or may not light.
2. **Weak Reception**—The receiver gives a weak output at the loudspeaker and may fail to receive some stations.
3. **Hum**—The receiver emits a steady low-frequency audio note of higher than normal level with or without an accompanying station signal.
4. **Oscillation Squeal**—The receiver emits a steady high-pitched audio squeal with or without an accompanying station signal. A variation is motorboating, where a low-frequency put-put sound is heard.
5. **Noise**—The receiver emits the station signal simultaneously with annoying unintelligible irregular sounds not originating at the station.
6. **Distortion**—The receiver reproduces the audio signal from a station in a form quite different from its source, and usually in an annoying form.
7. **Intermittent Reception**—The receiver intermittently falls into any one of the other defects and then returns to normal.
8. **Station Interference**—The receiver gives response from two stations at the same time or produces squeals and distortion due to interaction between two stations.

Fig. 2-2. Common conditions of defective receiver operation confirmation, the serviceman should automatically choose the condition from his list that fits the facts. This step alone will eliminate parts of the receiver as the cause for the defective condition.

In the various chapters on receiver defects, the complete approach to their solution will be given in greater detail. They will begin with the search for external clues and proceed from there to the directed tests for component isolation.

Making Repairs in Customer's Home. Often the external clues will be sufficient to indicate the cause of defective operation, and repairs can be made immediately in the home of the customer. If merely tubes are weak, they ought to be replaced with new ones.

A customer may object to replacing several tubes. Under such circumstances, the wise serviceman will replace the poorest ones, but he will also explain to the customer that there are other weak tubes that ought to be replaced. Such explanation saves embarrassment if the receiver goes bad on that account a short time later.

The search for external clues should not consume too much time. With a little experience, you can perform the search within a few minutes. As a result of the inspection, you may be faced with a question: Should the receiver be taken to the service shop, or should it be repaired in the customer's home?

Taking the Set to Your Shop. If the repair job requires any considerable amount of time, it should be taken to the shop, since it is not advisable to convert the customer's home into a workroom where conditions for working may be poor. Of course, where external clues fail to disclose the defect, the receiver must go the shop's workbench for further isolation procedures.

If the receiver is a small model, it is taken with its cabinet to the shop. But if the receiver is of the large console type, remove the chassis and loudspeaker from the cabinet and take only them with you. All nuts, bolts, washers, screws, etc., should be placed in an envelope and be left in the receiver cabinet in the customer's home. Knobs should be kept on their shafts for manipulation while testing.

As you prepare to leave with the customer's treasured possession, the customer usually asks in a troubled tone about the cost. He might not think it worthwhile to spend $8 to repair a receiver for which he paid $14. It is wise for you to withhold any quotation until you are certain about what must be done. Inform the customer that you will give him a price in a day or so and will then proceed with the repair if he so desires. But never repair the receiver without first giving the customer an approximate cost and obtaining his approval.

If the defect is due to some inherent weakness in receiver design or due to a particular locality and cannot be repaired, explain in simple language why the defect cannot be fixed. The customer will usually be satisfied.

Place of Know-how and Experience in Servicing. Two factors distinguish the beginning serviceman from the established one. One is an understanding of how the receiver and its various components work normally, as well as how they break down. The second factor is simply experience. Together these factors shorten servicing time and therefore make for greater assurance of success.

As you learn to repair more and more receivers, you will establish the places where certain models of receivers are liable to fail. With more experience you will learn to differentiate between hum, noises, squeals, and so forth. These audible sounds defy description on paper, but are soon learned through repeated hearings and provide excellent clues for finding the defect.

Just remember that having lived through an experience is in itself not valuable. You must learn to treat experiences as learning techniques which must be recorded and classified for repeated use. In a later chapter, we shall see how you can systematically build up such a valuable servicing experience.

Value of Reasoning. The understanding of how receivers and circuits work can also shorten servicing time. Such an understanding, however, goes beyond the mere reading of a book. It is a functional understanding that is the combined result of reading and experimenting. It is the type of understanding that has entered your nervous system and lies ready to spring into your reasoning process when triggered by a real service problem. Radio servicing is simply problem solving, and it requires the application of reasoning at every step.

Let us see how such an understanding can help in reducing the time consumed in localizing a defect. In Fig. 2-3 is the block diagram for a basic superheterodyne receiver, with signal waveforms shown at various stages.

All stages before the second detector make up the r-f section; all stages after it make up the a-f section.

Example of Dead Set. Suppose this set is dead when brought in for servicing, and is of the universal a-c/d-c type. This means that the tube heaters are connected in series. If the search for external clues discloses nothing and the tubes are found to be good even though none are lit, you must examine the complete heater circuit. This examination starts at one terminal of the line-cord plug and works back to the other terminal of the plug. If the heater circuit includes a line-cord resistor in series with the tubes, you must check to be certain that this resistor too is not open.

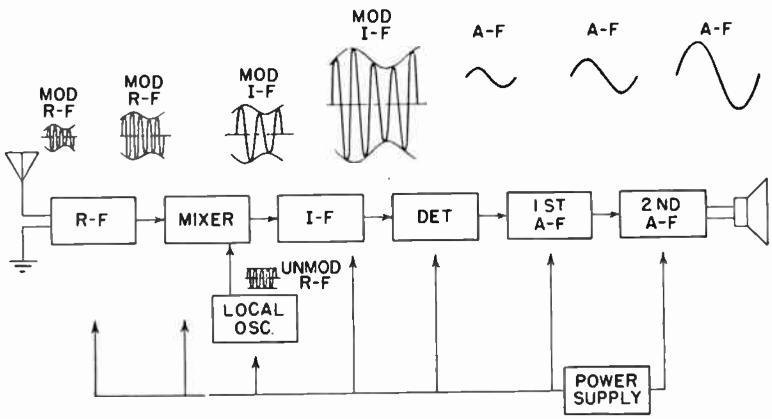


Fig. 2-3. Block diagram of a superheterodyne receiver with signal waveforms

If the a-c/d-c receiver is dead and one or two tubes do not light, you should suspect a cathode-heater short in one of the tubes. Figure 2-4 shows how a cathode-heater short in the converter tube would short out the detector-first a-f tube heater. The condition would further be confirmed by the heaters of the other tubes glowing brighter than usual because of increased voltage across them.

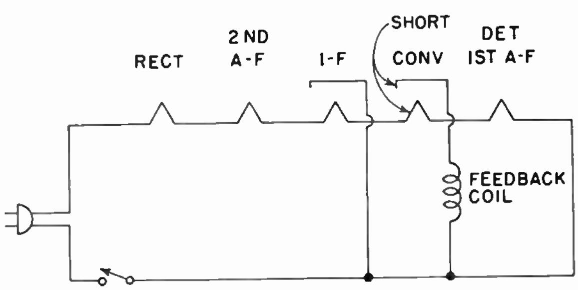


Fig. 2-4. How a cathode-heater short in the converter tube shorts out the first a-f detector tube heater

Example of Set That Hums. Understanding of circuits can be helpful in checking the source of hum. Since the prime function of the filter condensers in the power supply is to remove hum ripple, you check them first when hum is present, especially if the B voltage is low at the same time. If you suspect open condensers, shunt across them with good condensers of about the same capacitance and listen for hum elimination. If you suspect that the filter condensers are partially shorted, unsolder one lead of each condenser and substitute similar good ones. Again, listen for improvement.

If the rectifier-tube plates become red hot, and the power transformer, if present, becomes overly hot, you may suspect that the input filter condenser is partially shorted. This reasoning comes from an understanding that such a short would draw too much current through the rectifier tube and the power transformer. You would be even more certain if distortion were present at the same time, because a partially shorted input filter condenser would cause a low B voltage for the plate of all other tubes.

If hum appears only when a station is tuned in, begin your search in the r-f section of the receiver. If hum is present for only one station, you would suspect that it is a condition of the broadcasting station for which nothing can be done by the serviceman. The condition may be checked with another receiver tuned to the offending station. If the hum is heard all over the tuning dial, on and between stations, direct your attention to the a-f section of the receiver and to the power supply.

If the hum comes in only when a station is tuned in, you will also look for an open power line filter condenser.

Example of Oscillating Receiver. Now take the oscillating receiver. If the tuning of the receiver affects the pitch of the oscillation note slightly, the r-f section of the receiver is suspected. Often, bringing the hand near each r-f tube will cause an oscillating stage to change the pitch of the oscillation note and the defective stage is located. This check will not be used, of course, on the oscillator tube of a superheterodyne.

If the pitch of the squeal is not affected by tuning, pull out the last i-f tube. Now if the oscillation squeal does not cease, confine your attention from the second detector through the audio-frequency section. A high-pitched oscillation squeal directs attention to the plate bypass condensers of the output stage.

If the oscillating note is of a low-frequency motorboating type, look for an open output filter condenser in the power supply.

Example of Distortion. When distortion is the complaint, check the a-f section of the receiver, because distortion usually originates in that section. A rubbing voice coil will cut out the low-frequency notes and produce poor tone. Short-circuited or leaking coupling condensers are a fairly common cause of distortion. If the distortion is accompanied by hum or oscillation or weak signal, check the output filter condenser of the power supply.

Example of Weak Receiver. Knowing the function of a part in a receiver and the operation of the different circuits aids the serviceman in his search for defects, because he can analyze what happens when the parts or circuits are defective. Let us examine the analysis of the weak receiver. If the signal output is weak for both local and distant stations, the receiver sensitivity is probably good. If a tuning eye or tuning meter is present and is functioning normally, direct your attention to the a-f section of the receiver.

If distant stations are not received while local stations are received, the receiver sensitivity is probably poor. Inspect the r-f section of the receiver, especially if the tuning eye or tuning meter (if present) does not operate properly. If this same defect exists, but background hiss is present, the r-f section is probably good. You then suspect that there is little signal input. A likely culprit is an open primary in the antenna transformer.

Poor sensitivity could be caused by misaligned trimmer condensers. When poor sensitivity is present but the tuning dial tunes at the proper settings, the oscillator trimmers are probably all right. You then check the antenna trimmers and the i-f trimmers. If the tuning dial settings are off, complete realignment is called for. If the trimmer cannot be peaked, all their associated tuning circuits must be checked.

When hum or oscillation or distortion accompanies poor sensitivity, check the output filter condenser of the power supply.

Example of Interference. When the complaint is station interference, your thinking will be conditioned by the nature of the interference. Improper receiver alignment could cause broad tuning and lack of selectivity. You should try peaking the trimmers to improve reception. If squeal occurs only on one or two stations, you will readily suspect image-frequency interference. Try either changing the i-f trimmer frequency slightly or installing a wave trap. If code interference comes in all over the dial, you can assume a code station operating at the intermediate frequency of the receiver is the cause. An i-f wave trap then is installed.

Example of Intermittent Trouble. The intermittent condition is not an easy one with which to reason. The only guide is the condition that is intermittent. If hum is intermittent, then whatever causes the hum must be investigated from the point of view of not being a constant condition.

Very often, reasoning will disclose the defective condition immediately and make further isolation unnecessary. When a receiver is brought to the service bench, you have the culprit in home territory. Here, you know how much noise pickup you normally have. You know the interference conditions of the area. You know the normal strength of signals of most stations. The comparison of operation of the receiver on your bench and in the customer's home may point to a cause of poor operation.

The examples just given show how little additional knowledge is needed to locate defects by logical reasoning the professional way. The step-by-step procedures for doing this will be presented in the chapters on receiver defects.

When to Stop Guessing. How much time should you spend in trying to reason and check for a suspected defect? The answer is only so long as is necessary to check what you believe is the most likely cause. Otherwise, you will fritter away valuable time making guess after guess. It would be much wiser for you to embark on recognized isolation procedures at once after your first guess failed to find the defect.

Of course, reasoning does not cease because isolation procedures have begun. On the contrary, it accompanies and directs every step in such isolation procedure with the purpose of shortening the time necessary to find the receiver defect. Isolation procedures are merely reasoning by the serviceman, assisted by test instruments which he uses in controlled experiments to detect the clues.

Performing Directed Tests. At all times, you must try to narrow down the area of investigation within the receiver in the shortest possible time. If there are no external clues and reasoning fails to disclose the defect, start making tests. These tests are not aimless ones but are directed toward disclosing clues which are normally not evident.

Some of these tests require specialized professional servicing instruments. Others require simple checks or no instruments at all. In some cases, signal generators, vacuum-tube voltmeters, multimeters, or similar instruments are utilized. In other tests, the signal chain from the antenna to the loudspeaker is interrupted so as to make some stages of the receiver inoperative. This type of test then checks the operation of the remaining stages which have not been made inoperative.

In still other tests, circuits will be shocked into producing voltage surges which travel down the signal chain from the shocked circuit to the loudspeaker. If the shocking input points are carried from the loudspeaker back towards the antenna, a defective stage may be found when the voltage surge produced fails to reach the loudspeaker. You will receive detailed instructions for various test techniques in the later chapters of this book.

Choosing the Best Test. The choice of the type of test that you will perform depends on your available instruments, the nature of the defects, and your own personal preference. However, you must develop a sufficient flexibility in your technique to be able to call upon any one procedure which will be directed at locating the defect.

The circuit-shock procedure is effective for a dead receiver. It depends on the fact that any sudden change of plate current in a tube produces a voltage surge which is transferred through the signal chain to the loudspeaker, where it produces a click or growl. The procedure is to work back from the loudspeaker toward the antenna. When no response is heard, a defective stage is found.

Circuit shocks may be produced by removing grid caps, removing tubes, shorting a control grid momentarily to the tube cathode, touching the socket grid terminal, shorting the tube cathode momentarily to the chassis, and so forth. Any procedure that causes a sudden plate-current change will do the trick.

Making a stage inoperative is effective in locating hum, noise, or oscillation squeal. For a-c receivers, start at the input of the receiver and remove tube after tube as you move toward the loudspeaker. When the removal of one tube eliminates the defect, the defective stage is located.

In universal a-c/d-c receivers and battery receivers, this procedure for making a receiver inoperative cannot be used. Instead, a 0.5-mfd condenser is used to short out the control-grid input circuit of each tube and thereby to make the stage inoperative. As before, the test is made from the receiver input toward the loudspeaker until the defect disappears. If the input grid circuit of the output tube is shorted out and the defect still persists, the output stage and power supply are investigated. In this test, you must be on guard for hum, noise or oscillation that sneaks around the blocked stage through some common coupling.

Choosing the Best Measuring Technique. The signal generator is used in a signal-substitution technique for diagnosis of a dead receiver, or of a weak receiver. A signal similar to that existing at a particular stage when the receiver is normally tuned in is injected by the signal generator at that stage. The loudspeaker or an output meter is the output indicator.

Signal substitution begins at the loudspeaker and works back to the antenna. When no signal rides through to the output indicator, the defective stage is found. Since each successive stage from the antenna except a diode detector amplifies the signal, less and less signal-generator input is required. Therefore, when a lowered signal-generator input, as we move back, fails to give a loud response, a weak stage is found.

The signal generator is also used to check alignment. When a fixed signal input from the signal generator gives an output which may be increased by varying the trimmer condensers, realignment is indicated. Where the output indicator is a cathode-ray oscilloscope, stages producing distortion may be located by observing it.

The signal-tracing technique is similar to the signal-substitution method. A modulated r-f signal is introduced at the antenna by means of a signal generator. The character of the signal is inspected by means of some indicator like a vacuum-tube voltmeter or cathode-ray oscilloscope, stage by stage, from the antenna to the loudspeaker. At each stage, the indicator may show an inoperative stage, or one causing noise, hum, distortion, weak signals or intermittent operation.

For testing avc operation, a voltmeter of high sensitivity or a vacuum-tube voltmeter may be connected from the avc bus to the chassis. Proper avc voltage and avc voltage variation, as the receiver is tuned from station to station, may be observed.

Isolating the Defective Part. Once you have localized the defective stage, you are like the hunter who has cornered his quarry. The last measures necessary for the kill are taken. Test the tubes in that stage if you have not already done so. Then, you may measure voltages with a voltmeter to determine the defective part, or you may use your ohmmeter to determine open circuits or short circuits of components. The remaining technique of replacement or repair is more or less routine.

In the next few chapters of this book, the various isolation procedures for standard receiver defects will be given in more detail. After these procedures are fully learned, you can become quite efficient as you build up your store of experience.

Section Isolation. When getting started, you will probably begin your service procedure by checking each stage. But as your experience grows, you will find your speed increasing if you can localize the defect to a section of the receiver, thereby ruling out some stages for check.

Take, for example, an inoperative superheterodyne receiver. An audio-frequency signal is introduced at the ungrounded end of the volume control. This point is the input of the a-f section of the receiver. Normally, the note should be heard loudly and clearly in the speaker. If the audio note is not heard, the defect lies between this point and the loudspeaker.

Of course, this check presupposes that the power supply had been checked and found to be good. A simple voltage check at the output of the power supply would determine if all is well in the power supply.

Instead of the signal generator, you could have placed the tip of a plugged-in soldering iron or a wet finger on the ungrounded terminal of the volume control. If the a-f section of the receiver is in good shape, a very strong growl is heard in the loudspeaker.

When the power supply and a-f section of the receiver have been found to be good, you move back to the converter tube. The signal generator is made to feed a modulated signal at the intermediate frequency of the receiver to the mixer grid. If the modulation note is not heard in the loudspeaker, the trouble lies in the i-f amplifier or the detector stage. At this time, you may increase the output from the signal generator and may wobble the generator frequency control around the intermediate frequency to see if the i-f trimmers are misaligned.

If the modulation note is heard, the i-f amplifier and detector are presumed to be functioning. Without changing the signal-generator connections, shift the receiver tuning dial and the generator frequency control to 600 kc, the latter being audio-modulated. If the modulation note is not heard, the oscillator section is not functioning. If the modulated note is heard, stages before the converter may be assumed to be defective.

Other Shortcuts in Locating Trouble. Simple directed tests may be used for other defects. If the defect is hum or oscillation squeal, you can make the last i-f amplifier tube inoperative by pulling out the tube or by shorting out the control-grid input circuit of the tube. If the defect disappears, the defect is probably in the r-f section of the receiver, since that section has been cut off from the speaker. If it does not disappear you may reasonably suspect the a-f section or the power supply.

If rotating a volume control to its minimum volume setting reduces hum, noise, or squeals from the receiver, an r-f defect is indicated. Otherwise the defect lies in the a-f section or power supply. Do not fail to check the volume control itself for these defects.

If the receiver has a tuning indicator, like an electron-ray tuning indicator, and it works normally, the r-f section, detector, avc, and power supply are probably functioning properly. If a tuning indicator is not present, a voltmeter with high sensitivity may be connected from the avc bus to chassis to get the same effect.

Stage Isolation. When you have limited the defect of a receiver to a particular section, proceed to narrow the defect down to a particular stage.

Once again, the technique depends upon the complaint, the available test instruments, and your own preferences. If the defect can be localized to a section of the receiver, begin your stage-isolation procedure in that section. Otherwise, an over-all stage-by-stage testing technique must be followed in order to locate the defective one.

Component Isolation. Once the defective stage is found, you must narrow the defect down to the one or two defective components in that stage. In this step, the multimeter is the serviceman's constant companion. The voltmeter and ohmmeter share honors in locating short circuits, open circuits, resistances that have changed, or any other defective condition.

In using these instruments, you must remember that voltage measurements are made with the receiver energized. Ohmmeter measurements are made with the power off. Also, d-c voltmeter polarity must be watched, and proper ranges used for both instruments. The voltmeter sensitivity must be kept in mind when making voltage measurements in order to interpret the results properly.

In checking components, you will be helped considerably if you know how components can become defective and which are most likely to go bad. You should also look for conditions where one component goes bad and makes an adjacent component go bad. For example, a defective cathode resistor might ruin an accompanying bypass condenser.

Defective Components in Receivers. Components that become defective in a radio receiver, in their order of frequency of breakdown, are tubes, condensers, resistors, and coils. A more complete listing is given in Fig. 2-5.

Items Becoming Defective	*Frequency of Defect*
Tubes	60%
Filter condensers	10%
Bypass condensers	9%
Resistors	5%
Voice coils	4%
Bad connections	3%
Volume controls	3%
Output transformers	2%
Coils	1%
Bad contacts	1%
Power transformers	1%
Others	1%

Fig. 2-5. Table showing per cent of times various defects occur in radio sets

This list may serve as guide in checking for defective components in a particular stage.

It would also be helpful for you to have an understanding of how various components develop defects, and how they may be checked. The following lists give such a component analysis:

Tubes

Condition	*How Checked*
Low emission.	Tube checker.
Open heater.	Tube checker; ohmmeter.
Shorted electrodes.	Tube checker; ohmmeter.
Cathode-heater leakage.	Replace with new tube.
Gassy tube.	Replace with new tube or measure voltage across grid resistor.

Condensers (Electrolytic)

Condition	*How Checked*
Short.	Ohmmeter check.
Leakoge.	Ohmmeter check; try reversing leads and take larger of two readings. Substitution of good condenser.
Open.	Shunt with similar good one in receiver while in operation. Substitute good condenser.

Condensers (Paper and Mica)

Condition	*How Checked*
Short.	Ohmmeter check.
Open.	Shunt with similar good one in receiver while in operation.
Leakage.	Open one lead and check with ohmmeter.

Condensers (Tuning and Trimmer)

Condition	*How Checked*
Shorts.	Open connections to condensers and check with ohmmeter. Rotate dial while checking.
Leakoge due to dust.	Blow aut and observe operation.
Poor contacts.	Clean wiper contacts and observe operation on tuning condensers.

Resistors (Fixed)

Condition	*How Checked*
Changes in resistance.	Open one lead and check with ohmmeter.
Open.	Open one lead and check with ohmmeter.

Resistors (Variable)

Condition	*How Checked*
Uneven contact.	Move contact arm and observe noise or intermittent operation.
Open.	Check with ohmmeter.

Coils and Transformers (Air-core)

Condition	*How Checked*
Shorted turns.	Ohmmeter check; difficulty in aligning trimmers.
Open.	Ohmmeter check.
High resistance due to corrosion.	Ohmmeter check.
Lowered Q.	Broad trimmer adjustments.

Coils and Transformers (Iron-core)

Condition	*How Checked*
Shorts.	Ohmmeter check in some cases; overheating. Substitution of part.
Open.	Ohmmeter check.

Loudspeakers

Condition	*How Checked*
Open voice coil.	Disconnect one lead and check with ohmmeter.
Speaker-field defects.	(See iron-core coils). Test for magnetism with iron rod.
Off-center voice coil.	Push cone in and out and feel for rubbing.
Grounded speaker field.	Ohmmeter check between coil and frame.
Cone defects.	Visual inspection.
Defective spider.	Visual inspection.

Switches

Condition	*How Checked*
Open.	Ohmmeter check.
High-resistance contact.	Ohmmeter check.

Sockets

Condition	*How Checked*
Leakage.	Visual inspection.
Shorted prongs.	Ohmmeter check.
Open prong contact.	Visual inspection.

Connections

Condition	*How Checked*
Open.	Ohmmeter check; moving leads.
Shorts.	Ohmmeter check; moving leads.

The list just given will hasten the job of locating a specific defect. Once a defective component is found, a question presents itself to the serviceman. Should he repair the defect or should he replace it?

Correcting the Defect. When the defect is one where repair is simple and is not likely to cause a reoccurrence of the defect, then repair is indicated. Where repair is impossible or is unlikely to be permanent, replacement with new and similar parts should be made. Where replacement involves a fairly expensive part, call in the customer and explain why replacement is superior to repair.

In replacing resistors and condensers, exact replacements are usually not necessary, unless space requirements make it so. Condensers with higher voltage ratings and resistors with higher wattage ratings may normally be used. As for resistance and capacitance values, the replacement part may be as much as 20 per cent different from the original part. Of course, you will be playing safe with an exact replacement.

Air Check. After the receiver has been repaired, you must subject it to an air check. This check is merely that of operating the receiver for a fairly long period of time. It assures the serviceman that all the customer's complaints have been removed and that no new defects have resulted from the repair.

The set is turned on and the tuning dial is rotated to a non-station position. Listen for hum that is too loud, for noise, oscillation squeal, etc.

The volume control is rotated back and forth to see if noise results. The tone control, if present, is rotated while listening to a station to check for smooth operation.

The volume control is then set at moderate volume and the tuning dial is rotated from 550 kc to 1,600 kc. Check that all stations come in at the right position of the dial. Observe selectivity by noting the amount of dial space covered by each station. If a strong local station covers 30 kc of the dial, selectivity is poor.

Listen for tone quality by listening to speech and music. Each should be clear and crisp. More of the low tones should be heard from a larger receiver.

Check the receiver power-handling ability by turning the volume control on full. Distortion and rattling should not occur for a large speaker.

Finally, all switches are checked for proper operation and control. You may then feel certain that your customer will be satisfied.

The Service Charge. The last step is the determination of the service charge. It is advisable to compute this as soon after the air check as possible. At this time, you know specifically how much time was spent and what parts were replaced. A record of both items as well as a case history should be kept in your notebook. Where a customer balks at the price, an itemized listing is the soundest argument.

In the next few chapters of the book, specific and detailed techniques will be presented for the various receiver defects. The overview picture just given in this chapter will enable you to fit the following chapters into their proper setting and gain a greater ease and skill in servicing.

3

Dead Receivers

Receiver Is Dead. The customer will on occasion report that his receiver is dead. Such description merely means that the receiver is not giving the desired output, in fact is giving no output. The dead receiver is very much alive except for one or two components and will spring into full life when the few defective components are repaired or replaced.

Your job in the case of a dead receiver is that of localizing the defective component. It is one of the easiest problems encountered in radio-service work because there will be definite and complete breakdown of a component resulting in an inoperative stage.

Your only need is a definite and professional procedure for isolating the defect quickly. The essence of successful servicing is speed. Given the most meager training and experience, any mechanic can locate a defect—if time is unimportant. But that type of mechanic never runs a paying business or holds down a job.

Servicing Procedure. The servicing procedure for the dead receiver is started by listening to the customer's complaint and confirming the condition as a dead receiver. The next step consists of surface inspection of obvious defects. If a quick survey reveals a burned part or an unlit tube, you have a timesaving indication of the trouble. This inspection should not consume too much time, since it is an inefficient isolating technique at its best. With more and more experience, you will consume less and less time in this step.

Checking Input Power. If none of the tubes light, regardless of whether the receiver is of the a-c or a-c/d-c type, the power source and the input power circuit up to the rectifier should be checked. Is there voltage at the wall outlet? Does the line plug make good contact at the outlet? Does the line cord feel limp and soft at any point, indicating a break? Vulnerable points are those at the plug and those where the line cord enters the chassis. Is the line fuse, if present, burnt out? Does the on-off switch operate? Shorting across the switch will resolve this question.

Isolating the Defect. If no definite, obvious clues are found, you must proceed to apply service knowledge and directed isolation tests to locate the defective stage. These tests will vary somewhat with different types of receivers. For this reason, this chapter will be divided into separate divisions dealing with the a-c receiver, the universal a-c/d-c receiver, the three-way portable receiver, and the auto receiver. Many of the tests will be common to all and will be so described.

After the defective stage has been found, the procedure for isolating the defective components is the same, regardless of the type of receiver. Therefore, a description of such procedure for one type of receiver will be applicable for other types. And also, the final steps in repair procedure will be the same for all.

Typical A-C Receiver. The best way to examine the possible causes for a dead receiver is to have a standard receiver in mind. Then, any similar type of receiver can be handled with understanding, especially if its schematic diagram is available.

Figure 3-1 shows a typical a-c superheterodyne receiver. As we describe various procedures, it is advisable to keep referring back to this diagram. Be sure that you understand the reasons for each test. Be sure that you can interpret the results of the tests, so that you can understand the reason for the next isolation test. These will be explained as we go along.

Search for External Clues. First look at the tubes. If all the tubes fail to light, the investigation for external clues begins at the source of power. Insert a test lamp into the wall socket and determine if there is voltage. If there is no voltage, examine the house fuse to see that it is not blown. If there is voltage, wiggle the plug in the wall socket to see that it makes good contact. If the tubes still fail to light, examine the plug to make sure that the wires are firmly connected under the two screws. Then feel for obvious breaks in the line cord. This is done by feeling the line for unusually soft spots.

Next, inspect the line fuse *F*-1, if one is present, to determine if it is blown. The on-off switch SW-1 is then checked to see if it is operating properly. Simply shorting across the switch will disclose if it is the cause for nonoperation. If transformer *T*-7, in addition, smells burnt, determine

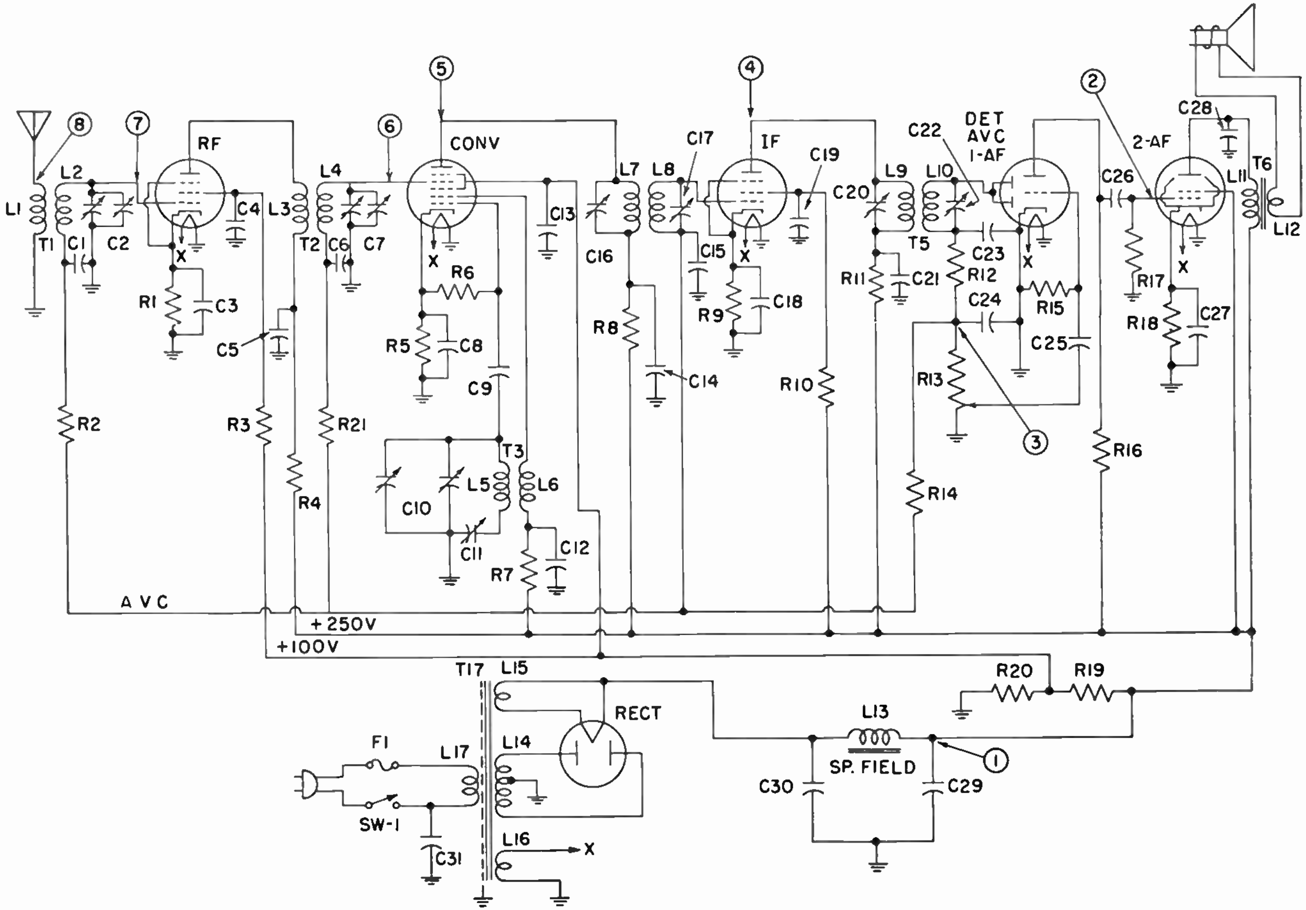


Fig. 3-1. A typical a-c superheterodyne receiver

with a neon lamp whether the power line is direct current, which cannot be used.

Tube Clues. If the tubes do light, examine the tubes carefully to see if any of them are not lit. In the case of metal tubes where a visual check is not possible, you can feel the shell for warmth. Any tube that does not light is then tested in a tube checker to make sure that the heater is not burned out. If the tubes that do not light are found to be good, inspect the socket and heater leads to the socket for any defects.

If all the tubes light and are good, examine the receiver tubes to see if any grid caps have been disconnected, or if any grid-cap leads are shorted, thereby grounding out the signal. Determine whether tubes have been shifted and placed back in wrong sockets.

Other External Clues. Examine all special switches, like phono and band switches, to see if they are in their proper positions. When a speaker plug is present, make sure that it is fully inserted in its receptacle. A final inspection should then be made to see if the antenna is connected to its proper antenna post, and the ground lead to the ground post.

The inspection for external clues is the least efficient part of the procedure for locating defects. It should therefore be reduced to a very short time. Confine your efforts to localizing tests. During this latter procedure, your service know-how must be directing the tests and interpreting their results. The greater the application of the service theory, the shorter the time required for the directed tests.

Isolating the Defective Section. It is often wisest to perform directed tests on the receiver at once to isolate the defective stage. However, so long as it is not too time-consuming, you should first try to find the defective section, so that stage isolation will be confined to a smaller portion of the receiver.

Quick Phono Test. If the receiver also has a phono player, you may turn to the PHONO position and play a record. Since the pickup of the phonograph is connected to the input of the a-f section of the receiver, failure to hear the record indicates a defect in the a-f section or the power supply. Otherwise, the r-f section is defective.

Quick Tuning-indicator Test. If the receiver has an electron-ray tuning indicator (tuning eye), you have another means of localizing the defective section. Figure 3-2A shows how a tuning-eye tube is connected in a circuit.

Resistor *R* is usually located inside the tube base. The tuning eye tube is virtually a vacuum-tube voltmeter connected to the output of the r-f section of the receiver. In this position, it may give valuable clues as to the operation of the r-f section. When a low negative voltage is applied to the grid of the tuning-eye tube, the eye is opened wide. As the applied voltage increases the eye narrows down.

You first tune the receiver for a station, which is not heard because the receiver is dead. If the eye closes as in Fig. 3-2*B*, the r-f section and power supply are all right, and the defect is in the a-f section. If the eye does not close, as in Fig. 3-2C, the r-f section of the receiver is defective. If the eye shows none of the characteristic green fluorescence, as in Fig. 3-2*D*, it probably has no plate voltage, and a power-supply defect is indicated. Of course, you must be sure that resistor *R* in Fig. 3-2*A* is not open.

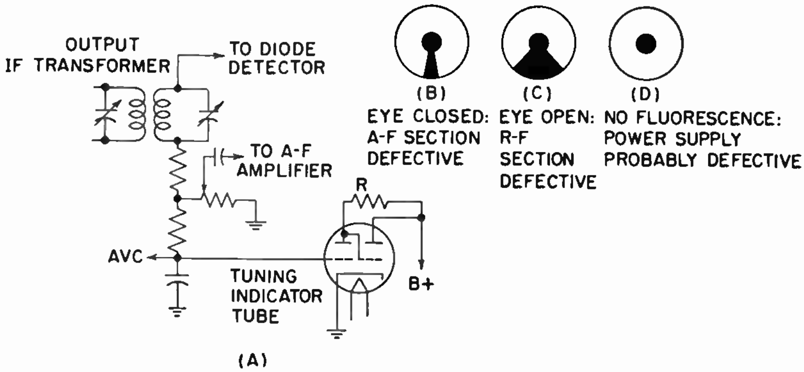


Fig. 3-2. A cathode-ray tuning indicator in a circuit, and meanings of indications when the set is tuned to a strong local station

Quick Volume-control test. Other quick tests may be performed to isolate the defective section. For example, the tip of a plugged-in soldering iron is touched to point 3 shown in Fig. 3-1. Normally a strong growl should be heard from the loudspeaker if the volume control is turned up full. If it is not heard, the defect lies in the power supply or the audio section (every stage from the point of test through the loudspeaker). If it is heard, the defect lies before the test point, in the r-f section.

Isolating the Defective Stage. The localization of the defective section would immediately confine your efforts to only a few of the stages. However, to give the over-all picture, it is best that the check of all stages be given.

The simplest localization procedure is circuit-shock procedure with the receiver turned on. Here a stage is disturbed so that there is a plate-voltage change. This voltage change produces a signal pulse which travels towards the loudspeaker, producing a click or buzz. In the a-c type receiver, the simplest disturbance methods are removing and replacing the grid clip, or removing a tube from its socket and replacing it.

Shocking the Second A-F Stage. When the second a-f tube is removed, a click should be heard. If it is not, place a d-c voltmeter across the power supply output, from point 1 of Fig. 3-1 to ground. A reading of 200 to 300 volts clears the power supply of blame. Otherwise, the receiver is turned off, and an ohmmeter check of the components in the power supply is made. No B-plus voltage, coupled with red-hot plates in the rectifier, indicates a shorted input filter condenser C-30. No B-plus voltage, together with an overheated rectifier tube, even though the plates are not red, indicates a shorted output filter condenser C-29.

If low B-plus voltage is found and the power supply components are good, plate and screen voltages of all the tubes should be checked at once for possible shorts. If the power supply is good, further ohmmeter checks must be made of the loudspeaker, output transformer, and all components of the second a-f stage, including the tube. Remember that circuit-shock tests are made with the receiver turned on, while ohmmeter checks are made with the set turned off.

Shocking First A-F Stage. Remove the first a-f tube. A click indicates it is operating. If no click is heard, the tube and all its components are tested with an ohmmeter. These include all components up to the signal grid of the second a-f tube.

Shocking I-F Stage. If all is well thus far, remove the i-f tube. A click indicates that everything is normal in the i-f and detector stage. If the click is not heard, check the i-f tube and its components, the detector components, the volume control, and all components up to the first a-f tube signal grid.

Shocking the Converter Stage. If no defect is indicated, remove the converter tube. Here, the shock test is not so valid, because the click produced will not indicate if the oscillator portion is working. You might try removing the r-f tube. If this produces a click, the defect is probably in the input circuit to the r-f tube or in the oscillator. These components may then be checked with an ohmmeter.

If the click is not heard when the converter tube is removed, the tube and its components should be checked with an ohmmeter. If the click is not heard when the r-f tube is removed but is heard when the converter tube is removed, then a defect in the r-f tube or its components is indicated.

Many servicemen isolate defective sections of a stage by measuring voltages at various points and then checking these sections with an ohmmeter. Voltage checks are made with the receiver turned on. Other servicemen use the ohmmeter directly, since it will be used eventually.

Stage Isolation with a Signal Generator. A more professional isolation procedure is that in which the signal generator is used. A signal, similar to that present at each stage when a station is normally tuned in, is injected into each stage to produce an audible tone from the loudspeaker. Start from the second a-f stage and work back to the antenna. The first stage that fails to link up with the signal chain and produce the note is the defective one.

Signal Feed to Second A-F Stage. Many signal generators provide a 400-cycle audio-frequency signal which may be injected into the signal grid of the second a-f tube, as shown in Fig. 3-3 (to test point 2 of Fig. 3-1). The audio note should be heard loud and clear. If it is not, the power supply, loud speaker, or any component from the test point to the loudspeaker is defective.

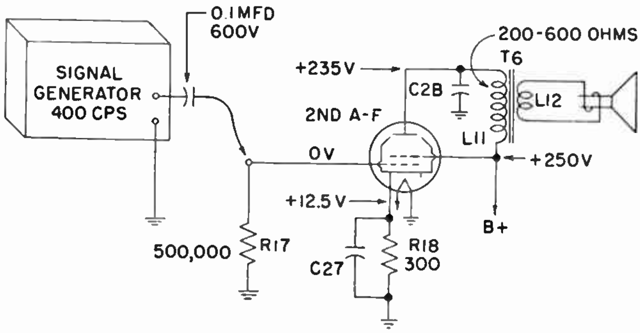


Fig. 3-3. Injecting an a-f signal into the second a-f amplifier tube. Voltages shown are measured with d-c voltmeter from test point to chassis

The power supply is checked at once for voltage at its output. For an a-c set its d-c voltage should be 200 to 300 volts. If it is not, possible defects are a defective transformer or rectifier tube, a shorted filter condenser, or an open filter choke.

The loudspeaker is then up for check. A normal low-level hum should be heard from it. If it is not, the voice coil or its connections may be open, thereby receiving no signal. To check this, feed 3 volts from a battery across the voice coil with the receiver turned on. Failure to hear a click indicates a voice-coil defect.

When checking the voice coil with an ohmmeter, remember to disconnect one end from the output transformer. Many servicemen give the loudspeaker an over-all check by disconnecting the loudspeaker and connecting in one from their test bench for comparison.

Likely Second A-F Troubles. If all thus far is well, the second a-f stage and its components are up for check. Likely troubles are an open primary of the output transformer, open wiring between the power supply and the tube, a defective tube, a shorted plate bypass condenser, or an open cathode bias resistor. Figure 3-3 also shows typical voltage and resistance measurements for a second a-f stage. Voltage is given between points indicated and the chassis.

Signal Feed to First A-F Stage. If all the checks thus far show that the power supply, the loudspeaker, and second a-f stage are operating properly, move back to check the first a-f stage. A 400-cycle audio signal from the signal generators is fed to the ungrounded end of the volume control with the control turned on full, as shown in Fig. 3-4. This point, shown as point

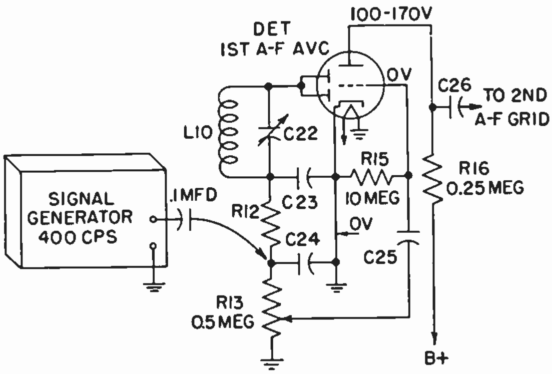


Fig. 3-4. Checking the first a-f amplifier stage. Typical voltage and resistance values are given

3 in Fig. 3-1, is the input of the audio-frequency section of the receiver. If every component from this test point to the loudspeaker is in good shape and operative, the audio note is heard loud and clear. If the note is not heard the defect is in the volume control, the first a-f tube, or any component up to the signal grid of the second a-f tube.

Likely First A-F Troubles. The first and easiest check is that of the tube, made in a tube checker or made with a substitute tube known to be good. Sometimes the volume control opens or shorts. This condition would be indicated if no audio note is heard from the ungrounded end of the volume control but is heard when the hot lead of the signal generator is applied to the grid of the first a-f tube. Condenser C-25 rarely gives trouble; sometimes, however, it may open and should be checked by bridging with another good condenser. A defective volume control is best replaced rather than repaired.

The plate resistor R-16 may open. This condition would be indicated when the audio signal from the generator applied to the first a-f tube plate produces the audio note, but fails to do so when injected into the first a-f tube grid.

Coupling condenser C-16 may open. This would be indicated when the a-f signal from the generator produces the note from the second a-f tube signal grid but fails to do so when injected into the first a-f plate. Bridging the condenser with a good one would clear the defect.

The last check is for open leads to the power supply. This check is made with the voltmeter and ohmmeter when defective components are sought. Figure 3-4 also shows typical voltage and resistance measurements for a first a-f stage.

Checking A-F Section with Modulated I-F Signal. If the signal generator makes no provision for an audio-frequency signal, a variation in the checks must be made. The hot lead of the signal generator is connected to the plate of the last i-f tube, and the generator is set for a modulated signal at the intermediate frequency of the receiver, as shown in Fig. 3-5. If the tone

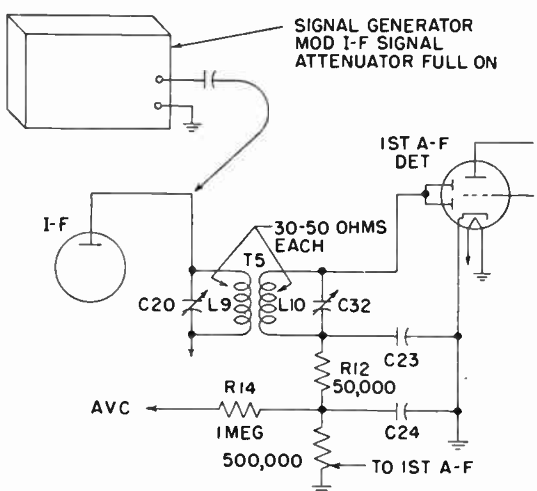


Fig. 3-5. Injecting an a-f signal into the audio section when no pure a-f output is available from the signal generator. Typical voltage and resistance values are also given. For iron-core i-f transformers, primary and secondary resistances are 5 to 15 ohms

is heard from the loudspeaker, the second detector and audio section are good. If no tone is heard, the bad stage is isolated with a set of earphones whose leads are connected in series with 0.05-mfd condensers, shown in Fig. 3-6A.

One phone lead is connected to the chassis and the other to the first a-f plate, as shown in Fig. 3-6*B*. If the modulation note is heard in the phones, the first a-f stage is good; otherwise it may be defective, depending on the condition of the output i-f transformer, the detector, and the volume control, which may be checked immediately.

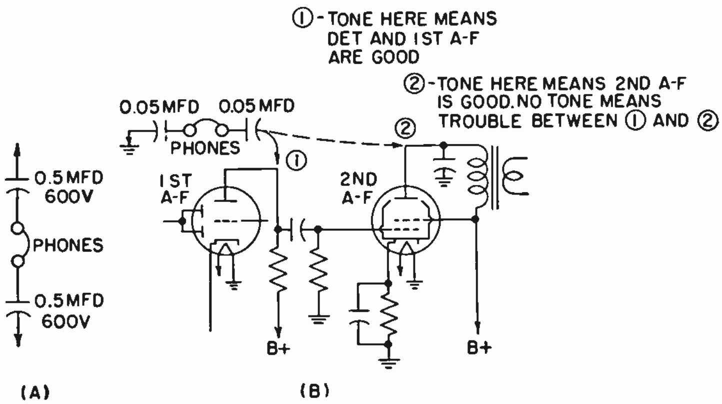


Fig. 3-6. Checking the audio amplifier stages of a receiver

If the first a-f stage is good, the phone-check lead is shifted to the second a-f tube plate. The modulation note heard in the phones once again indicates that the stage is in good shape. No tone at the second a-f tube plate indicates trouble between the first a-f tube plate and the second a-f tube plate.

This check made with the phones has tested the detector and audio section. However, it takes longer and is therefore used only when no audio test signal is available.

Signal Feed to Second Detector. If using the audio test signal, you would have only checked the audio section up to now. The second detector stage must therefore be checked separately. This is done by injecting a modulated signal at the intermediate frequency of the receiver into the plate of the i-f tube at test point 4 (the last i-f stage if there are more than one), as shown in Fig. 3-5. If the modulation note is heard from the speaker, the detector is functioning. If no note is heard, the i-f output transformer, the avc circuit, or the detector tube and its components may be defective. The signal generator must be turned on full, since it takes a large r-f signal to drive the detector stage.

In the i-f transformer, the windings *L*-9 and *L*-10 may open or short, or the trimmers C-20 and C-22 may short. These conditions may be checked with an ohmmeter. The detector tube may be defective. The serviceman should not assume that the tube is good because the first a-f section checked good. Rarely does the i-f filter, consisting of resistor *R*-12 and condensers C-23 and C-24, cause trouble. Sometimes avc resistor *R*-14 opens. This opens the grid returns of the controlled tubes and may cause hum in addition to causing an inoperative receiver.

Figure 3-5 also shows the typical resistance values associated with the detector stage. Since the diode plates have no d-c voltage, voltage values are omitted.

Signal Feed to I-F Stage. If all is well thus far, the i-f stage is up for check. A modulated signal at the intermediate frequency of the receiver is injected into the plate of the converter tube, test point 5. If there are two i-f stages, this test is first made from the plate of the first i-f tube.

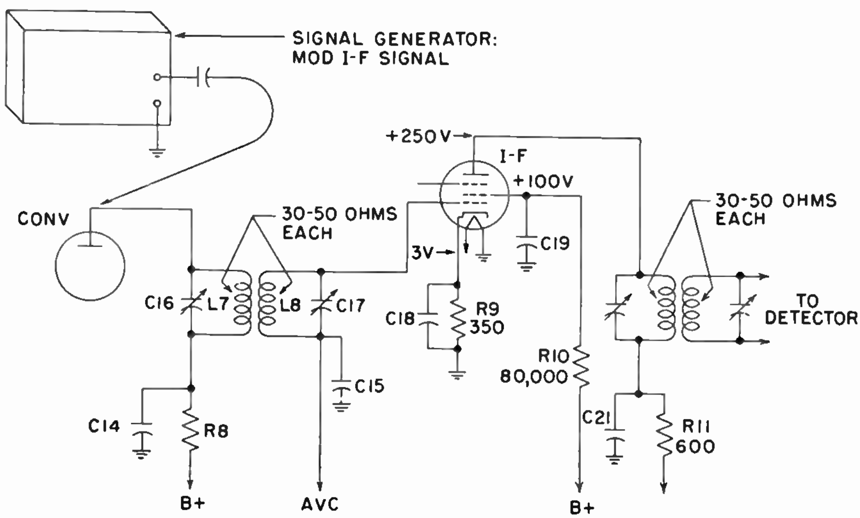


Fig. 3-7. Checking the i-f stage. For iron-core i-f transformers, primary and secondary resistances are 5 to 15 ohms

Figure 3-7 shows the setup. The oscillator is made inoperative by shorting across the oscillator section of the gang tuning condenser. If in doubt, short both sections. If the modulation note is heard in the loudspeaker, the i-f stage is working. If it is not heard, the input i-f transformer T-4, the i-f tube, the i-f components, or the decoupling filter may be defective.

If it has not already been done, the first check is that of the tube. The tube is checked in a tube tester, or replaced with one known to be good.

Typical I-F Defects. The most usual defect of the i-f transformer is an open winding. An ohmmeter check would soon disclose this fact. Sometimes the primary of the input i-f transformer shorts to ground in the shield can. This would be indicated when no voltage is found on the converter plate. Or the secondary may be shorted to the can. An ohmmeter check from the secondary to the chassis would indicate this defect. The i-f trimmers may short. The ohmmeter is used to check this.

Sometimes self-bias resistor *R*-9 opens, thereby opening the plate circuit. An ohmmeter check would disclose this fact. Or a voltage check from the i-f tube cathode to ground would show an abnormally high voltage.

A shorted screen bypass condenser C-19 could also cause a dead receiver. It would be indicated when no screen voltage is found. An ohmmeter check would confirm the condition. Before replacing it, the serviceman should check the screen voltage dropping resistor *R*-10 for damage due to the condenser defect. Resistor *R*-10 itself may open and cause a dead receiver. An ohmmeter check would determine this condition.

Decoupling filter condenser C-21 may short. This condition would be indicated when no B+ voltage is found on the i-f tube plate and when decoupling filter resistor *R*-11 overheats. An ohmmeter check from i-f tube plate to chassis would indicate the defect by showing very low resistance. When replacing condenser C-21 because it is shorted, resistor *R*-11 must also be replaced.

Fig. 3-7 shows the typical resistance and voltage values of an i-f amplifier stage. Voltages are measured from test points to chassis.

Signal Feed to Converter. The converter is the next area for investigation. The converter really combines two distinct stages, the oscillator stage and mixer stage. Each stage must be checked separately. First tackle the mixer. The test point for this check is the signal grid of the converter tube, point 6 in Fig. 3-1. This point may be most readily accessible at the stator terminal of the mixer section of the gang tuning condenser. The signal generator then injects a modulated signal at the intermediate frequency into the test point. The modulation note should then be heard from the loudspeaker. If it is not heard, the defect may be in the mixer portion of the converter tube, or the mixer components. The setup for this signal check is shown in Fig. 3-8.

The converter tube is most easily checked either in a tube checker or by substituting a tube known to be in good condition. The mixer components to be checked are the input transformer *T*-2, its tuning condenser *C*-7, screen bypass condenser *C*-13, plate bypass condenser *C*-14, and cathode resistor *R*-5. A fault in plate bypass condenser *C*-14 would have been found when checking the i-f stage from point 5 in Fig. 3-1. The defect in input transformer *T*-2 and its tuning condenser *C*-7 would be a short to chassis. This may be checked with an ohmmeter. Trouble in the screen or cathode circuits would be revealed by voltage analysis.

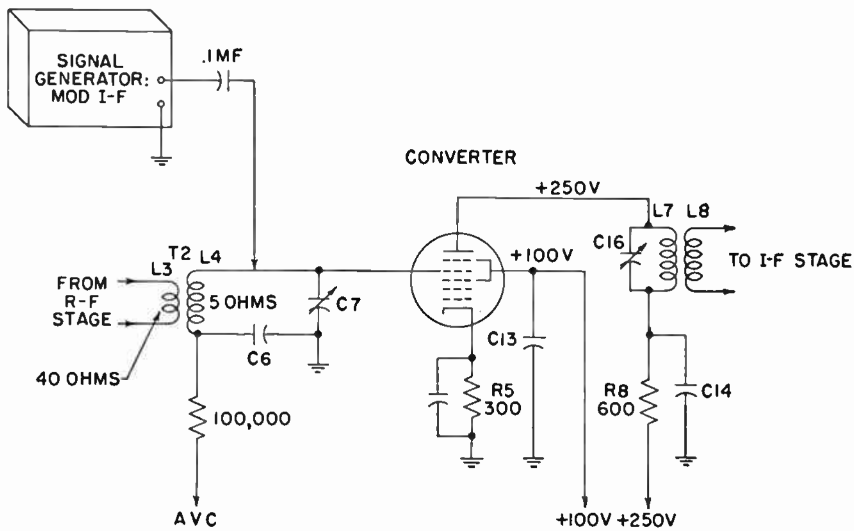


Fig. 3-8. Signal check for the mixer section of the converter

Figure 3-8 also shows the typical resistance and voltage values of the mixer section of the converter. Voltages are measured from test points to chassis.

Oscillator Test. The next check is that of the oscillator portion of the converter. Here, also, the test point is the signal or mixer grid of the converter, test point 6 in Fig. 3-1. The short previously placed across the oscillator section of the tuning condenser is removed. The receiver tuning dial is set to some low frequency position, like 600 kc. The signal generator then is used to inject a modulated 600-kc signal into the mixer grid. Failure to hear the modulation note from the loudspeaker, with the volume control fully advanced, indicates a defect in the oscillator. The setup for oscillator check is shown in Fig. 3-9.

Oscillator Troubles. Possible oscillator defects are a defective converter tube or a defective component in the oscillator stage. The first and simplest check is that of the converter tube. It is wisest for the serviceman to try one or more substitute tubes, rather than to test the tube in a tube checker. On several occasions, a converter tube checks good in a tube checker but fails to oscillate in the receiver. For that reason a substitute tube is a more reliable check.

Occasionally oscillator coils will open. This condition can be checked with an ohmmeter. If the feedback oscillator coil *L*-6 opens, a further indication would be no voltage at the oscillator anode. An exact replacement of the oscillator coil is important.

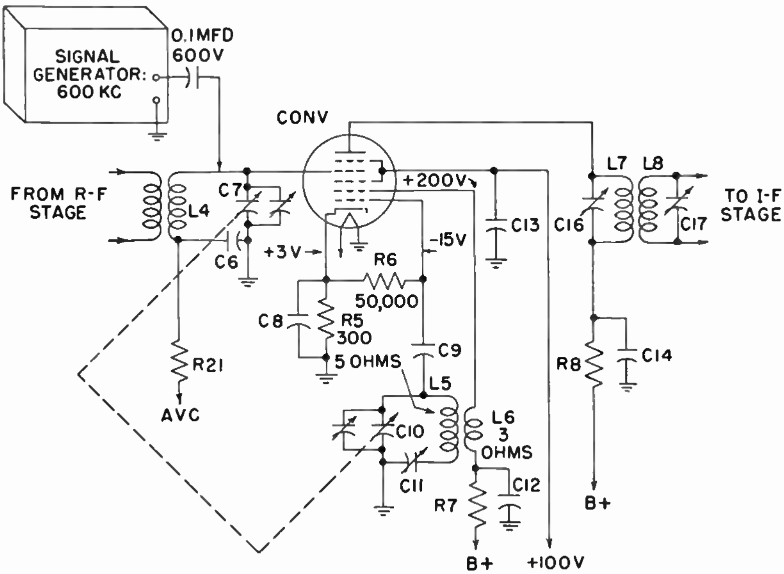


Fig. 3-9. Checking the oscillator section of the converter. Receiver tuning dial is set at 600 kc

Sometimes the oscillator tuning condenser shorts. This condition may be checked by disconnecting the lead to the stator plate and by placing an ohmmeter across the stator and rotor terminals. The short may be due to conductive dirt, a bent plate, or loosened plates, and must be repaired accordingly. An open oscillator anode dropping resistor *R*-7 or short in its associated bypass condenser C-12 would cause the oscillator stage to be inoperative. They are readily checked with an ohmmeter. Self-bias resistor *R*-5 may open. This condition would be indicated by an abnormally high voltage from cathode to chassis, and would be confirmed with an ohmmeter. Oscillator grid resistor *R*-6 may open. Again, the ohmmeter would disclose this fact.

Figure 3-9 shows the typical resistance and voltage values for the oscillator section of the converter. Voltages are measured from test points to chassis.

Signal Feed to R-F Stage. The last stage up for check is the r-f stage. The test point is the r-f grid, shown as point 7 in Fig. 3-1. The receiver tuning dial is set at a quiet point around 1,500 kc. A modulated signal at about 1,500 kc is injected from the signal generator into the test point. Normally, the modulation note will be heard from the loudspeaker. The setup for this check is shown in Fig. 3-10. Since the previous check was made from the control grid of the converter tube, failure to hear the modulation note indicates a defect in a component from the r-f control grid to the mixer grid.

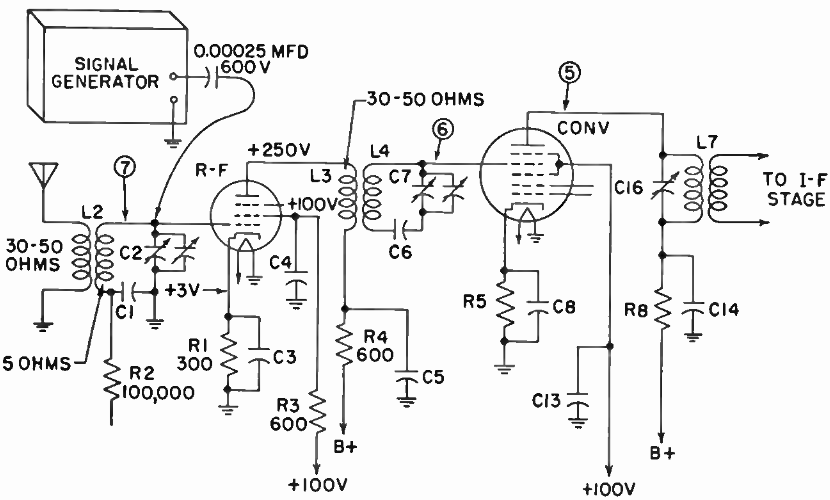


Fig. 3-10. Signal check for the r-f stage. Receiver tuning dial is set at 1,500 kc

R-F Troubles. Possible defects in the r-f stage are a defective antenna transformer, a defective r-f tube, or defective r-f stage components. The r-f tube is most easily checked in a tube checker. Other possible defects in this stage may be checked with the ohmmeter or voltmeter.

Either winding of the antenna transformer may open. This condition is most readily found with an ohmmeter. The antenna tuning condenser, in common with other tuning condensers, may short for one reason or another. An ohmmeter check from rotors to stators would indicate the short; the repair job would depend on the cause of the short.

Self-bias resistor *R-1* might open. The condition would be found with an ohmmeter. An abnormally high voltage from cathode to ground would be an indication of the same condition. Screen bypass condenser *C*-4 might short. A voltmeter check would show no screen voltage, and an ohmmeter check would confirm the condition. If such a short exists, screen decoupling resistor *R*-3 must be checked for damage. Resistor *R*-3 might open, removing screen voltage. An ohmmeter would confirm the condition. Plate decoupling bypass condenser *C*-5 might short. Again, no voltage on the plate would indicate the condition; and an ohmmeter check would confirm it. If the condenser is shorted, decoupling resistor *R*-4 must be investigated for damage. Resistor *R*-4 might open, removing plate voltage. Again an ohmmeter check would confirm the condition. And finally the primary of the r-f interstage transformer might open. There would be no plate voltage on the r-f tube; an ohmmeter would indicate the condition.

Figure 3-10 shows the typical resistance and voltage values of the r-f stage. Voltages are measured from test points to chassis.

Antenna-circuit Troubles. A receiver which operates from the r-f grid, test point 7, and does not operate from the antenna, point 8 in Fig. 3-1, must have the defect located in the antenna coil *T*-1, the only component between these two test points. The coil or leads will be open or shorted. An ohmmeter checks the condition.

The signal generator is a potent service weapon. Although the description of its use may have seemed lengthy, the actual procedure is quick, since you move rapidly from test point to test point.

Using the Signal Generator on Other Circuits. The various circuit designs that one encounters in practice are subjected to analysis in a similar manner. For example, some superheterodyne receivers employ separate oscillator tubes. This practice is found in some old receivers, and is very common in the high-frequency circuits of short-wave sets, f-m sets, and TV receivers. The isolation technique for finding a faulty stage will be the same as the one just given, where one single converter tube combines both the mixer and oscillator functions. Voltage and resistance checks must be adapted to the separate tube setup.

In most very early receivers, the second detectors are screen-grid tubes rather than diode detectors. For those early receivers, the detector is checked by injecting a modulated signal at the intermediate frequency into the last i-f amplifier stage. The modulation note should then be heard from the loudspeaker if the detector is operating.

In a multiband receiver, servicing procedures are the same as for any other receiver up to the r-f portion. Each band is then checked separately. The additional factor for possible defects is the range switch.

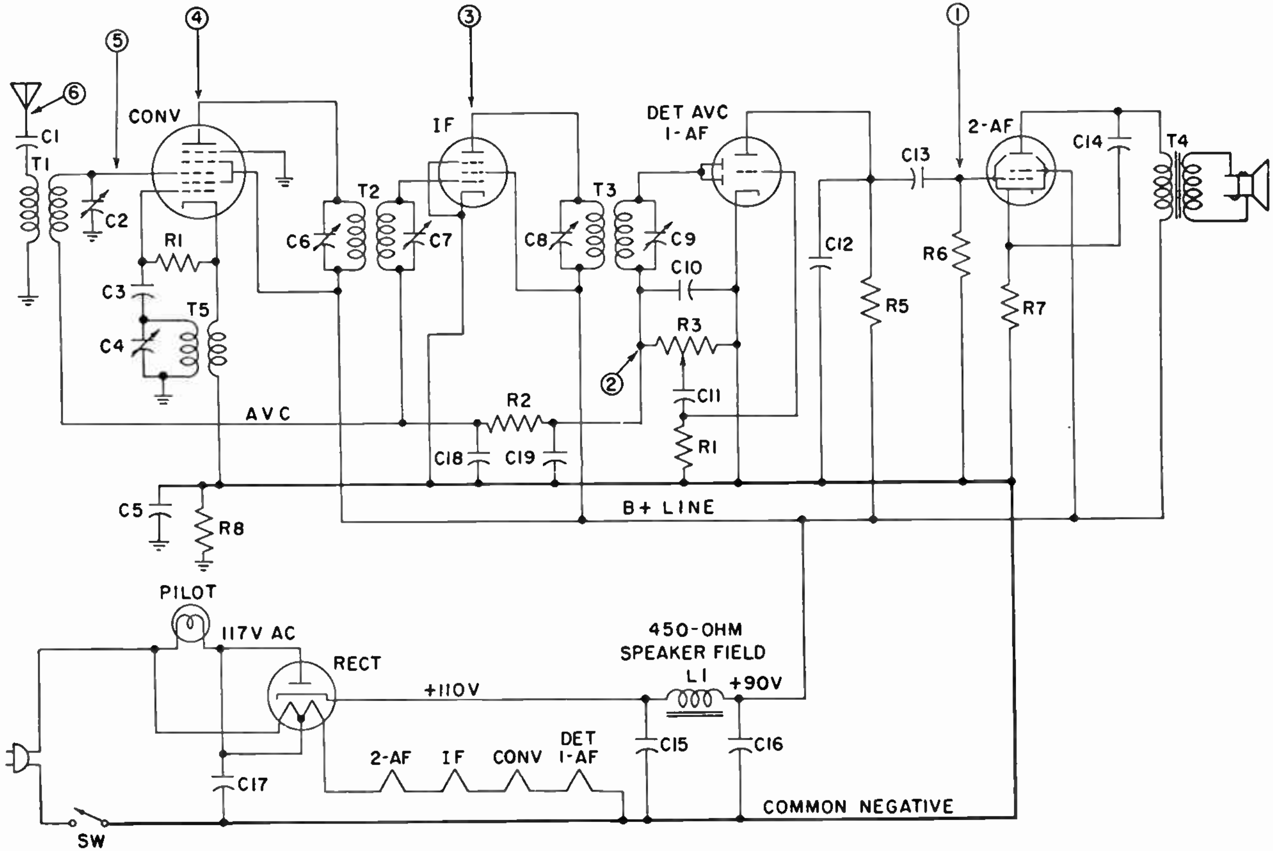


Fig. 3-11. A typical a-c/d-c receiver. Voltages are measured between points shown and common negative (at switch). With switch closed, resistance measured between prongs of plug will be 200 to 400 ohms if all tube heaters are good

In somewhat later receivers, some tubes have top grids. Signal check would be the same as for later receivers. However, an additional cause for no operation is a grounded grid lead due to wearing away of the insulation of the lead.

Typical A-C/D-C Receiver. Once again, the best way to check a dead a-c/d-c receiver is to keep a typical receiver of that type in mind. Figure 3-11 is the schematic diagram of such a typical receiver.

The signal circuits of the a-c/d-c receiver are practically the same as for the a-c receiver. As a result, the signal check is practically the same as previously described. Most of the differences in the causes for a dead receiver are those arising out of different power supplies.

Search for External Clues. When the serviceman is given a dead a-c/d-c receiver, his first look is at the tubes. If he finds that none of the tubes are lit, he suspects that one of the heaters is open. All the tubes go out because the heaters are connected in series. If a tube checker is available, all tubes are immediately checked. If one is not available, a simple procedure is that of measuring across the heaters with the 150-v range of an a-c voltmeter while the receiver is turned on. On this range, essentially zero reading will be obtained for good tubes. For the tube with the open heater, full line voltage of about 117 volts will be obtained.

The pilot lamp is an important element in the a-c/d-c receiver. It is usually across part of the rectifier heater. If the lamp opens, the rectifier heater may draw too much current and open also. When the pilot lamp is open, it should be replaced at once with a good lamp.

If all tube heaters are in good shape and the tubes do not light, examine all components from the wall outlet to the heaters, as was done for an a-c receiver. There is one additional factor. Before 1939, many a-c/d-c receivers utilized a line-cord resistor, a ballast tube, or a line-voltage dropping resistor in series with the heaters to furnish the proper voltage to the tube heaters. They, too, may open and must be replaced. An ohmmeter check would readily disclose this fact. The only check that might be confusing is the line-cord resistor. Here the resistor wire is connected from one terminal of the plug to the rectifier heater. Use the ohmmeter to measure between the receiver end of this resistor and each line-cord plug prong. If the resistor is good, one of the prongs should give a reading of around 100 ohms; if bad, the reading will be infinity for both prongs.

Inspection may show that some tubes are overly bright while one or two others do not light. This would indicate a cathode-heater short in one of the tubes. The defective tube would be found with a tube checker.

If the tubes light and are in good shape, proceed with an isolation procedure.

Isolating the Defective Section. The section isolation test for the a-c/d-c receiver is similar to that performed for the a-c receiver. The main check is that of placing the tip of a plugged-in soldering iron on the center terminal of the volume control, which is R-3 in Fig. 3-11. If a strong growl is heard from the loudspeaker, the defect lies somewhere between this test point and the antenna. If the growl is not heard, the defect lies somewhere between this point and the loudspeaker or in the power supply.

Isolating the Defective Stage. The various stages of the a-c/d-c receiver may be tested in the same manner and with the same reasoning. However, where the circuit-shock procedure is employed, tubes may not be removed, since the heaters are in series. The removal of one tube would make all the others go out.

The signal stages of the a-c/d-c receiver may be shocked into producing a signal by momentarily shorting the signal or control grid to the cathode, or by shorting the tube cathodes to the chassis, or by connecting a 0.1-mfd/600-volt condenser from the tube plate to the chassis. When a stage is reached, as you move back from the output stage, where the click is not heard, this shocked stage is defective. The hunt then continues for the defective component.

As with the a-c receiver, the stage-shock technique is not foolproof. A more professional procedure will employ a signal generator for isolating a defective stage. In this latter procedure, the same technique is used as was employed with the a-c receiver. The ballooned numbers in Fig. 3-11 indicate the stage test points and the order of test. The complete check of stages is summarized in Fig. 3-12.

Test Signal	*Test Point Indicated in Fig. 3-11*	*Stages Checked*
400-cycle	1	Second a-f, loudspeaker, power supply.
400-cycle	2	First a-f (including volume control).
Modulated i-f	3	Detector (including output i-f transformer).
Modulated i-f	4	i-f (including input i-f transformer).
Mod. 600 kc (receiver tuned to 600 kc)	5	Converter oscillator section.
Mod. 1,500 kc (receiver tuned to 1,500 kc)	6	Converter mixer section (including antenna and antenna input circuit).

Fig. 3-12. Summary of the signal-check procedure for a receiver

Isolating the Defective Component. The procedure for locating defective components within a defective stage of an a-c/d-c set is similar to that for the a-c receiver. The voltmeter and ohmmeter are used to determine the specific defect.

With minor differences, the signal circuits of the two types of receivers are the same. The main difference lies in the power supply. Figure 3-11 gives typical voltage and resistance data. With the exception of voltage reading, a-c/d-c receivers are checked just as a-c receivers. Plate voltages will be around 100 volts. Screen voltages will be about the same value or slightly lower.

Circuit Variations in the A-C/D-C Receiver. Several interesting variations are found in the power supply of universal a-c/d-c receivers. Where a p-m dynamic loudspeaker is used, there is no speaker field for filtering. A filter choke may be used in its place. The resistance of the latter is about 250 to 600 ohms.

More commonly now the speaker field is replaced by a resistor whose resistance is between 500 and 2,000 ohms. The filter condensers used with such a resistor have a capacity of at least 40 mfd. Because of the voltage-dropping effect of the resistor, the B-plus voltage will be about 70 to 80 volts. A power supply of this type is shown in Fig. 3-13.

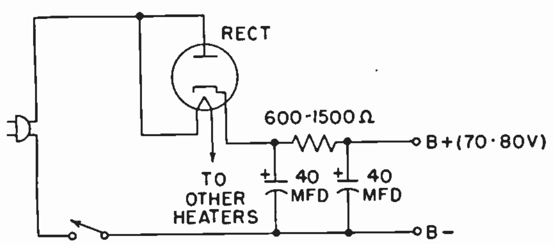


Fig. 3-13. A typical a-c/d-c power supply with a filter resistor

Since the resistor in the power supply is subject to considerable heating because of the large currents through it, it may change in value or open. When open, there will be no B-plus voltage.

Some receivers use a two-section filter, as shown in Fig. 3-14. The second a-f amplifier tube, which does not require as much filtering as the other tubes, receives a higher plate voltage. Typical values are shown.

Another interesting variation is the replacement of the rectifier tube by a selenium rectifier. Figure 3-15 shows a typical power supply of this type, where the selenium rectifier replaces a type 35Z5 tube rectifier. In such a circuit, the resistor in series with the heater string dissipates considerable heat and may open. If it does so, none of the tubes light. In replacing a selenium rectifier, attention must be paid to proper polarity.

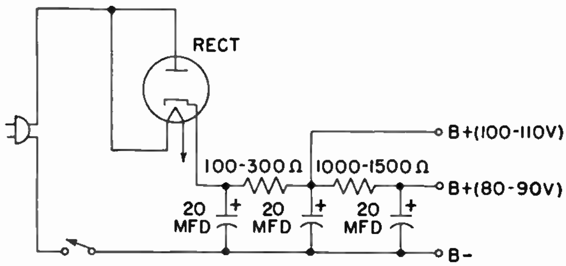


Fig. 3-14. An a-c/d-c power supply with a two-section filter

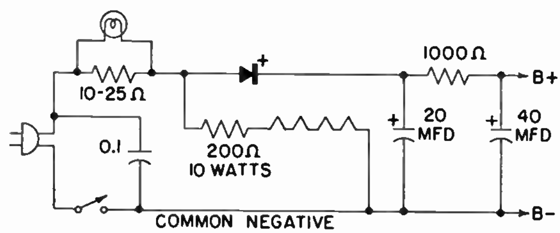


Fig. 3-15. Typical a-c/d-c power supply using a selenium rectifier

Dead Auto Receivers. The servicing of automobile receivers presents special problems to the serviceman because of the conditions peculiar to those receivers. One of these conditions is the antenna mounted on the car body. The other, and more important condition, is the type of power supply which is powered by the car battery. In other respects, the signal circuits of the auto receivers are the same as those of the home radio and are checked in the same manner.

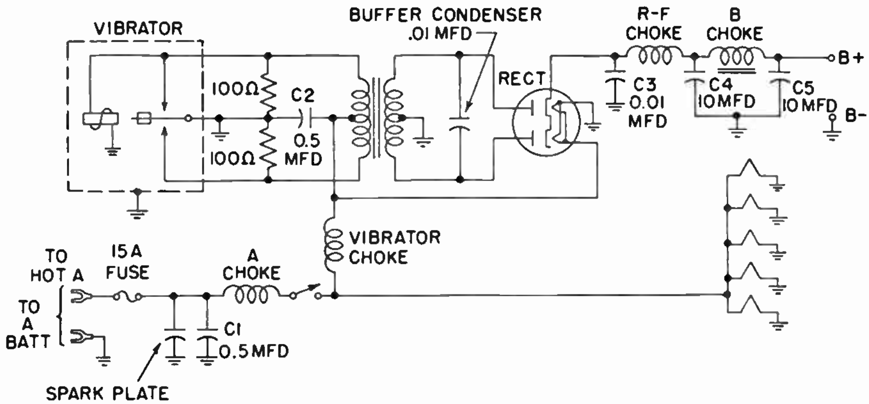
One possibility for inoperation of the car radio is the grounding of the antenna on the body where the antenna is mounted. A simple check is to disconnect the antenna plug from the receiver and to plug in a similar antenna directly. If reception is then obtained, the serviceman then checks the antenna mounting to locate the short.

Most auto receivers employ a vibrator power supply, energized by the car battery and furnishing the B voltage for the receivers. There are two types of vibrator power supplies—the nonsynchronous and the synchronous types. Each will be taken up separately.

Auto-radio Vibrator Action. The vibrator is essentially an electromagnetic switch. When energized, the switch opens and shuts very rapidly. This action in the case of the nonsynchronous vibrator interrupts a steady, direct current and makes it possible to operate a transformer. From the transformer on, the power supply operates in a manner similar to an a-c power supply.

The synchronous vibrator is a more complex switch with a double set of contacts. These points serve a double function. They make it possible to operate the transformer on direct current, and they also rectify the transformer output. As a result, the use of a tube rectifier is not needed. The transformer is then followed by a filter system.

The two types of vibrator are similar in appearance. They are essentially a cylindrical can with a tubelike base. The unit is inserted into a socket similar to that for a tube.



VOLTAGE DATA:

CAR CHASSIS TO HOT A LEAD___6V
CAR CHASSIS TO C.T. OF TRANSFORMER PRIMARY___5.5V
CAR CHASSIS TO RECT. PLATES___150-250V (AC)
CAR CHASSIS TO RECT. CATHODE___160-260V
CAR CHASSIS TO B+___150-250V

RESISTANCE DATA:

CAR CHASSIS TO RECT. PLATES___150-300 OHMS
RECT. PLATE TO PLATE___300-600 OHMS
TRANSFORMER PRIMARY___LESS THAN 1 OHM

Fig. 3-16. A typical nonsynchronous vibrator auto power supply

Vibrator Troubles. Having determined that the antenna is all right, you then make an external check of the vibrator. Turn on the set and listen for the operation of the vibrator unit. It should emit a very low purr when working.

If you do not hear the purr, it may be that the vibrator points are stuck. Give the set a smart slap. If the set begins to play, advise the customer to permit you to install a new unit. Tell him that the vibrator points are bound to stick again and trouble will occur.

If the slap does not start vibrator operation, you must make an external check of the A supply from the battery. Examine Fig. 3-16, which shows a typical nonsynchronous auto power supply. The lug from the battery feeds through a fuse and switch to the vibrator. The fuse is quite accessible. Check it to see that it is not blown. If it is, replace with a new fuse and see if the set operates. If the fuse is good, look for any high resistance points in the lead to the vibrator which might lower the voltage to the unit, thereby preventing its operation. A likely point is in the fuse case enclosing the fuse. Be sure the inside of the case makes clean firm contact with the fuse.

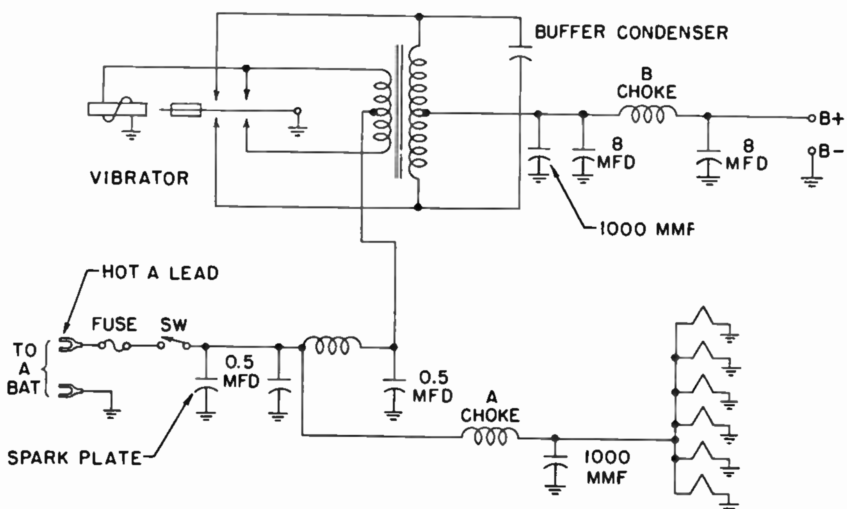


Fig. 3-17. A typical synchronous vibrator auto power supply

Figure 3-17 shows a typical synchronous auto power supply. Note that here again the same conditions exist. The hot A lead is inspected in the same manner for defects.

Checking Auto-radio Tubes. If the vibrator works and the set still fails to work after making the visual checks described above, remove the cover of the set and inspect the tubes. See that they all light. Testing them in a tube checker will confirm the condition of an inoperative tube.

This is as far as you can go with simple external visual checks. If the set still fails to operate, it becomes necessary to remove the set from the car and service it on the bench like any ordinary receiver.

Bench Setup for Auto Radios. The bench should be set up for the conditions found in the car. For an A supply, use a standard 6-volt storage battery. One word of caution! If the set uses a synchronous vibrator, you must be sure that the pole of the battery connected to the hot A lead is the same as that for the car. Synchronous vibrators have polarity. The vibrator and its socket are often so constructed that the vibrator may be shifted in its socket to obtain the proper polarity.

Battery Polarity. To determine which terminal of the A battery in the car is grounded, connect a 0-to-10 voltmeter with the negative lead on the car chassis and the positive lead on either terminal of the ammeter on the instrument panel. If the voltmeter reads 6 volts, the negative terminal of the battery is grounded and the radio A lead must go to the positive terminal of your battery. If the voltmeter needle swings backward, the positive terminal of the battery is grounded and the radio lead goes to negative.

You cannot use a standard house antenna for a car radio. A simple 3-foot length of hookup wire will simulate the short auto antenna.

Auto Radio Tests. Refer once again to Fig. 3-16 showing the nonsynchronous power supply. When the set is on the bench, check to see that the spark plate condenser and condenser C-1 are not shorted. Inspect the A choke and vibrator choke with an ohmmeter to see if they are open. Then check the switch for positive action with an ohmmeter. It closes and breaks 5 to 8 amperes of current and may not function or may develop a high-resistance contact.

Then check the B-plus voltage of the power supply with a voltmeter. You should get a reading of 150 to 250 volts if the B supply is good. Sometimes the buffer condenser shorts, producing a greatly reduced B voltage. If this is the case, replace the buffer condenser with an *exact duplicate.*

For the rest of the check, follow the standard test procedure. In all other respects, the auto radio resembles an ordinary superheterodyne receiver.

Shortcut. Many defective conditions would be indicated by fuses that blow, since they are accompanied by increased current drain from the battery. This fact suggests a quick procedure. If there is no B voltage, disconnect the B-plus lead at the output of the filter system and measure voltage again. If the B voltage rises much higher, the defect is in the signal section of the receiver. If there is still no B voltage, the trouble lies in the power supply. Then the serviceman connects a car ammeter of 0 to 20 amperes range in series with the hot lead to the battery. If the ammeter shows a larger drain than that indicated in the service literature for the receiver, he knows a short exists in the power supply and checks the components involved.

For the most part, the servicing procedure for the auto receiver with a synchronous vibrator is the same as that for one with a nonsynchronous vibrator. Just be sure of the polarity of the vibrator in the former case.

Locating Defects in Three-way Portables. When the complaint is presented that the receiver does not work, first determine what the customer has in mind, since there are two basic modes of operation: from the power line and from batteries. Which mode of operation—or perhaps both—fails to operate?

Set Operates Only on Power Line. If only battery operation is dead, first check the condition of the batteries, because their useful life is limited. If the batteries are still in good shape, inspect the battery plugs, battery leads, and the switches involved. If the set does not work on either mode of operation, the tubes should be checked in a tube checker. If that test instrument is not available, the tube filaments may be given a continuity check with an ohmmeter. But in that case, do not use the R $\times$ 1 scale of the instrument, because the meter battery may burn out a battery tube.

Be sure to check the changeover switch which controls the mode of operation. A bent contact or a dirty contact will be able to stop set operation in any one position. Where a repair cannot be made, replace the switch with a similar one.

Set Operates Only on Batteries. If the complaint is that the receiver fails to operate from the line, the external search starts at the wall outlet, where a test for voltage is made. Inspect the plug. Look for breaks in the line to the receiver. Check the power switch for proper operation, as well as the line-battery switch.

If no defect is found, the rectifier tube is checked to determine if it is operating. Assuming that the rectifier is good, check the B voltage with a voltmeter. If little or no B voltage is present, the components of the B filter system are checked with an ohmmeter.

If the set has a selenium rectifier, a shorted filter condenser might have damaged the rectifier. The latter is best checked by opening the B lead to the receiver and checking the filter system. If this is in good shape, turn on the set and measure B voltage with a voltmeter. If there is no B voltage, replace the selenium rectifier.

There is another point to keep in mind. The oscillator operation is easily stopped if voltages to the converter tube fall. Check the oscillator filament voltage. If it appears low, replace the A battery with a new one, even though it seems to be all right for most purposes.

If the complaint is that the set fails to operate from either line or battery, then the receiver circuits must be checked as for any standard receiver. This now definitely includes a tube check. A common trouble is the burning out of tube filaments. Changes in values of the equalizer resistors will redistribute the voltage across the various tube filaments and overload one or more of them, thereby injuring them.

Checking Tubes in a Portable. Tubes are checked either in a tube checker or by measuring voltage across the filaments. Observe one important precaution. If you turn on the power in the receiver and find one filament open, you might be tempted to replace the defective tube with a new one. But don't do it. If you do, one or more of the tube filaments may flash and burn out. The reason is clear. Look at Fig. 1-10. If one of the tube filaments opens, the 80-mfd condenser will have about 150 volts across it, and will retain this voltage for some time. When you put in the new tube, that high voltage is applied across the filaments. Poof! goes one or more tubes. To prevent this, first discharge all filter condensers before replacing a defective tube.

In some receivers, this effect will not occur because resistors are connected to act as a bleeder across the condensers, discharging them if a filament opens. But it is still best to discharge the condensers as a matter of routine. Removing a tube and then replacing it may cause the same disastrous effect.

If the tubes are good, service the set from the line mode of operation. Check the B voltage. If this checks all right, proceed with the standard signal check.

4

Servicing and Aligning Weak Receivers

Is the Receiver Really Weak? When a receiver is presented to the serviceman with the complaint that it is weak, it becomes more important than with any other complaint to determine if a real defect exists. The receiver itself may be perfectly normal in spite of the customer's opinion. Perhaps he may have suddenly decided to try to receive some distant station and only succeeded in obtaining weak reception. The receiver may simply be incapable of picking up enough signal strength to give loud output, and you would do well to explain this condition to him in nontechnical language.

Has the Customer Moved? Or, the customer may complain that some local stations are now coming in more weakly than previously. You may find by questioning him that he recently moved. In so doing, the receiver owner may have moved into an area where reception of the weakened stations is inherently poor. Again, a simple, sympathetic explanation will be sufficient. Or in moving, he may have had a less efficient antenna system installed. Your job then becomes that of installing a more efficient antenna. If the customer brings the receiver to your service shop, you may indicate to him the need for a new antenna by connecting the receiver to your own shop antenna.

If the receiver has a loop antenna, you may show him that reception for some stations will be improved by rotating the receiver for maximum signal pickup. Most customers are aware of this phenomenon but often overlook it as a cause of weak output.

Is It a Summer Complaint? The complaints of weak reception will increase in number as the summer months roll in. Because of the more intense sunlight, there is a shifting of the ionized Kennelly-Heaviside layer of air up in the sky. This shifting results in the attenuation of radio signals. Once again, most customers will feel satisfied if you explain the cause in simple terms.

When is the complaint that the receiver is weak valid? Generally, weak reception as a real defect exists when, under the same conditions as previously existed, the same radio stations are received at a volume considerably lower than usual.

Clues for the Weak Receiver. This chapter will lump together the a-c and the a-c/d-c receiver, since the signal circuits are practically identical. Furthermore, the tests for weak reception are primarily a variation of the tests performed on the dead receiver.

Once you have determined that the complaint of a weak receiver is justified, begin the search for clues that will save you time in tracking down the defect. The manner in which the weak output occurs is often a general guide to the defective section in the receiver.

Clues Pointing to R-F Section. For example, if distant stations come in weak and strong local stations come in normal, you may reasonably conclude that the defect is in the r-f section of the receiver. Probably the r-f section is not giving enough amplification for weak signals; the strong local stations deliver enough signal strength and do not require as much r-f amplification.

If the receiver has a loop antenna, rotate the receiver and see if improvement results. The loop antenna has directional properties and picks up any one station with different strengths when turned in different directions. No repair is necessary in that case.

If the receiver is a superheterodyne and you hear a fairly loud hiss as you tune to the weak distant station, you may feel sure that the r-f section is amplifying properly but is not receiving a strong enough signal. It is then advisable to check your antenna system for defects, or the antenna coil primary for an open. These are the input to the r-f section of the receiver. If it is the summertime, the shifting of the Kennelly-Heaviside layer might cause the weak condition described above, and the receiver would be all right. If you suspect that cause, check the set at night, when conditions in the atmosphere improve.

Clues That Clear the R-F Section. Or the type of weakness might be such that both distant and local stations come in weak. Here the likelihood is that the defect lies in the stages after the i-f stage. A further clue is found if the receiver has an electron-ray-tube tuning eye. If the eye closes normally when you tune in a station, you know that the r-f section, the second detector, and the avc circuits are functioning normally; and the defect is in the audio-frequency section or loudspeaker.

If no distant stations are received and local stations come in weak, any part of the receiver including the power supply may be defective. For such a condition, you would do best by beginning with localizing procedures, which are described later.

The type of weakness may be such that reception is normal until you tune to one end of the tuning dial. Obviously, this condition cannot be due to an over-all defect. A check of the various tuning circuits will show one or more to be out of alignment. Later in this chapter we shall examine a generalized procedure for realignment of a receiver.

Clues in All-wave Radios. If the receiver is a multiband type and it is weak on one band while normal on all others, it is obvious that only those components associated with the weak band need be checked. This fact limits the check to a misaligned r-f tuning circuit for that band, a defective band switch, or open coils in its r-f tuning circuit.

In some cases of weak reception, the installation of a good ground connection will improve matters. Sometimes, installation of a good outdoor antenna, where such antenna is not used, will help the receiver response. This is especially true if the receiver is in a rural area well over 25 miles away from the desired stations.

The clues given above will help to locate the defective section for the most part. However, if they fail to do so, you had better begin at once on the over-all localizing procedures. Do not waste time on random search.

What Conditions in the Receiver Can Cause Weak Response? Before beginning on the localizing procedure, it would be best to keep in mind what conditions in the receiver can produce weak reception. You will then make faster progress in locating the specific defect, once you have localized the defective stage.

Tubes are often a cause of weak reception. A vital aspect of any tube is good filament or cathode emission of electrons. As the tube grows older with use, its emission may decrease to a point where it does not permit proper tube amplification. This is so common that you ought to test all tubes at the start for emission in a tube checker, when the complaint is weak reception.

How Tuned Circuits Can Cause Weak Response. Tuned circuits are another cause of weak reception. Each circuit consists of a coil and condenser; together they produce fairly high resonant circuit gain for a desired small band of frequencies. Gain here may be lost in either of two ways. Slight variations of the condensers may make the tuned circuit resonant to a frequency different from the desired frequency. The circuit is then said to be misaligned. Thus, in a superheterodyne receiver, the trimmers of an i-f transformer may have been altered to such a position that the tuned circuits are not exactly resonant to the intermediate frequency of the receiver. In a tuned radio-frequency receiver, the ganged tuning circuits may not all be exactly resonant to the same frequency at any one setting.

The second reason for loss of gain of a tuned circuit may occur in various ways. For example, introduction of resistance into a tuned circuit, such as corrosion of a connection, will cause reduced gain, even though the circuit is properly aligned. Similar loss will be caused by excessive moisture in a coil or shorted turns in a coil winding. This defect is indicated if the tuned circuit tunes very broadly.

The tuned circuit should not be tampered with, however, unless other possible causes for weak reception have first been thoroughly investigated. Further details on alignment will be given later.

How Condensers Can Cause Weak Response. A third possible cause of weak reception is that resulting from defective condensers other than those related to resonant circuits. For example, open coupling condensers may permit only strong stations to come in weakly while causing the receiver to be dead for other stations. Leaky coupling condensers will also result in weak reception by reducing the bias on the coupled grid. Further, an open cathode bypass condenser will result in degeneration of the stage of which it is a component and will give weakened reception.

Similarly, an open plate bypass condenser may cause weak reception by permitting the output stage to oscillate with resulting lowered B-plus voltage. Another condenser defect that may cause weak reception is an open avc filter condenser.

Loudspeaker Troubles. The loudspeaker may also be a cause of weak reception. In an electrodynamic loudspeaker, where the field coil is not used as a filter choke in the power supply, an open field coil will result in lack of proper magnetic strength, with resulting weak reception.

The voice coil may also result in weak reception when it is defective. A warped or rubbing voice coil may result in weak reception by preventing free movement of the cone. Distortion usually accompanies this latter condition.

Other miscellaneous causes of weak reception may now be listed. In a-c receivers, a short in the power transformer will deliver low voltage from the power supply. Similarly, a short in the primary of the output transformer will deliver a weak signal to the voice coil. An open antenna coil will prevent strong signals from being delivered to the following stages. High resistance contacts, like dirty wiper contacts in the tuning condensers, may result in weak reception. A grounded aerial or leadin, or a break in the leadin will also produce the same effect. With battery receivers, weak batteries must be checked as a frequent cause of lowered output.

Often, a defect that results in weakened reception will result in lowered voltage to some tube electrode and may be detected in that way. A leaky screen bypass condenser will reduce screen voltage. A cathode bias resistor that has altered its resistance may bias the grid excessively negative and result in weakened output, usually with accompanying distortion. An open input filter condenser in the power supply will result in lowered voltage output from the power supply and weakened output. An excessively leaky input filter condenser will produce similar results.

Localizing the Defective Section. External clues plus the knowledge of which components may cause weak reception should aid in quickly localizing the defective section. If they fail to indicate a cause, do not waste time in a fruitless search. Proceed at once to the systematic localizing procedures. Remember that timesaving is extremely important to a successful serviceman.

The Defective Section—Circuit-shock Tests. The procedure for checking a weak receiver is similar to that used in the case of the dead receiver. The difference lies in the response obtained. We check the sections of a dead receiver to see at what point no response is obtained. With the weak receiver, we check to see at what point we obtain weaker than normal response.

The simplest check involves circuit-shock procedures. Here the technique is to produce clicks at various test points by means of shocking procedure and to listen for a weak or strong click. However, your ability to distinguish between loud or soft clicks is not too reliable. Therefore, further supplementary procedures are necessary to reinforce your troubleshooting analysis.

Turn the volume control full on, and touch the ungrounded end of the volume control with your finger. If a loud hum or buzz is heard from the loudspeaker, you may assume that the audio section, the power supply, and the loudspeaker are normal. Look for the defects in the r-f section of the receiver.

If the receiver has a phonograph, you can check by merely playing a record. Normal volume indicates that the defect is in the r-f section, since the phono input is applied to the a-f section.

A weak response from the input to the audio section indicates a defect in that section, and it must be checked further.

Defective Audio Stage—Circuit-shock Tests. The first check in a weak audio section should be that of the tubes. The tube checker will disclose any tube with low emission. This condition will often be true of tubes that have been in operation for some time.

The second step is that of checking the voltage at the tube electrodes—the plate, screen, grid, and cathode voltages. Abnormally low voltages immediately point to a defective component in that stage or in the power supply. If the plate or screen voltages are low, check B-plus voltages at the power supply for a defect in that section. Here, the power transformer windings may be shorted, the rectifier may be defective, or the filter condensers may be open or excessively leaky.

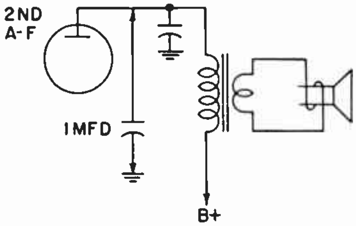


Fig. 4-1. Click test for an operative output circuit

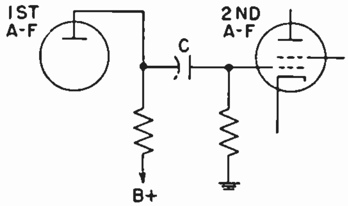


Fig. 4-2. The coupling condenser C in the audio section

The voltage check may be preceded by listening for weak clicks as the various stages are checked. Connect a 1-mfd/600-volt condenser from the plate of the output tube to the chassis, as shown in Fig. 4-1. If a loud click is heard, the loudspeaker and power supply may be assumed to be normal.

When a loud click is not heard, check the B-plus voltage of the power supply for a defect in that section. If it is all right, check the speaker by placing a blunt iron tool near the center pole piece and observing if the field is properly energized, as indicated by a strong pull. Weak energizing may be due to an open or shorted field coil. Then check the motion of the voice coil by pressing it gently in and out and observing whether it has free and unhindered motion.

If the tubes are good, voltages are more or less normal, and the loudspeaker is in good shape, then you might well investigate the coupling condensers, such as C in Fig. 4-2, which might have developed a high-resistance leak. A quick check is to open one terminal of the condenser and bridge a new condenser of similar capacity from plate to grid, as shown in Fig. 4-3. If volume perks up, you have located the defect.

Another condition to investigate is a possible open plate filter condenser in the output stage, shown in Fig. 4-4. This condition might throw the output stage into oscillation and produce weak output. The quick check is to bridge the old condenser with a new one of equal capacity and to listen for increased volume.

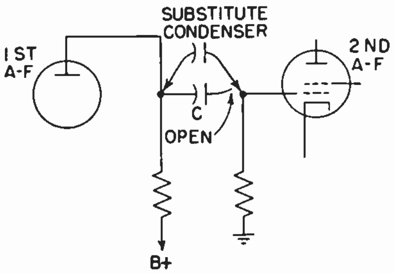


Fig. 4-3. Checking the coupling condenser with a substitute condenser

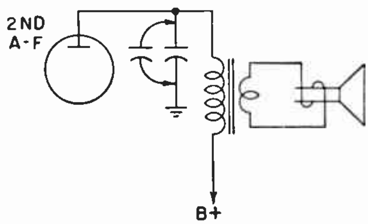


Fig. 4-4. Checking for an open output filter condenser with a substitute condenser

Defective R-F Stage—Circuit-shock Tests. If the power supply and audio section are in good shape, turn to the r-f section of the receiver. Here circuit-shock tests are not very effective, since misalignment of tuned circuits would not readily be disclosed and yet might be a cause of weak reception. However, other defects may be found.

If the tubes in the i-f and r-f stages have been in operation for some time, you had best test them in a tube checker. When they have been found to be all right, you can try circuit shocking from the last i-f tube back to the antenna. This can be done, if the tubes have grid caps, by removing and replacing the grid caps. Each time you remove and replace the cap, you should usually hear a loud thump or buzz. At the stage where the test sound first comes through weakly, you must check for a defective component with the voltmeter and ohmmeter. This test, however, is not completely reliable because, in some receivers, you get very little sound even when the set is working properly.

Where the tubes have no grid caps and the tube heaters are in parallel, as in a-c receivers, shock the stages into producing thumps by pulling out the tubes one at a time. Once again, the loudness of the test sound indicates the defective stage, and the search for the defective component must be made within the defective stage.

Where the tubes have no grid caps and the heaters are in series, as in an a-c/d-c receiver, you cannot pull out tubes. Stages are shocked by connecting a 1-mfd/400-volt condenser from the plate of each tube to the chassis, proceeding from the i-f amplifier to the r-f amplifier. The first stage where a loud click is not heard indicates that the stage previously passed is defective. Thus, if you fail to obtain a click from the plate of the converter tube, the following i-f amplifier stage is probably defective. If the last i-f stage fails to produce a click from its plate, the detector stage or volume control is probably at fault.

Since circuit-shock tests are a rather invalid procedure for analyzing the weak receiver, many servicemen proceed directly to the signal substitution method, using a signal generator.

Locating Defective Stage with Signal Generator. In a receiver each stage except the diode detector of a superheterodyne receiver amplifies the signal before it passes it to the next stage. When you have an idea of the approximate amplification or gain to be expected from each stage, you can quickly localize the stage that isn't giving normal gain and is causing weak receiver output. Once you have located the weak stage, the localization of the defective components within that stage is routine.

For servicing purposes, exact determination of stage gain is not essential, since the offending stage will usually be far below normal for the owner to consider his receiver to be weak. Adequate stage-gain measurement can be made with a signal generator and an a-c voltmeter.

How to Measure Gain. The technique of stage-gain measurements is simple and logical. A modulated signal from the signal generator, at the proper frequency for the stage tested, is fed in to the input of the stage, as shown in Fig. 4-5. The voltage of the generator signal is adjusted at

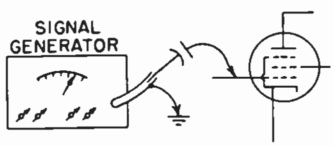


Fig. 4-5. Feeding a signal from a signal generator to the input of a stage

all times to produce a constant output from the receiver, known as *standard output*. Standard output is determined with the a-c voltmeter connected as an output meter. Then the signal from the signal generator is fed into the output of the same stage—the grid of the following stage.

Obviously, you must step up the voltage output of the generator to obtain the same standard output as previously, since you do not now have the gain of the stage. Then, by dividing the signal-generator voltage at the output of the stage by the signal-generator voltage at the input of the stage, you obtain the gain of the stage. This sequence is illustrated in Fig. 4-6.

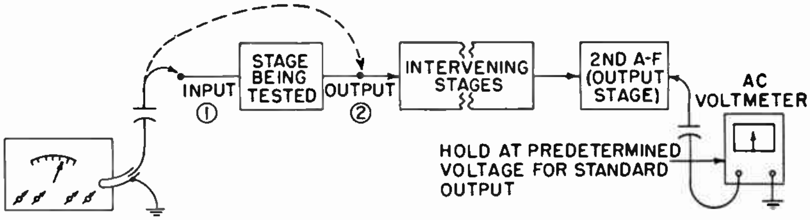


Fig. 4-6. Sequence of measurements to obtain the gain of a stage

Example of Gain Measurement. An example will illustrate the point. If 50 microvolts of signal from the signal generator fed into the input of a stage gives standard output, and 3,500 microvolts of signal from the generator fed into the grid of the following tube (output of the stage being tested) gives standard output also, then the gain of the stage is 3,500/50, or 70.

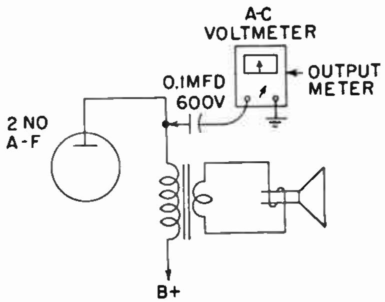


Fig. 4-7. Connection of an a-c voltmeter as an output meter

Standard output used in stage-gain measurements has been set by the I.R.E. at 50 milliwatts of signal power fed into the speaker. For the serviceman, this output may be more conveniently approximated by connecting an a-c voltmeter across the primary of the output transformer, in the manner shown in Fig. 4-7. The condenser in series with the a-c voltmeter serves to isolate the d-c plate voltage from the meter, permitting only the useful signal voltage to be delivered to the voltmeter.

In stage-gain measurements, the signal input level from the generator 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. Therefore, so long as you adjust the signal voltage from the generator to a level that indicates 16 volts on your output meter, you know you have standard output, or approximately 50 milliwatts of output power.

Setting the Signal Generator. Now how do you know the signal level output from the signal generator? Few signal generators furnish an exact indication of the signal voltage output from the generator. But fortunately for servicemen, exact indications are not necessary. Comparative measurements will serve just as well. You can take various receivers, which are known to be in perfect operating condition, and can record the signal generator attenuator setting necessary at the grid of each tube in each stage to give standard receiver output. Then average the setting for each stage. Thereafter, if a receiver with weak output is checked and it becomes necessary to give *much greater* signal-generator output than the average value previously determined at a particular grid, then you know you have found the weak stage.

Typical Gain Values. Average stage-gain data for superheterodyne receivers is given in Fig. 4-8, along with the signal frequency and signal strength required from the signal generator for each measurement.

Stage	Test Frequency	Range of Gain	Sig. Gen. Fed Into	Dummy Antenna	Input from Sig. Gen.
r-f	600 kc (mod)	10–40	Ant. terminal	400-ohm resistor	5–12 μv
Converter	600 kc (mod)	60–80	Converter sig. grid	0.1 mfd/600 volts	50 μv
i-f	i-f (mod)	80–120	i-f grid	0.1 mfd/600 volts	3,500 μv
1st a-f	400–cps	30–60	1st a-f grid	0.1 mfd/600 volts	0.032 volts
2nd a-f	400–cps	5–15	2nd a-f grid	0.1 mfd/600 volts	1.6 volts

Fig. 4-8. Average stage-gain data and signal-generator settings for broadcast-band superheterodyne receivers. Last column gives signal inputs in microvolts and volts required to give standard output from receiver. For first two stages, receiver should be tuned to 600 kc

As you move back from the loudspeaker toward the antenna, less and less signal voltage is necessary from the signal generator in order to obtain the same standard output, because of the gain of each stage (except a diode detector).

Since most signal generators do not give an exact indication of generator output, you had best record the average settings for each stage to obtain standard output, and consider that setting (regardless of what the signal generator attenuator indicates) to correspond to the average values shown in the last column of Fig. 4-8. Thus, if you feed the output of the signal generator into the grid of the i-f amplifier and obtain standard output, you may assume that the setting represents about 3,500 microvolts, regardless of what is indicated by the signal generator attenuator control. The same interpretation may be made of other settings, and gain of a stage may be readily calculated.

Where the manufacturer of a receiver furnishes instructions for making gain-per-stage measurements, follow theirs. Where no data is furnished, use the typical settings given in Fig. 4-8.

Locating the Weak Stage. You now have a rapid technique for isolating a weak stage. Whenever you find it necessary at the input of a stage to increase the voltage from the signal generator to a level considerably above normal to obtain standard receiver output, you have located the stage causing weak reception. Where two i-f stages are used, the gain of the mixer and each i-f stage will be lower than where a single i-f stage is used.

Control Settings. In checking stage gain, the volume control is set at maximum, the tone control (if any) is set at the minimum bass position, and the fidelity control (if present) is set at maximum selectivity. These settings give the greatest response from the receiver.

When checking the i-f stage of a superheterodyne receiver, the previous r-f stages of the receiver should be made inoperative by shorting across from the stator plates of the oscillator section of the gang tuning condenser to the frame of the condenser. This section may be found by touching the stator plates of all sections of the condenser gang while a station is coming through. When the station disappears or perhaps a new one comes through, you have located the oscillator section.

Dummy Antenna. When making stage-gain measurements, a dummy antenna should be connected in series with the hot lead of the signal generator, using the components specified in Fig. 4-8 unless advised differently by the receiver manufacturer.

The oscillator section of the converter has been left out of this discussion, since it is never involved in weak reception. The oscillator stage will cut out completely or at one end of the dial, long before its lowered signal voltage will cause weak reception, and the receiver would then be dead.

For a trf receiver, the same techniques as for the superheterodyne receiver may be used. Here the detector stage will provide gain also, ranging from 5 to 50. Other stages will give much the same gain as for superheterodyne. Thus, gain of a trf stage will range from 20 to 40.

Isolating the Defective Component. After you locate the stage that is causing weak reception, you track down the defective component within the stage by means of your ohmmeter and voltmeter. The procedure is the same as that for the dead receiver, keeping in mind the conditions in the receiver, presented at the beginning of this chapter, that might cause weak response.

Misalignment as a Cause for Weak Reception. The average superheterodyne receiver has many tuned circuits, each of which has to be in resonance at its proper frequency for best operation of the receiver. When they are not in resonance, the receiver responds with a loss of sensitivity and selectivity to an extent depending on the degree to which the tuned circuits are out of resonance. When the tuned circuits are not in proper resonance, the receiver is said to be misaligned.

In most receivers, alignment adjustment for tuned circuits is performed by varying small semivariable condensers. In some receivers, alignment adjustment is performed by varying the position of powdered-iron core slugs in the coils of the tuned circuits. This latter procedure varies the inductance rather than the capacitance of the tuned circuit. However, the alignment procedure remains the same.

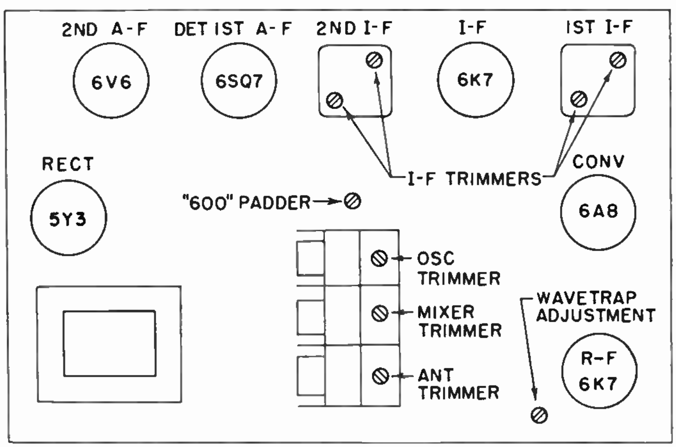


Fig. 4-9. Location of trimmers and padders on a typical a-c superheterodyne receiver

The basic tuned circuits which may have to be aligned are listed below in the order in which they are handled: (1) i-f trimmers; (2) oscillator trimmers and padders; (3) r-f trimmers; (4) antenna trimmers.

The term trimmer is usually used for small variable condensers in *parallel* with larger tuning condensers or in parallel with coils. The term padder is usually used for small variable condensers in *series* with the components of a tuned circuit. Figure 4-9 shows the typical location of these adjustment condensers on a six-tube superheterodyne receiver.

When Should a Receiver be Re-aligned? When signal checking the i-f stage, the standard servicing procedure was to feed a signal to the stage input and to wobble the generator control around the intermediate frequency, say, 455 kc. If the signal came through at or near 455 kc, the stage was considered good. However, suppose the signal came through weakly at 455 kc. And further, suppose that in wobbling, two stronger signals come in at, let us say, 420 kc and 440 kc. In all probability, misalignment of the trimmers is the cause. You should try re-alignment.

There are many factors that could have produced this condition. Someone without training may have tinkered with them. Or a previous serviceman may have replaced a component without having taken the trouble to re-align the set. Or natural aging of components sometimes creates the condition.

Equipment Used in Receiver Re-alignment. A receiver may be re-aligned by using two basic instruments which you encountered before. One is the signal generator to inject a signal at the proper frequency into the receiver. The other is an output meter, similar to the one used in making stage-gain measurements. It is connected as before across the primary of the output transformer.

The signal from the signal generator is injected at various points in the receiver, and the trimmers and padders are adjusted to give maximum response on the output meter. When the receiver being re-aligned is of the loop-antenna type and no antenna post is provided, the signal-generator output is radiated into the loop of the receiver. A two-turn loop of wire about 6 inches in diameter is constructed and connected across the output terminals of the signal generator. This small loop is then placed a few inches away from the loop antenna of the receiver. The strength of the signal fed to the receiver may be varied by moving the generator loop closer to or further from the receiver antenna and by varying the signal-generator attenuator.

Alignment Tools. The resonance adjustment for most tuned circuits is screw-controlled. Special alignment screwdrivers of polystyrene or bone fiber should be used. Similar alignment socket wrenches are available where the control is by means of hexagonal screws heads or nuts.

Setting Up the Conditions for Alignment. An output indicator of some sort is required to show when the trimmer or padder has been peaked. The maximum deflection on the output meter shows the point of peak alignment. If the receiver has an electron-ray tuning indicator tube, the closing of the eye may be used as an output indicator. If such a tuning eye is not present, an output meter across the primary of the output transformer may be used, as shown in Fig. 4-10.

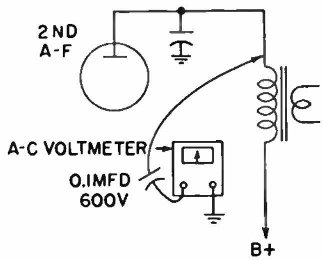


Fig. 4-10. Using an output meter for checking trimmer peaking

Where service notes by the receiver manufacturer on alignment are available, they should be followed exactly. When not available, you may safely follow the generalized procedure described below.

As little output from the signal generator as is necessary to give a reading on the output meter should be used. This precaution is necessary in order to be sure that no avc action takes place, since this would throw off the output-meter indications. Do not work to an output indication above 16 volts if you wish to avoid avc action.

When the receiver is re-aligned, its controls should be set in such positions as to give maximum sensitivity. The positions of such controls, when present, are listed below:

VOLUME CONTROL—Turned on full.
TONE CONTROL—Set to minimum-bass position.
SELECTIVITY CONTROL—Set to low-fidelity (maximum selectivity) position.
SENSITIVITY CONTROL—Set to maximum-sensitivity position.
TUNING DIAL—Set to frequency required.

Aligning the I-F Amplifier. The first step in the re-alignment procedure is the adjustment of the i-f trimmers in the i-f transformers. Where service notes are available giving the intermediate frequency, the problem is simple. But how can you know the intermediate frequency of a receiver where service literature is not available?

The most common intermediate frequency of recent years is 455 kc. Other intermediate frequencies used in very old sets are 175, 260, and 465 kc. Modern auto sets often use an intermediate frequency of 260 or 262 kc.

If you are uncertain of the intermediate frequency, connect the signal generator to the mixer grid and short out the oscillator section of the gang tuning condenser. Then rotate the signal-generator frequency control from 500 to 150 kc to produce a modulated note, and observe at what frequency the response note is heard from the receiver loudspeaker. Usually, the misaligned i-f transformer will not be too far from its correct setting. From the observed frequency of response and the knowledge of commonly used intermediate frequencies, you can tell what the correct frequency should be.

Avoiding Harmonic Response. You should not be confused by a harmonic output from the signal generator. An example will make the point clear. Suppose the intermediate frequency of a superheterodyne receiver is 260 kc, but you are not aware of the fact. You short out the oscillator tuning condenser section, and feed a modulated signal from the signal generator into the mixer grid. At 130 kc, you get a weak response from the loudspeaker. You then erroneously assume that the nearest common intermediate frequency is 175 kc, and try to align the i-f transformer at that frequency with very poor results.

What went wrong? Actually, when you obtained loudspeaker response at 130 kc, it was the second harmonic ($2 \times 130 = 260$) frequency from the signal generator that produced the effect. To avoid this error, start the signal generator at 500 kc and work down. In this case, the first response would come at 260 kc, the second response at 130 kc ($260 \div 2 = 130$), the third response at 86⅔ kc ($260 \div 3$), and so forth. The *highest* frequency at which you obtain a response is the intermediate frequency.

Connections for I-F Alignment. You are now ready to align the i-f transformers. The receiver and signal generator are hooked up as shown in Fig. 4-11. The output meter is adjusted for a high a-c range and connected through a 0.1-mfd condenser to the plate pin of the second a-f amplifier

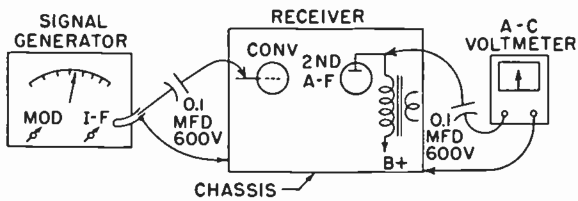


Fig. 4-11. Setup of equipment for aligning i-f transformers

tube. The signal generator is adjusted for a modulated signal at the intermediate frequency of the receiver. The stator plates of the oscillator section of the gang tuning condenser are shorted to the condenser frame. The receiver controls are set for maximum gain. Allow about 15 minutes for the receiver and signal generator to warm up before proceeding.

I-F Alignment Procedure. Adjust the attenuator of the signal generator to produce a weak modulation note from the loudspeaker and as low an indication on the output meter as possible. Alignment begins on either trimmer condenser of the second, or output, i-f transformer. The trimmer screw is carefully turned back and forth until the modulation note is loudest from the loudspeaker. Then reduce the modulation note to a low level once again by means of the signal-generator attenuator, and adjust the other trimmer screw of the output i-f transformer in like manner. Repeat the same technique with the two trimmers of the input, or first, i-f transformer.

Now for the final adjustments. Set the output meter at a range of about 50 volts and adjust the signal generator output by means of its attenuator to give a reading of about 5 volts. Adjust the trimmers of the output i-f transformer and then the trimmers of the input i-f transformer, in each case adjusting the trimmer screws to give peak, or maximum, indication on the output meter. When all trimmers have been set to give peak response on the output meter, the alignment of the i-f transformers is complete.

Aligning Oscillator Using Cut-plate Condensers. In some receivers, the individual sections in the gang tuning condensers are alike. In others, the oscillator section has a smaller set of rotor plates, called cut plates. The alignment procedure is somewhat different for the oscillator stage of each type. Let us first present the procedure for the cut-plate type.

Remove the short used in the i-f alignment procedure from the oscillator section of the gang tuning condenser. The hot lead of the signal generator is fed through a 0.00025-mfd/600-volt condenser to the antenna post of the receiver. The output meter is switched to a high-voltage range. Keep the receiver controls in the position for maximum sensitivity. Tune the receiver to a quiet point on the tuning dial at about 1,500 kc. Adjust the frequency control of the signal generator to deliver a modulated signal at the same frequency as that to which the receiver is tuned.

Now loosen the oscillator trimmer screw all the way, and then carefully close it until the signal is heard loudest. Then reduce the signal generator output by means of its attenuator, and switch the output meter to a 50-volt range. Finally, adjust the trimmer screw very *carefully* for peak, or maximum, voltage on the output meter. The oscillator tuned circuit is now re-aligned.

Aligning R-F and Antenna Trimmers. The antenna and r-f trimmers, if present, are located on the tuning sections, other than the oscillator section, of the gang tuning condenser. Set the receiver at a quiet point at about 1,400 kc. Set the signal generator so as to produce a modulation note at the same frequency as the receiver. Adjust the attenuator to produce a low reading on the output meter. The r-f and antenna trimmers are then each wobbled back and forth to produce peak response on the output meter.

Alignment of Receivers with Similar Condensers. Many sets, whose sections of the gang tuning condenser are similar, use both trimmer and padder condensers for proper resonance adjustment. Figure 4-12 shows the schematic diagram of such an oscillator tuned circuit. Condenser C-1 is the oscillator tuning condenser of the tuning gang. Condenser C-3 is the oscillator trimmer condenser. Condenser C-2 is the oscillator padder condenser, often called the 600 *padder*. In re-aligning this oscillator circuit, both padder and trimmer condensers must be readjusted.

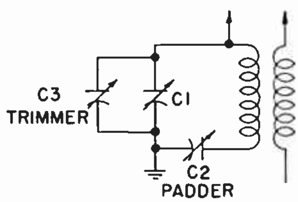


Fig. 4-12. The trimmer and padder condensers for oscillator alignment

In receivers with oscillator padder condensers, the alignment is a bit more complex. As previously described, the signal generator is fed through a 0.00025-mfd condenser to the receiver antenna. However, now tune the receiver to 600 kc, and adjust the signal generator to produce a modulation note at 600 kc. Adjust the 600 padder condenser for peak response. This adjustment has been made at the low-frequency end of the broadcast range.

Now tune the receiver to a quiet point at the high-frequency end, at about 1,500 kc. Adjust the signal generator to produce a low modulation note at the same frequency as that of the receiver. Loosen the oscillator trimmer screw, and slowly tighten it until the modulation note is heard loudest. Adjust the generator attenuator for a low reading on the output meter, and adjust the trimmer for peak voltage on the output meter. Then proceed to align the r-f and antenna trimmers as described in the section above.

Rocking Procedure for Aligning the 600 Padder. The oscillator alignment is not yet complete. Tune the receiver and signal generator to 600 kc, and readjust the 600 padder for peak response. Set the attenuator to give an output-meter reading of 16 volts. Then tune the receiver slightly higher than 600 kc, say 605 kc. Leave the signal generator at 600 kc, and readjust the 600 padder for peak response. If the output-meter reading increases in this adjustment, repeat the entire maneuver until no further increase occurs.

If the output-meter reading does not increase, tune the receiver slightly lower than 600 kc, say 595 kc. Adjust the 600 padder. If there is an increase in output, rock the receiver tuning condenser to a lower frequency and adjust the padder until maximum output is reached, that is, until variation of the padder screw does not produce an increase of output.

Signal Generator		*Receiver*		*Output Indication*
Frequency Setting	*Hot Lead to*	*Tuning Condenser Setting*	*Adjustment*	
i-f (usually 455 kc.)	Mixer signal grid.	Any (oscillator section shorted).	Output i-f trim. Input i-f trim.	Peak. Peak.
600 kc.	Antenna.	600 kc.	600 padder.	Peak.
1,500 kc.	Antenna.	1,500 kc.	Oscillator trimmer	Peak.
1,400 kc.	Antenna.	1,400 kc (tune for maximum output).	r-f and ant. trim.	Peak.
600 kc.	Antenna.	600 kc (rocking technique).	600 padder.	Peak.
1,500 kc.	Antenna.	1,500 kc (tune for maximum output).	Oscillator trimmer.	Peak.

Fig. 4-13. Generalized alignment procedure for a superheterodyne receiver

Essentially, in this step the receiver tuning gang is rocked back and forth around 600 kc, while the 600 padder is adjusted until any variation of the padder at the frequencies off 600 kc does not produce an increase in output on the output meter. Its purpose is to find the combination of 600 padder setting and receiver-tuning-dial position which peaks the output meter, even if the receiver tuning dial falls slightly off the 600-kc position.

The oscillator trimmer is then rechecked at about 1,500 kc for peak response. Feed in a test signal at 1,500 kc. Tune the set for maximum output. Then retouch the oscillator trimmer for peak.

The complete alignment procedure is summarized in proper order in the outline given in Fig. 4-13.

Aligning a TRF Receiver. The alignment of a tuned radio-frequency receiver is a somewhat simpler task than that of a superheterodyne receiver, since all the tuned circuits of the former type normally operate at the same frequency at any one time. There may be two tuned r-f amplifiers and a tuned detector. All these main tuning condensers are ganged together and operate from the same receiver tuning control. In the course of events, aging or the replacement of a coil may throw one or more of these tuning circuits out of resonance with the others. As a result, receiver volume will be weak and receiver tuning will be broad.

Use of Tuning Wand on TRF Set. A quick method to determine if re-alignment is necessary is the use of a tuning wand. It consists of a fiber rod with a band of brass at one end and a band of steel at the other. Insertion of the brass end into a coil reduces its inductance; insertion of the steel end increases its inductance.

Connections for TRF Alignment. An output meter is connected across the output transformer primary, as was done previously in superheterodyne-receiver alignment. A modulated signal at about 1,500 kc is fed into the antenna from the signal generator through a 0.00025-mfd/600-volt condenser to give a low indication on the output meter. The receiver is tuned to the same frequency. Now insert both ends of the tuning wand in turn into each coil of the tuning circuits. If the insertion of either end gives an increased indication on the output meter, that tuning circuit must be re-aligned. Normally, insertion of either end should reduce the output-meter indication.

TRF-alignment Procedure. Re-alignment of these tuning circuits is performed as follows: The receiver is tuned to a frequency of 1,500 kc, and its volume control is turned full on. Allow a warmup period of about 15 minutes. Feed a modulated 1,500-kc signal into the receiver antenna. The generator signal should be at a level to give a 16-volt output-meter indication. The small trimmer condensers in parallel with each section of the condenser gang are then adjusted to peak. Always align the tuning circuits in the order from the detector to the antenna. For each tuning circuit, adjust the trimmer to give peak or maximum response on the output meter.

Many trf receivers have condenser sections whose end plates are slotted radially. These are used for tracking adjustments. The segments of the end plate are bent slightly in or out for proper tracking. Be careful that you do not short the condenser when making this adjustment.

Other Alignment Techniques. There are other ways in which receivers may be re-aligned, using the signal tracer, vacuum-tube voltmeters, or oscilloscopes. However, they are in no way simpler than the procedures elaborated in the description just presented. Further understanding of their use will be given in a separate section of this book.

5

Hum

Customer Complains of Hum. When the customer complains that his receiver hums, he is referring to a defect of degree rather than a condition that does not exist in a normal receiver. Every receiver that operates from the power lines or a vibrator power supply will have a certain amount of hum. Normally, it is at a tolerably low level and is considerably below the desired signal level. However, under certain conditions, the level of the hum rises to a level that is quite high when it is compared with the desired signal level. At that time you get the call from the customer.

Start with Questions. A little questioning at this time is desirable. Did the receiver always hum? How recently did it begin to hum? Was the receiver serviced recently? If yes, what was the defect at the time? Does the receiver hum all over the dial? Or does it hum only when a station is tuned in? Was a new antenna recently installed? These are not useless questions; they are the beginnings of the application of your knowledge to the problem of localizing the defects. Of course, be sure to confirm the customer's complaint by turning on the set and listening yourself before proceeding.

Types of Hum Defects. Hum is manifest as a *steady* low-frequency audio note. It originates when a low-frequency voltage enters the signal chain of a receiver. Not many defects will permit such an entry, and the defect can readily be isolated as a result. It has been estimated that two defects account for about 90 per cent of excessive hum in receivers. First and foremost (75 per cent) is a defect in the filter section of the power supply. The second cause (15 per cent) is a leak between the cathode and the heater of a tube, especially in the audio-frequency section. Other defects account for the remaining cases of excessive hum.

How Hum Gets In. The point of entry of the low-frequency a-c voltage (hum voltage) determines the manner in which the hum appears from the receiver, and this in turn helps you to isolate the defective section. The audio-frequency stages are untuned and will pass along the hum voltage when such voltage is injected into one of these stages. As a result, the receiver will hum over the entire range of the receiver tuning dial. If a receiver hums excessively over its entire tuning range, you know that the defect must be in the a-f stages or in the power supply.

The r-f stages are tuned stages, tuned to frequencies which could not pass along the low-frequency hum voltages. Therefore, if the receiver were not tuned to a station and the hum voltages entered one of the r-f stages, the hum voltages would be blocked and the receiver would not hum. But when a station is tuned in, the hum voltage entering the r-f stage acts to modulate the station carrier signal, just as a voice or music modulated the carrier at the broadcasting station. Then, after demodulation at the detector, the hum voltage appears at the a-f section and produces hum at the loudspeaker. This type of hum appears only when a station is tuned in and is known as *modulation hum*, or *tunable hum*.

Locating the Defective Section. Reasoning from the type of hum being produced in the receiver, you can immediately isolate the defective section of the receiver. Tune it to an off-station position and turn the volume control down to a low level. If excessive hum is heard, the defect lies in the power supply or the a-f section. Swing the tuning dial through its range. The location of the defect is verified by the fact that the hum is heard continuously.

If no hum is heard, turn up the volume control and tune to a station. Any hum now heard is modulation hum, and a defect in the r-f section of the receiver is indicated. Swing the receiver tuning dial through its range. The location is confirmed by the fact that the hum disappears between stations and reappears at on-station positions. It is advisable to swing the tuning dial through its range in order to avoid being mislead by one poor broadcasting station whose signal received some hum modulation at the station, a condition which you cannot control.

Locating the Defective Component in the Power Supply. Assume that you have a receiver with continuous hum over the entire range of the tuning dial. Since the power-supply section is the most likely cause of this condition, we will analyze the power supply of an a-c receiver for possible specific causes.

Power-supply-circuit Review. Figure 5-1 is the schematic circuit of an a-c power supply. It is composed of a power transformer which has several secondary windings. One steps down the voltage for the rectifier filament. Another secondary steps the voltage up so as to apply about 300 volts on each rectifier plate. The third secondary steps the voltage down to that required by the heaters of the other tubes. Condensers *C*-1 and *C*-2 and filter choke *L*-1 make up the filter circuit to smooth out the rectifier output. Choke *L*-1 is often the speaker field. Resistors *R*-1 and *R*-2 are the voltage divider as well as a bleeder. Condenser *C*-3 is the line filter condenser.

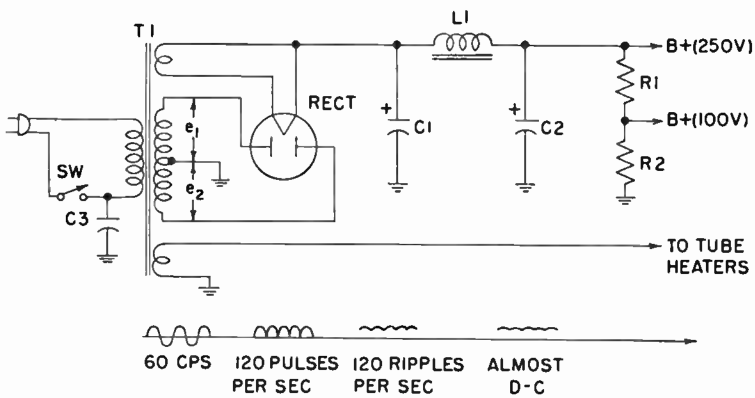


Fig. 5-1. A typical a-c power supply with accompanying waveforms

Beneath the schematic diagram are the waveforms of the B supply. In the secondary is a 60-cycle alternating current which is fed to the rectifier plates. The rectifier is a full-wave rectifier whose output is a direct current pulsing at a rate of 120 times a second. Condenser *C*-1 serves to peak the output voltage. It discharges into the filter choke a direct current rippling at a 120 ripples per second. Choke *L*-1 and condenser *C*-2 make up the final smoothing filter section. Condenser *C*-2 discharges almost pure direct current into the voltage divider. The small amount of ripple (120 ripples per second) left is negligible and accounts for the constant presence of tolerable hum even in a normal receiver.

Suspect the Filter Section First. The greatest possibility for hum, as may be seen from the waveforms, lies in the filter section. For then a voltage rippling at 120 per second would feed onto the tube and produce hum. And in the filter section, the most frequent cause of hum is either the output or input filter condenser C-1 and C-2. These condensers are electrolytic condensers and may undergo several changes. They may lose some of their electrolyte with age and drop in capacity. Any such condenser with a white salt creeping out of its edge should be suspected of this condition.

A filter condenser may develop excess leakage. For condenser C-2, this will make it draw too much direct current through choke L-1, thereby reducing its inductance and its ability to smooth out the ripples. If the condensers open, they will not function to smooth out the ripples at all. If any of these three changes occurs in the condensers, receiver hum will be excessive.

Testing Filter Condensers. The best way to test for these conditions is to obtain a good condenser of about the same capacitance and with at least the same working voltage of the original one. Shunt this good condenser across the terminals of the old condenser. Be sure to observe proper polarity with the good electrolytic condenser, lest you ruin it. If the hum disappears or drops in volume, you know the output filter condenser is defective and must be replaced with a new one.

A convenient device for shunting a condenser across a suspected one is that shown in Fig. 5-2. Two Fahnestock clips are mounted on a wooden

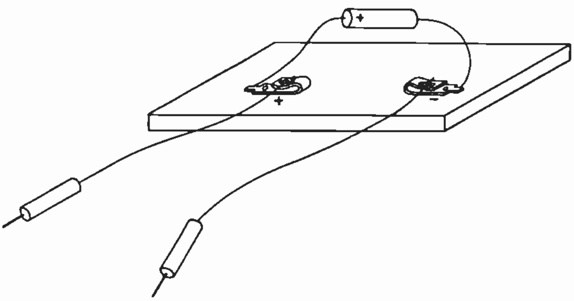


Fig. 5-2. A convenient device for shunting a condenser

board. Paint a + near one and a — near the other. Connect a good condenser across the clips, + to + and — to —. Then place two test leads under the clips and proceed with the shunting technique. It is a good idea to have several such Fahnestock clip boards around for similar purposes. A good all-round filter condenser useful for shunting in practically all receivers is a 20-mfd/450-volt electrolytic condenser. Of course, the + side goes to the + clip and the — terminal goes to the — clip.

Practical Suggestions. Where excessive leakage exists in the output filter condenser, the hum level may not decrease appreciably by this shunting technique. When this condition is suspected, as when the condenser operates too warm, open one lead of the condenser and place the good condenser temporarily in its place.

Sometimes, when the output filter condenser is shunted with a good one, hum will still be present but at a lower level. You should then suspect the input filter condenser *C*-1 as well. By means of test leads with alligator clips, shunt the input filter condenser similarly. If the condition is as suspected, hum should drop to its tolerable level.

Input filter condenser *C*-1 may lose capacity, develop excess leakage, or open and result in hum. But since its prime function is to maintain peak rectifier output voltage, B-plus voltage will be dropped to a low level and receiver output will be weak. Therefore, when you find hum plus a weak receiver output, check the input filter condenser. Shunt it, or substitute a good new condenser of similar capacity and working voltage to what you had previously.

Filter Blocks. Input filter condenser *C*-1 and output filter condenser *C*-2 are often in one can or block. Leakage may develop between these two condensers, with the result that the inductance of choke *L*-1 drops and hum level rises. The condition is not readily checked. Where you suspect that condition, open one lead in each of the condensers and substitute new ones to see if hum level drops to a tolerable level. Then the entire block is replaced.

As a practical suggestion, it is advisable to replace the entire block if one of the filter condensers becomes defective. This procedure is recommended because of space limitations in a receiver rather than other requirements. If space permits, you may only replace the defective component of the condenser block.

Filter Choke. On rare occasions, some of the turns of the filter choke may short and lower its inductance. Hum level would then rise. When the filter choke is the loudspeaker field coil, it should have a resistance of 1,000 to 2,000 ohms when good. You can best check it for a short with a substitute speaker of the same type. If bad, it may be necessary to replace the entire loudspeaker. Mounting details, wattage rating, resistance, and voice-coil impedance must be taken into consideration in the replacement loudspeaker.

Vibrating Laminations. There is another type of hum which may occur in power supplies which is not electrical in nature but purely mechanical.

Power transformer or filter chokes have iron cores made up of many laminations of iron. Sometimes the bolt holding them together loosens, and the plates in turn become loose. Then eddy currents flowing through the laminations as a result of the current through the coils cause the laminations to vibrate and emit a hum even when no station is tuned in. The sound is distinctly a mechanical one and is readily identified. Try tightening the holding bolts.

Locating Defective A-F Stage. Hum introduced into the a-f section of a receiver would result in hum over the entire tuning range of the receiver. If the power supply has been found to be perfect, then turn at once to the a-f section of the receiver and isolate the defective stage.

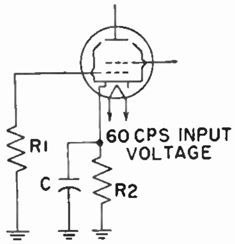


Fig. 5-3. A typical cathode-type tube circuit

What can cause hum to be introduced into an a-f stage? In most cases, it will be cathode-heater leakage. Figure 5-3 shows a typical cathode-type tube circuit. Resistor *R*-2 is the self-bias resistor. It furnishes the d-c voltage difference between the signal grid and cathode (grid bias).

Assume now that the cathode comes in contact with the ungrounded end of the heater. Heater current now has two paths to ground. One is through the heater and the other is through the cathode and self-bias resistor *R*-2. Since heater current is 60-cycle alternating current, this alternating current will appear across the self-bias resistor and hence make the grid receive a 60-cycle a-c voltage with respect to cathode. Then if filter condenser *C* is incapable of bypassing this a-c hum-producing voltage or if the tube has high amplification, the hum voltage will be amplified and the receiver will hum.

If the cathode comes in contact with the grounded end of the heater, heater current will not pass through resistor *R*-2 and hum will not result. Of course, this would ground the cathode and cause distortion or oscillation. The amount of hum would depend on whether there was direct cathode-heater contact or considerable leakage between the two.

Checking Cathode-heater Leakage. The simplest procedure for checking for cathode-heater leakage in an a-f tube is by means of a tube checker or by replacement with a new tube. Since both a defect in the a-f section as well as a defect in the power supply could cause hum over the receiver tuning range, check the a-f tubes and the rectifier tube at the start before proceeding further. If the tubes are all right, then proceed with the check on the power supply. If the power supply checks normal, then begin the systematic isolation of the defective a-f stage.

Hum-isolating Technique. The technique involved in determining the defective stage is that of interrupting the signal chain, beginning at the loudspeaker and working back to the volume control. As we move back from one point of interruption to the next, the first point where the hum comes in indicates a defect between this point and the last one tested. Figure 5-4 shows this technique in block form.

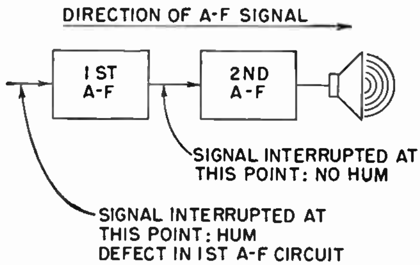


Fig. 5-4. Locating a defective stage in the audio section

Now turn to an actual schematic diagram of the audio section of an a-c receiver. Figure 5-5 shows such an audio section. Since the heater of a-c receivers are connected in parallel, you may remove any tube without af-

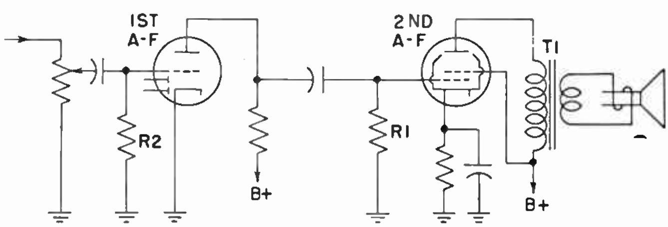


Fig. 5-5. The audio section of a receiver

fecting the heater supply to other tubes. Therefore, remove the second a-f tube from its socket. This blocks the a-f signal chain at the signal grid pin of the tube just removed. If hum is still heard, it is entering the signal circuit somewhere between the plate pin of the second a-f tube and the loudspeaker.

If the hum stops when the second a-f tube is removed, it is entering somewhere ahead of this output tube. Therefore, reinsert the second a-f tube and remove the first a-f tube from its socket. This step halts the a-f signal chain at the signal grid of the first a-f tube. Any hum now heard is entering somewhere between the plate pin of the first a-f tube and the second a-f amplifier stage. Poor tube pin contacts are also such a defect.

If no hum is heard, then the hum voltage is obviously entering between the input of the a-f section and first a-f stage. Thus by means of a signal-chain-blocking technique, you can isolate a particular defective stage or circuit.

Isolating Defective Component in A-F Stage. Let us examine how a hum voltage of excessive proportions enters an a-f stage. You have already found that cathode-heater leakage is one of the most prevalent causes. Here you merely check the tube in a tube checker or replace it with one known to be good. The simplicity of this step always makes it a first step.

Loudspeaker Hum-bucking Coil. Various other defects in the a-f section may result in hum. For example, many electrodynamic loudspeakers have a small stationary hum-bucking coil connected in series with the voice coil but mounted on the center pole piece of the loudspeaker. Any ripple voltage from the field coil normally induces some hum voltage in the voice coil. But if the hum-bucking coil is connected in opposite phase to the voice coil, the former will have induced in it the same hum voltage but in such phase as to cancel out that in the voice coil, and receiver hum will be minimized. If a previous serviceman replaced the voice coil and cone of the loudspeaker, he may have placed the voice coil in the same phase as the hum-bucking coil. The result would be loud hum. The remedy is simple: Merely reverse the connections of the voice coil.

Another source of hum may be an open grid circuit. An open grid circuit makes a tube more sensitive. It is thereby more subject to pickup of hum voltages by induction. Distortion of the signal would probably accompany this type of hum.

Induced Hum Voltages. Hum voltage may be induced into the a-f section in other ways. For example, a customer may have folded his long power-line cord and placed it in the back of the cabinet near a circuit which picks up the 60-cycle current in the cord. Or the metal shielding around a tube or around a lead may have been removed, and hum voltages are picked up by signal circuits. Sometimes a shield fails to make good contact with ground. When this condition occurs, the shield picks up hum voltages and then in turn induces them into the signal circuits which they were intended to shield. Receiver hum then becomes excessive.

Hum-producing Defects in Wiring. Sometimes, as a result of previous service work, lead dress has been disturbed—particularly in the region of the first a-f tube. Volume control leads and first a-f tube grid leads should all be short and dressed close to the chassis, away from wiring that carries 60-cycle current. Where this condition exists, try redressing leads carefully around the offending stage.

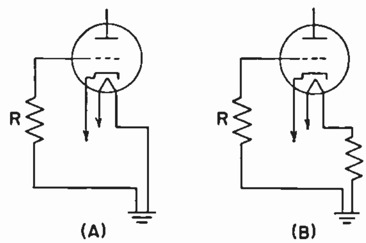


Fig. 5-6. A source of hum resulting from poor electrical contact

In some instances, a poor connection may result in hum. For example, take the circuit shown in Fig. 5-6. Circuit *A* shows the grid return and the heater connected to a common ground point. If this ground connection corrodes and forms a high-resistance contact, it behaves as in circuit *B*, where a high-resistance *R*-1 has been added in series with the heater. The heater current flowing through contact resistance *R*-1 will produce a 60-cycle a-c drop across the resistor, and this a-c voltage will in turn be fed to the grid of the tube whose return goes to the same ground point. Receiver hum results. Be sure to check all connections in a defective stage.

Other Causes of Hum. In some receivers with filament-type tubes using center-tap filament resistors, hum may develop if half of the resistor opens. This is illustrated in Fig. 5-7. If one half of the resistor opens, the grid return will be connected to one end of the heater rather than to the midpoint. This condition feeds 60-cycle alternating current into the grid, and hum results.

The volume control may also be defective and cause hum. If you can vary the loudness of the hum by rotating the volume control arm, the defect may be in the control or in its leads.

Another cause for hum may be an open cathode bypass condenser. Further, in a push-pull stage, tubes that are not balanced and do not have equal emission may result in hum. The best check is to substitute new tubes in the push-pull stage to note the effect. And finally, a replacement component like a transformer or choke may, because of insufficient shielding or because of placement, result in inducing hum in signal circuits. Altering the position of mounting of these components may eliminate the hum.

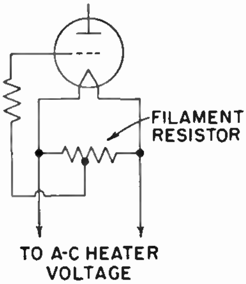


Fig. 5-7. A source of hum in a center-tap heater filament tube

The defects just described account for hum voltages getting into the a-f section of the receiver and for receiver hum over the entire tuning range of the receiver. Now let us examine the causes of modulation hum. Here, hum voltages are induced into the r-f section of the receiver.

Locating the Defective R-F Stage. The symptom of modulation hum itself limits the defect primarily to the r-f section of the receiver. The job immediately becomes that of isolating the defective stage. This task may be readily performed with a signal generator and an output meter. The technique consists essentially of feeding an *unmodulated* signal into the input of each stage, beginning with the second detector and working back toward the antenna. When the input of the defective stage is reached, the hum voltage will modulate the unmodulated signal from the signal generator and the hum will be heard. The defect then lies between the input of the defective stage and the input of the stage just previously checked.

Isolating Modulation Hum. Figure 5-8 shows the r-f section of a receiver. Let us isolate the defective stage for hum. Connect your output meter across the primary of the output transformer as in stage-gain measurements. At all times, the attenuator of the signal generator should be adjusted to give an output of about 25 volts. This precaution is necessary in order to avoid overloading any stage by too strong a signal.

Now set the signal generator to produce a modulated signal at the intermediate frequency of the receiver. Feed the signal through a 0.1-mfd con-

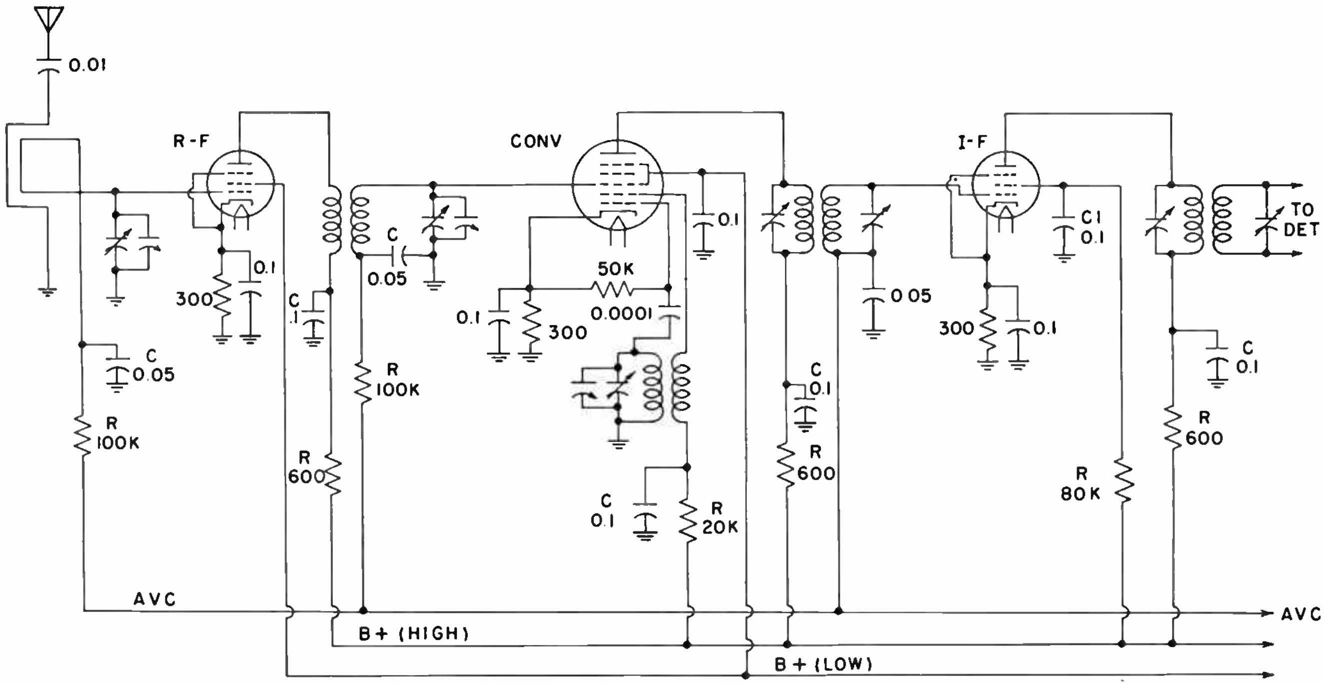


Fig. 5-8. The r-f, or front, section of a receiver, showing capacitors that can cause hum if open

denser to the plate of the i-f amplifier. Tune the receiver to a non-station position. The generator modulation note should be heard from the loudspeaker. Switch now to an *unmodulated* note at the intermediate frequency. If hum is now heard from the loudspeaker, the defect lies in the circuit between the plate of the i-f amplifier and the volume control.

If hum is not heard, retain the receiver at the same non-station position and the signal generator at the intermediate frequency. Feed an unmodulated signal into the plate of the converter tube. If you hear hum, the defect lies in the circuit between this test point and the plate of the i-f tube.

If you still hear no hum, set the signal-generator frequency control at the same non-station position as the receiver. Feed an *unmodulated* signal at this frequency into the plate of the r-f tube. If hum is heard now, the defect lies in the circuit between this test point of the receiver and the converter plate. If hum is not heard from the loudspeaker, the defect lies in the circuit between the antenna and the r-f amplifier plate.

Isolating the Defective Component. What defective conditions within the r-f section can result in modulation hum? The primary cause of hum in the r-f section is once again cathode-heater leakage. Therefore, the first task is to test the tubes in a tube checker or to replace each with one known to be in good condition.

Other conditions similar to those which caused hum in the a-f section may cause hum in the r-f section. Such conditions are open grid circuits, high-resistance contacts, poor lead dress, poor shielding provisions, and pickup of hum voltages by signal circuits by inductive means.

Decoupling-filter Troubles. One additional means of hum pickup is related to decoupling circuits. In Fig. 5-8, all the resistor-condenser combinations marked *R* and *C* make up decoupling filters in the grid and plate circuits.

The plate decouplers prevent any hum voltage from getting into the plate circuit from the power supply. However, if condensers *C* in these decoupler filters open, hum voltage may enter the plate circuit and be handed along the signal chain to produce modulation hum. A similar result may occur if the condenser *C* opens in a grid decoupling filter. Occasionally, these conditions are accompanied by motorboating—a put-put type of sound from the receiver.

Antenna-system Troubles. Poor antenna and ground connections may also cause modulation hum. The cure is to check antenna and ground connections, both at the receiver and outside the receiver for firm, good contacts. Sometimes it is necessary to prevent pickup from the power lines by grounding each line of the power line through condensers installed in the receiver. These condensers may be 0.1-mfd/400-volt condensers. If such condensers are already present, check to see that they have not opened.

Hum may also be picked up by an antenna running close to a power line. It is advisable in such a case to reconstruct the antenna as far as possible from the power lines and, if possible, at right angles to, rather than parallel to, the power lines.

Open Screen Bypass Condenser. Another condition may cause hum to result in a receiver. If a defect develops in the bias system of a tube, it may become extremely receptive to hum voltages, especially if the tube becomes overbiased. A thorough check should be made of the bias system of the tube involved. A screen voltage that has become too low may cause a similar condition with hum resulting. Check screen voltage with a voltmeter. If it is too low, check the power-supply source and the screen bypass condenser, marked C-1 in Fig. 5-8, for a leakage which would produce low screen voltage.

You now have a complete hum-localizing procedure. It was presented for the superheterodyne receiver. The same techniques, however, apply to a trf receiver as well. Just be sure to use proper frequencies when injecting signals with the signal generator.

Hum in A-C/D-C Receiver. The a-c/d-c receiver may develop constant hum or modulation hum for the same reasons that these defects develop in the a-c receiver. However, design differences in some cases make a slightly different technique necessary.

Circuit knowledge is just as applicable in the a-c/d-c receiver as in the a-c receiver. Hum heard over the entire tuning range of the receiver results from a defect in the power supply or the a-f section. Modulation hum results from a defect in the r-f section of the receiver. These clues should immediately center your attention on the proper sections for analysis.

After the proper sections are localized for investigation, the localization of the defective stage, or circuit, is next sought. It is primarily in this step that the technique varies slightly. Thereafter, the localization of defective components is similar.

Locating Defective Stage for Constant Hum. Constant hum from the receiver over its entire tuning range can only be due to a defect in the power supply or in the a-f section. Since tubes are the easiest to check and are the second most frequent cause of hum, the rectifier and a-f tubes should be checked first in a tube checker or by substitution of good tubes. If the tubes are in good condition, turn to the power supply for investigation.

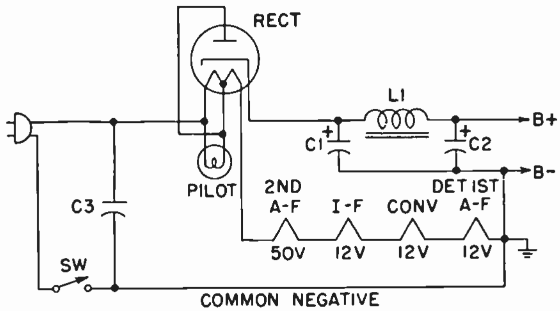


Fig. 5-9. A typical a-c/d-c power supply

Figure 5-9 shows a typical a-c/d-c power supply. The most likely defect in the power supply is a defective output filter condenser C-2. In review, the other possible defects may be listed as follows:

Defective input filter condenser C-1.
Leakage between condensers in a condenser block.
Short in the filter choke *L*-1 (usually speaker field coil, normally about 450 ohms).

If the cause of hum is not disclosed by a defective tube or by a defect in the power supply, then you must proceed with a systematic stage-isolation technique in the a-f section. A signal-chain-interruption technique is used once again. But it cannot be done in the same manner as with the a-c receiver where the a-f tubes were removed, one at a time. In the a-c/d-c receiver, tube heaters are in series (see Fig. 5-9), and removal of one would cut off the heater supply from all. Therefore, the signal chain must be interrupted with the tubes in their sockets and with receiver power turned on. This may be done by shorting out the signal at various test points through a 1- or 2-mfd/600-volt condenser.

Refer to Fig. 5-5, which might also be the a-f section of an a-c/d-c receiver. Turn on the receiver and hear the hum. Place the shorting condenser across the primary of the output transformer *T*-1. If hum is still heard, the defect lies between the output transformer and the loudspeaker. If hum is not heard, place the shorting condenser across the grid resistor *R*-1 of the second a-f tube, thereby blocking the signal chain at that point. If hum is heard, the defect lies between the grid of the second a-f tube and the output transformer. If hum is not heard, place the shorting condenser across grid resistor *R*-2 of the first a-f tube. If hum is heard, the defect lies between the grid of the first a-f tube and the grid of the second a-f tube. If hum is not heard, the defect lies between the volume control and the grid of the first a-f tube. In this manner, the defective stage may easily be found.

Isolating Defective Stage for Modulation Hum. As in the a-c receiver, modulation hum in the a-c/d-c receiver indicates a defect in the r-f section of the receiver. The technique for isolating the defective stage in this section is identical with that used on the a-c receiver r-f section. Thereafter, isolating the defective component is similar to that used with a-c receivers.

Isolating Defective Component in A-F and R-F Sections. The same conditions that cause hum originating in a-f and r-f sections in a-c receivers cause hum in a-c/d-c receivers, and are checked in the same manner. By way of review, general hum originating in the a-f sections may be caused by the following defects:

Cathode-heater leakage.
Reversed hum-bucking coil.
Open grid circuit.
Induced hum voltages.
Open shields.
Poor lead dress.
Poor contacts.
Open center-tap filament resistor.
Defective volume control.
Placement of new transformers and chokes.
Unbalanced push-pull stage.

Cathode-heater leakage is a fairly common occurrence in a-c/d-c receivers, particularly in second a-f amplifier tubes. The greater the heater voltage, the greater the possibility of hum resulting from cathode-heater leakage.

In the typical heater string of Fig. 5-9, the left side of the detector-first a-f tube heater is 12 volts above B-minus, or ground; the left side of the converter tube heater is 24 volts above ground; the left side of the i-f tube heater is 36 volts above ground; and the left side of the second a-f tube heater is 86 volts above ground. Obviously the second a-f will receive the largest magnitude of hum voltage resulting from cathode-heater leakage, the i-f amplifier the next highest hum voltage, the converter the next highest hum voltage, and the detector-first a-f tube the least. The order of connecting the heaters in the string is a design factor because hum voltage resulting from cathode-heater leakage is most devastating in the detector-first a-f tube, then in the converter, and least offensive in the second a-f tube.

Causes of Modulation Hum. And now, by way of review, the defects that may result in modulation hum resulting from the entering of hum voltages into signal circuits in the r-f section are listed below:

Cathode-heater leakage.
Open grid circuits.
Poor contacts.
Poor lead dress.
Poor shielding provision.
Induced hum voltages.
Open decoupling filter condensers.
Poor antenna and ground connections.
Open line filter condenser (C-3 in Fig. 5-9).
Defective biasing voltages.
Pickup from nearby power lines.

These are the same defects as those found in a-c receivers and are checked in the same manner.

Hum in the Three-way Portable Receiver. Hum trouble in a three-way portable receiver is best analyzed with the power supply in mind. Figure 5-10 shows a typical power supply for such a receiver. Here, too, general

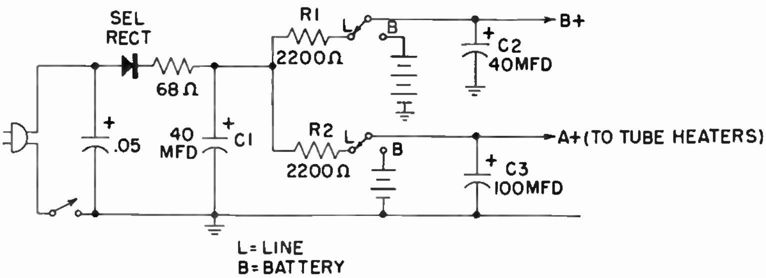


Fig. 5-10. A typical power supply for a three-way portable receiver

hum over the entire tuning range of the receiver indicates a defect in the power supply or the a-f section, and modulation hum indicates a defect in the r-f section.

The quickest means of determining if the defect is in the power supply when general hum exists is to switch the receiver from power line to the battery mode of operation. If the hum disappears, the defect is probably in the power supply. The power supply is then up for investigation.

Two filter circuits exist in the power supply for the power line mode of operation. The B-filter system is an R-C filter consisting of condensers C-1 and C-2 and resistor R-1. If these condensers lose capacity or develop excess leakage or open, or if resistor R-1 changes considerably in value, filtering will become inefficient and hum voltage will be fed to the tubes.

There is also the A-filter system consisting of condensers C-1 and C-3 and resistor R-2. If these become defective in a manner similar to the B filter, hum voltage is fed to the heater string, and receiver hum results. The test for the condensers is shunting with or substituting a new good condenser. The resistors may be checked with an ohmmeter.

Thereafter, if the power supply checks all right, the a-f section is examined for defective stage isolation in the same manner as the a-c/d-c receiver was handled. Similar defective conditions are to be checked in a defective stage.

Modulation hum should direct your attention to the r-f section. The signal-generator technique described under the a-c receiver section for locating the defective stage is equally applicable here. Once again similar defects in the defective stage should be sought.

Hum in Auto Receiver. The cause for hum in the auto receiver may be isolated in the same manner as was done for other types of receivers. But the type of power supply used here introduces a few new possibilities. Poor grounds and poor shielding are extremely annoying conditions resulting in hum. The components of the power supply and of the unit itself should be properly and completely shielded. The filter condensers filtering the leads to and from the power supply should be checked for opens or leakage. Thereafter localization of the defective component is as was previously described. It should be noted that hum in the auto receiver is of a higher frequency than that found in receivers fed from a 60-cycle source.

6

Squeals and Put-puts

Squeals and Put-puts. Here the customer will report to you that his receiver whistles or makes noise. This is useless as a clue to a defect. You will have to check the complaint carefully yourself and make your own observations of defective operation.

You will recognize the whistle as *squeal*, a high-pitched audio note from the loudspeaker. The squeal will not be mistaken for hum, because the former is a note of much higher pitch.

The noise will in this case be found to be a *put-put* sound, not unlike the sound of a small motorboat. It, too, is an audio-frequency note but of a frequency considerably lower than hum frequency.

At first, it would seem that you are dealing with two unrelated service problems, but both squeals and put-puts (often called motorboating) have common causes. They are both conditions within the receiver called *oscillation*, of undesirable type.

After having identified the nature of the receiver defect, you will have to verify the condition of squeal further for the manner in which it manifests itself. Does the receiver squeal all over the dial, on stations and between stations, whether volume is high or low? Does it squeal all over the dial, but only on stations? Does it squeal only at one end of the dial and only on stations? This complete verification of the customer's complaint will serve as the beginning of the localization procedure. Squeal appearing on only one station is a special type to be described later.

What Is Oscillation? In order to understand the innumerable ways in which undesirable oscillation might arise, it would be advisable to review the nature of oscillation. A mechanical analogy will make the point clear.

Suspend a pendulum by a string and draw it about one foot to a side of the center resting position. Then let it go. The pendulum will vibrate, or oscillate, back and forth, as shown in Fig. 6-1. The curves under the pendulum show the path of the pendulum bob as it swings back and forth with the passing of time. Note that the oscillation is slowly damped and the bob finally comes to rest.

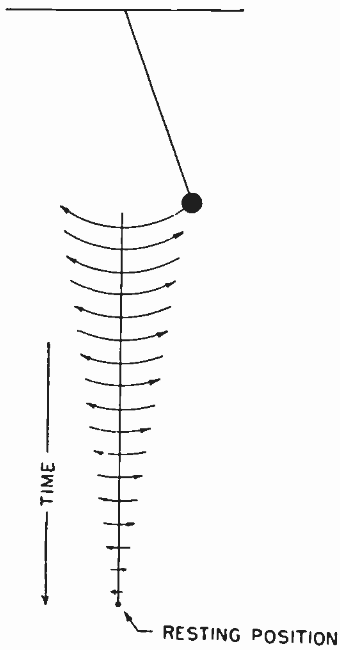


Fig. 6-1. The oscillating pendulum

What damped the oscillation? Losses within the pendulum system itself slowly robbed the bob of its energy and finally stopped it. These losses are the friction of the bob against the air and the friction within the string where it is attached at its support. Were it not for these losses, the bob would swing forever equally to each side of the center resting position.

Maintaining Oscillation. How might you sustain the oscillations? If at the instant the bob reached the top of the swing and was about to move in the opposite direction you tapped the bob slightly with your finger, the bob would swing equally in the opposite direction. And if you kept tapping the bob every time it reached the top of the swing, the bob would continue to oscillate with undiminished energy.

Three factors entered into the process of producing sustained oscillations: The first factor was the ability to get your finger at the bob. The second factor was your imparting of energy to the bob by means of your finger to overcome the losses that would dampen the oscillations. And the third factor was that you had to impart the energy from your finger at just the right instant. Had you tapped the bob before it reached the top of its swing, you would have stopped the oscillations rather than sustained them. Your finger is said to have been in phase with the swinging bob.

How Amplifier Circuits Oscillate. Amplifier circuits built around tubes are perfect setups for oscillation, because the characteristics which make them good amplifiers provide the conditions necessary for undesirable oscillation. Signals are passed down the signal chain of the receiver, constantly being amplified. If, because of some defective coupling path, some of the amplified signal is fed back to the input of a stage with sufficient energy to overcome losses in the input circuit and in proper phase, that stage will begin to oscillate, producing the squeal. In receivers, not only may undesirable coupling take place within a single stage, but an amplifier stage may couple with another stage earlier in the signal chain and cause the earlier stage to begin to oscillate.

Mechanical Causes of Oscillation—Microphonics. Oscillations within a receiver may result electrically as a result of some mechanical defect. Normally, loudspeakers are floated off the cabinet and the chassis by means of rubber suspensors. Similarly, a tuning gang condenser is floated on rubber. In time, the rubber may vitrify and become hard. Vibrations from the speaker may then be fed to the tuning gang, causing it to vibrate at an audio frequency with a resulting oscillation squeal. This condition will be more marked when the volume control is turned up high.

At other times, the elements of a tube may be slightly loose. A loud signal from the loudspeaker, or a jarring of the receiver, may set these elements vibrating, and the loudspeaker output will sustain the vibration. A loud howl is emitted by the loudspeaker. Such oscillations are often referred to as *microphonics*, about which more will be said later.

How Triodes Can Oscillate. Figure 6-2 shows a triode amplifier. The station signal in tuning circuit *L-C* is amplified in the tube and appears as a larger voltage across the plate load *L-1*. The plate and grid act as a small condenser shown as C_{gp}.

In a triode, this capacitance is large enough to feed a fairly large amount of the output signal back to the grid, particularly at high radio frequencies, and in proper phase. As a result, the tube is thrown into a state of undesirable oscillation. The higher the *Q* of the grid circuit, the greater the amount of voltage fed back to the grid circuit. Because of this factor, high-gain stages with high-Q tuned circuits have the greatest tendency to be thrown into undesirable oscillation.

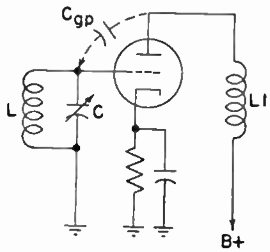


Fig. 6-2. A triode amplifier showing the grid-to-plate capacitance that can cause oscillation

Screen-grid Tubes. To overcome the grid-to-plate capacitance which provides a feedback path, the screen-grid type of tube (pentode and beam-power tubes) were designed. Thus, the 2A3 triode has a grid-to-plate capacitance of 16.5 mmfd, and the 50L6 beam-power tube has a grid-to-plate capacitance of 0.8 mmfd.

This reduction in grid-to-plate capacitance is accomplished by placing a grounded grid—the screen grid—between the signal grid and the plate. The screen grid cannot be grounded directly since, for proper operation, it must be operated at a positive d-c potential. It is therefore grounded, so far as the a-c signal is concerned, through a condenser which offers a low-impedance path to ground for the signal.

How Screen-grid Tubes Can Oscillate. Figure 6-3 shows a typical pentode-type tube circuit. Resistor *R*-1 drops the d-c screen potential to the proper level. Condenser *C*-1 is the screen bypass condenser which grounds the screen for the a-c signal. If this screen bypass condenser opens,

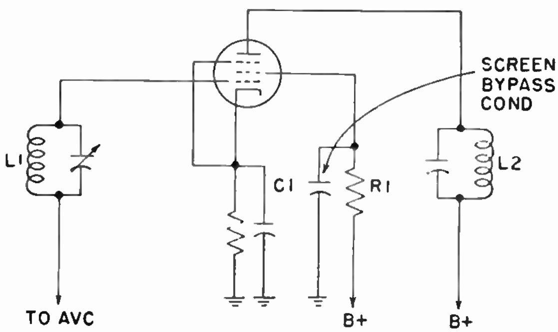


Fig. 6-3. A typical pentode circuit, showing the screen bypass condenser that can cause oscillation if open

the screen grid is no longer grounded for the signal. Feedback from the plate to grid circuit increases and undesirable oscillation begins.

Or, the plate circuit may feed energy back to the grid circuit *outside* the tube and result in oscillation. If the leads going to the plate pin and the grid pin are close, such undesirable coupling may take place. To minimize this possibility, the grid and plate leads should be as short as possible and dressed to be as far apart as possible. Further to prevent external circuits from coupling with electrodes within the tube, the tube itself may have a grounded metal shield around it or be a metal tube whose grounded shell acts as a shield.

Sometimes, magnetic coupling takes place outside the tube, and undesirable oscillation results. Thus, in Fig. 6-3, coil *L*-2 may couple magnetically with coil *L*-1. To prevent this possibility, the coils are placed within grounded metal shields.

Coupling between Separate Stages. In radio receivers, you must not only be concerned about coupling within each individual stage, but you

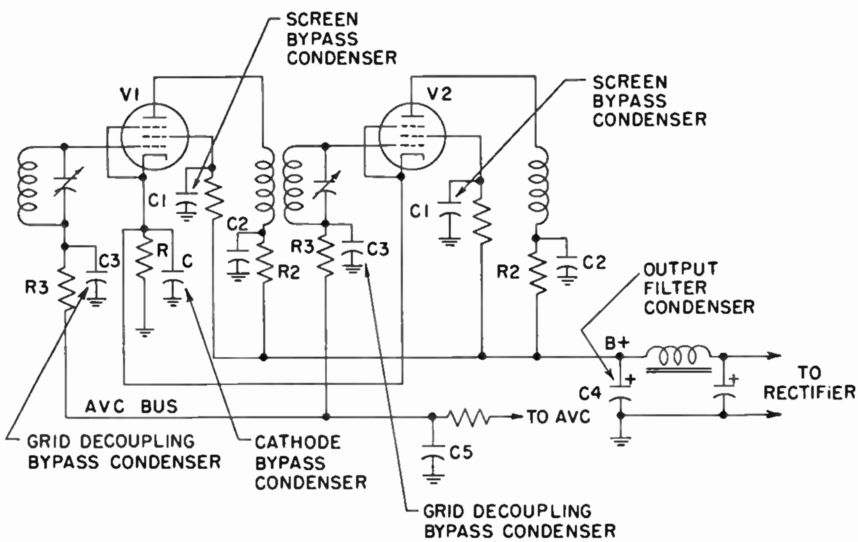


Fig. 6-4. A two-stage circuit showing decoupling and bypass condensers that can cause oscillation if open

must also take into account over-all coupling between stages. Take, for example, the two-stage circuit in Fig. 6-4. The possibility of oscillation resulting from open screen-grid bypass condensers C-1 was just mentioned. There are other possibilities.

Feedback may occur between two stages where there is a common component in which coupling takes place. The normal procedure for eliminating coupling through the common component is to bypass the signal to ground around the component by means of a condenser.

Note that the self-bias resistor *R* is common to the cathode circuit of both tubes V-1 and V-2. The two stages are decoupled by means of cathode bypass condenser *C*. Should this condenser open, signal current flowing in the plate circuit of tube V-2 would flow through self-bias resistor *R*, and would produce a signal voltage drop across it. This, in turn, would feed to the grid of tube V-1. The feedback would be in phase and produce oscillation.

Decoupling-condenser Troubles. Similarly, there is a possibility for coupling in common output filter condenser *C*-4. Signal current in the plate circuits of tubes V-1 and V-2 both pass to ground through the output filter condenser *C*-4, which is common to both circuits. A voltage drop takes place across this electrolytic condenser. Particularly for r-f currents, electrolytic condensers are poor as r-f bypass condensers. Since plate current also passes through the self-bias resistor, the voltage developed across *C*-4 will be fed to the cathode and then in turn to the signal grid of tube V-1. If this feedback voltage is in proper phase, oscillation results.

To overcome this possibility, a plate decoupling filter is placed in either or both plate circuits. These are shown as resistors *R*-2 and condensers *C*-2. The path for the signal current is now through bypass condenser *C*-2, a paper condenser, to ground without going through the common component *C*-4. Of course, should plate decoupling bypass condenser *C*-2 open, condenser *C*-4 again becomes the common component and undesirable oscillation might result.

Bypass-condenser Troubles. A similar possibility of coupling exists as a result of a common component *C*-5 in the avc supply. For both tubes V-1 and V-2, the grids return to ground through condenser *C*-5, in which coupling may develop. To eliminate this possibility, decoupling filters, made up of resistors *R*-3 and condensers *C*-3, are placed in the grid circuit of either or both tubes. Signal path to ground in the grid circuits is through bypass condensers *C*-3, thereby decoupling the grid circuits. Should the grid decoupling bypass condenser open, condenser *C*-5 again becomes a common component, and undesirable oscillation might result.

Another bypass condenser may be responsible for oscillation. Take the audio-output stage shown in Fig. 6-5 as an example. Plate output bypass condenser *C*-1 tends to keep the second a-f tube from oscillating as an r-f oscillator. Distributed inductances and capacitances in the plate and grid circuits of the stage simulate resonant circuits which could maintain r-f oscillations. Condenser C-1 bypasses these r-f currents to ground. But if the condenser opens, oscillation could follow. Sometimes, this oscillation results in distortion or a rushing type of noise. In such condition, operating voltages drop and the output tube overheats.

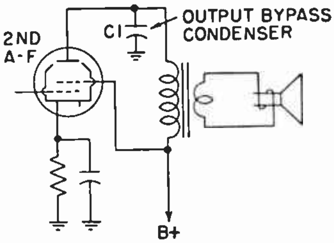


Fig. 6-5. An audio-output stage, showing the output bypass condenser that can cause oscillation

Lead and Contact Troubles. Coupling between stages may also develop as a result of poor lead dress, particularly if the receiver was serviced recently. Two leads may have been moved so as to couple signal energy from one to the other. Or, poor shield contacts may make shields ineffective and permit coupling.

A peculiar condition of poor contact might couple two stages and result in oscillation. The wiper contact of a tuning gang condenser connects the rotor shaft to the condenser frame, which is in turn grounded. If one of these wipers becomes defective, because of dust or corrosion under it, it will fail to ground its section of the tuning gang. This poor contact will force signal current to flow along the rotor shaft and through another wiper to ground. As a result, the two sections are coupled, and undesirable oscillation may develop.

Oscillation as a Result of Stage Instability. Instability in a stage may also result in oscillation squeal. When the grid bias of a tube is decreased, the mutual conductance of the tube increases, and the tube becomes more subject to oscillation. Similarly, if for one reason or another the plate and screen voltages become higher than normal, the tube may oscillate.

Another condition that might cause instability in an amplifier and result in oscillation is improper alignment. Examine the i-f amplifier in Fig. 6-6. The tuned primary of input transformer T-1 loads the tuned secondary, and similarly, the tuned secondary of output transformer T-2 loads its tuned primary. If the primary of T-1 is misaligned, it loads its secondary to a lesser degree and the Q of the secondary rises. As a result, a small feedback will develop a large voltage across it, and oscillation may follow. Similarly, if the secondary of the output transformer is misaligned, the Q of the primary rises. This condition contributes to the tube instability.

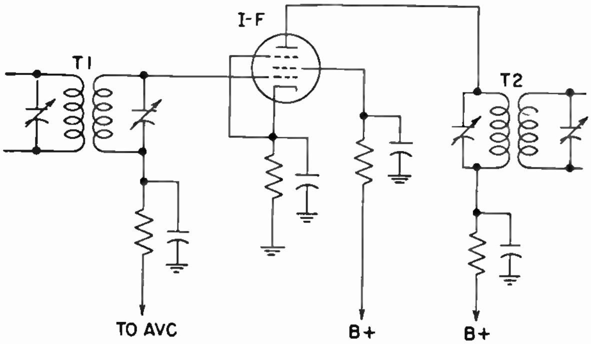


Fig. 6-6. A typical i-f amplifier stage, in which improper alignment can cause oscillation

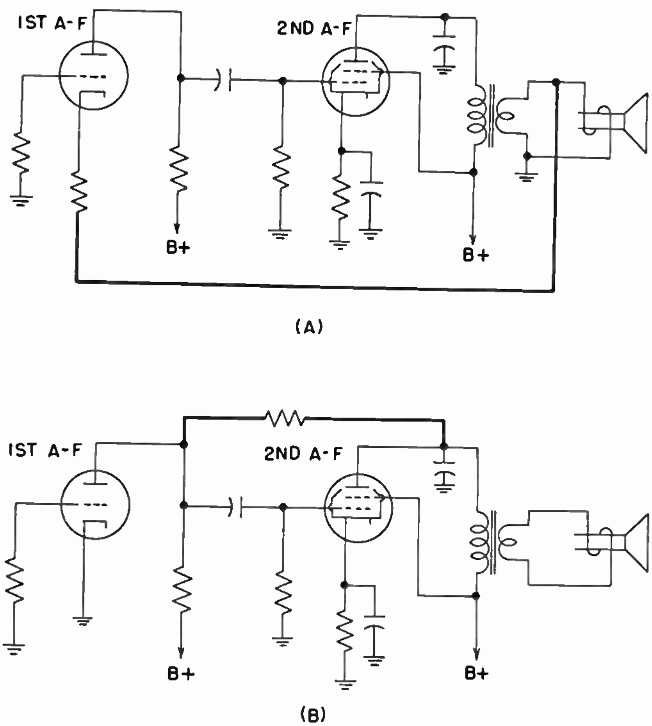


Fig. 6-7. Two types of inverse feedback circuits

Inverse Feedback and Oscillation. Inverse feedback is the converse of regeneration which results in oscillation. In regeneration, signal voltage feeds back in phase with an earlier circuit. In inverse feedback, some signal voltage is deliberately fed back to an earlier stage, *out of phase*, to produce a degenerative effect. In audio stages, inverse feedback provides improved over-all audio fidelity.

Figure 6-7 shows two inverse feedback circuits. The feedback paths are shown in heavy lines. Circuit B is not readily subject to oscillation. But circuit A may cause undesirable oscillation. For example, if in previous service work the output transformer was replaced and the new output transformer was connected with its leads reversed, a regenerative voltage rather than a degenerative one would be fed back, and the audio amplifier would begin to oscillate. Normally, this would have been noticed as soon as the replacement was completed. If you discover such a condition, you must reverse the transformer primary winding leads.

Put-puts or Motorboating. Motorboating results from a low-frequency regenerative feedback and usually is characteristic of a-f circuits. Take, for example, the two audio stages shown in Fig. 6-8. The signal current path from the plate circuit of the second a-f tube is from the plate, through the primary of the output transformer *L*-1, and through output filter condenser C-1 to ground.

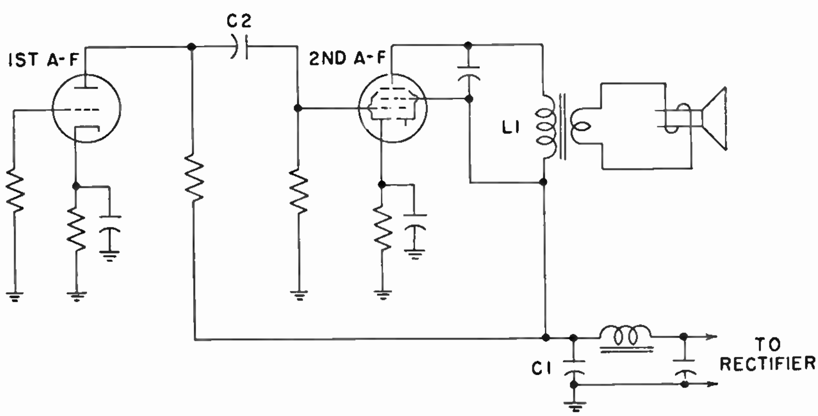


Fig. 6-8. A typical audio-frequency section

If condenser C-1 opens or loses capacity, a fairly large signal voltage will be developed across it which will be fed to the plate of the first a-f tube. From here, the feedback voltage will feed through coupling condenser C-2 to the grid of the second a-f tube and set up the motorboating type of oscillation.

To minimize this possibility, a plate decoupling filter is placed in the plate circuit of the first a-f tube. Thereafter, if the plate decoupling bypass condenser opens, motorboating results. Increased hum would accompany these defects.

An open grid circuit is another possible cause for motorboating. The open grid circuit would remove grid bias and increase the mutual conductance of the tube, making it more susceptible to oscillation.

Locating the Defective Section. The defective section can often be located by the manner in which the oscillation manifests itself. If the oscillation occurs on and off stations all over the receiver tuning dial, even when volume is turned down, the defect probably is in the a-f section. If the oscillation ceases as you reduce the receiver volume, check the i-f stages and the volume control. The volume control is at the input of the a-f section. Therefore, if it can stop oscillation, the defect is before the volume control.

If the oscillations are tunable (come in on all stations), the probability of location is in the i-f stage, although the r-f stages are not above suspicion. But if the oscillations come in only at stations primarily at one end of the tuning range of the receiver, the location is probably in the r-f section.

Do not waste too much time trying to localize the section. When you have doubts about the section, begin at once on the systematic procedure for localizing the oscillating stage, and then find the defective condition. Of course, this latter procedure in itself is not too simple a matter because several stages may be acting together to produce the undesirable effect. But a planned approach in any case will be timesaving.

Localizing the Oscillating Stage. There are several ways of approaching the problem of localizing the oscillating stage that is producing the squeal. Some are effective in most cases; others frequently fail in the job of localization.

One approach to the problem is that of holding the hand near each tube in turn while the receiver is producing squeal. Hand capacitance, when close to the oscillating tube, may upset the delicate balance and cause oscillation to cease or the pitch of the oscillation squeal to change. But foolproof results cannot be counted on with this measure.

Another approach to the problem is that of introducing losses into the grid circuit of a tube believed to be oscillating and thereby causing oscillations to cease. Hold one terminal of a 10,000-ohm resistor or a 0.1-mfd condenser and touch the grid terminals of the tubes with the other terminal. When oscillation squeal ceases, you have reached the oscillating stage. However, a strong feedback voltage may override the losses introduced, and oscillation continues.

Still another approach to the problem depends on the fact that an oscillating tube draws grid current. As a result, a voltage drop develops across the signal grid-load resistor. If, when measured with a voltmeter of high sensitivity, the voltage drop across this grid-load resistor is 1 volt or more, you may assume that the stage is oscillating.

Signal-interrupting Technique. Standard techniques for isolating oscillation include the technique of interrupting the signal chain, or using a signal generator.

In the signal chain interruption method, the technique employed is similar to that used with hum localization. For a-c receivers, begin at the power output tube and proceed to remove one tube at a time moving toward the antenna, replacing each after the check. When you reach a stage where removal of a tube fails to prevent oscillation, then you know that the next stage toward the loudspeaker is oscillating. Figure 6-9 is a block diagram illustrating this method.

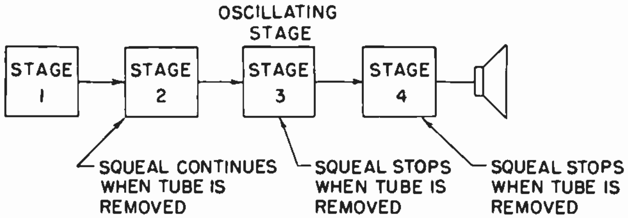


Fig. 6-9. A method for locating an oscillating stage

Since you may not remove a tube in an a-c/d-c receiver without making the entire receiver inoperative, you must interrupt the signal chain by making a stage inoperative in another manner. For such receivers where heaters are in series, connecting a 0.5-mfd condenser from grid to chassis or common negative will make the one stage inoperative, while permitting the others to function. Then the same procedure and analysis is made as for the a-c receiver. Block each stage in turn, moving from the loudspeaker to the antenna. When one stage fails to stop the oscillation squeal, you know that the next stage toward the loudspeaker is oscillating.

Stage Isolation with a Signal Generator. The signal generator may be best used in localizing an oscillating stage where the oscillation is tunable, that is, the squeal is heard only when a station is tuned in. Connect the ground lead of the generator to the chassis of the receiver. Tune the receiver to an off-station position, and tune the signal generator to a modulated frequency, the same as that of the receiver. Connect the hot lead of the generator through an appropriate condenser to the antenna post of the receiver. (For a loop-antenna receiver, make connections the same as for alignment.)

You should hear the generator modulation note plus the oscillation squeal from the loudspeaker. Switch the generator so that modulation is removed. You now hear only the oscillation squeal from the loudspeaker. Now move the hot lead from signal grid to signal grid of each tube, moving toward the loudspeaker. Of course, at the grid of the i-f stage, you must retune the signal generator to the intermediate frequency of the receiver.

At the grid of the first a-f tube, you adjust the signal generator for an a-f output, although tunable oscillation is usually an r-f section condition. The a-f check may be omitted here.

The procedure is carried on until the oscillation squeal fails to be heard. You know then that the trouble is in the next stage back toward the antenna. Figure 6-10 is a block diagram illustrating this method.

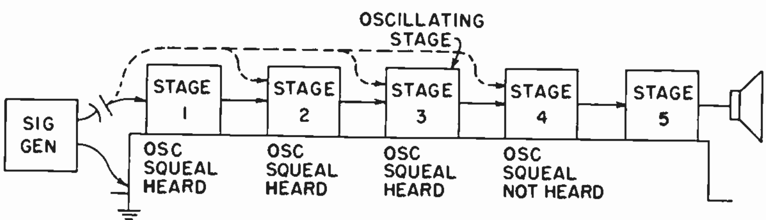


Fig. 6-10. Locating an oscillating stage with a signal generator

The method is not foolproof, because the connection of the signal generator to the signal grid of the oscillating stage often loads the grid circuit so that oscillation stops. It may then be that the first stage where you fail to hear the oscillation squeal is the oscillating stage. In locating the cause of oscillation both stages must be carefully investigated.

Stage Isolation for Microphonics. If a receiver squeals only at high volume and ceases at low volume, the trouble might be an i-f stage. If you find that the i-f stages are not oscillating, you might suspect a condition of microphonics, a condition found often in compact receivers where components are crowded together. Look at once for the condition of the rubber floats of the loudspeaker and the gang tuning condenser, as well as of those of the chassis (if any).

If one of the tubes is microphonic, tune in a station and turn the volume control down until the microphonic squeal ceases. Tap each tube in turn sharply with your finger. When the microphonic tube is reached, a *bon-n-n-g* is started and soon dies out. Replace the tube with a good one. Any tube may be microphonic, but the detector-first a-f tube in a superheterodyne receiver is a very common offender. Inspect carefully the shock-mounting for that tube.

Locating the Defective Component. Locating the defective component that is resulting in oscillation squeal is not simply a matter of investigating the components of the oscillating stage. That is why the servicing for oscillation squeal may be a little more time-consuming than other operation defects. Two or more stages or some remote component may be involved. However, with the backlog of understanding of reasons for stage oscillation presented earlier in this chapter, timesaving procedures may be followed.

When the stage oscillation results in put-puts or motorboating, turn at once to the power supply, and bridge the output filter condenser with a new electrolytic condenser of similar capacitance and working voltage. If this step fails to stop the motorboating, check all a-f grid circuits for an open with an ohmmeter. Remember that decoupling resistors must be included when making this grid circuit continuity test.

Replacing Bypass Condensers. When you find the oscillating stage that is producing oscillation squeal from the receiver, try bridging the bypass condensers with a similar good condenser. Use a condenser with very short leads and hold the condenser at the center. If you find that the squeal ceases, replace the open bypass condenser. Don't be disappointed if the replacement does not stop the squeal. Bringing your hand near the oscillating stage may have stopped oscillation, and the bypass condenser that was bridged may not have been open in the first place. Look for another cause.

The bypass condensers which should be checked for a possible open are listed below for your convenience:

Screen bypass condenser.
Plate decoupling bypass condenser.
Grid decoupling bypass condenser.
Cathode bypass condenser (common to two stages).
Plate output bypass condenser (second a-f stage).

Checking the Shielding. If none of the bypass condensers are open, next investigate the shielding and contacts around the oscillating stage. Check to see that all r-f coils and transformers are in shield cans, and that these shield cans are properly contacted to the chassis. For checking good contacts of shields to ground, make a firm contact between the shield cans and the chassis by means of a nail or screwdriver. Check to see that shields around grid lead wires are properly grounded or that grid leads going to grid caps are inside the tube shield. See that shields around tubes are not missing. Often, you can tell by the presence of the socket mounting whether a tube shield is missing.

Similarly, sometimes connecting a jumper from volume control shell to the chassis stops oscillation squeal, because it grounds the shell.

There is another way in which poor shielding may lead to oscillation squeal. In metal tubes such as the 6F6, the shell is connected to pin 1 and grounded from that pin. The shell thus acts as a metal shield. Sometimes the tube is replaced with a glass equivalent and no external shield is provided. As a result, stage oscillation may follow. On a few occasions, the connection of the shell to pin 1 becomes defective, and the result is an ungrounded shield with the possibility of oscillation. These conditions must be checked by replacing with a new tube.

Checking the Tuning Condenser. With regard to poor contacts, there is one condition to be investigated when an r-f stage before the i-f stage is oscillating, as evidenced by tunable squeal at one end of the receiver tuning dial. This possible defect is the wiper contacts on the gang tuning condenser. Corrosion on, or dirt under, the contact may result in oscillation. Be sure to clean these contacts thoroughly.

Checking Lead Dress. Another condition to investigate around the oscillating stage is the possibility of poor lead dress, particularly if the receiver was recently serviced. Grid and plate leads should be as short as possible and separated as much as is convenient. Use a wooden stick and push suspected leads apart gently. If, while the oscillation squeal is coming through the loudspeaker, you gently push leads apart and change the pitch of the squeal or reduce it, then try further separation to remove coupling and oscillation.

Another condition to investigate around the oscillating stage are voltages which might lead to stage instability. Be sure that grid-bias voltage is not too low and plate and screen voltages are not too high.

Also, do not overlook the possibility of oscillation squeal resulting from incorrect replacement of an output transformer in a receiver with inverse feedback. Instead of providing degeneration, the incorrect replacement would cause regeneration and stage oscillation.

And finally, if all other conditions seem to be correct, improper alignment may be the possible cause of oscillation in r-f and i-f stages. Realignment is then called for.

Oscillation in Other Types of Receivers. Oscillation squeal in the three-way portable receiver will result from similar defective conditions as those just described. But a few additional conditions may result in squeal. On the battery mode of operation, oscillation of a stage may follow when the B batteries age and deliver too low a voltage.

Another possibility occurs in the power-line mode of operation. Because of the position of the power-output tube, the audio-plate current would flow through the remaining tube filaments to ground. Such a condition would cause audio regeneration. To prevent this condition, an audio by-pass condenser is provided to bypass the audio signal to ground. Should this condenser open or should its capacitance become less with aging, then oscillation might result. Of course, hum would also appear in this defect.

In the auto receiver, causes for an oscillating stage are the same as those described for the a-c/d-c receiver. They are localized for stage and component in the same manner.

SUMMARY OF PROCEDURE

An oscillation defect is not an easy one to locate. Your best bet is to poke around the receiver with a condenser, placing it across those suspected of being open. When the oscillation disappears, connect in a replacement condenser.

The next procedure to follow, if condenser check fails, is to survey carefully all shielding. Take nothing for granted in this step. Do not be satisfied with the thought that a shield seems properly grounded. Be sure.

As a last resort, sometimes throwing the i-f trimmers slightly out of alignment may remove an otherwise insoluble case of oscillation squeal.

7

Noise in the Receiver

What is Radio Noise? By one definition, noise is any spurious sound which comes riding in with the station signal but which did not exist at the source originally. This definition of noise would include hum, squeal, crackling, motorboating, and similar sounds. However, since hum and squeal have been treated under different chapters, we shall eliminate those two types of spurious sound.

The type of noise we shall consider in this chapter is that which is characterized in the loudspeaker as scratching, crackling, hissing, clicking, explosive sounds which mar normal receiver reception. Noise of this type is irritating and completely unmusical, as distinguished from hum or squeal.

Noise will normally appear from the loudspeaker of any receiver, but its level is so low as compared with the level of the desired signal that it is not very disturbing to the listener. The ratio of signal to noise is said to be high. However, when the signal-to-noise ratio is low, the noise level is so great, as compared with the desired signal level, that the receiver is brought in for servicing. Of course, confirm the condition by listening yourself.

Where Does Noise Signal Come From? The problem of servicing a receiver for noise is complicated by the fact that the defect may be more than merely a receiver defect. The origin of the noise may be outside the receiver. As a serviceman, it becomes your job to determine the origin of the noise, even before you tackle the problem of locating the actual specific cause.

Noise may have three main origins: The first is antenna-ground pickup.

The second is noise signal via the power lines. The third is noise originating within the receiver itself. You must determine the origin of the noise and then systematically track down specific offenders.

Determining Source of Noise Signals. The source of the noise is determined by a process of elimination. The first step is to remove antenna pickup. Disconnect the antenna and the ground from their posts on the receiver, and connect the two posts together with a short piece of wire. Tune the receiver to a station position, and turn the volume control all the way up. If you hear noise from the loudspeaker, it is coming from the power lines or from within the receiver itself. If no noise is heard, the antenna-ground system is the source.

Tracing Noise with a Portable Radio. You might bring along to the customer's home a three-way portable receiver to see whether noise in the defective receiver is coming in over the power lines. Operate this test receiver in the power-line mode of operation, as an a-c/d-c receiver. Turn it on and tune to a station. If you hear noise on the portable receiver, it is coming in over the lines. To further verify this, switch to battery mode of operation. Noise should disappear.

Use of Power-line Filter. As a second procedure, you might bring along a line filter such as the one shown in Fig. 7-1. These filters may be purchased from many radio-supply companies. Insert the filter plugs into the

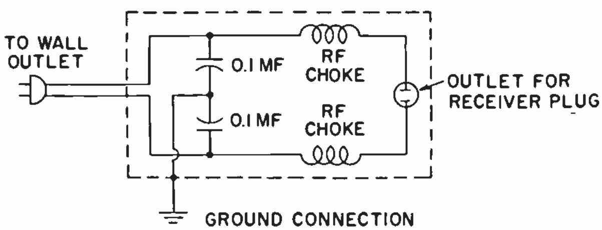


Fig. 7-1. A line filter

wall outlet. Then insert the receiver plug into the filter receptacle. Turn on the receiver and tune to a station. If noise is heard at the same loud level as previously, the receiver may be presumed to be the source of the noise. If noise level is diminished, the power lines are the source of the noise.

Noise-isolating Procedure. The entire procedure is summarized in Fig. 7-2. The antenna-ground system and power lines may be removed as suspected offenders at once by taking the receiver to your shop where conditions are known. If noise is still heard from the receiver in your shop, you may assume that the receiver is the source.

If the noisy receiver is of the loop-antenna type, you cannot short out the antenna. In such a case, rotate the receiver in a circle. Since loop antennas are directional in character, any variation of the noise level is an indication of noise pickup by the antenna.

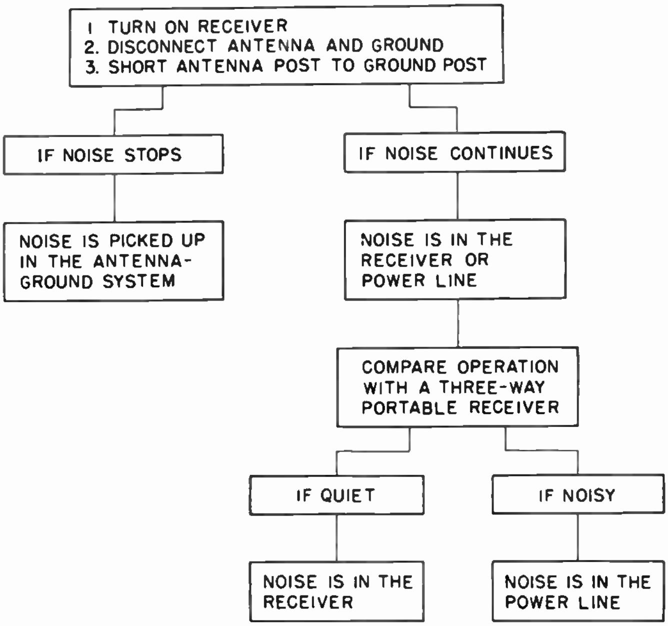


Fig. 7-2. Procedure for isolating the cause of noise

Causes of Noise in the Antenna-Ground System. There are two possibilities for noise signals in the antenna-ground system. One arises as a result of some physical defect in the antenna-ground system. The other results from antenna-ground pickup of noise signals like any other radio waves. Let us consider the first cause.

In a typical outdoor radio-antenna installation, the flat-top is mounted on the roof between two glass or porcelain insulators. The leadin is connected to the flat-top and runs down to the antenna post of the lightning arrester. From this point, there is a jumper to the antenna post on the receiver. From the other lightning arrester post, a wire is connected to an outside grounded metal post. Finally, there is a lead from the ground post of the receiver to a grounded pipe, like a radiator or water pipe in the house. In coming through the window, the leadin is often attached to a flexible insulated flat copper mesh, known as a *window leadin strip*. The other end of the strip is connected by means of a wire to the receiver antenna post.

There are many connections in such an installation. Wherever these connections are poor or intermittently open, noise will result. These may be found by pulling sharply at various points along this signal line. If the noise increases in the receiver as you make this check, you can be fairly sure that a contact is poor.

It is a good idea to solder all antenna-system connections, even where connection screws or nuts are provided. Look for loose strands of wire from a frayed end which might be grounding intermittently. Where the ground lead makes contact with the radiator pipe, be sure that the pipe is clean raw metal.

There are other possibilities in the antenna-ground system. As a result of constant flexing, the window strip might break within its cloth holder and make intermittent contact. If the noise increases when you bend the window strip, replace it.

Another cause of noise in the installation may result when the antenna flat-top or the leadin intermittently grounds against an object like a rain drain, a tree, or some similar object. Such a defect will be readily found in any routine inspection.

Ground-pipe Troubles. Sometimes, the defective condition exists in an obscure manner. For example, what you may have thought was a ground pipe may turn out to be one very poorly grounded. Corrosion may have developed at the threaded joint, thereby making poor contact. To check this condition, strike the pipe a sharp blow with a book or similar object. If this condition exists, noise from the receiver will increase. Just find yourself a different ground pipe and apply the ground clamp to a freshly sandpapered section, if you do not have a clean surface.

Another obscure cause occurs as a result of these ground pipes. It results from the fact that the pipes under the flooring intermittently touch each other as you walk over the floor. These intermittent contacts often result in receiver noise. To check the condition, walk heavily across the floor. If receiver noise increases as you do so, you probably have the condition described above. Try to find a grounding pipe not affected by these contacts. Otherwise, you will have to get to the pipes and wedge insulating materials like wooden boards between the contacting pipes.

These conditions usually will not occur in loop-type receivers. However, in some such receivers, the loop ends are attached to clips which in turn fit into spring clips. These may become corroded and cause similar noise.

Antenna Pickup of Noise Signals. The second main way in which noise may enter the antenna-ground system is by pickup, like any other radio signal. The receiver antenna is incapable of differentiating between a station wave and a noise wave. As a result, the two will be picked up and result in noisy reception from the speaker.

One type of noise wave is that produced in nature and known as *static*. It originates from lightning, where an oscillatory spark leaps from a cloud to ground, ground to a cloud, or from cloud to cloud. This spark produces a splash of radio waves of many frequencies which produce noise voltages in nearby antennas. Do not try to remove such noise. It will occur only infrequently, and most customers will understand if you explain the situation in nontechnical terms.

Much more significant is man-made noise picked up by the antenna. It is likely to be of longer duration and extremely annoying to the listener. More important, however, is the fact that you can do something about it. The procedures for locating and eliminating man-made noise are covered in an entire chapter later.

Sources of Noise within the Receiver. Our main consideration in this chapter is localizing noise that originates within the receiver itself. The way in which the noise occurs will be a helpful guide.

Noise within the receiver in most cases occurs when a sudden voltage change takes place in a signal circuit. The sudden change leads to a voltage pulse which travels down the signal chain and emerges as noise from the loudspeaker. One of the main causes for such voltage pulses is a poor contact, where a connection suddenly opens and suddenly closes and continues the process.

Another cause is an intermittent shorting of the signal chain; this shorting must be brief, or the receiver will be reported as dead. Still another cause of noise may arise from the loudspeaker, where the voice coil must vibrate freely and as a unit. When it fails to do so, noise results.

And last, a loose part in the receiver or its cabinet or something on the cabinet may be vibrating, thereby producing a peculiar noise which may be mistakenly assumed to be produced electronically by the receiver. Each cause for receiver noise will now be considered with respect to likely components.

Noise from Intermittent Shorts. Let us first turn to the question of shorts. Often this condition results from defects within the tubes. Internal intermittent shorts between tube electrodes may cause noise. This condition is often found by means of a tube checker, especially if you rap the tube sharply while it is being tested.

Coils are also causes of noise. As a result of aging, dampness, or other conditions, the insulation between windings may break down, and the turns of wire may intermittently short. The result again would be noise. In excessively damp regions, you should expect such a defect.

Dust, loose pieces of solder, overheated plastic insulation, and similar conditions may cause partial or complete intermittent shorts which also produce noise in the receiver. Often, conductive dust or other materials around the base of a tube socket, where the tube pins are close together, may cause such shorts. Or sometimes the plastic tube base becomes overheated and partially conductive. Noise results. Unless you can scrape away the overheated section, replace the socket with a new one.

Tuning Condenser Shorts. Occasionally, shorts develop between the stator and rotor plates of one or more sections of the gang tuning condenser. Where these shorts are intermittent, noise results. The short may be due to dust, conductive dirt particles, or bent plates. The application of a gentle stream of air, as from a bicycle pump, will blow out the dust.

Where the short in the tuning condenser is due to conductive particles or a bent plate, listen carefully for a scratching sound as you rotate the tuning knob slowly. When you hear it, examine the plates carefully under a strong light. Bend back the bent plate carefully until no short exists.

Sometimes intermittent shorts occur between rotor and stator plates because the stator plates fall out of line when their holding screws become loose. Pry the stator assembly back into line, and place spacing shims between the rotor and stator plates on both sides of the rotor shaft; then tighten the stator holding screws.

Potentiometer Shorts. A more frequent cause of receiver noise is the poor contact or intermittent open contact. Many components may develop such a defect. A very frequent noise producer is the potentiometer used in volume and tone controls. There are many reasons why these components misbehave. The carbon resistance strip often cracks up and produces irregular contact with the movable arm. Or poor contact may develop between the rotor and the ring which is supposed to maintain a good contact with it. This defective condition exists if the amount of noise from the receiver increases when you rock the volume or tone control back and forth. When a defective control is found, replace the potentiometer.

Shorts in Tubes. Tubes may again be a cause of noise. The tube may not be making firm contact with the prong clamps of the socket. Any vibration of the tube would then produce intermittent contacts and noise. Sometimes the internal connections of the tube electrodes to its prongs may be defective. Such defects may be found by turning on the receiver and snapping the defective tube with your finger. If the amount of noise increases sharply, the trouble is in the tube or its socket.

If the socket prong clamps are bad, bend them with long-nose pliers to make positive contact. If the defect is within the tube, replace the tube.

Poor Soldered Joints. Another cause of noise is a corroded soldered connection. The condition results from a chemical action. When two dissimilar metals are in contact with moisture, they act like a dry cell, and a corroding process results. Eventually, this corroding process produces an intermittent contact or a partial open, across which a spark may jump. Such corrosion may even take place between turns of a coil. Both produce a noisy receiver.

The primary coils of i-f transformers and of output transformers are very often subject to this type of corrosive process, because circuits carrying direct current are particularly subject to corrosion. An ohmmeter check will often disclose the condition, because the resistance of such coils is much higher than normal. Power-transformer turns corrode only infrequently because of the heavy wire used.

It is usually advisable to replace a defective transformer, unless corrosion is at the ends of the coil windings. Then merely clean the wire and resolder to its terminal.

Poor Joints in Condensers. Sometimes, because of tension resulting from temperature changes or similar conditions, the pigtail leads of paper condensers may pull away from the metal foil in the condenser and make only intermittent contact, thereby producing noise pulses. If this is the case, wiggling the condenser, while the receiver is turned on, would increase the amount of noise.

Poor Contacts. On occasion, a shield that is grounded may make poor indefinite contact with the chassis. This, too, would in some cases produce sputtering noises from the receiver loudspeaker. Or dirt at the wiper contact of a tuning condenser would have a similar effect.

Dirt and corrosion on the contact of a switch could also be an offender.

Cleaning the switches with carbon tetrachloride removes dirt. If corrosion has taken place, you had best replace the switch with a new one. Sometimes contact in switches is bad because the contacts have lost their tension. With open switches, try bending the contacts with long-nose pliers. Otherwise replace the entire switch. When such defective switches are operated, they produce noise.

With three-way portable and battery receivers, there is another source of noise. Battery connections or plugs frequently corrode at the battery and produce noise because of poor contact. The batteries may also become noisy when they are run down, producing sputtering and crackling sounds. While the receiver is battery-powered, test the voltage of your B batteries. If a 67½-volt battery reads less than 54 volts, change it for a new one.

There are many unusual ways in which noise results from intermittent opens and shorts. We have presented the main causes. When hunting for such noise producers, do not overlook any possibility.

Loudspeaker Defects. The next source of noise centers around the loudspeaker. Rattling sounds are often emitted by the speaker while the receiver is tuned to a station. Such disturbing sounds may result from various conditions. If the voice coil becomes warped or goes off center, it might rub against the pot and center pole piece, producing the noise as a result. Sometimes, the paper cone rips or breaks loose from its basket rim or the voice-coil form with the same effect. Or grit and dirt may get into the free space between the voice-coil form and the pole piece. And again, the spider might loosen and rattle, or the turns of the voice coil may unravel and rattle.

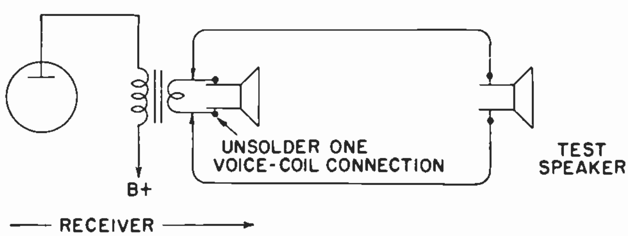


Fig. 7-3. How to use a bench-test speaker for checking a suspected loudspeaker in a receiver

Where a loudspeaker produces noise as a result of the conditions stated above, it is usually best to replace it. If the correct size is not readily obtained, have a new cone-voice-coil assembly put in by a firm that specializes in this work.

Sometimes recentering of the voice coil will stop the rattle, if this can be done conveniently. On many modern speakers the spider is cemented in position and cannot readily be loosened for recentering.

In checking a loudspeaker as a source of noise, you might simply replace it with a test-bench loudspeaker and see if the noise ceases. Figure 7-3 shows how to connect in a test speaker. The test loudspeaker is a p-m dynamic type. Open the voice coil of the receiver loudspeaker and connect the test speaker across the secondary winding of the output transformer. Now operate your receiver. If noise no longer is present, a careful check of the receiver loudspeaker is called for.

Loose Parts. The last main group of causes for noise is nonelectric in nature. The vibratory operation of the loudspeaker may throw into vibration any freely moving object in and around the receiver. A buzzing sort of noise is heard whenever a station is turned on, particularly on high volume. Such offenders may be loose bolts, loose shields, a loose tuning-dial window, a loose board in the cabinet, a cabinet handle, an ornamental object on the cabinet, and similar objects. The noise will quickly disappear if you place your hand on the vibrating object and damp the vibration. Here, too, no object is above suspicion.

Localizing the Defective Section. Before beginning the localizing procedure for a defect within the receiver, you must first go through the steps listed in Fig. 7-2. Our major consideration in this chapter is a defect within the receiver.

Begin by turning on the receiver. Then proceed to throw any band switches or similar switches back and forth while listening for noise. See if this causes the noise to vary in character or to disappear temporarily. Then vary other controls like the volume control or a tone control. If the noise increases as you vary any of these, you have probably found the source of the noise. The next control to vary is the receiver tuning dial. Swing it over the entire range. If you find noise increases or occurs at certain points as you do this, give the tuning condenser a careful going over.

You may next try to localize the defective section of the receiver, if the manipulation of the front-panel controls give no indication of the cause. While the receiver is tuned to a station and is emitting noise, turn the volume control all the way down. If the noise disappears, the defect is in the r-f section of the receiver. If the noise is undiminished, the defect lies in the receiver a-f section or in the power supply. If the noise is merely reduced, the location is indeterminate, and a stage localization procedure must be followed.

The procedure just presented refers to modern receivers where the volume control is at the input of the a-f section. In older receivers where the volume control is not so located, begin the stage-localization procedure at once.

Isolating Defective Stage by Signal Blocking. Do not waste time if any section-isolation procedure gives indeterminate results. Proceed at once to the over-all stage-isolation tests. This procedure is similar to that used with hum. Since noise is passed along the signal chain, we may interrupt the signal chain at various points to find where the noise is first introduced.

With an a-c type receiver, begin with the output tube and work back along the signal chain toward the antenna. Refer to Fig. 7-4 for details. You may treat the a-f section as a unit. Pull the detector-first a-f tube V-3 from its socket. This interrupts the signal chain at the second detector plates. If you continue to hear noise, the cause lies between the triode plate of tube V-3 and the speaker, or in the power supply.

Check every possibility in these circuits. Try substituting the bench-test speaker. Check the power transformer for corrosion and shorts. Do the same for the output transformer and the filter choke in the power supply (often the speaker field). Check the output tube V-4 for shorts, poor internal connections, poor seating in its socket, and dust or leakage paths on its socket. Wiggle the leads of paper condensers to determine if the pigtail leads make good contact with the foil plates. Check all connections for corrosion. On occasion, carbon resistors crack and produce noise; as a last measure, check them also.

If the noise stops when tube V-3 is removed, then the defect probably lies ahead of the triode plate of the tube. Replace tube V-3 and remove tube V-2 from its socket. This step stops the signal chain at the signal grid of the i-f tube. Now if the noise is still heard, the defect lies somewhere between the i-f tube signal plate and the first a-f tube plate. Check tube V-3, its socket, and the seating of the tube in its socket. Check the output i-f transformer for corrosion, particularly the primary winding. Check the volume control. Check paper condensers and carbon resistors as before. Check for shorts against the i-f shield can. And check all soldered connections for corrosion.

If the noise stops when tube V-2 is removed, then the defect lies ahead of the plate of the i-f tube. Replace tube V-2 and remove tube V-1. The signal chain now is interrupted at the plate of the converter tube. If noise is now heard, the defect lies between the converter plate and the i-f tube plate. Again check all components. Check the i-f tube, its socket, and its seating in the socket. Check the input i-f transformer, particularly the

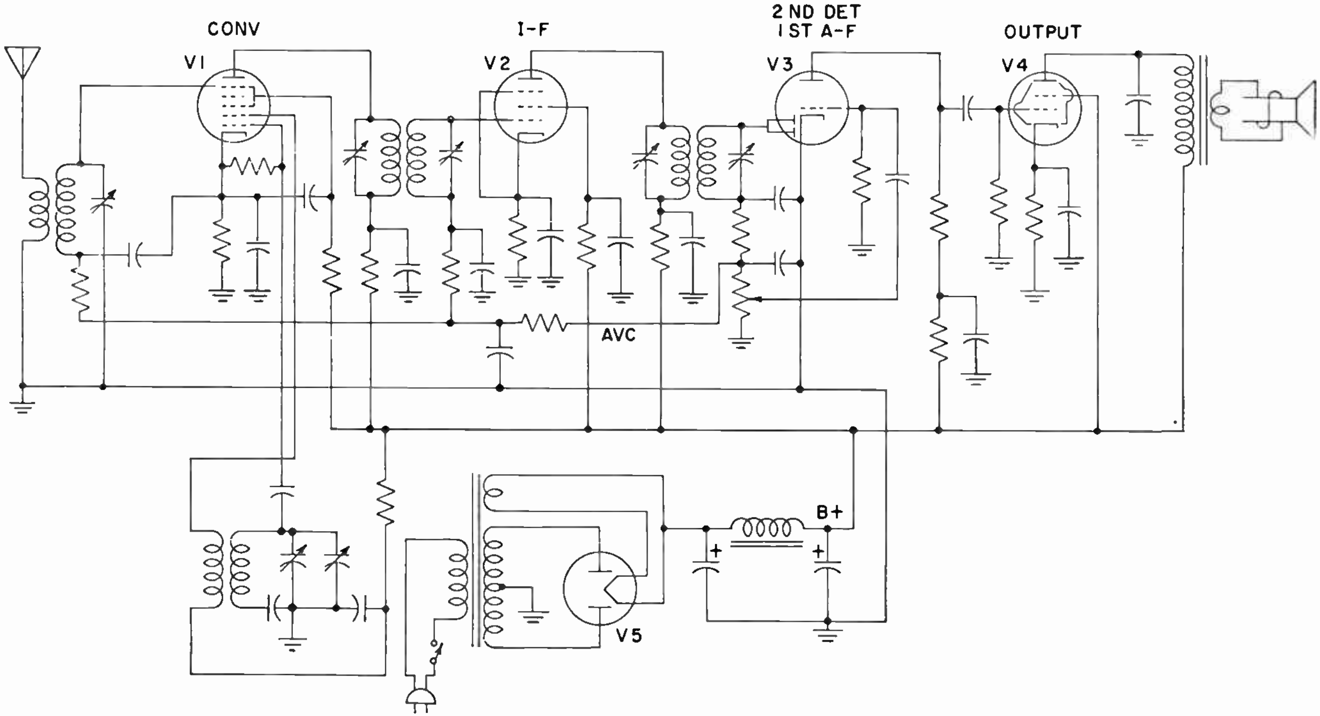


Fig. 7-4. Typical a-c receiver

primary coil. Check that nothing in the i-f shield can shorts against it. Check paper condensers and resistors as previously. Check all soldered connections for corrosion. Check shield contacts.

If noise stops when tube V-1 is removed, the defect lies between the antenna and the converter tube plate. Check tube V-1 and its socket. Check the oscillator coils. Check the gang tuning condenser. Check all shields for proper grounding contacts. Check soldered connections for corrosion. Check paper condensers and carbon resistors, as before.

Of course, you cannot pull tubes in the signal-interruption test with an a-c/d-c receiver. Here you operate as before with hum. Make each stage inoperative by connecting from signal grid to chassis or common negative, through a 0.5-mfd condenser, working back from the output tube. In that way, you can limit the defect between the signal grid of one tube and the signal grid of the next tube. The items to check will be the same as for the a-c receiver.

Locating Defective Components. After you find the defective stage, hunt for a defective component. So varied are the causes of noise that you must approach the job with a full understanding of how noise signals may enter the signal chain. Many clues will be found if you approach the problem systematically.

Of course, the localization of a defective loudspeaker is simple. If noise disappears when you use a substitute bench-test speaker, you immediately have the defective component. Complete replacement or repair is then called for.

Suppose you find that a defective stage produces noise even when no station is tuned in. Then, probably, the noise pulses are entering by means of sudden variation of the supply voltages. You should then first turn to inspection of the plate and screen-grid circuits. If these circuits are not defective, then look to the bias circuits of your control grid.

Other clues will present themselves. Corrosion at a terminal may often be seen and recognized by green copper salt which is formed as a result of the chemical action. Arcing across an open section of a coil or momentary shorting may sometimes be seen in a dark room. Sounds, too, may be clues. A steady crackling sound, heard constantly, may indicate a corroded i-f transformer primary or an output transformer primary. Often rapping gently with a wooden pencil at various components will increase noise when the defective one is tapped.

Corrosion in coil windings may not be found by jarring the component. It is best found with an ohmmeter test. Good windings in r-f and i-f transformers normally have a resistance of less than 100 ohms. A corroded winding, however, will have a resistance of several hundred ohms. The resistance of the output transformer winding will also increase greatly when the coils corrode.

After a defective component has been found, it should either be repaired or replaced. Do not try to be too skillful in improvising a temporary repair where a replacement is called for. Remember that your customer will judge you by the length of time that his serviced receiver plays well, rather than by how ingeniously you improvised a repair. And the customer is ready to pay for any repair that stands up.

Noise in the Auto Receiver. The modern auto receiver is for the most part a superheterodyne receiver with the same signal chain as a home receiver of a similar type. Therefore, it is subject to the same receiver conditions that cause noise as those for any other receiver, and they may be localized in the same manner. However, the auto radio has a few additional possibilities for noise pickup because of its location with respect to external noise producers (spark plugs, distributor, generator, static discharge, etc.) and because of its vibrator-type of power supply. Each will be considered in turn.

In many cases, the elimination of noise resulting from the external noise producers is a matter of original installation. Of course, if you are called upon to install a car radio, you must be completely informed as to proper methods of eliminating noise. But also, from a servicing point of view, you must be prepared to determine where the original installations went bad.

As a first step, determine whether the receiver itself is noisy or whether installation is bad. Perhaps the simplest method is to remove the receiver from the car and operate it in your shop off an auto antenna. If you continue to hear noise, the defect is in the receiver. If the noise stops, the installation is bad. Or you may operate the receiver in the car while the car is parked and listen for noise. If any is present, the receiver is probably defective. But a few other possibilities exist. The antenna may intermittently short to the car body, or the lead from the storage battery to the receiver may have some defects. These may be checked simply by inspection.

Let us at this point assume that the receiver and its antenna and supply line are good. We then turn to the installation problems.

Auto-radio Installation. In a typical automobile-radio installation, the receiver is contained in a metal case, which is usually mounted to the dash of the car behind the instrument panel, as in Fig. 7-5. The antenna is a telescoping rod mounted on, and insulated from, the cowl of the car. The antenna is connected to the radio receiver by a short length of shielded lead-in wire. Power for the receiver is usually obtained through a lead connected to the ammeter on the instrument panel. The ammeter is in turn connected to the ungrounded side of the storage battery. The car frame or chassis acts as the common return lead; the receiver picks up its ground connection through its mounting bolts.

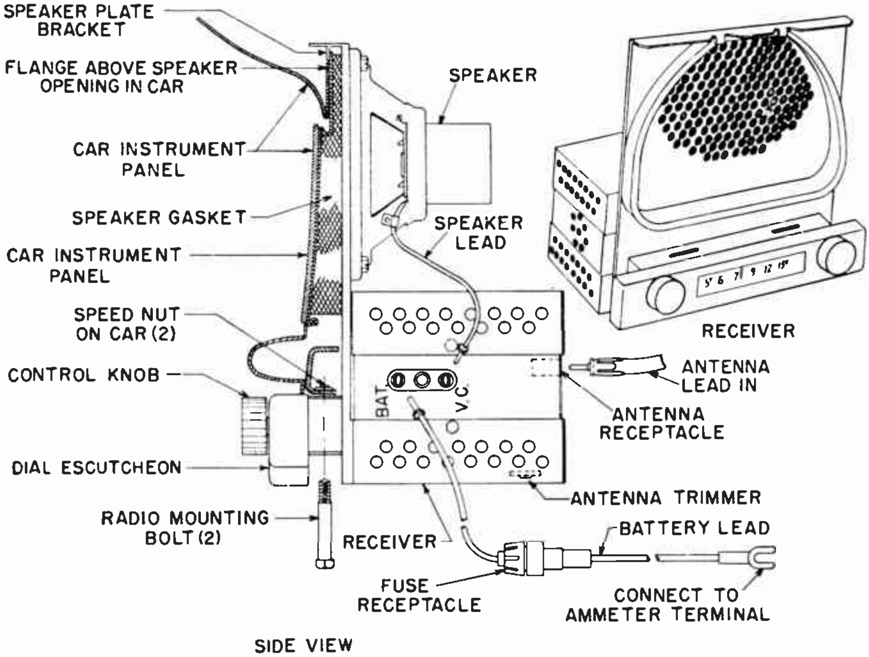


Fig. 7-5. Typical installation of auto radio having attached speaker. Only two bolts, fitting into speed nuts already on car instrument panel, are needed to mount the set in the car for which it is intended

The auto radio and its antenna system are surrounded by noise-signal sources. Wherever a spark occurs, a noise signal is sent out. These noise signals are so broad in frequency that they cover the entire tuning band.

The reduction in level of the noise signals is handled in three main ways in the installation aspect of the auto radio. First, the radiation of noise waves is reduced at the source by suppressors, filters, shields, etc. Second, the antenna is placed in a position where it will have minimum noise pickup. And third, the radio itself is completely shielded within a metal case.

Interference-suppression Techniques. One of the worst sources of noise is the spark produced at the distributor and the spark plugs in the ignition system. When a defect exists in the installation, ignition interference is heard from the receiver as a series of ticks at the same rate of speed as the spark plugs are firing in the motor.

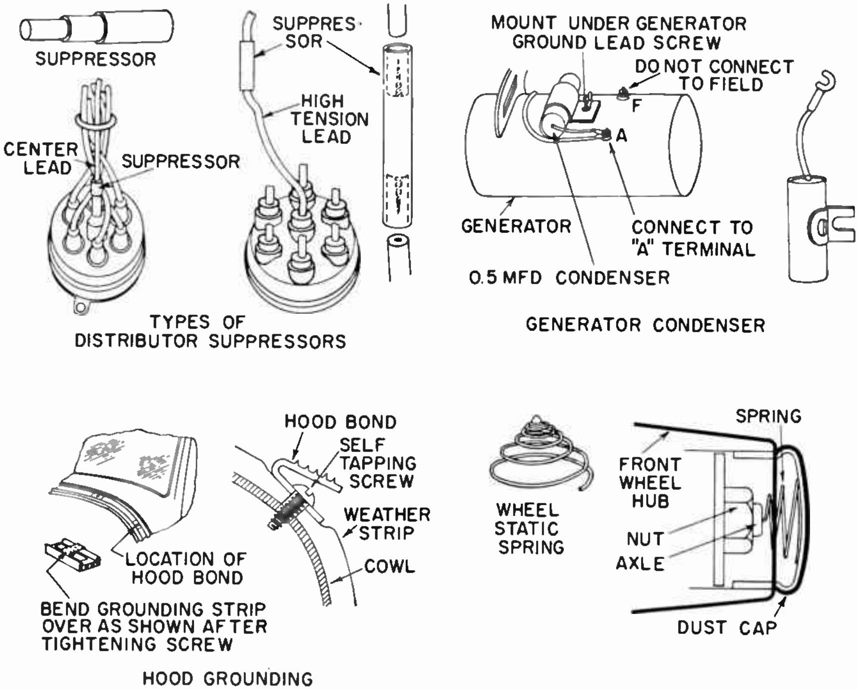


Fig. 7-6. Methods of suppressing noise in auto-radio installations

Ignition-noise radiation is usually reduced by installing a suppressor resistor, purchased at any auto- or radio-supply shop, in series with the high-tension lead which runs from the ignition coil to the center connection of the distributor, as shown in Fig. 7-6. Do not install suppressor resistors in each spark-plug lead, because that would interfere with the engine performance. In some cars, ignition leads are made very short and are enclosed in grounded metal conduits, thereby reducing noise radiation.

Hood Grounding. The metal car hood also aids in reducing ignition interference. If it is well grounded to the car frame, the hood acts as a shield between the engine and the antenna. A hood bond is usually employed to give a good ground connection, as shown in Fig. 7-6. It is a piece of flexible brass, one surface of which has been serrated to give an effect like the teeth of a file. A self-tapping screw connects one end of the bond to the frame, while the teeth of the hood bond make good contact to the hood when it is closed.

Generator Condenser. Sparking at the generator commutator is another cause of noise. It is heard from the receiver as a high-pitched whine which changes in pitch and loudness as you accelerate the car. It is reduced by placing a condenser on the battery side of the generator, as shown in Fig. 7-6. This condenser is a standard generator condenser, purchasable at any auto supply shop. Be sure that there is no paint on the generator that might prevent proper grounding of the condenser.

Wheel Static Springs. Another source of noise is *wheel static*. The wheels generate static electricity when they turn, and this static electricity sparks across to the axle, thereby producing noise signals. The front wheels are greater offenders because of their weighting.

Wheel-static interference usually starts when the car is traveling at a fair speed above 20 miles per hour on a smooth, dry road, and sounds like atmospheric static. To identify it, drive the car until the interference starts. Then turn off the ignition key and coast. If you still hear noise which gradually disappears as the car slows down, the cause is wheel static. Wheel-static interference is reduced by installing static-collector springs (spring contacts that ground the wheel to the axle), as shown in Fig. 7-6.

Tire Static. Another similar type of static is that known as *tire static*. It results from a static charge picked up by the tires and is produced when the charge sparks across to the wheel. Some makes of tires are worse offenders than others. Tire static is heard as a steady whine, or as a thump that occurs with each revolution of the wheel, when the car is traveling over 20 miles an hour. To check for tire static, drive over a dry road and hear the noise. Then wet the tires and drive over the same road. If now you do not hear it, the noise was caused by tire static. The condition can be helped by painting the outside sidewalls and tread of the tire with a conducting paint made up of a mixture of naphtha, powdered graphite, and rubber cement. But the treatment will have to be renewed periodically as the paint wears off.

Brake Static. Sometimes noise, known as *brake static*, occurs because of faulty brakes. The static occurs at regular intervals and increases with the speed of the car. It occurs when the brakes drag, or when high spots on the brakes touch the wheel. To remedy the condition, have the brakes readjusted or re-aligned.

Receiver Grounding. The receiver itself is well shielded by its metal case and normally will not pick up noise signals except from its antenna.

The mounting bolt, as shown in Fig. 7-5, holds the case to the dash and provides the ground for the receiver case. Be sure that the ground connection is good and that no paint is under the bolt.

Another good ground contact must be made at the antenna end of the shielded leadin wire. The cup that encloses this contact usually has a serrated edge and makes good contact to the body cowl when the antenna assembly is tightened in place. Check to see that this ground contact is good, thereby reducing noise pickup by the leadin.

In spite of the procedure described above, noise sometimes still gets to the receiver. Interference of this type is known as *chassis pickup*. It is identified by its presence even after the antenna is disconnected from the receiver. Such interference is usually brought to the receiver by the steering column, temperature and oil-line tubing, and the brake, throttle, and speedometer cables that lead through the dash from the motor compartment. This interference can be removed by bond-grounding the cables and the tubing where they enter the dash from the motor compartment. The steering column is similarly bonded to ground. Clean the cables, tubing, and steering column with fine sandpaper; then wrap the bonding braid around these parts and connect under holding screws.

Noise from Power Supplies in Auto Radios. The wiring, such as the battery lead which enters the receiver, is also a source of noise pickup. But the receiver design places filters at the entrance point for this wiring

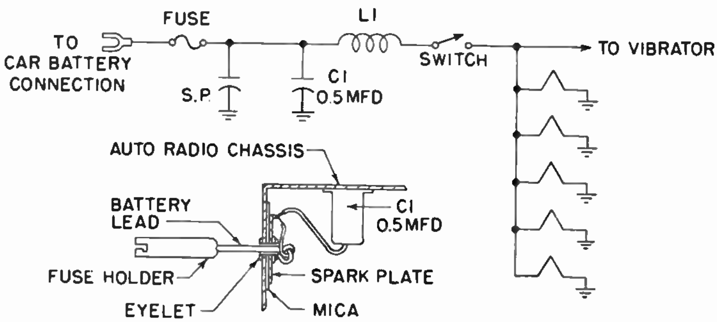


Fig. 7-7. The battery circuit in an auto radio, and typical construction of spark plate behind entrance hole for battery lead

inside the radio, to bypass any noise signals. The battery lead commonly goes to the tube heaters and vibrator of the receiver, as shown in Fig. 7-7. Condensers S.P. and C-1, together with r-f choke *L*-1, act as a filter circuit to bypass to ground noise signals picked up in the engine compartment by the wiring.

Condenser S.P. is a spark-plate type of condenser, consisting of a metal plate insulated from the chassis by a thin sheet of mica. The metal is one plate of the condenser and the chassis is the other. Figure 7-7 shows such a spark plate connected in the circuit.

Condenser C-1 is a normal 0.5-mfd condenser. The r-f choke L-1 is about 30 to 50 turns of heavy wire wrapped in the form of a flat coil, about 1½ inches in diameter. Since this filter is in a low-voltage circuit, it rarely breaks down. The main source of noise from this input circuit is in poor contacts at the battery, in the fuse holder, or at the switch. These conditions are checked in the normal way as for any type of receiver.

Vibrator Noise. The next source of noise signals from the power supply arises from the vibrator and its accompanying circuits. The making and breaking of current at the vibrator contacts are accompanied by sparking, which causes noise in the receiver. This interference is known as *hash*. Practical vibrator circuits provide for spark suppression and hash filters.

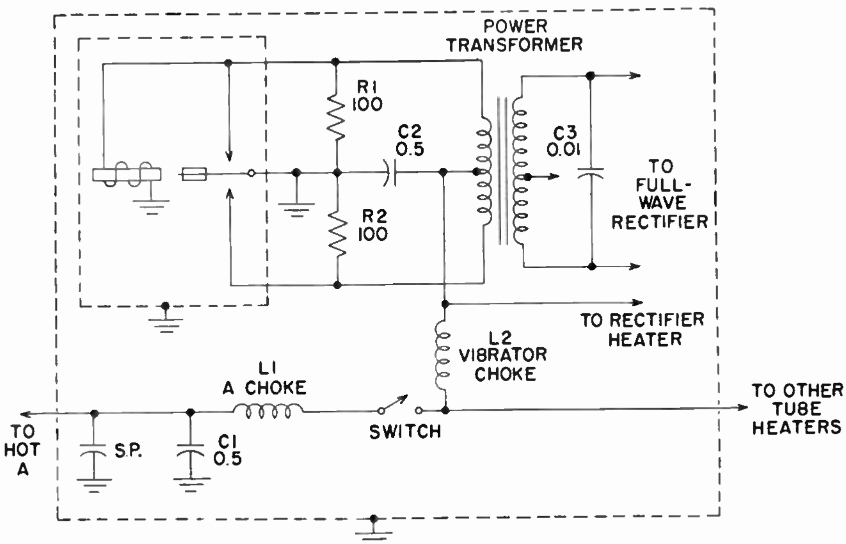


Fig. 7-8. Typical vibrator circuit in an auto radio

A typical vibrator circuit is shown in Fig. 7-8. Condenser C-3 is known as a *buffer*, or *timing condenser*. One of its functions is to reduce sparking at the contacts of the vibrator. It is extremely important that you replace a defective buffer condenser with one of exact capacitance, if you wish proper spark suppression. Buffer condensers are of the oil-filled type with capacitances from 0.005 to 0.03 mfd and with a rating of 1,600 volts. An open buffer condenser would raise the hash level.

Resistors *R*-1 and *R*-2, connected across the vibrator contact points, are also effective in reducing sparking and hash. They range in resistance from 50 to 200 ohms. These resistors rarely give any service difficulty. Sometimes condensers are used in the same circuit instead of resistors *R*-1 and *R*-2.

The vibrator choke and condenser C-2 form a hash-filter circuit. A similar hash filter is sometimes connected to the B-plus output lead. In the former case, the filter bypasses vibrator hash signals out of the receiver heater lead to ground. In the latter case, the filter bypasses vibrator hash from plates and screen-grids to ground. An open condenser C-2, or a shorted vibrator choke, would increase the hash level.

Other methods used for hash suppression are the total shielding of the vibrator in a grounded metal case as well as the power supply itself. Where grounding of the metal cases is poor, noise may increase in level. Not to be overlooked in the sources of noise is the vibrator itself. A vibrator with pitted points or poor spring tension may result in noise. When other factors have been checked, replace a vibrator with a new one and see if the noise diminishes.

From this point on, the power supply resembles any standard supply. It should therefore be checked in the usual manner when noise is present.

8

Man-made Interference

Man-made Noise. In the previous chapter, the major emphasis was on noise originating within the receiver or in its antenna-ground system. In this chapter, the emphasis is on noise that originates from a source outside the receiver. It is assumed that you have already cleared the receiver system of suspicion.

The problem of external man-made noise is an important one. Even an expensive receiver of fine quality will exasperate the owner when noise mars listening entertainment. Most customers will be willing to go to a fairly high expense to reduce or eliminate this irritant.

Your first task as the serviceman is to verify that the source of the noise lies externally or within the receiver. You will recall that this is done by disconnecting the antenna and ground from the receiver. If the noise persists now when the receiver is turned on, the cause lies within the receiver and must be tracked down. If the noise stops, it was picked up by the antenna as a noise wave or entered the receiver through the power lines.

With loop-antenna receivers, you can make the check by using a power-line filter to determine if the line is the source. You can also rotate the receiver to see if noise level changes somewhat, in order to determine if the noise is picked up by the antenna as a wave.

Noise that enters the receiver through the antenna-ground system or through the power lines is usually man-made, in the sense that it is caused by some man-made device.

The only exception is natural electric static, which normally cannot be eliminated.

How Man-made Noise Enters the Receiver. Man-made noise is produced primarily by electric devices which produce sparks, like motor devices with brushes, thermostats, circuit breakers, and similar devices energized from the power lines. The spark then sends r-f energy by waves to the antenna of the receiver and by current pulses through the receiver power cord.

Sparks at the motor brushes produce pulses of current which oscillate at radio frequencies up and down the lines from the motor to the receiver, and produce noise pulses through the lines. Also, these oscillating line currents radiate noise waves out into space which are picked up by the antenna.

Another way in which noise is produced is by disturbances in the power supply and transmission lines of a community which cause pulses of current to travel down these lines. Examples are leaks to ground or other conductors through tree limbs, leaky power-line lightning arresters, cracked insulators, loose pieces of wire hanging on a line, and generator defects.

Your job in handling the customer's complaint depends on your ability to locate the offending device, your right to adjust the device, the cost involved in eliminating the noise, and your judgment as to the best way to get the best results.

Questions Help Identify Noise. Your next job is to track down the source of noise from either of two sources: pickup from the power lines or noise pickup by the antenna-ground system. Before you begin the localizing check, try to get a more detailed description of the noise by asking pointed questions of your customer. The answers may be the first clues for your problem. Whenever possible, check the customer's answers.

In Fig. 8-1 are listed two important questions with possible answers and possible sources. They are not meant to be final by any means. Try to get even more specific descriptions. Such answers plus your own observations can narrow the search.

Isolating Noise with a Portable Radio. Do not waste too much time trying to determine the source of the noise only by means of questions. As a service technician, you will have to perform purposeful experiments to obtain more definite clues. Perhaps the best way to start is to bring a sensitive battery-powered portable receiver with a loop antenna into the customer's home. Make sure the noise is still coming from the radio; then disconnect all electrical circuits by removing the house fuses. Tune in the same station on your battery receiver. If you do not hear noise, it probably came into the customer's receiver via the power lines.

What Is the Nature of the Noise?	Cause
1. Rhythmical crackling, buzzing, whining sound.	Brush motor or generator.
2. Staccato sounds of short duration.	Doorbells, telephone dials, devices that make and break contacts for short periods.
3. Loud buzzing or rushing sound.	Neon signs, fluorescent lights, X-ray and diathermy machines.
4. Crackling, scraping sound.	Loose connections in wiring, rubbing pipes, disturbances in transmission lines.
5. Clicking sounds now and then.	Electrical switching devices.
6. Loud buzzing sound.	Heavy sparking devices like arc projectors, trolley-car switches, etc.

When Is the Noise Usually Heard?	Cause
1. When walking across floor.	Loose plugs in sockets, rubbing pipes, loose electric lamps.
2. When the house elevator is operated.	Elevator motor.
3. When a trolley car goes by.	Trolley-car switching, trolley-line sparking.
4. Regularly at short intervals.	Refrigerator, oil burner, etc.
5. In the morning only.	Electric shavers, electric juice extractors, etc.
6. When house lights go on.	Defective electric house device, poor fuse contacts, defective outlets, etc.
7. When neighbor X first installed an electrical device.	Inspect the new device (if possible).

Fig. 8-1. Identifying noise

Locating Noise Sources in the Home. Now plug in the customer's receiver again, after checking the socket, plug, and line, and turn it on. Replace the fuse that serves that receiver, making certain that it is in good condition and makes good contact in its socket. Switch on each of the other devices fed by the circuit of that fuse, one at a time. Listen for noise. Each fuse serves a number of lamps and outlets, as shown in Fig. 8-2.

When noise begins in the receiver as a device is turned on, check it for poor socket contact, loose plug wires, loose and defective lamps, defective control switch, power-line breaks, etc. Repeat the procedure for each other fuse and its related circuit. The remedy in each defective case is obvious.

Locating Noise Sources Outside the Home. If the noise is heard from the receiver before any home devices are turned on after a good fuse is replaced, it is probably originating in the power lines outside the home. A search of the home area may disclose an offending device. Check the house-elevator motor. Find out if a doctor has electrical equipment which is frequently used. Determine if a neon sign is on the power lines. Check for a store in the building or nearby that uses electrical machines. In many cases, the problem is best handled at the source of the noise. When you cannot tackle the noise at its source, your next best procedure is that of installing one or more line filters. More will be said about these filters in a later section of this chapter.

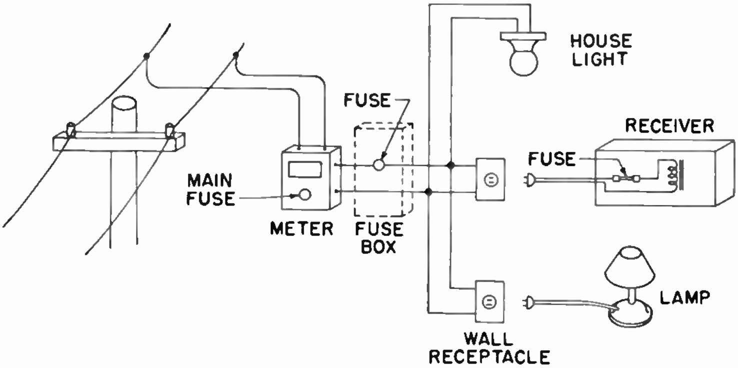


Fig. 8-2. Typical home power-line circuit

Take your portable test receiver a short distance from the customer's house, and tune it to a station. Rotate the receiver until the noise is loudest. The line of the top of the loop antenna then points to the source of the noise. About a block away, repeat the rotation of the receiver until the noise is loudest. The point where the imaginary extension of the top of the loop antenna in each case crosses is the location of the source of the noise, as shown in Fig. 8-3. Verify the location by walking with the receiver to that point. The noise will increase as you approach it.

Outdoor Power-line Noise. If the source turns out to be some power-line defect, do not try to clear up the condition yourself. Notify the power company, and they will send a trained employee to check and rectify the condition. Public utility companies are glad to repair any defect, because it helps to sell more receivers, which consume more electrical energy, and because it often forestalls further breakdown of their equipment.

Noise-producing Electric Motors. Because they are used in such large numbers, vacuum cleaners are a common source of man-made noise. They contain a small brush-type motor which rotates at high speed, causing much noise. Such motors may be readily filtered right at the appliance.

However, unless the noise is a community problem, you cannot provide filters for all.

Another device that may produce noise is the common soda-fountain stirrer. Here, too, brush-type motors are causes of the noise. They may be silenced by placing filters at the device. The filters should be mounted between the motor and the on-off switch.

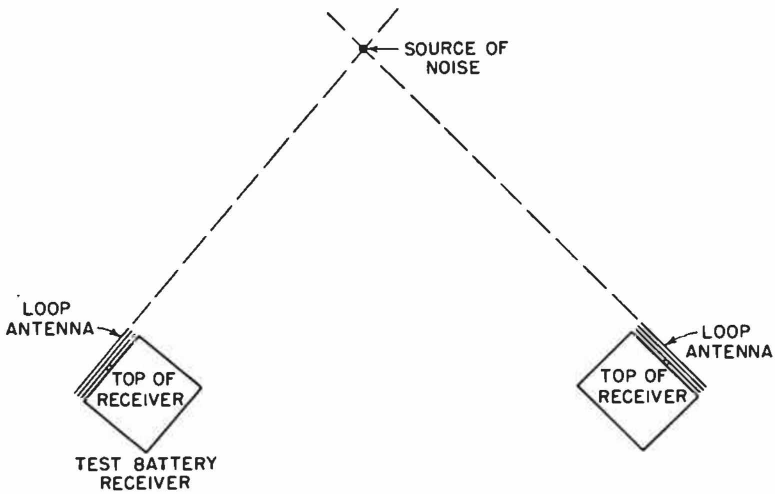


Fig. 8-3. Locating a source of noise

Electric drills and sanders with brush-type motors are also great noise producers. Dirt falls in the motor and produces excessive sparking. Filters mounted as close as possible to the motor and mounted firmly can reduce the noise. A similar condition exists with food mixers.

Large brush-type motors and generators are frequent noise producers. Here an electrician is usually required, to sand and clean the commutator, readjust or replace the brushes, and connect each brush. Study your local electrical laws, because very often they specify that only licensed electricians can make changes in electric wiring.

Electric refrigerators, especially of the older type, may be quite noisy. Sometimes, the electrical noise can be considerably reduced by bonding the motor frame, compressor frame, and refrigerator chassis with a stout, braided metal bond.

Sewing-machine motors, dental drills, and barber shop hair-dryer motors, are also possible troublemakers. Again filters will remedy the situation. Oil burners, too, have motors which may require filtering. In addition, most oil burners employ a spark to ignite the fuel. The spark may be suppressed with suppressor resistors similar to those used in automobiles. Where these suppressors are needed, tell your customer to have them installed by his oil-burner serviceman. Work with that serviceman if necessary, but don't do this type of work by yourself.

Filters may also be needed across the thermostat leads. The frame of the oil burner may have to be bonded to the boiler and then to a grounded water pipe. Similarly, the core of the high-tension transformer may have to be grounded. Filtering the input leads of the transformer often helps too.

Other devices that employ thermostats or switches, like heating pads and irons, can produce sparks and noise. First, be sure contact points are clean, since they will produce prolonged sparks if in a dirty condition. Spark suppressors or filters placed across the spark gap will reduce noise considerably.

A doctor's diathermy and X-ray equipment may also produce noise. The cure is to place the equipment in a metal-screened room, where good contacts are made between all joints of the grounded screen including the door, and to filter the power lines to the equipment. Since the cost of such an installation may prove prohibitive, the best procedure is to give the customer sympathy for an incurable condition.

Neon-sign Noise. In some cases, neon or neon-type signs may be a source of noise. But often the reasons for the interference may be obscure. Sometimes a little air leaks into the glass tubes, and the gas pressure inside increases. As a result, the transformer voltage is no longer high enough, and the sign flickers. This flickering produces noise. The remedy is to get the sign owner to have the tubes refilled with new gas under proper pressure, or have the sign replaced.

Sometimes a new sign transformer produces noise because it is electrically leaky. You can determine this condition by switching off the sign and disconnecting the secondary leads from the sign. Then turn on the a-c supply. If the transformer is leaky, you will hear a frying sound. The only remedy is to try to get the transformer replaced.

In some cases, placing a filter across the primary terminals of a neon transformer will eliminate noise pulses from the line. Grounding the transformer case sometimes also helps. Often, noise is produced because of leakage where sections to the tubing cross over. Insertion of pieces of mica at the crossover may remedy the situation. Sometimes wire or chain supports of a neon sign acquire different potentials which cause noise. Supporting the sign with a nonmetallic support, like a good grade of rope, may help. Here again, don't touch the equipment yourself; neon signs should be handled only by experts in that field, because of the high voltages involved.

Public-utility-equipment Noise. Flashing traffic signs can also be great noisemakers. The problem is handled by placing a condenser across the flasher. In addition, the supply lines to the sign might be filtered. Report traffic-light troubles to the police department.

Noise may originate with trolley buses or cars and their power lines. If a trolley bus goes by and produces excess sparking, report its number to the transportation company. Sometimes the simple replacement of a defective trolley wheel will remedy the interference effect. If noise is constant from the trolley-bus power lines, report it again to the company. A sparking generator at one of its power stations might be the cause.

Telephone equipment, especially dial phones, may be a source of noise of the clicking type resulting from the opening and closing of relays. Report such a condition to the telephone company, and they will install special filters.

Fluorescent-light Noise. Modern fluorescent lights introduce another noise producer. A typical simple fluorescent-lamp installation is shown in Fig. 8-4. The starter is normally closed. When the line switch is closed,

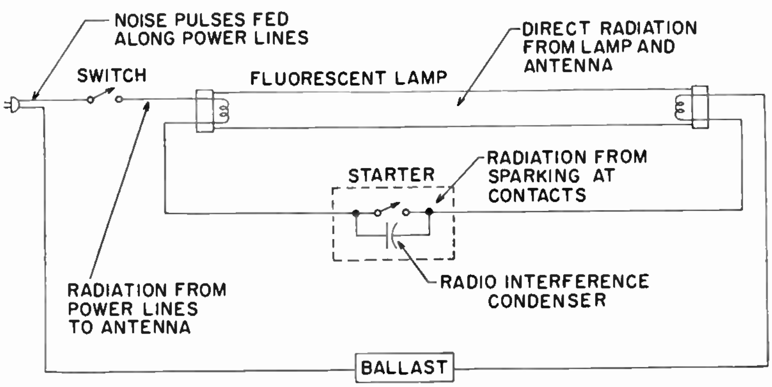


Fig. 8-4. A simple fluorescent-lamp installation

the starter opens after a brief period of heating, and a spark is produced. A small condenser across the starter contacts absorbs the spark and reduces the amount of noise. Try using new starters if noise is produced by the lights. The condenser may have failed. Or you might try moving the radio receiver and its antenna and leadin at least 10 feet away from the lamp, the range of direct radiation from the lamp. Line filters made directly at the lamp will eliminate line radiation as well as line-noise pulses.

Belt Static. Another source of noise is the static discharge from moving belts. Figure 8-5 shows a simple method of draining the charge from the belt while it is in motion. A wooden block is mounted with small metal springs dangling from it and with the springs making contact with the belt. Wire the springs together and bring the wire under the motor mounting bolt with good contact between the two. Run a wire from the bolt to a well-grounded object. The springs will remove any charge from the belt and run it to ground.

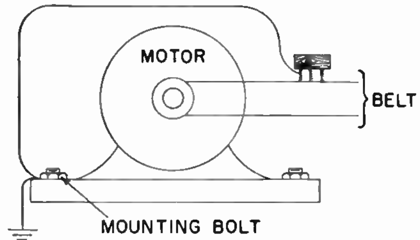


Fig. 8-5. Draining static charge from a motor belt

In this section you have seen several ways in which noise was produced by various devices. It is by no means a complete list. Many more could be added. However, after localizing a noise producer, you will find the examples given above helpful in determining what to look for.

Suppressing Sparks. In suppressing the spark of various electric make-and-break contacts, you must be careful that you do not interfere with the proper operation of the electric device. Thus, relays and vibrators should not be subjected to spark suppression, unless you check thoroughly afterward for proper operation. However, switches and temperature-control

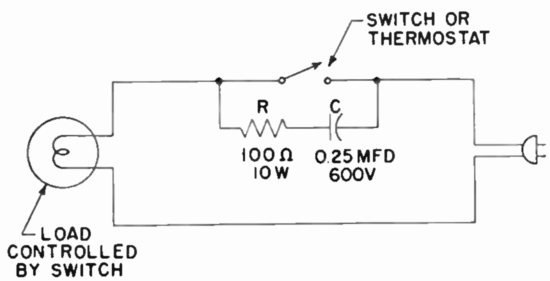


Fig. 8-6. Spark suppressor across a switch or temperature thermostat

thermostats such as those used in electric heat pads, automatic electric irons, and similar devices, and motors and generators may have their sparks suppressed. A simple suppressor is a condenser or condenser and resistor in series placed across the spark contacts. Figure 8-6 shows a spark suppressor that may be used across a switch or temperature thermostat.

For spark suppressors at the brushes of motors and generators, simple condensers may be used. A typical suppressor is shown in Fig. 8-7 for a motor or generator with two brushes. The condensers are of the dual capacitor type. The condensers have a capacitance of 0.5 to 2.0 mfd and a voltage rating at least 50 per cent greater than the working voltage of the motor or generator. Whenever possible, ground the frame of the noise-producing device first; this often cures the trouble.

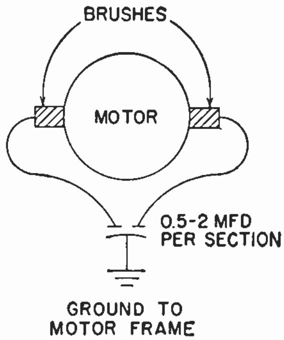


Fig. 8-7. Spark suppression at the brushes of motors and generators

Important Warning. The previous sections on suppressing noise at the source told you how to handle the problem. However, it should be emphasized again that it may be inadvisable in many cases to make the remedy yourself. If anything goes wrong with the equipment with which you have worked, you may be blamed for it, even if your operation was not the cause. Perhaps it would be more advisable to tell your customer to call in the expert on the noisy equipment—the electrician, the refrigerator man, the oil-burner man, etc.—to make the necessary repairs. He will be quite willing if you explain that in many cases the repair should be made more for the sake of saving the equipment from breakdown than for the purpose of removing radio noise.

With regard to man-made noise, your job is primarily to locate the source of noise for your customer, and to furnish line filters in the customer's home. Do not let yourself open to a damage suit.

The technique for locating noise sources has already been presented. Let us now turn to the question of line-noise filters.

Line-noise Filters. Line-noise filters serve two purposes when applied at the noise-producing devices. First, the filter prevents noise pulses from traveling along the power lines. Second, as a result of the elimination of line pulses, radiation of noise from the power lines is also eliminated.

Noise filters are of various types. You may have to try various combinations to obtain best results. Most filters are simple condensers or combinations of condensers and r-f chokes. A few combinations are shown in Fig. 8-8. Various other combinations may be more satisfactorily used. The box with the *N* in it in each case represents the noise producer. Generally, the filter should be mounted as close to the device as is possible and convenient.

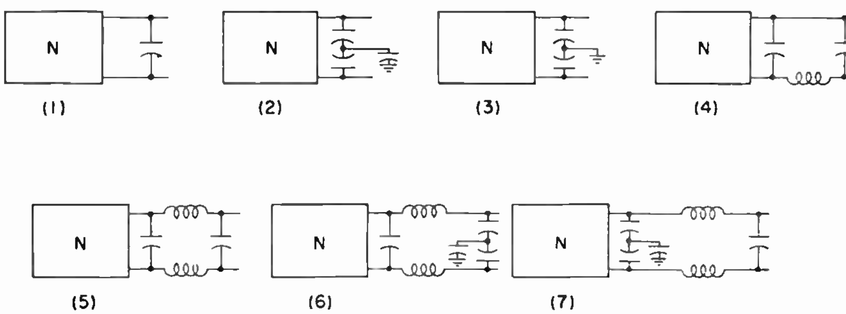


Fig. 8-8. Various types of noise filters

Where a filter unit is mounted in a steel box, as when it is used with heavy nonportable equipment, all wiring from the noisy equipment to the filter should be in accordance with underwriters' regulations. Where shorting of a filter condenser is likely to short the power lines, it is advisable to place a fuse between the condenser lead and the power line. The condensers used must have a voltage rating of 600 volts or more to withstand surges. Their capacitances range from about 0.1 mfd to 1.0 mfd.

Line Filter Test Board. You will often have to experiment with various combinations to see which filter gives best results at minimum cost to your customer. Figure 8-9 shows a simple board with filter components on it which you may connect up into any combination. Each component is connected to a binding post so that you may run jumpers to them for any desired combination. Someone at the receiver must report results to you as various filter combinations are tried, if the noisy device is not near the receiver. A set of sound-powered phones, similar to those used in television installation work, is valuable for this purpose.

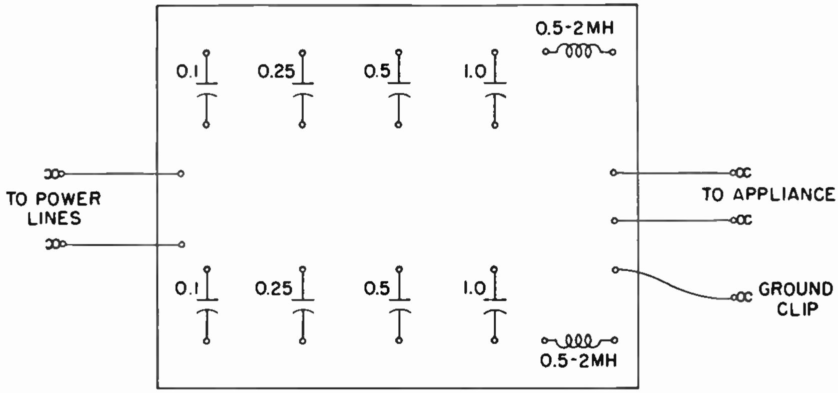


Fig. 8-9. Test filter board

If you find that noise pulses are coming into the receiver through the power lines and you cannot locate the noisy device or cannot filter it (remember our previous warning), then your next-best procedure is to filter the power lines at the receiver. You may use filter circuits similar to those used in filtering noisy devices at the source. Such a simple filter is shown in Fig. 8-10. The filter is enclosed in a metal shield can, and the shield can

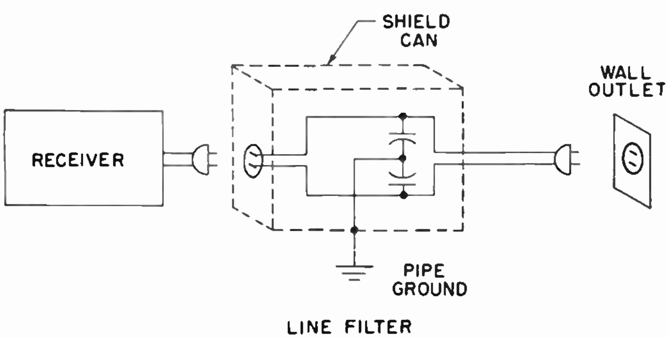


Fig. 8-10. Filtering line noise at the receiver

is in turn grounded securely to a cold-water pipe or radiator pipe. Commercial versions of this can be obtained from a radio-parts jobber.

When the receiver has a built-in loop antenna, noise can often be reduced or even eliminated by moving the receiver to another part of the room or by rotating the set.

9

Intermittents

The Complaint of Intermittent Operation. When a receiver is brought in for intermittent operation, you will rarely find the customer describing its operation as "intermittent." In such a defect more than in any other, you will get a fairly accurate description of the poor operation. He will say that the receiver plays all right and then fades. Or, he will say that the receiver plays all right and then begins to hum, or squeal, or go dead, or sound distorted, or become noisy.

You can see that the receiver in intermittent operation suffers from a defect which causes any one of the common receiver defects—hum, squeal and motorboating, noise, a dead receiver, or distortion. The factor which makes it difficult to find the defective condition in intermittent operation is that the defect does not remain constantly bad. For example, while checking a receiver which intermittently hums for defective components which cause hum, the defective component suddenly acts normal and the hum disappears. You cannot check for hum any longer, because the hum is gone. Yet the defective component is still there and may make the receiver hum at any moment.

You have no choice but to wait until the defect operates once again and then check for the defective component. For this reason, the servicing of an intermittent receiver may consume much of your servicing time. Do not put aside your other service jobs for the intermittent one. Rather, permit the intermittent receiver to run at one side of your bench while you do other servicing and wait for the defect to become operative. Then turn your attention to the intermittent receiver. Obviously, you must take an intermittent receiver to your service shop rather than work in the customer's home if your first examination does not disclose the cause.

Questioning the Customer. Customer information in this defect is extremely important, because you may find the receiver in its normal phase of operation at the time of first inspection. However, valuable information will only be forthcoming if you direct the questions to secure specific data. Below are listed some typical questions:

1. Specifically, what happens in the receiver?
2. Does the receiver play normally, become defective, and play normally at regular intervals? About how long does the receiver play normally before it goes bad?
3. Does the receiver play normally and then remain defective? Does the receiver operate normally if you walk across the floor, jar the receiver, throw the receiver line switch on and off, or turn on and off some other electrical device in the house?
4. Does the receiver become defective whenever it is operated or only at specific times of the day?
5. Does the receiver fade gradually or suddenly?

Confirming the Complaint. Be sure that the complaint is a valid one. Intermittent fading of a receiver may be a natural condition over which you have no control. Often, about sunrise and sunset, stations may fade as a result of the shifting of the Kennelly-Heaviside layer. This is an upper layer of air which plays an important part in passing on the radio wave from a fairly distant station. Explain the matter in simple terms to your customer with regrets.

You may also find that at certain times of the day line voltage drops, producing a weaker output. Tell the receiver owner to notify the utility company about the condition. They may take steps to obtain better regulation of the voltage. If noise comes on at some particular time of day, investigate the possibility of a noise-producing device that goes on at some regular time of the day.

Most often, you will confirm the complaint of the customer on the service bench. But some complaints, especially intermittent noise, may be checked at the home. At the same time, you will begin to search for external clues. Check the antenna and ground installation for breaks or poor connections. Shake the leadin and see if this increases noise. If it does, hunt until you find the cause. Walk around the room and see if the noise develops. If it does, examine ground pipes for rubbing. Such rubbing pipes may be separated with an insulated wedge or bonded together firmly with a conducting wire. Inspect the seating of the receiver plug in its wall socket. Be sure that the contacts are good. Examine the house fuse to see that it is seated firmly in its receptacle. Turn on electrical lamps and devices. Where one of these produces noise, check it for loose connections or poor socket contacts. If the receiver suddenly becomes louder or drops in level when some electrical appliance is turned on, a poor ground connection or poor antenna is probably the cause. Receivers of the a-c type are more subject to this defect.

If you cannot find the defect at once, take the receiver to your shop. Explain to the customer that the nature of the complaint may require more time than the normal servicing job. He will ordinarily be willing to put up with this condition if he has confidence in your ability to make a permanent repair. Some servicemen engender good will by leaving a small portable receiver at the home of the customer while they take the defective receiver to their shop. The loaned receiver is a good technique for still another reason. If the intermittent receiver at your shop refuses to act up badly, you may check with the customer to see if the loaned receiver is acting badly intermittently. If it is, then his set is cleared of suspicion. If it is working well, then at least his installation is good, and you must check his receiver further.

Defects Which Cause Intermittent Operation. Paper condensers are one of the most common causes of intermittent operation. The leads of these condensers are pressed into contact with the rolled metal foil plates. Hard wax at the ends of the condensers holds the leads in place. Too much tension on the leads or excessive heat which softens the wax may permit the leads to pull slightly away from their plate contacts. Jarring or release of tension could then drive the leads to make good contact with the plates, and all is well again—until the next break.

The defective operation produced intermittently by such an open condenser depends on the location of the condenser. For example, an open coupling condenser of the type described could cause intermittent fading or weakening of the receiver output as well as intermittent distortion.

Very often, when checking such a receiver, bridging the suspected condenser with a good one cures the defect. Then when the test condenser is removed, the defect seems to be gone. This is an almost certain indication of an intermittently open condenser. The bridging technique helped to heal the open connection, but rather superficially. Remove the old condenser and replace it with a new one.

Electrolytic filter condensers of the tubular cardboard type sometimes cause intermittent hum. In such cases, leakage develops intermittently between the condenser and its grounded metal support through the insulating cardboard. The condenser then intermittently fails in its filtering function.

Intermittent Tubes. Another very common cause of intermittent receiver operation is the tube. Its heater, because of its high temperature during operation, is greatly subject to expansion changes. Sometimes the heater breaks as a result of the expansion, but the broken ends remain in contact when the tube is cold. As soon as you turn on the receiver, the heater becomes hot and expands. The broken ends separate and the tube goes out. It then may cool and permit the broken ends of the heater to remake contact; the tube lights and functions again. This intermittent action repeats itself regularly. The receiver operates normally and then goes dead in synchronization with the action. In intermittents of this type the music fades out gradually as the open causes the heater to slowly cool off. Then, after the tube cools and contact is remade, the music comes on gradually with the slow warming up of the heater.

With glass tubes, you will see the heater go out and easily spot the defective tube. In the case of metal tubes, you can tell if the tube is out by feeling the metal shell for warmth.

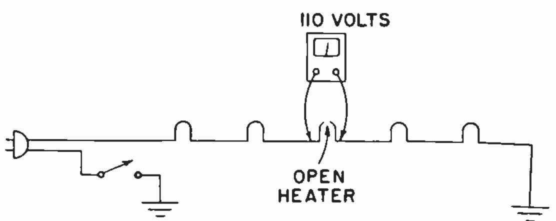


Fig. 9-1. Checking for an open heater with a voltmeter

Where the tube heaters are in series, as in a-c/d-c receivers, all the tubes go out when the defective heater of one tube opens. You can tell which tube is defective as soon as the tubes go out by measuring across each heater with an a-c voltmeter, as shown in Fig. 9-1. All good heaters will give no reading. When you place the voltmeter across the broken heater, you will get a reading of 110 volts. The tubes with the higher heater voltages are most likely to break their heaters, since they are hottest in operation.

Because of the heat developed within a tube and expansion effects that follow, tube elements may short within the tube intermittently and produce various intermittent defects. These defects depend on which electrodes short and usually last until the set is shut off and the tube cools down. Sometimes you may cause the condition to develop by tapping the tube lightly.

Intermittent Grid Caps. Tubes with grid caps often develop intermittent defects, especially where the grid-cap clip has been removed quite often. The connection between the control-grid lead and the grid cap may break or become corroded, making intermittent contact as the tube vibrates mechanically. If you hear noise, hum, or distortion as you tap the grid cap lightly, the defect probably lies there. Apply a hot soldering iron with a little solder to the top of the grid cap for a few seconds. Of course, it is better to replace the tube. Often the soldering job will not stand up too long.

While you are at it, check and resolder the connection between the grid lead and the grid-cap clip. Replace the grid-cap clip and tap the grid cap again to see if the defect is gone.

Intermittent Connections in Tubes. The electrodes of tubes are welded to their leads within the tube. Sometimes these welds open under the influence of heat and open the particular electrode where this occurs. The defective condition which results depends on the electrode affected. The defect usually lasts until the receiver is shut off and the tube cools. Tapping the defective tube lightly often causes the defective weld to open or close. When you locate such a tube, replace it with a new one.

Intermittent Contacts in Tube Sockets. And still another way in which a tube enters into intermittent operation of a receiver is in its seating in its socket. Corrosion of the socket or spread socket prongs may cause the tube electrode to make intermittent contact with its socket prong as the tube vibrates. Again, the defect depends upon the tube pin affected. You can often detect such a condition by rocking the tubes gently in their sockets and by listening for the appearance or disappearance of the defect. Replacement of the socket or squeezing the prongs will fix these conditions.

In one sense, grid emission might be called a cause of intermittent operation. The distortion resulting from this occurs only after the receiver has been in operation for a while and the grid has become sufficiently hot.

Intermittent Tuning Condensers. Tuning condensers may also be a cause of intermittent operation. Conductive dirt that falls between the plates may at various positions of the tuning dial short the rotor and stator plates. This may cause the receiver to go dead intermittently or cause noise. If the receiver is noisy as you turn the tuning dial, you know that the defect lies in the tuning condenser.

Sometimes, dirt collects between the wiper contacts and the rotor plates. This, too, may cause intermittent noise, fading, or oscillation squeal as good and poor contacts are alternately made. If you suspect such poor contacts as the cause of the defect, clean the contacting surfaces and see if the condition is corrected.

Intermittent Resistors. Resistors, too, may cause intermittent defects. Fixed resistors may break internally as they become hot and remake contact as they cool or vibrate. This is especially true of resistors in circuits that carry currents.

Variable potentiometers, such as those used in volume controls and tone controls, are especially subject to defects which cause intermittent operation. Pitting or wear of the carbon element causes it to make varying contact with the movable slider arm. To check the volume control, try tapping it with the arm in several positions, and see if you can produce the intermittent condition. If the volume control is bad, your best procedure is to replace it with a new one.

Intermittent Coils. Coils also may cause intermittent effects. Tension produced by the thermal expansion of a coil form may cause the thin wires of a coil to break from its connecting lug. Slight vibration sometimes remakes contact, and all is well again until expansion opens the break. Air-core coils are subject to this condition.

Corrosion in the metal of thin-wire coils may produce an exceedingly tiny break in the wire. It may intermittently open and close. Or a tiny arc may bridge the gap and give the effect of a continuous circuit. A sudden voltage drop may quench the spark and open the circuit. The arc may appear again when the voltage rises or a surge is produced by switching the receiver on or off or switching other electrical devices on and off. You may be able to resolder a coil terminal to its lug if it has broken off. A corroded coil should be replaced.

Intermittent Pilot Lamps. Pilot lamps may also cause intermittent noise. These lamps often are poorly seated in their receptacles. As a result the lead tip at the base of the lamp may make intermittent contact. Examine the lamp base for a rounded lead tip. If it is flattened and worn, add a bit of solder with your soldering iron.

Intermittent Connections. Thermal expansion may cause bits of solder, especially if connections are made with excess solder, to move and touch another conductor. The nature of the intermittent defect would depend on where such shorting took place. Sometimes the terminals of i-f transformers intermittently short against the transformer shield can, and the receiver goes dead. Occasionally the speaker field of an electromagnetic dynamic loudspeaker shorts intermittently to the center pole piece of the speaker. Such a short may produce an intermittent dead receiver or intermittent fading. Sometimes conductive dirt gets into an i-f transformer and shorts the trimmer condenser. Vibration may open the short and later remake the short. A cleanup job is called for.

Auto-radio Intermittents. In auto receivers, in addition to all other causes, the vibrator of the power supply may cause an intermittently dead receiver. As the vibrator points wear or the spring weakens, the unit will sometimes fail to start. The car owner soon discovers that if he flips the receiver switch on and off several times or hits a bump which vibrates the car, the receiver begins to play. Check the condition by turning on the receiver, and listen for the vibrator buzz. If you do not hear it, slap the receiver sharply. If now you hear the buzz, the vibrator is probably defective. You may further confirm the condition by feeding 4 volts to the vibrator rather than the usual 6 volts. If the vibrator does not buzz, it is probably defective.

Intermittent noise in a car radio may also be due to poor contact of the fuse in its holder. Inspection readily discloses the condition. One other possibility in the car radio may be a defective on-off switch. Low voltage and high current is fed to the switch. Poor contact in the switch might cause intermittent fading. Of course, the switch may be a cause of intermittent operation in any radio receiver.

Intermittent Soldered Joints. All receivers are subject to intermittent defects resulting from poorly soldered joints. These may corrode and open and close intermittently with vibration. The great number of such soldered connections in a receiver make the probability of such a condition quite likely.

Intermittent Oscillation. There is one superheterodyne-receiver defect which is closely akin to intermittent operation, known as *critical oscillation*. In critical oscillation, reception will be normal at the high-frequency end of the tuning range, erratic at the middle frequencies, and dead at the low-frequency end. This condition is due to failure of the oscillator at the low-frequency end of the tuning range.

You can check the condition in the following manner. 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. Assume it is 1,100 kc.

Now start at the high-frequency end and tune in the other direction. If you receive all stations, including the one at 1,100 kc, and then receive a few further on, like one at 1,000 kc and one at 900 kc but no others, you have critical oscillation.

The reason for the receiver behavior is that oscillator operation is more efficient at high frequencies than at low frequencies. An oscillator tube with weak electron emission might oscillate at the high-frequency end of the tuning range but not at the low end. Once the tube is oscillating, it might continue even beyond the position of normal nonoscillation. Try the substitution of another oscillator tube. Sometimes you may have to try various oscillator tubes before you get one that removes the critical oscillation. In other receivers the tubes subject to critical oscillation may be perfectly satisfactory.

Other conditions may also cause intermittent oscillation. Dirt in the oscillator section of the tuning gang may be the cause. If nothing seems to clear the condition, try substituting a cathode self-bias resistor of lower ohmage.

Intermittents Caused by Heat and Vibration. Generally, most intermittent defects are the result of unstable opens, shorts, or leakages. Heat is one general cause of the intermittent action. Heat causes parts to expand and move slightly. In reverse, the cooling of parts causes them to contract and move back.

Vibration is another general cause of intermittent action. Vibration as a result of speaker action or external causes can make parts that are close together touch or move apart.

Rubber-covered leads are a fairly common cause in this respect, especially when they pass through small openings in the chassis. The rubber dries and cracks, permitting the lead to short intermittently.

Electrical surges are a general cause of intermittent action. They may cause small open circuits to be closed by an arc or be opened by the quenching of the arc. Electrical surges and vibration will give highly irregular action. Heat usually causes regular intermittent effects, since the defect produced by thermal action often clears as the defect removes the heating factor and cooling restores normal action.

Localizing the Defective Section. Before you begin your localization tests, give the receiver a complete visual inspection. You may spot the defect quickly and save time. Examination may show an extremely corroded connection. Turn on the receiver and pull on the leads to this connection. See if the receiver acts up when you do this. If it does, you probably have found the defect. In a similar way, tapping the tubes may cause the receiver to act up. If it does so, the tube or socket or leads of that stage may be the cause.

Observation of the receiver in a darkened room might disclose a tiny electrical arc which is causing the intermittent condition. You then have the defective component and take suitable remedial steps. Similarly, observation of glass tubes may show by going out when the intermittent condition develops. If metal tubes are used, feel the outside shell after a few minutes for warmth to see if the heater is open.

Look for conditions which might produce shorts. Look for connections that lie close to the chassis. See if the terminals of components are very close to each other. Check shields for contacts that are well grounded. Inspect rubber-covered leads that go through small chassis holes to see that the rubber insulation is not cracked, permitting the copper lead to be intermittently grounded.

Isolating Intermittents. You could go on from here and wiggle every lead, every paper condenser, and every resistor. But you are racing with time. It is more advisable to localize the defect systematically if your overview search does not immediately disclose the cause.

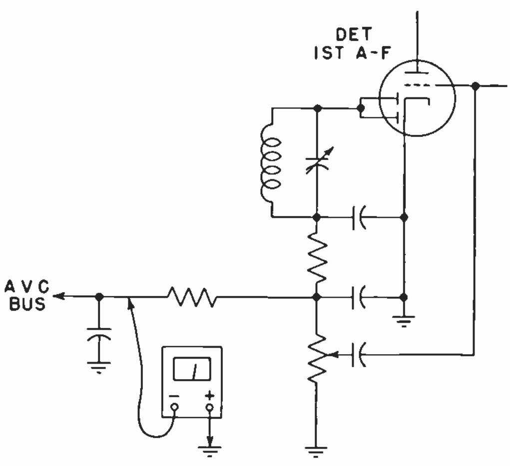


Fig. 9-2. Checking for fading with a meter at the avc bus

With a-c receivers that go intermittently dead or grow weak (fade), you may localize the defective section of the receiver with a d-c voltmeter of high sensitivity (high resistance). Tune to a station and connect the meter to the avc bus, as shown in Fig. 9-2. Note that the positive terminal of the voltmeter goes to the ground. Leave the meter permanently connected until the receiver fades or goes dead. If the reading of the meter changes when the receiver acts up, the defect lies in the r-f section of the receiver or in the power supply. If the meter does not change in value when the trouble occurs, the defect is in the a-f section of the receiver.

You do not need a voltmeter if the receiver has an electron-ray tuning indicator, since the latter is in effect a vacuum-tube voltmeter connected to the avc bus. Tune the receiver to a station, and see if the tuning indicator varies its indication as the receiver acts up. If it does, the r-f section or power supply is defective. If the indicator does not change, the a-f section is at fault.

You may make the same localization test on an a-c/d-c receiver, except where the heater circuit intermittently opens and closes. The receiver would then go completely dead, since the heaters are all in series. Where this occurs, you have a type of localization test, because then you will direct your attention to the heater circuit.

Isolating Intermittents with a Signal Generator. The signal generator may be used to localize the defective section of an a-c receiver when the intermittent condition is fading or a dead receiver. Tune the receiver to

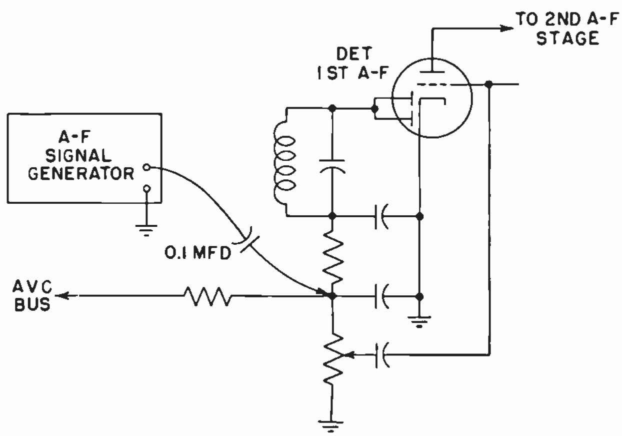


Fig. 9-3. Using a signal generator to check for fading

a quiet non-station position. Set the signal generator to give an audio output. Connect its ground lead to the chassis and the hot lead to the ungrounded end of the volume control (input of the a-f section), as shown in Fig. 9-3. You will continue to hear the generator note from the receiver loudspeaker. If the note suddenly disappears or drops in volume or produces another defect, the a-f section or power supply of the receiver is probably where the defect lies. If the note continues to come through unaltered for a long time, the defect probably lies in the r-f section of the receiver.

Locating the Specific Defect. Once you have found the defective stage, you have limited your field of operation. Proceed now with both tests and reasoning. The nature of the intermittent complaint may guide you in finding the specific defect. For instance, oscillation squeal would direct your attention to the screen bypass condenser, a grounded shield, or a similar device. Or intermittent distortion would lead you to check the tube, a coupling condenser, and so forth.

If you cannot correct the defect, proceed to tap and rock the stage tube gently. Try replacing tubes in some cases. Wiggle all leads firmly to see if connections are good. Use your judgment on how hard to wiggle to break a defective connection but not a good one. Listen for the effect of such wiggling in the receiver. Pull and wiggle the leads of paper condensers and fixed resistors in the stage. Push all shield cans and shield wires. See if such action makes a difference in the receiver output. Inspect coils for signs of corrosion. As a last resort, if all else fails you should replace each component of the defective stage—one at a time, starting with paper condensers. With each replacement, see if the defect stays permanently cleared up.

You may be guided in your hunt for the defect by the receiver behavior if the intermittent condition is due to thermal action. Here the receiver plays normally and acts up at regular intervals. The shorter the interval between normal and defective output, the greater the heat at the defective part or the smaller the defective component. Thus, tubes and defective connections act up quickly. Heavy transformers or large resistors usually have the longest period between normal and defective output. These principles may direct you to the defect a little more rapidly than otherwise.

Air Check. Your reputation as a serviceman among your customers depends primarily upon your skill in repairing receiver defects. More servicemen lose their reputations with intermittent defects than with other receiver defects. Such a state of affairs develops from the fact that many servicemen remove the intermittent defect without testing the permanence of the repair. They return the receiver to the customer, only to have it brought back shortly after. You will feel quite silly when this happens to you.

Be sure to give a receiver which you believe cured of an intermittent defect a thorough air check. Turn it on, tune to a station, and let it run continuously for several hours in the receiver's own cabinet or in a closed box. Change your station several times. Turn the line switch off and on several times. From time to time slap the receiver chassis sharply. If the receiver continues to play normally during this air check period, you may be reasonably sure that the defect is permanently cleared up.

10

Distortion

What Is Receiver Distortion? Distortion in a receiver in one way is similar to hum—both conditions normally exist in every receiver. However, the extent to which they make themselves manifest is the aspect that is of interest to you as a serviceman. A 5 per cent distortion is acceptable to receiver designers. And even 10 per cent distortion is not too objectionable to the average listener. Tube manufacturers give the percentage of distortion for their tubes at recommended operating voltages in their tube manuals.

However, when the customer reports his receiver, he usually is not referring to the permissible distortion inherent in the receiver design. If he complains that the quality of his small, inexpensive receiver is not so good as his neighbor's large, expensive receiver, a short, friendly, nontechnical explanation will make him satisfied with the limitations of his own receiver.

Usually, the customer will be comparing the quality of his receiver with its previous quality. He will claim that the receiver doesn't sound well, or has poor quality, or sounds muffled. On rare occasions, a customer with an extremely discriminating ear will report that the receiver is not reproducing high or low notes quite as well as it used to do. By and large, most complaints will not be of this latter type, but rather of the type where distortion is of a degree where receiver reproduction is barely intelligible and extremely irritating to hear.

Questioning the Customer. Regardless of whether you think the customer's complaint is valid or that of a fussy individual, your service is to the customer and not to the receiver, especially in the case of distortion. If you do not find the receiver too bad, determine just what the customer finds objectionable. By questioning, determine if the receiver ever had a quality which the customer found satisfactory. Try to find out if the receiver was recently serviced. Determine if the receiver distorts all over the tuning dial or only on a few stations. Has a new antenna installation recently been put up? Does distortion develop after about a half hour of operation or right at the start?

You may think some of the questions are unnecessary, since you will confirm any condition yourself rather than rely on the customer information. But remember first that customer information may point out an avenue of investigation and save you time. Furthermore, questioning carried on in a professional manner will impress your customer with your ability as a professional worker. The doctor will always obtain the case history of his patient and ask pointed questions before examining him.

Harmonic Distortion. The main type of distortion which you will be called upon to service in an amplitude-modulated type of receiver is that known as *harmonic distortion* (sometimes, *amplitude distortion*). You will have to know a little about the nature of this type of distortion if you wish to understand its servicing aspect better. However, do not be troubled if you fail to follow it completely, since it will not retard your service skill.

Examine Fig. 10-1. In it are shown the I_p-E_g (how plate current changes when grid voltage changes) curves for a particular tube as found in the tube manual. Three curves are shown: the upper one for a plate voltage of 300 volts; the center one for a plate voltage of 250 volts; and the lower one for a plate voltage of 200 volts. Assume that, for our normal operation of the tube, a plate voltage of 250 volts is used.

Undistorted Output. For normal distortionless output, we must operate our tube on the straight portion of the curve, carefully avoiding the upper and lower bends of the curve. To obtain this result, the signal grid bias is set approximately at the center of the straight portion of the curve. Thus, the grid bias E_g is shown by the solid vertical line. An input signal *A* causes the grid voltage to swing back and forth around its bias point. This causes the plate current I_p to swing up and down along the straight portion of its characteristic curve. The result *A* is a symmetrical, faithful reproduction of the input signal, and no distortion exists.

Strong-signal Distortion. Now assume that a signal of twice the strength or magnitude is applied to the signal grid of the tube as shown at *B*, operating with the same grid bias. The voltage excursion of the grid drives the plate current into both the upper and lower bends of the characteristic curve. The output curve at *B* now does not resemble the input curve, since the peaks are flattened. This flattening introduces new tones which did not exist in the original input signal. We say that harmonics have been introduced which cause distortion of the signal.

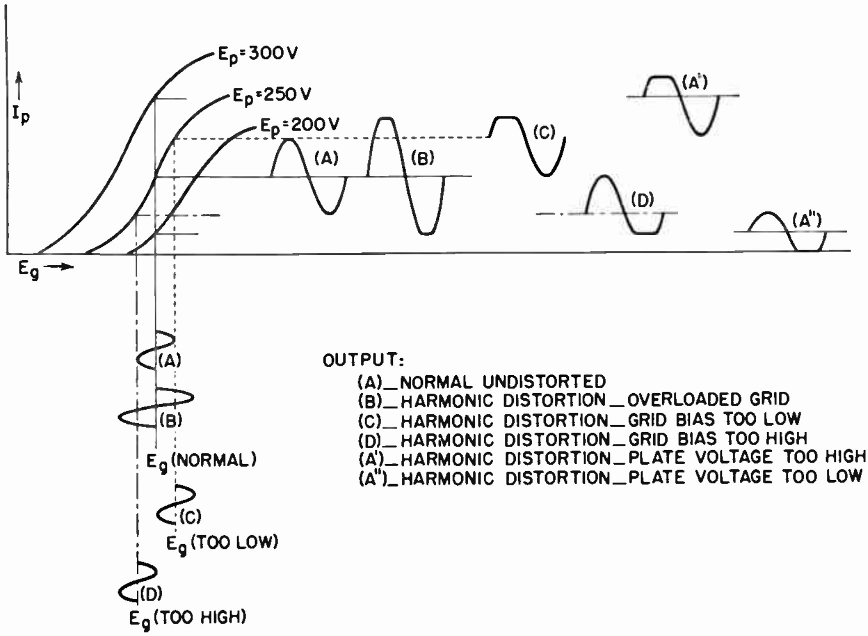


Fig. 10-1. Plate current–grid voltage curves of a tube

Meaning of Harmonics. What are harmonics? A sound is merely a vibration of an elastic material at a certain number of vibrations per second. Let us say that a saw blade is vibrating at a frequency of 256 vibrations a second and is emitting a particular note. If we can make the blade vibrate at twice that frequency (2×256), or 512 vibrations per second, the pitch of the note will be higher, and we say the new note is the second harmonic of the original note.

Now make the blade vibrate at three times the original frequency (3×256), or 768 vibrations per second. The pitch is still higher, and we say this note is the third harmonic of the original note. Thus, when a tube gives distorted output by producing harmonic notes which did not exist in the input signal, we say that we have harmonic distortion. Such distorting harmonics were introduced into curve *B*.

Distortion Caused by Low Grid Bias. Let us return to Fig. 10-1. Assume once again that our input signal is not too great in strength, as shown at *C*. But this time our signal grid bias is too low. The excursion of the plate current this time carries it into the upper bend and the output *C* is distorted because its upper loop is flattened. Again we have harmonic distortion.

Distortion Caused by High Grid Bias. A similar type of distortion occurs if a normal input signal is applied to the signal grid, as at *D* when the grid bias is too highly negative. The plate current swing this time carries it into the lower bend of the characteristic curve. Harmonic distortion once again is present, since the output *D* has its lower loop flattened.

Distortion Caused by Wrong Plate Voltage. Let us make another assumption. Assume that grid bias is normal and that the signal input is as at *A*. But this time plate voltage is too high, namely 300 volts. We are operating, therefore, on the upper characteristic curve. The output *A'* is distorted because the plate current swing carries it into the upper bend, flattening the upper loop.

A similar type of distortion occurs when plate current falls too low. Assume that grid bias is normal, as is the signal input, as at *A*. The plate voltage falls to 200 volts, and we are operating on the lower characteristic curve. This time the excursion of the plate current carries it into the lower bend of the characteristic curve, and the lower loop is flattened.

When hunting for the causes of harmonic distortion, you must look for any condition which would change the grid bias or the plate voltage of a tube. So far as too great an input signal is concerned, you will rarely find that the incoming signal is too large. Usually, the difficulty is that the stage operation has deteriorated to a point where it cannot handle a signal of normal strength. Even more rarely, too large an aerial near a strong station may give a too strong signal.

Frequency Distortion. On very few occasions, you will be called in for another type of distortion known as frequency distortion. The sounds heard from a receiver are not simple monotones but complex mixtures of tones of many different frequencies. Where frequency distortion exists, an amplifier stage will fail to amplify equally the tones of different pitches, and the output will accentuate low, middle, or high frequencies more than the others.

Where the frequency distortion is apparent only to a customer with a very discriminating ear, you will have to take frequency response curves. More will be said about this procedure later. Normally, only where frequency distortion is extreme will you be called in. Your job then is to check alignment for extreme sideband cutting or check condensers for defects, since a change in capacitance of a condenser will alter its ability to handle signals of different frequencies.

Specific Causes of Harmonic Distortion. Let us now examine specific defects in a receiver which can cause harmonic distortion. Most of these defects will occur in the a-f section, the loudspeaker, and the power supply. Let us take the schematic circuit of Fig. 10-2 as a typical audio section of a receiver in which distortion defects may arise.

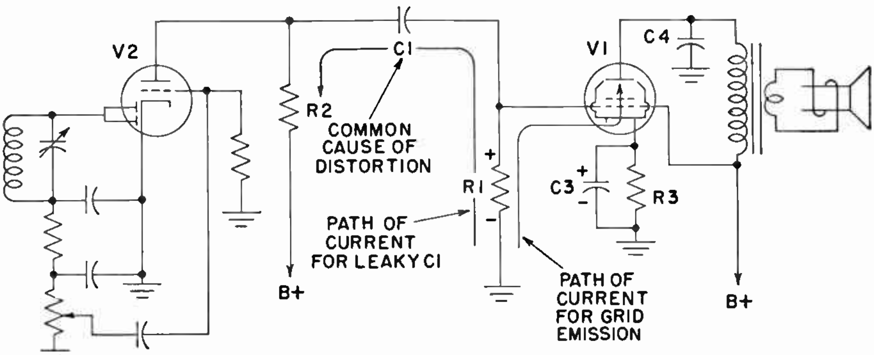


Fig. 10-2. Typical audio section of a receiver, showing common causes of distortion

One of the most common causes of distortion is a leaky coupling condenser between stages. Assume that coupling condenser C-1 becomes leaky. A current of electrons from the power supply now flows from ground across grid-load resistor *R*-1, across the leaky coupling condenser C-1, across plate-load resistor *R*-2 to B-plus. The direction of this current tends to give a voltage drop across *R*-1 such that the grid end is positive, and the grid of the tube V-1 is driven more positive, as shown in Fig. 10-2. The voltage drop across the self-bias resistor is such as to make the grid of the tube negative. The net result is that the bias on the tube is either less negative than normal or even positive, depending on the extent of leakage across condenser C-1. This means that the bias of the tube is too low, and it operates around the upper bend of its characteristic curve, producing distortion.

You may check for a leaky coupling condenser in the following manner: Normally, no current flows through grid-load resistor *R*-1. If current flows across *R*-1 because coupling capacitor C-1 is leaky, a voltage drop will take place across it. You may check for such a voltage drop with a voltmeter of high sensitivity (high resistance). Place the positive lead of the voltmeter at the grid end of resistor *R*-1 and the negative lead at the other end of the resistor. No reading clears condenser C-1. If you get a reading, the condenser may be leaky. Notice that we have said that the condenser "may" be leaky. There is another condition known as *grid emission* which could cause the same effect. Later, we will show how to differentiate between the two conditions.

Grid Emission. What is grid emission? Sometimes during the process of manufacture of a tube, a small portion of cathode-emitting material accidentally deposits upon the control grid. As a result, the grid may emit electrons, especially if the tube becomes quite hot. This condition cannot be detected by a tube checker, since heat is a prerequisite condition. When the grid emits electrons, it causes electrons to flow from ground across resistor *R*-1 to the grid, as shown in Fig. 10-2. The direction of electron flow is such that the grid end of resistor *R*-1 is positive, driving the control grid more positive. The same distortion as occurred with a leaky coupling condenser results. This condition is especially bad with zero-bias type of operation, that is, where cathodes are connected directly to ground. Distortion caused by grid emission usually becomes evident after the receiver has been in operation for a short while.

To differentiate between coupling-condenser leakage and grid emission, connect your voltmeter across grid lead resistor *R*-1. If you have no reading, neither condition exists. If you obtain a voltage drop across *R*-1, remove tube V-1, if you have an a-c receiver. No voltage reading now indicates grid emission in the tube. Replace the tube with a new one. A voltage reading with the tube removed indicates a leaky coupling condenser.

You cannot remove a tube in an a-c/d-c receiver or three-way portable receiver. Here you must unsolder either lead of the coupling condenser, with the voltmeter across the grid-load resistor. If the voltage drop across the resistor disappears when the condenser is opened, you have coupling-condenser leakage. If it does not disappear, you have grid emission.

Poor Grid Bias. Defects in the tube-biasing system may also produce harmonic distortion. Refer once again to Fig. 10-2, tube V-1. If self-bias resistor *R*-3 should open, it would seem that there would be no cathode current. But cathode bypass condenser C-3 is usually an electrolytic condenser with considerable leakage resistance. A voltage drop would occur across it to bias the grid. Since the leakage resistance is much greater than the resistance of self-bias resistor *R*-3, the voltage drop across condenser C-3 is quite large, and the control grid receives a very large negative bias. The tube operates around the lower bend of its characteristic curve with resulting harmonic distortion.

Usually, the voltage drop across condenser C-3 is so large as to destroy the condenser. Then the receiver is reported as dead. When self-bias resistor *R*-3 opens and the grid receives a very high negative charge, plate current drops. As a result, the voltage drop across the plate-load resistor decreases (output transformer primary) and the plate voltage of the tube rises. A higher-than-normal plate voltage then would point to a possible open resistor *R*-3.

Another bias defect would result if cathode bypass condenser C-3 shorts, thereby shorting out the voltage drop across self-bias resistor *R*-3 and removing the grid bias. The tube would then be operating around the upper bend of its characteristic curve and would produce harmonic distortion. Because there is no grid bias, plate current would be large and produce a large voltage drop across the plate-load resistor. As a result, plate voltage would be quite low.

Cathode-heater Leakage. A cathode-heater short may also upset the bias system and produce distortion. Examine the tube stage in Fig. 10-3. Grid bias is obtained from the voltage drop across self-bias resistor *R*-3. Should the cathode of the tube short to the grounded side of the heater, resistor *R*-3 would be shorted out, and there would be no bias on the tube. Distortion would result. In this case, as with a shorted cathode bypass condenser, plate voltage would be low.

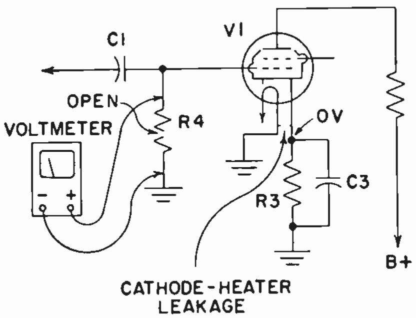


Fig. 10-3. Source of distortion from cathode-heater leakage

There are a few occasions when an open grid-load resistor like *R*-4 of Fig. 10-3 may cause distortion (usually accompanied by weak output and hum). The free-floating grid picks up electrons and becomes excessively negative. You may suspect a leaky coupling condenser or grid emission and connect a voltmeter of high sensitivity across the grid-load resistor as shown. As you do this, the distortion disappears. The reason for this receiver behavior is that the voltmeter bridges the open section of the resistor *R*-4. When you remove the voltmeter, the receiver sounds distorted again. Replace resistor *R*-4 with a new one.

Wrong Bias in Fixed-bias Circuits. Circuits that employ fixed bias, rather than self-bias, are especially likely to produce distortion. Take for example, the fixed-bias circuit of Fig. 10-4. Notice that the center tap from the high-voltage secondary winding goes to ground through resistors *R*-1 and *R*-2. The plate currents from all receiver tubes must pass through these resistors. As a result, a voltage drop takes place across them, and the transformer end of resistor *R*-1 as well as the point between *R*-1 and *R*-2 are more negative than ground.

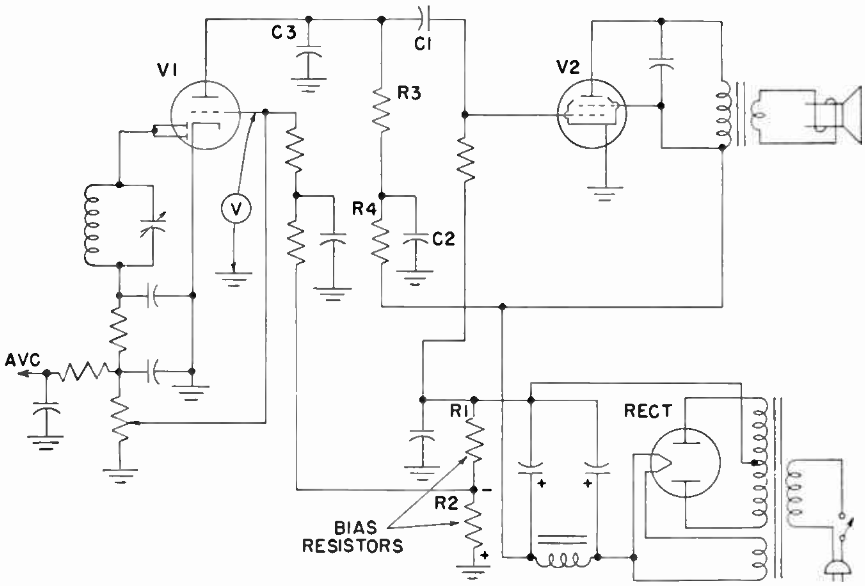


Fig. 10-4. A fixed-bias circuit, showing resistors that provide a fixed grid-bias voltage

The cathodes of tubes V-1 and V-2 are connected directly to ground. The control grid of tube V-2 obtains its negative bias by being connected to the negative end of resistor *R*-1; the control grid of tube V-1 obtains its negative bias by being connected to the junction between *R*-1 and *R*-2.

Suppose that coupling condenser C-1 becomes slightly leaky or that grid emission appears in tube V-2. The grid bias of tube V-2 decreases and the plate current goes up. But this rise in plate current produces a greater voltage drop across resistors *R*-1 and *R*-2 through which the plate current flows. As a result the grid of tube V-2 receives a greater negative bias, and a sort of restoring situation develops for the tube. However, the larger voltage drop across resistor *R*-2 feeds a larger negative bias to tube V-1, which does not have a leaky coupling condenser or grid emission. The tube is forced to operate around the lower bend of its characteristic curve, and distortion results.

Measuring Bias Voltage. A condition like the above is found by making a voltage check between the grid of V-1 and ground, as shown in Fig. 10-4. Tube V-1 will probably be working at a lower-than-normal plate voltage. The better indication is that the bias voltages across resistors *R*-1 and *R*-2 will be higher than normal. When checking the bias voltage at the grid of tube V-1, it may be noticed that the distortion is partially cleared up. This is because the meter resistance, in parallel with the grid load, tends to restore normal bias voltage on the tube. These indications point to a heavy current flow through the following output tube, which of course focuses attention to the coupling condenser and the possibility of grid emission in the tube.

Leaky Decoupling-filter Condensers. Another effect producing distortion may result from a fixed-bias circuit. Refer once again to Fig. 10-4. Assume that decoupling-filter condenser *C*-2 becomes leaky. As a result, the voltage of the plate of tube V-1 drops. The grid bias remains about the same as when normal, because the drop across resistors *R*-1 and *R*-2 is primarily dependent on the large plate current of the output tube V-2. The normal bias is too negative for the tube at its lowered plate voltage, and distortion results.

If the receiver is an a-c receiver, you may check for leakage in condenser *C*-2 in the following way: Remove tube V-1 from its socket. If all is normal, there is no voltage drop across resistor *R*-4, since no plate current is flowing. But if condenser *C*-2 is leaky, electrons flow from ground through condenser *C*-2, through resistor *R*-4 back to B-plus. If your voltmeter shows a voltage across *R*-4, you know that condenser *C*-2 is leaky and must be replaced.

Similarly, if condenser *C*-3 is leaky, the same effects result. But this time your voltmeter will show a voltage drop across both *R*-3 and *R*-4 with the tube removed. In an a-c/d-c receiver, you cannot remove the tube; merely unsolder the plate lead at the tube socket.

Distortion by Overloading the R-F Amplifier. As was stated previously, overloading of a stage is usually an indication of a defect in the receiver which prevents it from handling normal signals properly. On rare occasions closeness to a powerful station will cause overloading and distortion.

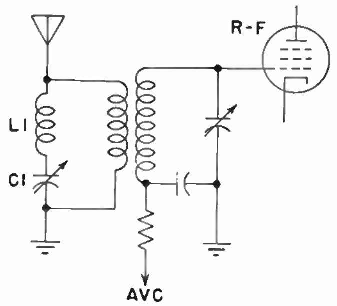


Fig. 10-5. Using a wave trap to remove overloading by a powerful station

You may remedy the situation by shortening the antenna, rotating the receiver if it has a loop antenna, or constructing a wave trap in the antenna circuit for the station involved, as shown in Fig. 10-5. Coil *L*-1 and condenser C-1 make up the trap. The trap is tuned to the frequency of the powerful station and passes some of its signal to ground. These traps may be purchased from most radio-supply houses.

In a loop antenna receiver, a similar trap may be placed in the converter signal grid circuit, as shown by *L*-1 and C-1 in Fig. 10-6.

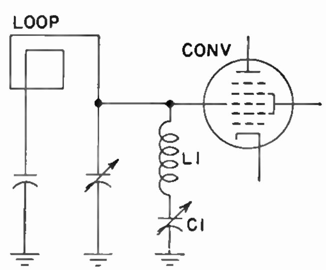


Fig. 10-6. Placing a wave trap in a loop-type receiver

Overloading. Let us examine receiver defects that result in overloaded stages. Several conditions may result from a defect in the avc system. Examine Fig. 10-7. Assume that avc filter condenser C-1 shorts or becomes excessively leaky. The avc voltage to the controlled tubes will be shorted out, and their bias may be too low. As a result, the controlled tubes could be overloaded and distort.

A similar effect would result if one of the controlled tubes develop grid emission. The flow of grid current through the avc filter resistor *R*-1 develops a voltage drop across it with such polarity as to neutralize the negative voltage normally fed by the avc system. The bias on the controlled tubes becomes too low, and a strong signal may overload them, producing distortion.

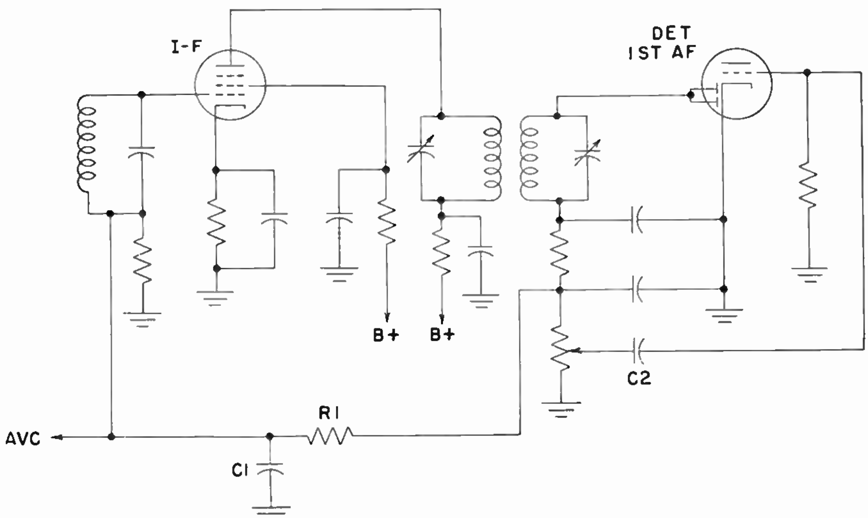


Fig. 10-7. How avc voltage can produce distortion

Refer once again to Fig. 10-7. If audio coupling condenser C-2 becomes leaky, some avc voltage will be fed across it to the grid of the first a-f tube, increasing its negative bias and driving the tube to the lower bend of its characteristic curve. The more you turn up the volume control (away from ground), the more avc voltage you feed to the tube and the more negative its bias and the worse the distortion.

Distortion in Audio Stages. Another condition, particularly in the second a-f output stage, may result in distortion. Since the output tube handles so much power, the stage is readily thrown into a state of r-f oscillation because of distributed inductances and capacitances of its input and output circuits. This oscillation is a parasitic type of oscillation which consumes much power from the power supply, lowering all operating voltages. Distortion results, often accompanied by a rushing sound or high-pitched whistle.

To prevent this tendency toward parasitic oscillation, a plate bypass condenser is used (C-4 in Fig. 10-2). If it opens, the distortion may follow.

This condition may be found when the output tube and the components of the power supply overheat and all voltages are low.

Distortion in Push-pull Audio Stages. Push-pull stages may produce amplitude distortion, just as do single-ended stages. A splendid characteristic of the push-pull stage is that it reduces or eliminates even-harmonic distortion. Because of the elimination of such distortion, each of the tubes of the stage may be overloaded somewhat without giving distorted output. For example, maximum undistorted output for a single 6A3 tube will be 3.2 watts, while a pair of push-pull 6A3 tubes will deliver a maximum undistorted output of 10 watts. The elimination of even-harmonic distortion, however, is dependent on a perfect balance in the push-pull stage.

Figure 10-8 illustrates a transformer-coupled push-pull stage. Both tubes V-1 and V-2 must have practically identical characteristics. If one tube grows weak, the balance is upset and distortion increases. Both tubes must be driven by equal signal voltages on their grids, and these voltages must be 180 degrees out of phase (that is, e_1 equals e_2, and e_1 is 180 degrees out of phase with e_2). Normally, this condition is obtained by center-tapping the secondary winding of the input transformer and connecting the center-tap to ground.

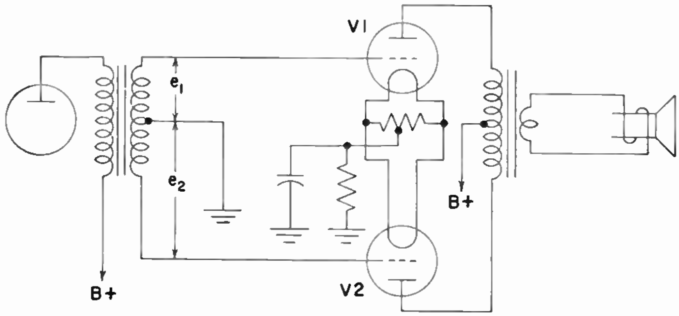


Fig. 10-8. A transformer-coupled push-pull stage

A short or open in either half of the secondary winding or the grounding of any of its turns would upset the balance and produce distortion. Replacement of defective tubes or input transformers is the remedy in these two cases. Finally, a short, an open, or grounding in either half of the primary winding of the output transformer would upset the balance in the same way as the input transformer and increase distortion.

Phase Inverters. When a push-pull stage is resistor-condenser–coupled to its driver stage, you have the problem of obtaining equal voltages that

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are 180 degrees out of phase for the grids of the push-pull tubes. Such conditions are usually obtained by use of another stage known as a phase inverter.

Figure 10-9 shows a block diagram of a phase-inverter type of push-pull amplifier. Notice that a negative voltage fed to the grid of the first a-f tube causes it to feed a positive signal to the grid of the phase-inverter tube and one of the push-pull output tubes. When the phase-inverter tube receives a positive signal, it in turn feeds a negative signal to the grid of the second push-pull output tube. Thus, the two push-pull tubes receive signals that are 180 degrees out of phase. But you must still have these signals equal in amplitude or voltage.

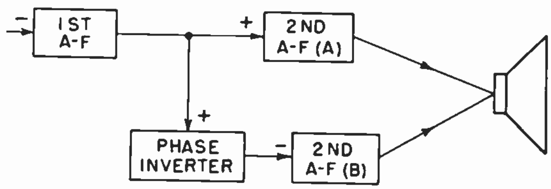


Fig. 10-9. Block diagram of a phase-inverter type of push-pull amplifier

To obtain this second condition, a portion of the positive output voltage pulse of the first a-f tube is tapped off the grid leak of the upper output tube and fed to the grid of the phase-inverter tube. Here the gain of the inverter tube brings the negative output pulse for the lower output tube to the same level as the positive pulse fed to the upper output tube. Figure 10-10 shows the schematic diagram of a typical push-pull amplifier using a phase inverter.

The circuit just described is in a state of fairly delicate balance for proper operation. Sometimes the phase-inverter tube grows weak. Signals of unequal magnitude are delivered to the grids of the push-pull tubes, and distortion results. If the values of the grid-load resistor *R*-4 or *R*-6 change, a similar effect occurs. Of course, any of the conditions which cause distortion in a single tube stage would also cause distortion in a push-pull stage.

The Speaker and Distortion. The loudspeaker, too, may introduce distortion into a receiver. The simplest way to determine if the loudspeaker is the cause is to open the voice coil of the loudspeaker and connect a test p-m dynamic loudspeaker across the output transformer secondary. If the distortion disappears, you know that the loudspeaker is at fault.

Several conditions in the loudspeaker can distort the output. First, the

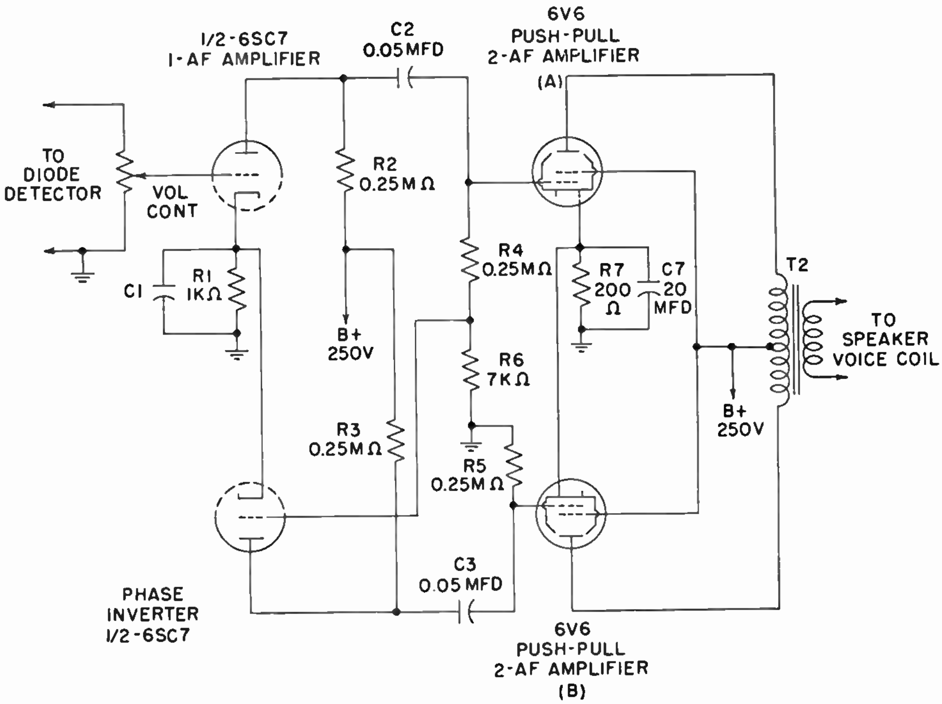


Fig. 10-10. Schematic diagram of a typical push-pull amplifier

voice coil may be warped or off center. The result is that the voice coil rubs against the speaker pot and distorts the sound. Or metal dirt may

Distortion	*Cause*
Scraping, raspy sound. Poor bass-note reproduction. Distortion.	Warped voice coil. Off-center voice coil. Dirt in gap around center pole piece.
Buzzing. Poor bass-note reproduction. Distortion.	Broken voice-coil cement.
Poor high-frequency reproduction. Distortion.	Warped paper cone.

Fig. 10-11. Loudspeaker defects that cause distortion

have gotten in the space between the outside pole piece and the center pole piece, producing a rubbing condition again. Again, the paper cone may have warped with age and exerted uneven pulls which draw the voice coil off center. Or the cement holding the voice-coil wires together might have cracked, producing a buzzing, distorted sound. Figure 10-11 lists the types of distortions produced by loudspeaker defects. A new loudspeaker will usually be needed, since modern voice coils and cores can rarely be repaired.

In certain circuits using an electromagnetic dynamic loudspeaker, distortion, coupled with a weak signal, may occur if there is an open field coil. Such a circuit is shown in Fig. 10-12. Notice that an open speaker field in such a circuit will not upset other voltages. Only the speaker will be affected. The residual magnetism of the pole piece will permit the speaker to operate very weakly.

You may check the strength of the pole magnet by holding a blunt iron object like a socket wrench near the center pole piece. If it is weak, check the field coil with an ohmmeter. In some cases, you may be able to replace the speaker field. In this case, follow the manufacturer's instructions. Where the construction of the loudspeaker prevents such a replacement, you will have to replace the entire loudspeaker with one similar to the defective one.

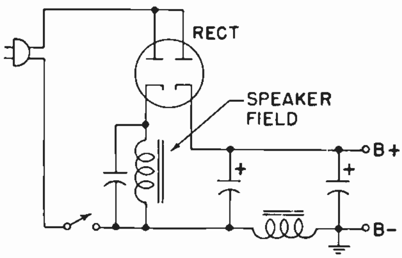


Fig. 10-12. An open speaker field coil can cause distortion

Other Factors Involved in Distortion. Other conditions may result in harmonic distortion. In three-way portable receivers, weak batteries may produce distortion in the battery mode of operation. In the power-line mode of operation, another condition may arise. The bias for tubes in such receivers is obtained from the plate current of the output tube. If such an output tube develops grid emission, it increases the bias of the other tubes. If it becomes weak, the bias of the other tubes becomes too low. In either case, distortion results.

Figure 10-13 summarizes the possible causes of harmonic distortion in a receiver. See if you can recall all the reasons why these conditions produce distortion. Although you will still be able to service receivers efficiently without complete understanding of the reasons, an understanding of them will enable you to meet minor variations with a more systematic approach.

R-F Section	*A-F Section*	*Loudspeaker*
Shorted or leaky avc filter condenser.	Leaky coupling condenser. Grid emission.	Voice coil defects: a. Warped coil. b. Off-center coil. c. Broken coil cement. d. Dirt around coil.
Grid emission from tubes receiving avc voltage.	Open self-bias resistor. Leaky or shorted cathode bypass condenser. Cathode-heater leakage. Leaky a-f coupling condenser from volume control. Unbalanced push-pull stage. Open plate bypass condenser. Low or high plate voltages. Poor output tube in three-way portable receivers.	Warped paper cone. Open speaker field.

Fig. 10-13. Summary of causes of harmonic distortion

Specific Causes of Frequency Distortion. When you encounter frequency distortion as a servicing complaint, you will usually find that the defect lies in some condenser that has changed in value. An example will make the point more clear. Assume that you have a condenser and feed across it a signal of a certain frequency. The condenser will offer a certain amount of impedance to the signal. Now increase the signal frequency. The condenser offers less impedance to it. Decrease the signal frequency; the condenser impedance becomes greater. Now keep the signal frequency constant at its original frequency but use a condenser of lower capacitance. The impedance of the condenser increases. Now use a condenser of higher capacitance. The impedance of the condenser decreases. You see then the variation of impedance with changes of frequency and capacitance.

Let us examine the circuit in Fig. 10-14 for possible causes of frequency distortion. Condenser C-1 is usually an electrolytic condenser. With time it dries out and loses capacitance. It then offers a higher impedance path than previously, especially to the lower audio frequencies. As a result, the lower audio-frequency notes may be diminished.

Again, if coupling condenser C-2 opens, a very small amount of capacitance between the leads will remain. This lowered capacitance offers high impedance to all audio frequencies, except the high frequencies, which are passed on to the signal grid of the output tube. Frequency distortion coupled with weak output results.

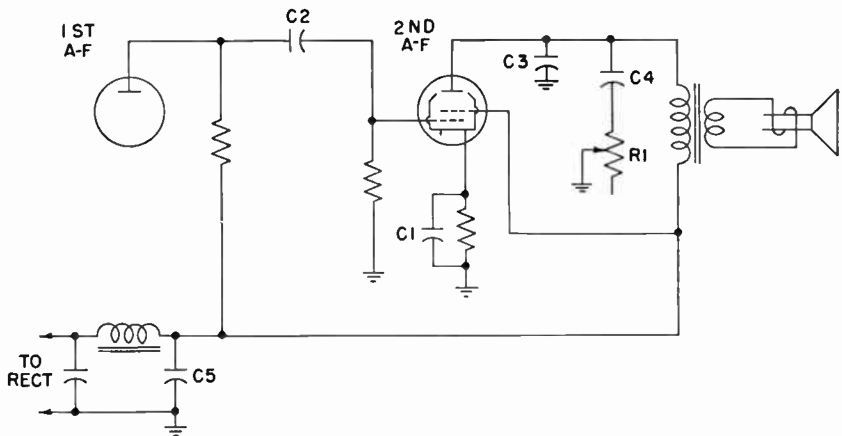


Fig. 10-14. Circuit for inspection for causes of frequency distortion

As was stated previously, condenser C-3 prevents r-f oscillation of the output stage. In addition, it bypasses many of the higher audio frequencies to ground. Sometimes, this condenser opens, but feedback is not such as to produce oscillation. But now it fails to bypass the higher audio frequencies, and these appear in the speaker output.

The power-supply output filter condenser C-5 may also cause frequency distortion. The signal path for the output tube is from the plate through the output transformer primary, through condensers C-5 and C-1 back to the cathode. Since condenser C-5 is an electrolytic condenser, it may dry and lose capacitance. It would then offer a higher impedance to lower frequencies, and the receiver output would contain only the higher audio frequencies. Of course, hum would also probably be present.

Condenser C-4 and variable resistor *R*-1 make up a tone control. When the arm of the resistor is near the connected end, more of the high audio frequencies are bypassed to ground. When the arm is near the unconnected end of the resistor, more of the higher frequencies are passed to the loudspeaker. If an internal short occurs in this variable resistor, more of the higher frequencies would pass to ground, and the receiver would have a greater bass response.

Another condition which may cause frequency distortion is sideband cutting resulting from fixed-tuned circuits, like the i-f transformers, which are peaked too sharply. The higher frequencies are then cut out, and the receiver output sounds too bassy. Merely vary the adjustments slightly to give a broader peak by varying the trimmer condensers.

Locating the Defective Section. Several external clues may enable you to go quickly to the cause of distortion. One is overheating of a component in the receiver. For example, when the plate bypass condenser of an output tube opens, it might cause r-f oscillation which would overheat the output tube and power-supply components. Sometimes complaints of two troubles give a clue. For example, if the power-supply output filter condenser dries and loses capacitance, it would produce distortion as well as hum. Again, if a coupling condenser opens, it would produce distortion as well as a weak signal.

Sometimes the sound of the distorted receiver output will direct your attention to the defect. But description of peculiarities of sound are extremely difficult, and localization by sound will grow with your own experiences.

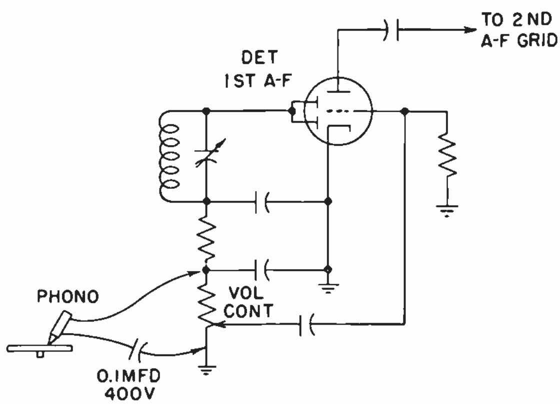


Fig. 10-15. Using an external phonograph for distortion check

If you fail to find a clue as to the source of the trouble, begin your localization procedure at once. For the sake of section isolation, as before, you may think of the receiver signal chain as being divided into the r-f section and the a-f section.

Most defects that cause distortion will occur in the a-f section, and you may begin stage isolation in that section. However, to be sure of the defective section, you may make a simple test. If the receiver has a phonograph attachment, switch on a record and listen for the output. Since the phonograph pickup arm is attached at the input of the audio section, the presence of distortion informs you that the defect lies in that section. If the record sounds undistorted, you know that the defect lies in the r-f section.

If the defective receiver has no phonograph attachment, you may connect the output from a phonograph pickup that you may have in your shop to the input of the receiver, as shown in Fig. 10-15. The pickup signal is placed through a 0.1-mfd condenser across the volume control of the receiver. The receiver is tuned to a non-station position. Again, if the record output is distorted, the defect lies in the a-f section of the receiver. Then, having localized the defective section, begin your stage-localization procedures.

Stage-localization Procedures. Since most distortion defects occur in the a-f section, we will assume that our section-isolation procedure indicates a defective a-f section, and proceed to localize our defective stage. Tune the receiver to a station. Begin by muting the loudspeaker of the receiver. Unsolder the terminal of the voice coil, and connect a resistor of comparable impedance to the voice coil (about 5 ohms, 10 watts) across

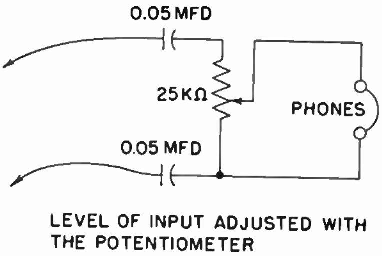


Fig. 10-16. A simple audio signal tracer

the output transformer secondary winding. Then, by means of the audio signal tracer shown in Fig. 10-16, check the output at various points. The simple audio tracer is a pair of high-impedance earphones fed from a wire-wound potentiometer. The two condensers block direct current when testing from the plate of a tube. Their working voltages should be high, about 400 volts or more.

Test Points for Audio Signal Tracer. Figure 10-17 illustrates the use of this device. Connect one end of the audio tracer to the chassis. The other end is then touched to various test points while you listen with the phones for distortion. The test points are numbered in sequence.

First comes the ungrounded end of the volume control. Distortion heard here indicates trouble in the r-f section or detector.

Second comes the grid of the first a-f amplifier. Distortion heard here may be due to a defective volume control.

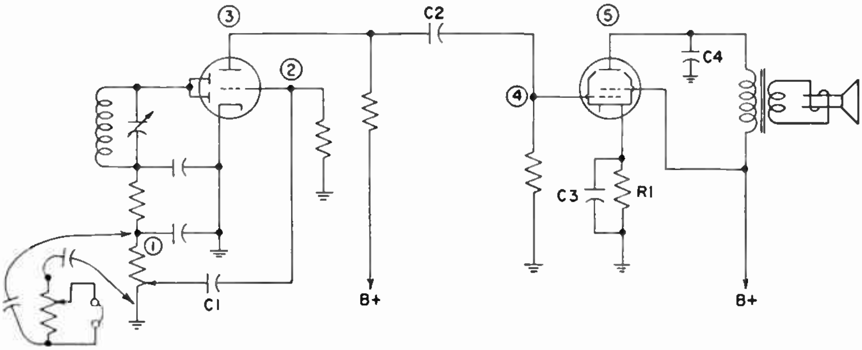


Fig. 10-17. Using the simple audio signal tracer

Third comes the plate of the first a-f amplifier. Distortion heard here indicates a leaky coupling condenser from the volume control C-1, grid emission from the tube, improper grid bias, or improper plate voltage.

The fourth test point is the signal grid of the second a-f amplifier. Distortion heard here, but not heard previously, will be of the frequency-distortion type and will be weak, indicating an open coupling condenser C-2.

Fifth comes the plate of the second a-f amplifier. Distortion heard here indicates a leaky coupling condenser C-2, grid emission from the tube, an open self-bias resistor R-1, a shorted cathode bypass condenser C-3, or one that has lost capacitance with age, an open plate bypass condenser C-4, or improper plate voltage. Note that a leaky coupling condenser or grid emission produces the distortion effects in the plate circuit of the tube affected.

If you still hear no distortion in your phones, the defect probably lies in the loudspeaker. Check it with a test-substitution speaker, after removing the resistor placed across the output transformer secondary winding. Where the output stage is a push-pull stage, be sure to test the grids and plates of each tube separately.

Isolating Defective Components. Once you have isolated the defective stage, examination of the receiver circuit, coupled with knowledge of how distortion occurs, will aid you in finding the specific defect. Figure 10-13, listing the common causes of harmonic distortion, will help you in that regard. The section on specific causes of harmonic distortion gave you methods of checking for common causes. Review that section and know it well. Generally, checking the tube electrode voltages of a defective stage will aid in isolating a defective component when these voltages are quite different from the normal values supplied by the receiver manufacturer.

QUICK SUMMARY PROCEDURE

There are many possible causes for distortion, as you have seen. However, since some defective conditions occur more frequently than others, you may make a quick check of these conditions before entering upon a more systematic series of checks. When distortion occurs, first try substituting new tubes. If this fails to cure the defect, open one terminal of all coupling condensers and substitute with good ones. If the distortion still persists, try loudspeaker substitution. From here on out, you will have to use the fund of knowledge furnished in the chapter just described.

Distortion can be a tough problem. Do not be discouraged if the cause is sometimes elusive. Experienced servicemen run into the same difficulty. Just keep your wits about you and be systematic. Follow the procedure recommended, whereby you narrow the analysis down from section to stage to component.

11

Interference

Interference Effects. The defects described in this chapter are of a type that you may rarely encounter in your servicing career. For the most part, they are conditions which will occur only if the receiver is located in a spot where unusual radio signals exist, such as closeness to a powerful station or in a fringe area. However, because you may get such a complaint on occasion, this chapter will tell you how to improve or eliminate the defect.

There are certain interference effects which are associated with normal station signals having definite wave characteristics, specific frequency dispositions, and a definite strength in their relation to the design of the receiver. All these interference effects can be handled once you learn to recognize the nature of the defect.

The manner in which these interference effects occur varies. Sometimes you will hear a steady whistle or a chirpy type of whistle, known as *birdies*. Sometimes, you will hear two stations simultaneously. At other times, you will hear code signals on the broadcast band. Or you may hear a low growl or fluttering signal as you tune for a station.

Each defect has a specific cause and must be handled in a manner dependent upon your proper analysis of the cause. You must be sure first that the interference effect is not produced by a defective component within the receiver. Perhaps your experience with similar complaints in a particular neighborhood will enable you to size up the situation at once. In some cases, as you build up your experience with such interference effects, you will be able to determine the condition by its unique sound. For the most part, the interference effects to be described in this chapter either have unique recognizable sounds, or appear on only one or two stations.

In the interference effects to be described, you have whole receiver response. There is no need for section- and stage-localization procedures. When you find such interference effects, a few simple adjustments at a few key points in the signal chain will help to overcome the condition. We shall therefore describe the defects in terms of the adjustments made to remedy them.

Interference Effects Remedied by a Wave Trap. Many of the interference effects are reduced or eliminated by the use of wave traps. These act to cut down the strength of the interfering signal. However, a knowledge of the type of interference, the frequency of the interfering signal, and connections and adjustments of the trap is essential to the application of the remedy.

Image Interference. The first interference effect to be described is that known as *image-frequency interference,* characteristic of superheterodyne receivers. This is especially troublesome when the receiver does not have an r-f amplifier. The antenna picks up station signals broadly at all frequencies and feeds them through a tuned circuit to the signal grid of the converter tube. Here it mixes with the local-oscillator signal to produce signals of several frequencies. The i-f transformer, however, is fixed-tuned and accepts only the signal that is the difference in frequency between the station and oscillator signal—the intermediate-frequency signal. This i-f signal is then amplified by the i-f amplifier and passed on to the second detector. The i-f transformer will accept any signal at the intermediate frequency.

We have just described a normal sequence. Let us be specific. Suppose you tune for a station at 1,000 kc, and the signal of this frequency reaches the converter signal grid. The local oscillator produces an unmodulated signal at 1,455 kc. The two signals mix in the converter tube, and the difference frequency ($1{,}455 - 1{,}000 = 455$ kc), or intermediate frequency, is accepted by the i-f transformer.

However, assume that another station at 1,910 kc is on the air. The single tuned circuit of the converter may not be selective enough to keep this signal from reaching the converter signal grid. When it does so, it mixes with the local-oscillator signal, and the difference frequency is ($1{,}910 - 1{,}455 = 455$ kc) 455 kc. This difference frequency is the intermediate frequency of the receiver and is accepted by the i-f transformer. Thus if the two stations at 1,000 kc and 1,910 kc are on the air simultaneously, both will produce signals in the signal chain and appear at the loudspeaker. The interference is heard as a whistle or as birdies, or as a mixture of modulations of both signals.

The interference effect is known as *image-frequency interference.* Any 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. Thus you will obtain image-frequency interference in New York City on station WMCA (570 kc) from station WHOM (1,480 kc) for receivers with an intermediate frequency of 455 kc.

You may reduce this type of interference in several ways. First, you may reduce the receiving antenna efficiency by shortening it, thereby suppressing the strength of the undesired station. Or you might install a wave trap tuned to the frequency of the undesired image station. This wave trap either blocks the undesired signal from the signal chain of the receiver or bypasses it out of the signal chain. Or you might re-align the receiver so that it operates at a slightly different intermediate frequency. Changing the intermediate frequency of a receiver by about 10 kc will not effect the receiver disadvantageously.

Direct I-F Station Interference. With regard to image-frequency response, it is not always an image station at twice the intermediate frequency above the desired station. Sometimes the harmonics of other broadcasting stations or of stations outside the broadcast band serve as image stations to produce the same effect. However, they are handled in the same manner.

Any superheterodyne receiver is especially sensitive to its intermediate frequency. With an intermediate frequency of, let us say, 455 kc, any signal at or near this frequency gets to the converter grid. This is especially true of receivers with no r-f amplifier and with high i-f gain. The converter passes the undesired signal at this intermediate frequency along the signal chain to produce interference with the desired station signal. The interference is usually experienced as a nontunable birdie, or audio tone, or code. It may cover the entire tuning dial with increased intensity at the low-frequency end of the band.

This type of interference is reduced in several ways. If the receiver is of the loop-antenna type, you may try rotating the receiver for minimum pickup of signal from the interfering station. Some receivers come equipped with a wave trap tuned to the intermediate frequency to minimize this effect. If the set does not have this trap, the installation of one in the antenna or converter grid circuit will help clear up the condition. It may also be a good idea to tune the trap to the frequency of the offending station, rather than to the intermediate frequency, as suggested in the alignment chapter.

I-F Harmonic Interference. Superheterodyne receivers are also subject to interference when a station whose frequency is twice the intermediate frequency of the receiver is received. Assume that your receiver has an intermediate frequency of 455 kc and that you are tuned to a station with a frequency of 910 kc (2 × 455 kc). The local oscillator will be producing a signal at a frequency 1,365 kc (455 kc + 910 kc). There will be a normal i-f signal at 455 kc. But in addition, the second harmonic of the desired station will also combine with the local-oscillator signal to produce a spurious i-f signal at 455 kc (1,820 — 1,365 = 455 kc). The two i-f signals vary at different rates as the receiver is tuned and produce a whistle. Since 1,820 kc is outside the broadcast band, this trap will not cut down reception of any desired station.

You may reduce this type of interference by re-aligning the i-f stages of the receiver so that the particular station is no longer at twice the intermediate frequency of the receiver. Or you may install a wave trap, tuned to the second harmonic of the station signal, in the signal grid of the converter.

Oscillator Harmonic Interference. Another interference effect that appears in superheterodyne receivers is that which results from the harmonic content of the local oscillator signal. In this defect, you hear short-wave speech or code at various points in the standard broadcast band. Such a condition is a likely one in receivers with loop antennas, because loop antennas resonate to several frequencies in addition to the fundamental one for which they are tuned, and even provide them with considerable gain.

Assume that you tune your receiver for a station at 1,000 kc. To produce an intermediate frequency at 455 kc, the local oscillator must produce a signal at 1,455 kc. Now if the oscillator output has a harmonic content, its second harmonic at 2,910 kc (2 × 1,455) will also be present. Furthermore, if your loop antenna is resonant to a short-wave signal at or near 3,365 kc or 2,455 kc, you will have an i-f signal at 455 kc (3,365 — 2,910 and 2,910 — 2,455) produced by the short-wave station at the output of the converter.

This type of interference may be handled in several ways. First, try turning the receiver loop to give minimum pickup from the interfering station. Or you might try substituting a regular shielded antenna coil for the loop. Such a replacement would of course, require complete re-alignment of the receiver. Another possible remedy is the reduction of the harmonic content of the oscillator signal. Before you attempt this, however, check the voltage at the oscillator grid. Normally, this voltage has a range of 5 to 10 volts, negative, for an a-c/d-c set, and a range of 8 to 15 volts, negative, for an a-c receiver. If you have higher grid voltages than normal, you may suspect that the oscillator is producing harmonics which produce the interference effect. To reduce this voltage and remove the harmonic output, try to replace the grid-leak resistor of the oscillator with one whose resistance is about half of the one removed. After making this substitution, be sure that the oscillator operates over the entire tuning range of the receiver. Tune in all stations between the high- and low-frequency ends of the dial. Sometimes placing a wave trap that is tuned to the frequency of the offending station in the grid circuit of the converter tube will improve the operation of the receiver.

I-F Formation. Another type of interference occurs when two stations whose frequencies differ by the amount of the receiver's intermediate frequency enter your antenna. Superheterodyne receivers, having no r-f amplifier stage and having poor selectivity, are likely to develop this complaint. The two signals combine at the input of the converter stage and form a constant signal at the intermediate frequency of the receiver. The presence of this spurious i-f signal, as well as that from the desired station, produces a whistle or birdie or second stations heard on practically all stations. Such interference could occur, for example, in Chicago because of station WCFL (1,000 kc) and station WHFC (1,450 kc), where a receiver has an intermediate frequency of 445 to 455 kc.

A similar condition might occur where the harmonics of two station signals may have a frequency difference equal to the intermediate frequency of the receiver.

Again you may handle the problem in several ways. You might try to reduce antenna efficiency by shortening the antenna. Or you might try shifting the intermediate frequency of the receiver slightly up or down. And finally, the installation of a wave trap, tuned to the frequency of one of the offending stations, may remedy the condition.

Cross-talk within Receiver. Still another interference effect that may result in superheterodyne receivers or trf receivers is the one known as *cross-modulation* or *cross-talk,* originating within the receiver. In this defect, a second station is heard in the background when you tune to some desired station. The undesired station signal is associated with the carrier of the desired station and only appears when you tune for the desired station. What usually happens is that the undesired strong signal is demodulated in the early stages of the receiver and remodulates on other carriers in the same stages. This defect is more likely in receivers having no r-f amplifier stage, or in receivers having exposed wiring and not having variable-mu tubes.

It is possible for the undesired signal to be picked up in other ways than by the antenna. There may be pickup by the power-supply line, by direct pickup by exposed grid leads, or by direct pickup by unshielded tubes of the receiver. It is sometimes necessary, therefore, in some cases to use several remedial measures.

This interference effect may be reduced by using one or a combination of the following remedial measures: One measure is to shield the exposed grid leads and wiring of the first stages of the receiver. Another procedure is to install a line filter for the receiver. And a third measure is to install a wave trap tuned to the strong local station that is causing the interference.

Adjacent-station Beat Interference. Another interference effect occurs from the mixture of two station signals whose frequencies differ by an amount which produces an audible note. It affects both superheterodyne and trf receivers, especially those with poor selectivity. The interference manifests itself as a steady, high-pitched tone or whistle. Thus two stations whose frequencies are 10 kc apart may send signals into your receiver and produce a 10 kc note or whistle.

To overcome this condition, you may install a wave trap, *sharply* tuned to the station adjacent to the one you desire. This procedure reduces the signal from the interfering station. If the receiver has a tone control, set it at a more bass position. And if the receiver has a fidelity control, set it at the selective position. This step will make the tuned circuits more selective in their blocking of the adjacent station signal. Sometimes realigning the i-f transformers for a sharper peak will aid the condition.

This condition is one that is very difficult to remedy, since the wave trap would in most cases be incapable of eliminating one station without at the same time eliminating the desired one. Do not be afraid to tell your customer that nothing can be done. He will be even more ready to accept this fate when he learns that all his neighbors have the same complaint for the two stations.

A summary of the interference effects described above is given in Fig. 11-1.

Type of Interference	*Receiver Effect*	*Receiver Affected*	Occurrence	*Remedies*
Image interference.	Whistle or two stations together.	Superheterodyne.	Near 1,610-to-1,750-kc, police band.	Wave trap. Re-align i-f.
Direct i-f station.	Nontunable code, birdie, or audio tone all over the band.	Superheterodyne.	At coastal areas near commercial stations.	i-f wave trap. Re-align i-f. Turn loop.
i-f harmonic.	Whistle when tuning a station with a frequency twice the receiver i-f.	Superheterodyne.	Near station operating at twice receiver intermediate frequency.	Wave trap. Re-align i-f.
Oscillator harmonics.	Short-wave code or sound on broadcast band at various points.	Superheterodyne.	Where short-wave signals are intense.	Wave trap. Reduce oscillator harmonics. Turn loop.
i-f formation.	Whistle, birdie, or two stations together.	Superheterodyne.	Usually in congested metropolitan areas.	Wave trap. Re-align i-f. Shorten antenna.
Cross-talk within receiver.	Two stations heard together only when tuned to a station.	Superheterodyne or trf.	Metropolitan areas with one or two very powerful stations.	Wave trap. Shield leads. Use line filter.
Adjacent-station beat.	High-pitched tone or whistle on a station.	Superheterodyne or trf with poor selectivity and high fidelity.	In areas where a strong station is adjacent to a desired station.	Sharply-tuned wave trap. Tone control more bass. Fidelity control in selective position.

Fig. 11-1. Interference effects remedied with a wave trap

Using the Wave Trap. A wave trap is a simple device used to reduce interference from a particular station. In essence, it is simply a resonant circuit tuned to the particular frequency of the interfering station. As such it consists of a coil and trimmer condenser for tuning adjustments. They may be purchased at a fairly low cost from any radio-supply shop in compact shielded units, so that it is not necessary for you to make it yourself.

Resonant circuits are of two types: One is called the parallel resonant circuit and the other is the series resonant circuit, as shown in Fig. 11-2. Both are primarily resonant to a particular frequency, but their behavior is quite different.

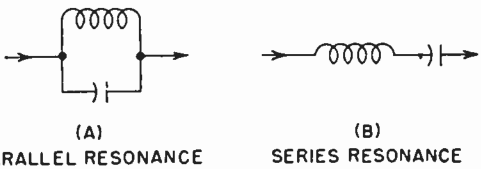


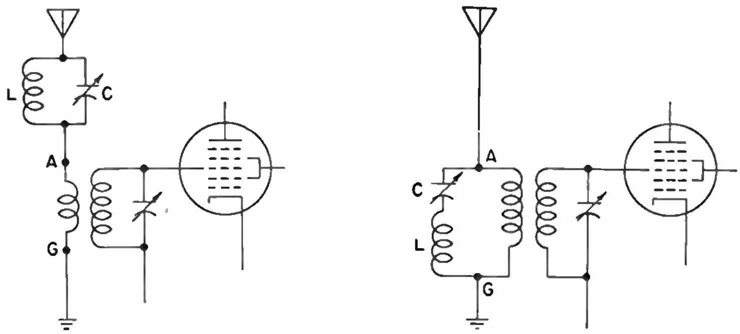
Fig. 11-2. There are two basic types of resonant circuits

The parallel resonant circuit offers a high impedance to a signal at the resonant frequency, and practically blocks its passage through the circuit. To all other frequencies, it offers considerably less impedance and permits them to pass through the circuit.

The series resonant circuit acts in an opposite manner. It offers a very low impedance to a signal at the resonant frequency, and permits it to pass through the circuit. To all other frequencies it offers very high impedance and practically blocks their passage.

How to Choose a Wave Trap. We have mentioned that you may use a wave trap to reduce the strength of some undesirable signal entering the antenna circuit. You may use either a series resonant or parallel resonant circuit to achieve this result. Which one should you use? The answer is dependent upon the type of antenna coil used in the receiver. On receivers with a low-impedance input, that is, with a primary winding of the antenna coil having a d-c resistance of less than 10 ohms, use a parallel resonant wave trap. On receivers with a high-impedance input, that is, with a primary winding of the antenna coil having a d-c resistance of 10 ohms or more, use a series resonant wave trap. Such wave traps are shown in Fig. 11-3, with the inductor shown as *L* and the condenser as *C*.

In the parallel resonant wave trap shown in Fig. 11-3A, the trap prevents the interfering station signal to which it is tuned from entering the primary of the antenna coil, but permits stations of other frequencies to do so. In the series resonant circuit shown in Fig. 11-3*B*, the trap offers a ready path for the interfering station to which it is tuned, to bypass the primary of the antenna coil and to pass to ground. But it offers a high impedance to other stations at other frequencies and forces them through the antenna coil primary winding.

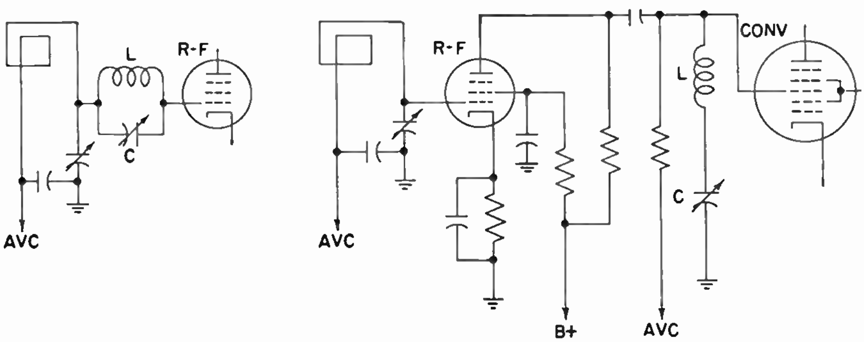


(A)
PARALLEL RESONANT WAVE TRAP
WITH LOW-IMPEDANCE INPUT

(B)
SERIES RESONANT WAVE TRAP
WITH HIGH-IMPEDANCE INPUT

Fig. 11-3. The parallel and series wave traps

Using Wave Traps with Loop Antennas. You may be wondering how you handle a receiver with a loop type of antenna. The problem may be handled in one of two ways. First, you may install a wave trap in the signal grid of the r-f amplifier tube or the converter tube, as shown in Fig. 11-4. In Fig. 11-4*A*, a parallel resonant wave trap, shown as L and C, is in the



(a)

(b)

Fig. 11-4. Location of wave traps in a loop-type receiver

grid circuit of the r-f amplifier tube. In Fig. 11-4*B*, a series resonant wave trap, shown as *L* and *C*, is in the signal grid circuit of the converter tube.

The other method is that of constructing an absorption type of wave trap. This is merely a tuned loop placed adjacent to the loop of the receiver. It serves to attenuate a signal in the receiver loop, whose frequency is that of the absorption trap. Wind a small loop with a long diameter of about 8 inches and a small diameter of about 4 inches. Obtain a two-section mica trimmer from an old i-f transformer, and connect the small loop to it. You may use one trimmer or both in parallel, depending on the frequency to which you want it to resonate. Tune the receiver to the interfering station, place the small loop parallel to the receiver loop, and adjust the trimmers until the loudness of the station drops sharply. Move the absorption trap closer and away until you get the greatest attenuation. Fasten the absorption loop in place. Such a setup is shown in Fig. 11-5.

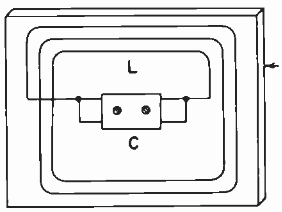


Fig. 11-5. A simple absorption wave trap

Broadening the Action of Wave Traps. You may vary the effect of the wave trap by making a small variation. If you wish the trap to be broader in its effect, that is, either block or pass a slightly wider band of frequencies rather than block or pass approximately one frequency, you may load the resonant circuit with a resistor. With a parallel resonant trap, connect a resistor of about 100,000 ohms across the condenser. With a series resonant trap, connect a resistor of about 10 to 100 ohms in series with the other components of the trap.

Wave-trap Installation Tips. When installing a wave trap in a receiver, be sure that you do not disturb the lead dress of the receiver more than necessary. Sometimes you may have to re-align a receiver after installing the wave trap. Of course, you must use a wave trap whose tuning range includes the frequency of the station that you wish to eliminate. Here is where you must size up the nature of the interference to determine the frequency you wish attenuated. When the wave trap is installed, tune it by means of its trimmer condenser until the interference is reduced or eliminated. In each case proper operation in the customer's home is the final check.

Other Interference Effects. There are other interference effects between stations which are not remedied by the installation of a wave trap. The following paragraphs will describe these effects, give their causes, and suggest specific remedies. In some cases, you will have to use more than one of the suggested remedies.

Oscillator Radiation. One such interference effect occurs in superheterodyne receivers without good shielding and in which the first stage is the converter tube. In such cases, the local oscillator of the receiver radiates a signal over a limited area. It may do so directly, or be transmitted through the power lines or via coupling with the antenna. The manifestation of the interference is a whistle heard on a particular desired station, disappearing at times or changing pitch at random. This type of interference occurs where two stations are separated by the amount of the intermediate frequency of the receiver.

Figure 11-6 shows how the interference occurs. The two receivers use an intermediate frequency of 455 kc. Receiver *A* is tuned to station *A* at 700 kc. Its local oscillator develops a signal at a frequency of 1,155 kc (700 + 455). Receiver *B* is tuned to station *B* at 1,155 kc. Now if the local oscillator of receiver *A* radiates, two signals at a frequency of 1,155 kc reach receiver *B* and produce the whistle.

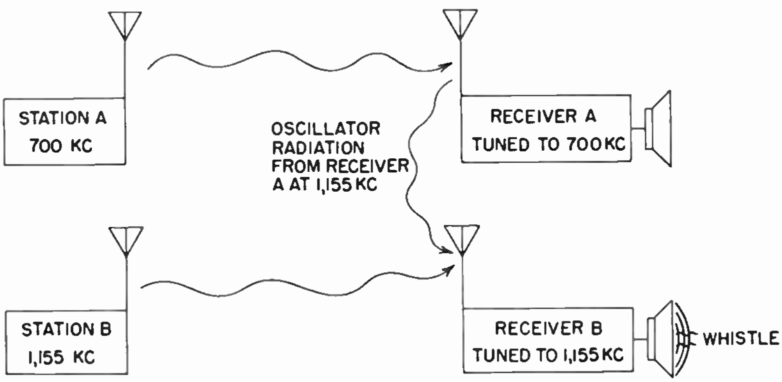


Fig. 11-6. Whistle caused by a radiating oscillator

The problem may be handled only if the offending receiver is a second one in the customer's own home. Obviously you cannot hunt for a neighbor's set and then play with that. You might alter the lead dress in the offending receiver to reduce coupling between the oscillator and the antenna. You might reduce the size of the antenna of the radiating receiver or install a good ground connection. Try shielding the oscillator stage completely and filtering its supply leads. You might try decreasing oscillator excitation by shunting the tickler section of the oscillator coil with a high-resistance resistor, or by reducing resistance of the oscillator grid leak. If you cannot locate the radiating receiver or are not permitted to tamper with it, install a filter in the power line of your receiver.

Cross-talk outside the Receiver. Another interference effect is cross-talk or cross-modulation, originating outside the receiver. It manifests itself as a second background station heard on or between other stations. This condition affects both superheterodyne and trf receivers in the vicinity of very strong stations and where overhead power lines are strung. When two strong radio waves cut across some elevated conducting material, they may be partially detected in the conductor and be reradiated at new spurious radio frequencies to nearby antennas. If one of these spurious frequencies is the same as that of a desired station for which you are tuning, you get cross-talk. The detector action takes place because of poor or corroded joints and contacts, poor ground contacts, and similar causes. This type of interference usually varies with the dampness of the weather and the wind, which might make joints vary as wires swing.

There is little that you can do about this interference effect. It fortunately is limited to a fairly small area. If you locate the cause, you may correct it by notifying the utility company, checking all ground connections for good contacts and grounding firmly all metal conduits. If the receiver has a loop antenna, try rotating the antenna.

Same-frequency Beat Interference. Another interference effect occurs when a receiver picks up signals from two stations operating at the same frequency. This is indeed a rare case, since the FCC allocates the same frequency only to stations separated by large distances.

If the stations are high-powered ones, the separation is almost the width of the country: east coast and west coast. Near either station there is no trouble, since the other is too weak to beat with the strong one. It is only at midway points where the station signals are of nearly equal strength that there may be trouble. Even here insensitive receivers will not be bothered, since they will not respond to either signal. It is only sensitive receivers in this midway area that will be troubled by a squeal or growl whenever the tuning dial passes over the frequency of the two stations.

If there is a sufficiency of good local program material in such a location, there will be no complaints other than that of a squeal point on the dial.

If desirable, this can be remedied by shortening the antenna or otherwise lowering the sensitivity of the receiver (either trf or superheterodyne). Of course, the sensitivity must be kept adequate for the desired program.

However, especially where there is a dearth of local program material, the owner of a sensitive receiver may request clear reception from either of two stations, most likely the stronger one in his area. Or the stations are likely to be separated by a time differential also, the customer experiencing good reception from the western station after the eastern one goes off the air. He then complains of a squeal or growl on the desired station. A wave trap will not work, since it will cut down both stations equally. The best remedy is to erect a flat-top antenna with the free end pointing towards the desired station. This will increase reception from the desired station and reduce it for the interfering station. In the case of loop-operated receivers, rotating the directional loop will accomplish the same effect. Also, if the set has a bass-boost type of control, operating the set in the minimum-bass position will reduce any growl that may still be present. If the set is not so equipped, you might try reducing the capacitance of the audio coupling condensers, or audio cathode bypass condensers.

Final Checks. Be sure that all final checks for interference conditions are made at the customer's home. The location of your shop, your antenna, and other factors at your shop may give quite different results from those obtained where the receiver normally operates. Figure 11-7 is a summary of interference effects which are not cleared by using a wave trap.

Type of Interference	*Receiver Effect*	*Receiver Affected*	Occurrence	Remedies
Oscillator radiation.	Whistle on a station, varying in pitch.	Superheterodyne with poor shielding.	City areas.	Shift i-f. Reduce oscillator excitation. Filter power line.
Cross-talk outside the receiver.	Second station in background on or between stations.	Superheterodyne or trf receivers.	Near strong stations and power lines or iron structures.	Correct poor connections and ground leads. Turn receiver loop.
Same-frequency beat.	Growl or flutter.	Superheterodyne or trf receiver of high sensitivity and fidelity.	Between two stations on same frequency.	Construct directional antenna. Turn receiver loop. Shorten flat-top. Tone control at treble.

Fig. 11-7. Interference effects not cleared with a wave trap

12

Servicing with the Vacuum-tube Voltmeter

The simplest instrument for tracing signals is the vacuum-tube voltmeter. It measures signal voltage—r-f, i-f, or a-f voltages—at any point in a circuit without disturbing the circuits to which the voltmeter is connected. In this way, as you proceed along the signal chain, you can see what happens to the signal. In addition, d-c voltages may also be measured without loading the tested circuits. You can use the vacuum-tube voltmeter for many other purposes, like receiver alignment, measuring voice-coil impedance, measuring the Q of a coil, determining the power output of a receiver, and many more.

The commercial instruments specifically called signal tracers are merely expanded combinations of vacuum-tube voltmeters. For practical service work, however, you can get along without a signal tracer if you have a good vacuum-tube voltmeter.

Value of Vacuum-tube Voltmeter. The main advantage of the vacuum-tube voltmeter is that it makes its measurements without loading circuits across which it is placed to any disturbing extent.

Figure 12-1 shows what happens in a circuit when measuring voltage with an ordinary moving-coil voltmeter whose sensitivity is 1,000 ohms per volt. On the 100-volt range, the voltmeter has a resistance of 100,000 ohms.

Assume that there is a 60-volt drop across two resistors, *R*-1 and *R*-2, connected in series and with the same resistance, 100,000 ohms. The voltage drop across each resistor will be equal—30 volts across each, as shown in Fig. 12-1*a*.

Now connect your voltmeter across resistor *R*-2, as shown in Fig. 12-1*b*.

You would expect to get a reading of 30 volts, but you do not because of the loading effect of the voltmeter. Resistor *R*-1 still is 100,000 ohms. However, the combined resistance of resistor *R*-2 and the voltmeter in parallel is 50,000 ohms. A redistribution of voltage drops occurs, and the voltmeter reads only 20 volts, as shown in Fig. 12-1c. You see then how a moving-coil voltmeter can give an incorrect reading. In addition, when measuring voltage across a tuned circuit, the voltmeter reading produces detuning.

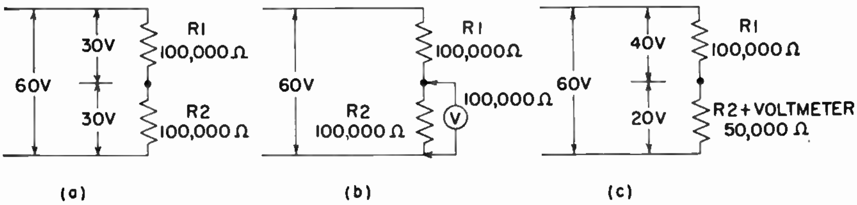


Fig. 12-1. Voltage variations when using a voltmeter

The disturbing effect of such a voltmeter decreases as you increase the sensitivity or resistance of the meter. Let us measure the same voltage with a voltmeter whose sensitivity is 20,000 ohms per volt. The results are shown in Fig. 12-2. For a 100-volt range, the resistance of the voltmeter is 2,000,000 ohms. The combined resistance of *R*-2 and the voltmeter is 95,238 ohms. The voltage distribution would be such that the voltmeter would now read 29.3 volts, which is nearer to the correct value.

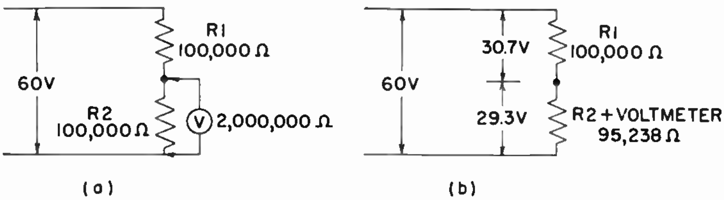


Fig. 12-2. Voltage variation with a high-resistance voltmeter

The vacuum-tube voltmeter gives even more accurate results because its impedance is in the order of 15 megohms or more. Its loading of a circuit is practically negligible and does not draw currents that would upset the circuit which it was measuring. Therein lies the main advantage of the vacuum-tube voltmeter.

Reading A-C Values. There is an important consideration when dealing with an a-c vacuum-tube voltmeter. Alternating voltages and currents have magnitudes that are expressed in various ways. It does not matter particularly which form of expression we use, so long as we know which one we are talking about. Figure 12-3 shows the various ways of expressing

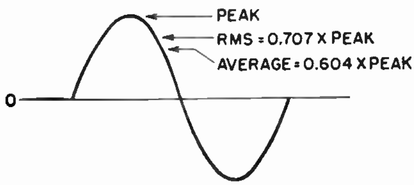


Fig. 12-3. Expressing magnitudes on a sine curve

magnitude of an a-c sine wave and their interrelationship. The greatest displacement of the alternating voltage or current from its zero position is the peak value. The root mean square (rms), or effective, value is 0.707 times the peak value. The average value is 0.604 times the peak value. Practically all a-c voltmeters read rms values.

Practical Vacuum-tube Voltmeter. The most widely used vacuum-tube voltmeter in use today by servicemen is of the type comparable to the

Fig. 12-4. The Sylvania Polymeter, Type 221 Z

moving-coil multimeter. The instrument is designed to measure a-c volts, d-c volts, and resistance as an ohmmeter. Such an instrument is the Sylvania Polymeter, shown in Fig. 12-4.

Voltage readings can be made up to 1,000 volts a-c or d-c. In addition, the d-c range can be extended up to 30,000 volts by the use of a special probe. The instrument is also capable of measuring r-f voltages up to 300 volts at frequencies from 10,000 cycles per second up to 300 megacycles per second by the use of a special r-f probe. This latter probe contains a type-1247 diode rectifier tube. You can also use the meter to measure d-c currents up to 10 amperes. And last, the instrument can be used to measure resistances up to 1 billion ohms. So you see that you have a very versatile instrument here.

Input resistance on all d-c ranges is constant at 16 megohms, a condition which would load circuits to a small extent. On the a-c ranges, the input impedance is 2.7 megohms. On the r-f mode of operation, the input impedance is 2.3 megohms.

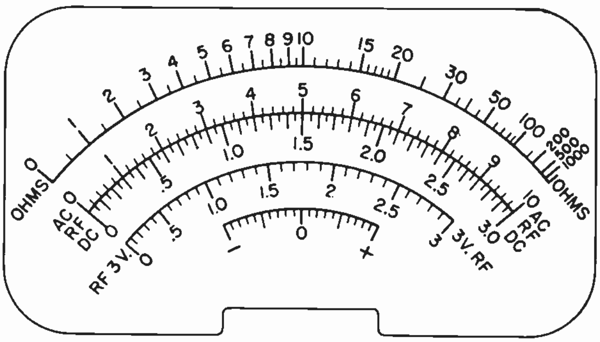


Fig. 12-5. The scales on the Sylvania Polymeter, Type 221 Z

There are five scales on the meter, as shown in Fig. 12-5. Resistance is read on the top scale. On the scale beneath it, you read a-c and d-c voltages, d-c current, and r-f voltages above 3 volts. On the scale beneath it, differentiated by being red, you read r-f voltages up to 3 volts. The bottom scale is one to indicate polarity of a voltage when you zero the meter at center by means of a zero-set control.

Practical Uses. Many service jobs can be performed with such an instrument. We will confine our discussion to applications to the a-m receiver. First, oscillator voltages at all points on all bands of a receiver may be measured, using the special r-f probe. You may also measure avc voltage at the diode or at the grids on the controlled tubes. Then audio voltage measurements may be made, including voltages from power transformers or audio voltages from the input of the audio section of the receiver to the speaker voice coil. All d-c voltages at the elements of any tube may be measured. The voltages of bias cells can be measured directly without injuring the cell. Of course, all resistance measurements of components within a receiver can be made. And, too, stage-gain measurements of all stages can be made by taking the ratio of the voltage at the output to the voltage at the input of the stage. There are many other uses to which you can put this versatile instrument.

Voltohmyst. Another practical vacuum-tube voltmeter is the RCA Junior Voltohmyst, shown in Fig. 12-6. It is designed to measure d-c voltages from 0.1 volt to 1,200 volts, as well as rms a-c voltages from 0.1 volt to 1,200 volts. It can also measure resistance values from 0.2 ohm to 1,000 megohms.

Fig. 12-6. The RCA Junior Voltohmyst, Type WV-77A

For all d-c voltage ranges, the input impedance is 11 megohms. The input impedance varies with the a-c voltage ranges. For the 3-, 12-, and 60-volt ranges, it is 0.2 megohm; for the 300-volt range, it is 1 megohm; for 1,200-volt range, it is 2 megohms.

Figure 12-6 shows several cables, attachments and controls. The cable with the alligator clip is the GROUND cable, which is directly connected to the chassis of the instrument. The other cable is the direct prod and is attached to the VOLTS OHMS plug. The voltages and resistances of a circuit are measured between this prod and the clip of the GROUND cable.

By means of the ZERO ADJ control, the meter pointer may be set at either the zero at the left of the dial or at the zero in the center. The latter position is useful in bias voltage measurements.

The OHM ADJ control is the device to set the pointer at the extreme right of the dial scale when using the instrument as an ohmmeter. This is similar to the adjustment found in the standard ohmmeter.

The control under the OHM ADJ knob is a function selector. It turns on the power and selects the function of the instrument for any particular measurement. The control under the ZERO ADJ knob is the range selector for d-c or a-c volts or ohms.

When making d-c voltage measurements, the direct prod is inserted into the WG-217 d-c probe, which places a 1-megohm resistor in series. Then the voltages are tapped on the plus side by the d-c probe and on the negative side by the GROUND clip. The function selector switch is set to —VOLTS or +VOLTS, depending on whether a positive or negative voltage is being measured.

When making a-c voltage measurements, measurement is made between the direct prod without the d-c probe, and the ground clip. The manufacturer suggests that a precaution may be taken when measuring a-c voltage where d-c voltage is present. The d-c voltage might upset the reading by permitting the instrument to offer too low an input impedance. In this case, place a good 0.5-mfd paper condenser ahead of the direct probe to act as a blocking capacitor.

When making zero-center measurements, the only note to be made is that the function selector is set at +VOLTS. The pointer will then move to right of center for positive voltage and to left of center for negative voltage.

And finally, when making resistance measurements, use only the direct probe and the ground clip. Where polarity must be observed, as in measuring leakage resistance of electrolytic condensers, the direct probe is always positive with respect to the GROUND clip.

Normally, the Voltohmyst can measure a-c voltages at a frequency from 30 cps to 3 megacycles. However, a crystal-diode probe is available and makes it possible to read a-c voltages up to 20 volts in the presence of d-c voltages up to 250 volts, at a frequency range of 50 kc to 250 mc. This crystal-diode probe consists of a germanium rectifier and a resistor-condenser network. It is merely attached to the direct probe in a manner similar to the d-c probe.

There are other devices available for extending the d-c voltage range and the ohmmeter range. But these find greater usage in other circuits, such as TV high-voltage supplies.

In addition to regular receiver measurements, the instrument may be used for many special applications. Some of these are oscillator grid-bias measurement, avc voltage measurement, bias cell voltage measurement, detection of gassy tubes, and insulation-resistance measurements.

The Vacuum-tube Voltmeter as a Service Instrument. The prime advantage of the vacuum-tube voltmeter is that it can make its measurements on a receiver while in operation, without disturbing the circuits tested. You may therefore trace a signal as it passes along the signal chain of the receiver. This characteristic qualifies it as a signal tracing instrument of great value to the serviceman.

It has however some minor disadvantages. First, vacuum-tube voltmeters are usually more expensive than a moving-coil voltmeter. Second, it is more likely to go bad, since it has more components which may fail. Third, the vacuum-tube voltmeter must be frequently recalibrated because of components that change in value.

For proper operation, a vacuum-tube voltmeter should be given a warmup period of about 20 to 30 minutes before you measure with it. Thereafter, acquaint yourself fully with the operation instructions as presented by the instrument manufacturer, and use accordingly.

Generally, when measuring a-c voltages in a circuit that also contains a d-c component, an isolating condenser is placed in series with the hot prod to isolate that d-c component. In talking about a-c vacuum-tube voltmeters in this text, assume the presence of such an isolating condenser.

Signal Tracing with a Vacuum-tube Voltmeter. The vacuum-tube voltmeter can serve many purposes for the serviceman. With this instrument you may make the same measurements that can be made with a moving-coil voltmeter. However, there are many measurements made by the tube voltmeter which cannot be made with the moving coil instrument. Furthermore, you can use the tube voltmeter as a tracer of a signal through the signal chain of the receiver, because the instrument gives minimum disturbance to the circuits under test. In this section, we shall show you how to use the vacuum-tube voltmeter as a signal tracer. In the next section we shall study how special measurements may be made.

Checking the Power Supply. Take the basic superheterodyne receiver whose schematic diagram is shown in Fig. 12-7. It will serve as a basis for understanding the testing technique to be described. How may you check defects in the power supply with the vacuum-tube voltmeter? You may check shorts or open circuits in the high-voltage winding of the power transformer *T*-7 by measuring the voltage between each plate of the rectifier tube and ground. Normally, the two voltages should be equal.

Then you may determine if the filter condensers *C*-29 and *C*-30 are functioning properly. Place an a-c vacuum-tube voltmeter across input filter condenser *C*-29. You will get a reading dependent on the design of the power supply. Now place the voltmeter across output filter condenser *C*-30. The reading should normally be very much less. If you have to replace a shorted input filter condenser *C*-29, you can determine the magnitude of the peak surge voltage before the other tubes warm up, so that you may replace it with one whose peak voltage rating is not underrated. Merely place the a-c voltmeter across the terminals where the condenser would normally be connected.

Finally, you can check B voltage with a d-c vacuum-tube voltmeter across condenser *C*-30, or from the plate of the output tube to ground. If all is well, you proceed to the signal chain of the receiver proper.

Checking the R-F Section of a Receiver. Begin by feeding an unmodulated r-f signal from a signal generator into the antenna of the receiver. Choose a non-station frequency at the low end of the tuning range. Turn on your receiver, and set its tuning dial at the same frequency as that of the signal generator. The reason for choosing a low-frequency signal is that at such a frequency the tuning condensers are at maximum capacity. Therefore, any vacuum-tube voltmeter input capacitance across them will detune the circuits to the least extent.

A signal is now being fed through the receiver up to the input of the a-f section. You may now trace it up to that point with the vacuum-tube voltmeter. Connect an r-f vacuum-tube voltmeter with its ground prod to the receiver chassis and the hot prod to the plate of the r-f amplifier tube (point 3). You do not use test points 1 and 2 because the measured voltages at those two points are too low—in the order of microvolts. A good voltage reading at point 3 indicates that all is working up to the plate of the r-f tube. If no signal or an extremely low signal is found, check the antenna and r-f input tuning circuits. Also check the r-f tube and its electrode

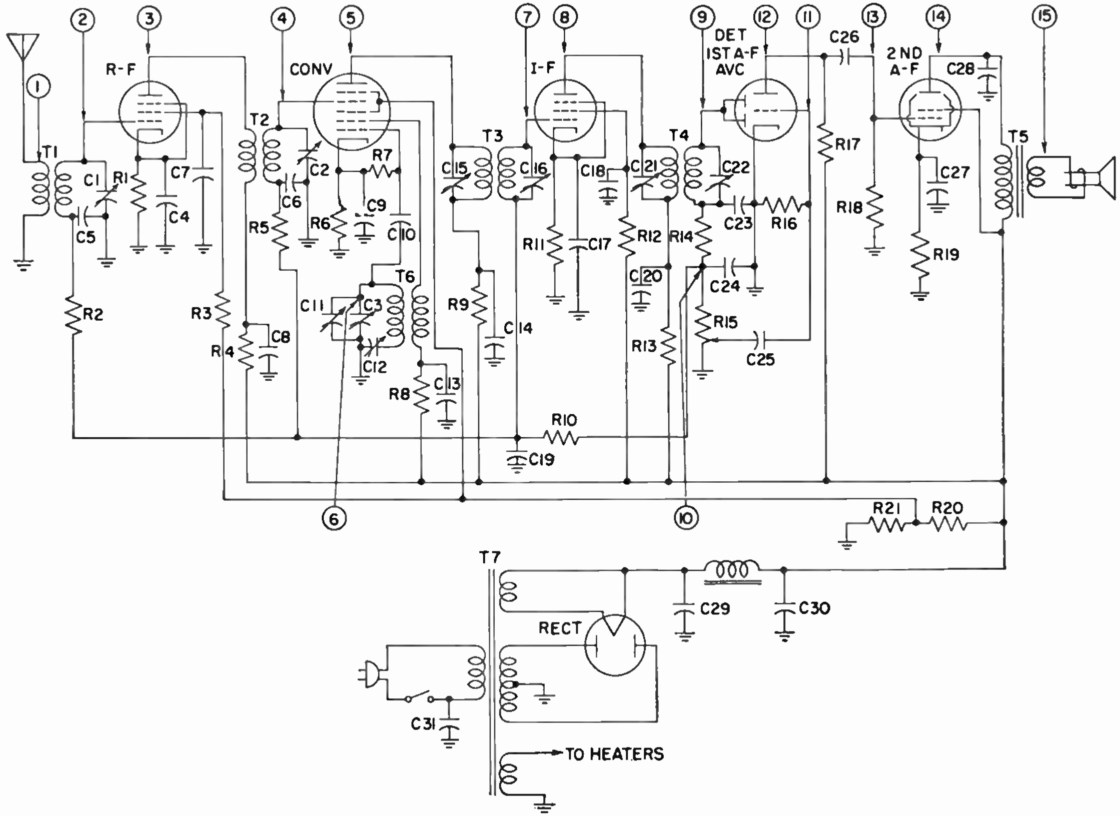


Fig. 12-7. A basic superheterodyne receiver

voltages with a d-c vacuum-tube voltmeter. When an abnormal voltage is found, check components in the normal manner.

Checking the Converter. Now shift the r-f probe to the signal grid of the mixer section of the converter tube (point 4). Normally, the signal should appear at this point with a somewhat higher voltage than at the previous test point. A weak signal or no signal at this point would indicate trouble in the following components: shorted or open windings in the r-f transformer *T*-2, or the secondary of *T*-2 may not be tuned properly according to the tuning-dial calibration, or an open avc bypass condenser *C*-6, which may be tested in the same manner as condenser *C*-5, or a shorted tuning condenser *C*-2, or dirty wiper contacts on *C*-2, or grid emission in the converter tube, or leakage from grid to ground.

Shift the hot probe to the plate of the converter tube (point 5). Many frequencies exist at this point, but you are interested in finding the signal at the intermediate frequency of the receiver and at an amplified level. The point to check for the i-f signal is the grid of the i-f amplifier tube. It may be measured there with an r-f vacuum-tube voltmeter at a gain of 60 to 80. Of course, you may measure the i-f signal at the converter plate if you have a tuned vacuum-tube voltmeter tuned for the intermediate frequency.

To check the operation of the mixer section of the converter tube, connect the hot prod of your untuned r-f vacuum-tube voltmeter to the converter plate, and block the oscillator by shorting the oscillator section of the gang tuning condenser. This permits the r-f signal to come through amplified. You may measure its voltage level with the voltmeter. It should be considerably greater than at point 4. If it is not, check the tube and its electrode voltages with a d-c vacuum-tube voltmeter. Where an abnormal reading is found, check the components involved.

Checking the Oscillator. The oscillator is the next stage up for check. Connect the hot prod of the r-f vacuum-tube voltmeter to the stator plates of the oscillator section of the gang tuning condenser (point 6) from which the short has been removed. You should get a fairly large reading on the voltmeter. At this point, you may check the oscillator operation over the entire band by changing the signal-generator frequency and the tuning dial of the receiver in step over the entire tuning range. If oscillator operation is defective, check the tube and its electrode voltages.

You may check the oscillator operation with a d-c vacuum-tube voltmeter placed across the oscillator grid resistor *R*-7. When the tube is oscillating, grid current flows and produces a d-c voltage drop across the resistor. If you measure no voltage across this resistor, the oscillator is not functioning.

Now shift the hot prod of the r-f vacuum-tube voltmeter to the grid of the i-f amplifier (point 7). This was the point at which you measured the voltage at the intermediate frequency. Failure to get a signal at that point or an abnormally weak signal indicates a defective converter tube or a defect in the input i-f transformer *T*-3. These transformers may be misaligned. Or the transformer windings may be open, shorted, or corroded. Also, the trimmer condensers may be shorted. Check the i-f tube for grid emission.

Checking the I-F Amplifier. Shift the hot prod of the vacuum-tube voltmeter to the plate of the i-f amplifier tube (point 8). You are measuring the i-f signal at that point. Normally, the voltage should be 80 to 120 times greater than that at point 7. Failure to get such a reading indicates a defective i-f tube or one with improper electrode voltages. You may measure these with a d-c vacuum-tube voltmeter and check components involved.

Shift the r-f prod of the vacuum-tube voltmeter to the diode plates (point 9). Normally, you should be measuring the i-f signal at voltage level slightly below that measured at the plate of the i-f amplifier. Failure to obtain a reading or the presence of an abnormally low signal indicates various possible defects: a misaligned i-f output transformer *T*-4, open or shorted windings, or shorted trimmer condensers, corroded windings, or a defect in the diode plate circuit.

Checking the I-F Filter. Before proceeding to the a-f section of the receiver, you might check the condition of the i-f filter composed of condensers *C*-23 and *C*-24 and resistor *R*-14. The purpose of the condensers is to offer a path of negligible impedance to the i-f signal. This i-f signal, therefore, will produce no voltage drop across these condensers. Place your r-f vacuum-tube voltmeter across these condensers. If you obtain the reading of any considerable value of voltage, the condensers are open. As a further check, connect your r-f vacuum-tube voltmeter from the grid of the first a-f tube (point 11) to ground. Since the signal generator is producing an unmodulated signal, there should be no audio voltage. If the i-f filter is defective, however, you will have an i-f signal on the grid. Therefore, any voltage reading on the voltmeter indicates a defective i-f filter. When making this check, listen for noise or hum from the loudspeaker, since they are signals which will get to the first a-f tube grid and give an erroneous reading.

Checking the AVC Circuit. Before leaving the r-f section of the receiver, you may check the avc system. Resister *R*-10 and condenser C-19 make up a filter system which removes the audio signal appearing at the ungrounded end of the volume control *R*-15 and permits only the steady d-c component to be applied through the avc bus to various controlled tubes.

To see if this avc filter is functioning properly, connect an a-c vacuum-tube voltmeter from the junction of *R*-10 and C-19 to ground. Switch your signal generator so that it produces a modulated signal. If the filter is good, you should get no reading on the voltmeter, since all that appears at the test point is a steady d-c voltage, which you may measure with a d-c vacuum-tube voltmeter from the same point to ground. Any reading on the a-c meter would indicate an open condenser C-19.

Checking the A-F Section of a Receiver. Now turn to the check of the audio section of the receiver. The signal generator must be set so as to deliver a modulated r-f output. Turn the receiver volume control full on. Connect an a-c vacuum-tube voltmeter to the ungrounded end of the volume control (point 10), and ground. A voltage reading establishes the presence of the audio signal.

Shift the hot prod of the a-c vacuum-tube voltmeter to the grid of the first a-f amplifier tube (point 11). Normally, you should get about the same voltage reading. If you do not, the volume control *R*-15 or the a-f coupling condenser C-25 is defective. You can shift the hot prod to the arm of the volume control to see if the audio signal is at that point. If it is not, the volume control is defective. Then place the a-c vacuum-tube voltmeter across condenser C-25. Normally, practically no voltage should appear across it. If you get a considerable voltage reading, the condenser is open.

Checking the First A-F Stage. Connect the a-c vacuum-tube voltmeter with the hot prod at the plate of the first a-f tube (point 12) and the other prod to ground. Normally, you should measure the audio voltage here at a considerable level above that which you obtained at the grid of the tube—about 40 to 60 times greater for a high-mu triode tube. Failure to get such a reading indicates a defective tube or improper electrode voltages. These latter voltages may be measured with a d-c vacuum-tube voltmeter.

Shift the hot prod of the a-c vacuum-tube voltmeter to the signal grid of the output tube (point 13). You should have approximately the same reading as from the previous test point. If you fail to get a proper reading, coupling condenser C-26 is probably defective. To check C-26 for leakage, connect a d-c vacuum-tube voltmeter from point 13 to ground, and remove the first a-f tube. Now if you obtain any reading on the voltmeter, the condenser is leaky. Replace the first a-f tube in its socket.

Checking the Output Stage. Shift the hot prod of the a-c voltmeter to the plate of the output tube (point 14). You should get a reading that is about 5 to 15 times greater than that at the grid of the tube for pentodes or beam-power tubes. For triode output tubes it will be less, about 2 to 5 times. If you fail to get the normal voltmeter reading, the tube or its electrode voltages are bad. Check the latter with a d-c vacuum-tube voltmeter. Where abnormal voltages are found, check the components involved.

While on the output tube, let us see how you could check components. Suppose you wished to check cathode bypass condenser C-27 for loss of capacitance or an open condition. Normally, its purpose is to bypass the audio signal, and it must offer negligible impedance to that signal. As a result, the audio signal produces no voltage drop across the condenser. Therefore, if you connect an a-c vacuum-tube voltmeter across the condenser, you should get no voltage reading. If you get a reading, the condenser has either lost capacity or is open. Incidentally, all bypass condensers may be checked for an open condition in a similar manner, since in each case these condensers are designed to offer negligible impedance to any particular alternating current. Shorted condensers would show up by the way they upset normal tube electrode voltages.

If you wish to measure the grid bias of the tube, connect a d-c vacuum-tube voltmeter across the cathode resistor *R*-19. The voltage drop across this self-bias resistor, as you recall, supplies the bias for the signal grid of the tube.

To complete the signal-tracing procedure, connect the hot prod of your a-c vacuum-tube voltmeter to the voice coil (point 15). The a-f signal appearing here will be at a considerably lower voltage than at the plate of the output tube, depending on the step-down ratio of the output transformer.

In signal tracing with a vacuum-tube voltmeter in service work exact measurements are not very important. The customer will not usually complain of defective receiver operation until the defective condition becomes extreme. Therefore, your job as a serviceman is to check wide voltage deviations from those normally expected. The servicing of weak and of dead receivers is probably your easiest job for that reason.

Checking for Hum, Noise, and Oscillation. When checking hum, noise, oscillation squeal, or motorboating in a receiver with a vacuum-tube voltmeter when no station or generator signal is present, you handle the defect as if it were a signal itself. Use the a-c vacuum-tube voltmeter to determine the stage in which the defect is introduced. Thereafter you may use routine measures to locate defective components. The problems of distortion and intermittent operation of a receiver are not so readily handled with a vacuum-tube voltmeter. They are more easily handled with the type of commercial servicing instrument called a *signal tracer*, which is basically a vacuum-tube voltmeter.

Special Service Measurements with the Vacuum-tube Voltmeter. The previous section presented a brief signal-tracing procedure in the receiver as a whole. For such a purpose alone, the vacuum-tube voltmeter would be an invaluable service tool. But many other checks and measurements may be made with such a voltmeter. In this section, some of these other uses will be described.

Measuring Stage Gain. Another important use of the a-c vacuum-tube voltmeter is that of measuring stage gain. This measurement is especially useful in locating a stage causing weak receiver reception. Many receiver manufacturers indicate average stage gain in their service notes for that purpose. You measure the input signal voltage at the signal grid of a tube, then measure the output signal voltage either at the output of the stage or at the signal grid of the next tube. By dividing the second voltage value by the first you obtain the gain of the stage.

Receiver Alignment. The vacuum-tube voltmeter may also be used for the alignment of a receiver. Each stage may be aligned with the voltmeter employed as an output indicator. Feed an unmodulated signal with a signal generator at the intermediate frequency of the receiver into the mixer grid of the converter tube. Connect the r-f vacuum-tube voltmeter from the plate of the i-f amplifier to ground. Then adjust the trimmers of the first i-f transformer for peak output. Connect the r-f vacuum-tube voltmeter from the diode plate of the second detector to ground. Adjust the trimmers of the second i-f transformer for peak output. The i-f section is now properly aligned.

To align the antenna oscillator and mixer stages, feed an unmodulated signal with the signal generator at some non-station frequency into the antenna of the receiver, and tune the receiver to that frequency. Connect your r-f vacuum-tube voltmeter from the grid of the i-f amplifier to ground. Adjust the antenna, oscillator, and mixer trimmers for peak response on the voltmeter.

In a similar manner, a receiver wavetrap may be properly aligned. Feed an unmodulated signal from a signal generator into the antenna of the receiver at the frequency to which the wave trap is supposed to be tuned. Connect your r-f vacuum-tube voltmeter from the mixer grid of the converter to ground. Then adjust the trimmer of the wave trap to give minimum response on the voltmeter.

Measuring Q of a Tuned Circuit. A fairly common cause of weak receiver response is decrease in the gain, or Q factor, of a tuned circuit. An r-f vacuum-tube voltmeter may be used to get a relative picture of such gain. Feed an unmodulated signal into the tuned circuit as shown in Fig. 12-8. Connect the voltmeter across the tuning condenser. Tune the con-

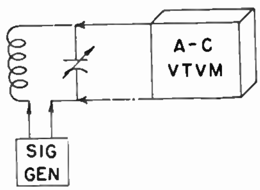


Fig. 12-8. Measuring the Q of a tuned circuit

denser for peak response. Now tune the condenser a bit off the resonant frequency. If the gain is good, the voltmeter indication should show a considerable drop.

Checking Efficiency of a Filter Circuit. An important use of the vacuum-tube voltmeter is that of determining the effectiveness of filter circuits.

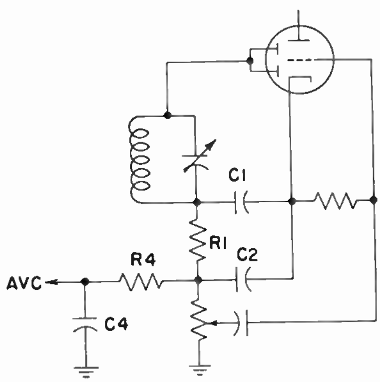


Fig. 12-9. Second detector and avc circuits of a superheterodyne receiver

Figure 12-9 shows the second detector and avc circuits of a superheterodyne receiver. The filter circuit, consisting of R-1, C-1, and C-2, prevents i-f signals from reaching the signal grid of the first a-f amplifier. To check its efficiency, feed a strong unmodulated signal from a signal generator into the receiver antenna at an off-station frequency, and tune the receiver to that frequency. Connect an r-f vacuum-tube voltmeter from the signal grid of the first a-f amplifier to ground. If the filter is perfect, you should get no reading on the voltmeter.

Resistor *R*-4 and condenser C-4 make up a filter which prevents any a-f or i-f signals from feeding back on the avc bus to the controlled tubes. Feed a strong modulated signal from a signal generator into the receiver antenna at an off-station frequency and tune the receiver to that frequency. Connect an a-c vacuum-tube voltmeter from the avc bus to ground. If the filter is efficient, you should get no indication on the voltmeter.

Measuring Receiver Output. The over-all power output of a receiver may also be determined with a vacuum-tube voltmeter. Disconnect the voice coil of the loudspeaker, and shunt the secondary winding of the output transformer with a resistor having the same ohmage as the impedance of the voice coil. Tune the receiver to a station, set the volume control for full undistorted volume, and measure the a-f voltage across the resistor. Multiply this voltage value in volts by itself and divide the result by the value of the resistor in ohms. The answer is the power output of the receiver in watts.

Checking a Phase Inverter. You may also check a phase-inverter stage feeding into a push-pull stage, by measuring the signal fed to the signal grids of the two second a-f tubes with an a-c vacuum-tube voltmeter. Tune the receiver to a station, or feed a modulated r-f signal to the antenna with a signal generator. If the magnitudes of the signals on the grid are not equal, try a new phase inverter tube and check resistor components involved.

Determining Voice-coil Impedance. Another special use of the vacuum-tube voltmeter is that of determining the voice-coil impedance of a loudspeaker. This may be necessary when replacing a loudspeaker or an output transformer. Figure 12-10 shows how to make such a test. Connect a 20-

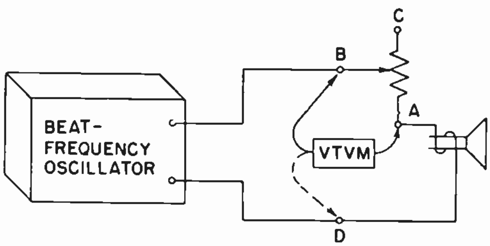


Fig. 12-10. Determining voice-coil impedonce

ohm wire-wound high-wattage variable resistor in series with the voice coil of the loudspeaker. Feed a 400-cycle audio note from a beat-frequency oscillator into the series combination. Connect one test prod of the a-c vacuum-tube voltmeter to point *A*, the junction of the resistor and the voice coil. Alternately, touch the other prod to point *B* and point *D*, while slowly moving the movable arm of the resistor toward point *C*, until you get equal voltmeter readings at *B* and *D*. When you obtain this condition, the impedance of the voice coil is equal to the resistance between points *A* and *B*. Measure this latter resistance with an ohmmeter, and you have the voice-coil impedance.

Checking Critical Oscillation of an Oscillator. The vacuum-tube voltmeter is also extremely useful in determining a condition of critical oscillation where the local oscillator oscillates at the high-frequency end of the dial but ceases to do so at the low-frequency end. Connect an r-f vacuum-tube voltmeter between the stator plates of the oscillator section of the ganged tuning condenser and ground, as shown in Fig. 12-11. Turn on the receiver and rotate the tuning dial slowly from the high-frequency end to the low-frequency end. The instant the oscillator ceases to oscillate, the voltmeter will show no reading.

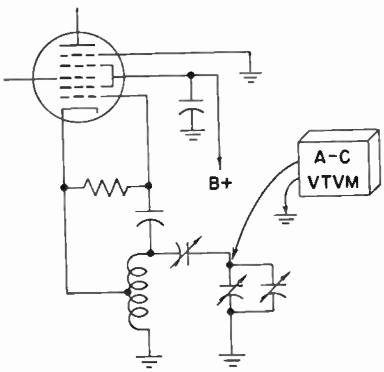


Fig. 12-11. Checking critical oscillation of an oscillator

Many other special measurements may be made with a vacuum-tube voltmeter. With experience in its use, the versatility of the instrument is almost limitless. More and more, it is becoming a constant companion of the radio serviceman.

13

The Oscilloscope

The Oscilloscope in Service Work. The cathode-ray oscilloscope is one of the more recent test instruments that have worked their way from the engineering laboratory onto the radio serviceman's bench. Unfortunately, failure on the part of the serviceman to master this valuable tool has too often caused the serviceman to place it to one side, gathering dust through disuse. The purpose of this chapter is to show how valuable the oscilloscope can be when thoroughly understood.

The primary value of this instrument is that it shows by visible means the information that we obtain with other test instruments in an indirect manner. As an ancient Chinese sage expressed it a long time ago: One picture is worth a thousand words. Because you see normal or abnormal results directly and quickly on the oscilloscope screen, you save time that you would normally consume by other means in making various checks and interpretations of the results.

The picture shown on the screen of the oscilloscope is known as a *waveform trace*. You have been handling waveforms before without realizing it. Every time you connected the signal generator to a test point in the

Fig. 13-1. Waveforms of various types of signals

receiver, you thought in terms of unmodulated r-f signals, modulated r-f signals, and a-f signals. Figure 13-1 shows the waveform picture of these signals. Similarly, when you thought of a distorted signal, you mentally constructed a waveform picture to fit the facts.

The oscilloscope shows these waveforms when properly connected at various points in the receiver. When the waveforms are different from what you normally obtain, you know you have located a defective part of the receiver.

The Cathode-ray Tube in the Oscilloscope. The heart of a cathode-ray oscilloscope is the cathode-ray tube. This tube (often abbreviated C-R tube) consists of three main parts: First, there is the electron gun, which produces a narrow electron beam. Second, there is a deflector system to direct the electron beam up and down or to one side and the other in simultaneous combinations of these movements. And last, there is the screen where the electron beam causes fluorescence and traces the waveform picture. Let's take these up one at a time.

The Electron Gun. Figure 13-2 shows a pictorial representation of a C-R tube. The electron gun produces the narrow beam of electrons which will eventually strike the fluorescent screen. The cathode, heated by the filament heater, emits a cloud of electrons. Next in line is control grid No. 1, a cylinder-shaped electrode, which controls the number of electrons passing through it by means of its applied negative bias voltage. The electron stream next passes through accelerating grid No. 2, which is positive with respect to the cathode, and which speeds up the moving electrons. (In some C-R tubes, accelerating grid No. 2 is not used.)

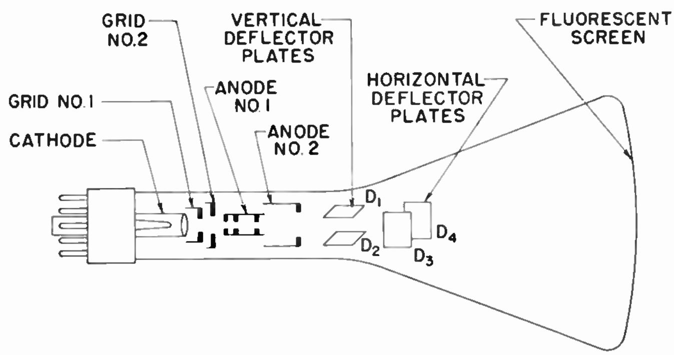


Fig. 13-2. Pictorial representation of a cathode-ray tube

The bias voltage supplied to grid No. 1 determines the number of electrons that will pass through the electron gun. This voltage is governed by the setting of a potentiometer adjusted by a front-panel control labeled INTENSITY or BRIGHTNESS.

Anode No. 1 is often called the *focusing electrode*. The electron beam emerging from grid No. 2 is too broad for practical use. Anode No. 1, by means of the electrostatic field around it, focuses the electron beam into a narrow beam. Anode No. 1 has a variable voltage applied to it controlled by a front-panel knob labeled FOCUS. Anode No. 2 accelerates this narrow beam toward the center of the face of the cathode-ray tube, where it produces a small fluorescent dot.

The Deflector System. If there were no deflecting device in the C-R tube, the thin electron beam would fall on the fluorescent screen somewhere around the center and would produce a visible stationary spot. The deflector plates make the spot move.

Consider that the horizontal deflector plate D_3 is made positive with respect to plate D_4. The electrons passing through the plates have negative charges. As a result, the electrons in the beam will be deflected towards plate D_3, which is positive. The more positive the voltage of plate D_3, the more the beam will be deflected toward it. The over-all result is that the fluorescent spot will not appear at the center of the screen but horizontally displaced toward D_3. Similarly, if plate D_4 is made positive with respect to plate D_3, the spot will be horizontally displaced toward plate D_4.

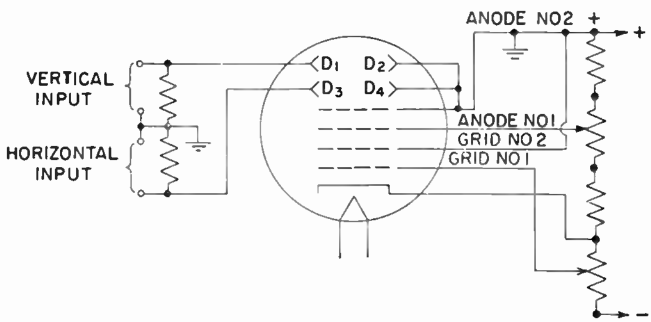


Fig. 13-3. The input circuit to the C-R tube

In the same way, the spot may be displaced vertically from the center by making plate D_1 positive with respect to D_2 or by making plate D_2 positive with respect to plate D_1. When both pairs of plates are energized, the spot goes off at an angle. You can visualize these better if you think in terms of a sort of tug of war. The spot is drawn up by the vertical deflector plates, and at the same time it is drawn to the right by the horizontal deflector plates. The combination of these two movements makes the spot go off at an angle.

In Fig. 13-3, you see the graphic symbol of the C-R tube with the deflector plates connected to the tube circuits. Note that one plate from each of the two pairs of deflector plates D_2 and D_4 is connected to anode No. 2. This arrangement is necessary in order to keep them at the same potential as anode No. 2 and to prevent defocusing of the electron beam. A low and adjustable d-c voltage is usually applied to each pair of deflector plates through two potentiometers in order to permit recentering of the spot when you find it necessary to do so.

The two centering controls for each set of deflector plates are found on the front panel of the oscilloscope and are labeled CENTERING.

The Screen. The inside surface of the large front face of the C-R tube is coated with a chemical called a *phosphor*. When the invisible electron beam falls on the phosphor, a visible spot occurs where the beam strikes. The color of the visible spot may be green, white, or yellow-orange, depending on the type of phosphor used. The glow persists for a short while after the electron beam moves to a new point. As a result, if the spot sweeps quickly across the screen—let us say from left to right—you will not see a moving dot but rather a line running from left to right because of this persistence.

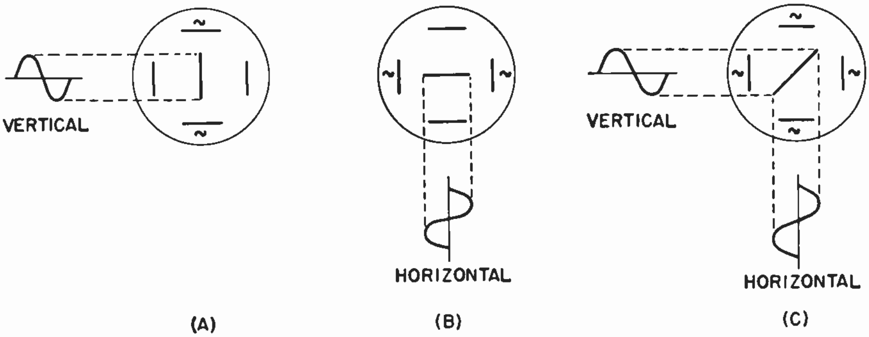


Fig. 13-4. Effect of sine-wave voltages on the deflection plates

Now what happens when a sine-wave a-c voltage is fed to the vertical plates? As you know, the sine voltage is one that varies from instant to instant, increasing from zero to a maximum and falling to zero, then rising to maximum with polarity reversed and falling to zero again. Since the displacement of the spot depends on the magnitude of the voltage fed to the deflector plates, the dot will start from center, rise vertically to maximum, fall to center, drop vertically to maximum, and fall to center. If you continued to feed in the sine voltage, you would see a vertical line as in Fig. 13-4A. The deflection below center will be equal to the deflection above center.

Spot-deflecting Action. An interesting point may be made at this time. The amount of displacement of the spot either above or below center, as measured by the length of the vertical line above or below center, is an indication of the peak value of the a-c voltage fed to the vertical deflector plates. Therefore, with proper calibration, the oscilloscope is now acting as an a-c voltmeter.

Similarly, if you fed the sine voltage to the horizontal deflector plates, you would get a horizontal line as shown in Fig. 13-4*B*. Remember, the vertical and horizontal lines are not really lines but only appear that way because the electron beam spot is rapidly moving up and down or horizontally back and forth, respectively.

If you feed the sine voltage in phase to the horizontal and vertical plates, the combined varying deflections will produce the slanting line shown in Fig. 13-4*C*. It is easy to understand this result because, at any one instant, equal voltages will be drawing the spot up or down and to the right or left.

There are other methods of producing deflection of the electron beam. The method just described is known as the *electrostatic* method, since the electrons are deflected by the electrostatic fields around the deflector plates.

With some C-R tubes, the deflection is obtained by means of magnet coils around the narrow neck of the tube. Here the magnetic field produced by the moving electrons in the electron beam reacts with the magnetic field from the magnet coils, and deflection results. This latter method is known as electromagnetic deflection. Electrostatic deflection is more commonly used in oscilloscopes. Electromagnetic deflection is more commonly used in television systems where longer cathode-ray tubes are used.

Sweep Voltage. We have thus far succeeded only in making an applied a-c sine wave look like a vertical line or a horizontal line or a slanting line. How do we get the a-c sine voltage to look like the standard sine voltage on the screen of the C-R tube? The answer is found in the sweep voltage of the oscilloscope.

A simple example will make the concept a little easier to digest. Suppose you were at a blackboard with a piece of chalk and traced a vertical line steadily up and down, as in Fig. 13-5*A*. This corresponds to the sine voltage applied to the vertical deflector plates. Now walk steadily and at a constant rate along the blackboard while you continue to write up, down and up along the vertical line. The result will be that shown in Fig. 13-5*B*. Now lift the chalk and move back. Place the chalk at point *A* and repeat the process. If your motions are the same as before, you will merely be tracing over the same curve.

The oscilloscope operates in a similar manner. The varying a-c sine voltage on the vertical plates produces a vertical line as the spot moves rapidly up and down. If now you apply only a uniformly rising voltage to the horizontal deflector plates, the spot will move uniformly across the screen horizontally. If you apply both voltages at the same time, you will obtain a picture of the a-c sine wave that you applied to the vertical plates on the screen. The uniformly rising voltage on the horizontal plates is known as the *sweep voltage.*

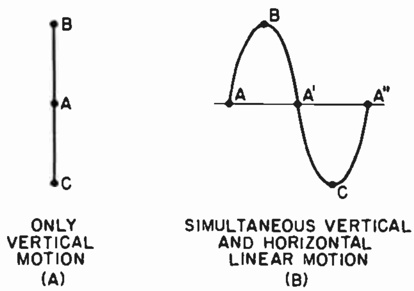


Fig. 13-5. Effect of adding a linear horizontal motion to a vertical motion

If the sweep voltage moves once across the screen while the a-c sine voltage applied to the vertical deflector goes through one cycle, you will see one cycle on the screen. If the sweep voltage moves once across the screen while the a-c sine voltage goes through two cycles, you will see two cycles on the screen, and so forth.

Sweep Retrace Action. There is another requirement demanded of the sweep voltage. After the sweep voltage has caused the spot to move horizontally at a uniform speed across the screen from left to right, the spot must quickly return to the left end of the screen to repeat its uniform horizontal movement. It is desirable that this return period or flyback time be as short as possible. The voltage to give this condition is produced by a special generator called a saw-tooth oscillator. In the saw-tooth generator, voltage rises at a steady rate, then drops rapidly as shown in waveform diagram of Fig. 13-6A. Note how the waveshape gives this generator its name.

Sweep Voltage Waveform. Figure 13-6*B* shows the uniform horizontal movement of the spot across the C-R tube screen with the application of a saw-tooth voltage to the horizontal deflector plates. Let us examine the figure. The saw-tooth voltage rises steadily with time from *A* to *E*. As a result, with equal passage of time, the spot moves equal distances from *A'* to *E'* on the screen. The time *E* to *F* is called the *flyback time,* when the spot jumps back quickly to position *A'* on the screen. Then the next saw-tooth voltage pulse repeats the action. Flyback time is too short to make the spot visible on the screen.

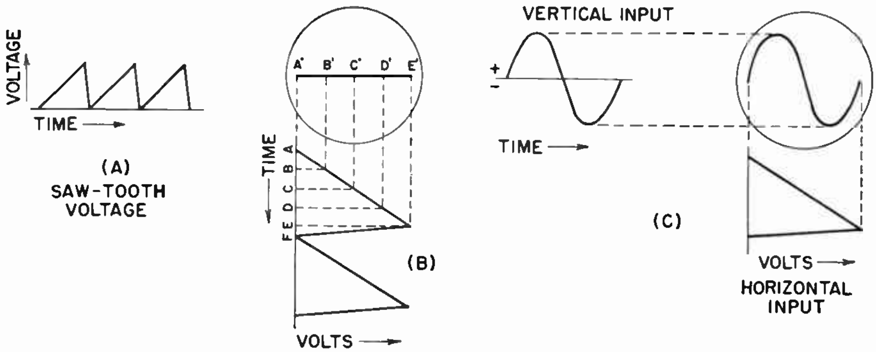


Fig. 13-6. Uniform horizontal sweep resulting from the saw-tooth voltage

Now, with the saw-tooth sweep applied to the horizontal deflector plates, apply an a-c sine voltage to the vertical plates. The resulting waveform picture on the C-R tube screen is shown in Fig. 13-6C. Note how you now get the waveform of the input to the vertical deflector plates on the screen when you have your saw-tooth voltage input to the horizontal deflector plates. If you had one saw-tooth pulse in the time that two cycles of a-c sine voltage were fed to the vertical plates, two cycles would appear on the screen; if you had one saw-tooth pulse in the time that three cycles were fed to the vertical plates, three cycles would appear on the screen.

The procedure described is the most universal method of observing a waveform picture on the C-R tube screen. The saw-tooth voltage developed by a saw-tooth oscillator in the oscilloscope is applied to the horizontal plates. The test voltage of any waveform is fed to the vertical deflector plates. On the screen is seen the waveform of the test voltage.

Synchronizing Circuits and Controls. In order to obtain a stationary waveform on the screen, the time for one sweep must be the same as one, two, or any whole number of repeating cycles fed to the vertical deflector plates. If this condition does not exist, the pattern will drift across the screen or become quite complex. Also, the input signal to the vertical input must be synchronized in proper phase with the sweep frequency voltage.

Various circuits and controls provide the proper synchronization of the horizontal sweep voltages and the vertical deflector voltages. The frequency of the saw-tooth oscillator is usually adjusted by two front panel controls: One is a multipole switch, often labeled RANGE. The switch selects a step which is a small range of frequencies over which the oscillator will oscillate. In conjunction with this control is another control labeled FREQUENCY. It is a continuously variable control which tunes the oscillator to a specific frequency within the selected range.

So far, we have the sweep oscillator frequency under control. But it must still be synchronized with the frequency of the test voltage going to the vertical deflectors. This latter job is performed by means of a front-panel control switch labeled TIMING SYNC or SYNC SELECTOR. It usually has three positions: EXT, "60" or LINE FREQUENCY, and INT. When this selector switch is on its INT position, internal synchronization occurs with the test signal voltage, and the test voltage waveform may now be seen on the screen. This is the usual mode of operation in radio-servicing work.

When the selector switch is in the "60" or LINE FREQ position, the synchronizing voltage is taken from a 60-cycle source present in the power supply of the oscilloscope.

And finally, when the selector switch is in its EXT position, an external signal voltage may be fed into the oscilloscope for synchronizing purposes. This external voltage is fed into the instrument via input jacks labeled SYNC. Later on, we shall see how to use these synchronizing voltages.

There is one further synchronizing control labeled SYNC. which varies a potentiometer. By proper adjustment it locks the trace on the screen in a stationary position.

The Complete Oscilloscope. You now have a basic picture of how the cathode-ray oscilloscope works. A few more items must be tied in before you have the complete picture. Figure 13-7 is a simplified block diagram of a complete oscilloscope. Note the vertical and horizontal amplifiers. The external voltages applied to the deflector plates may often be insufficient to produce appreciable deflections of the electron beam. To produce larger deflections and, as a result, a larger trace on the screen, the amplifiers are provided. These amplifiers, of course, must be free of distortion if you wish to get a true waveform picture of the test voltage.

The cathode-ray oscilloscope is designed primarily to trace the wave forms of a-c test voltages. A d-c blocking condenser is therefore inserted in series with each pair of plates in the oscilloscope to keep out undesirable direct currents.

The last item to be discussed is the power supply of the oscilloscope. Actually, there are two sections to the power supply. One is the low-voltage supply, furnishing about 400 volts for the amplifier and sweep circuits. The other is the high-voltage supply, furnishing about 1,500 volts for the operation of the C-R tube. The magnitude of this latter voltage is suffi-

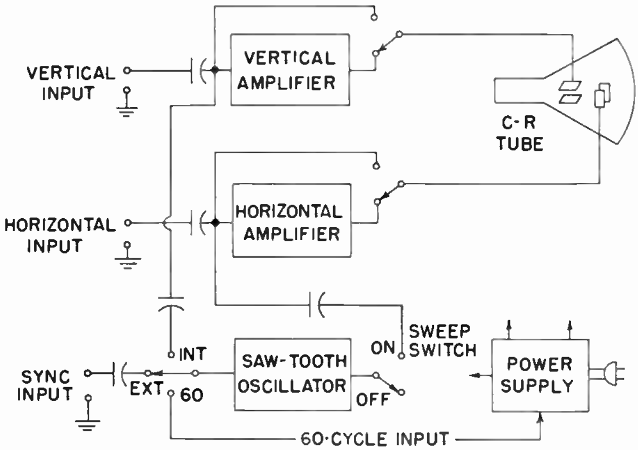


Fig. 13-7. Simplified block diagram of a complete oscilloscope

cient to discourage you from poking into the oscilloscope with the power on. An interlock switch automatically cuts off power when the instrument is out of its case, but do not rely on its foolproof operation. Remove the line plug if you have to work inside the instrument.

Oscilloscope Controls. You can best learn what your oscilloscope is capable of doing by inspecting its control knobs before you begin to use it in actual radio-service work. The best way to start is to read carefully the instruction manual furnished by the manufacturer of the oscilloscope. Then try to obtain the waveform trace on the screen of a simple a-c sine voltage, like the 400-cycle note from a signal generator.

Let us learn a little more about the oscilloscope controls by assuming that we are going to obtain the 400-cycle waveform trace on our screen. The front panel and controls of a typical oscilloscope are shown in Fig. 13-8. Assume further that we are using that instrument for the purpose mentioned above.

At the top of the front panel you see the screen of the oscilloscope. Alongside the screen are two controls labeled INTENSITY and FOCUS. These control the brightness and the sharpness of the waveform that you will see on the screen. Below the screen and the two controls just mentioned, the front panel is divided into three main divisions. All the controls on the left side are the vertical deflector plates controls. All the horizontal deflector plates controls are on the right side of the panel. And in the center and lower right are all the timing or sweep-voltage and synchronization controls.

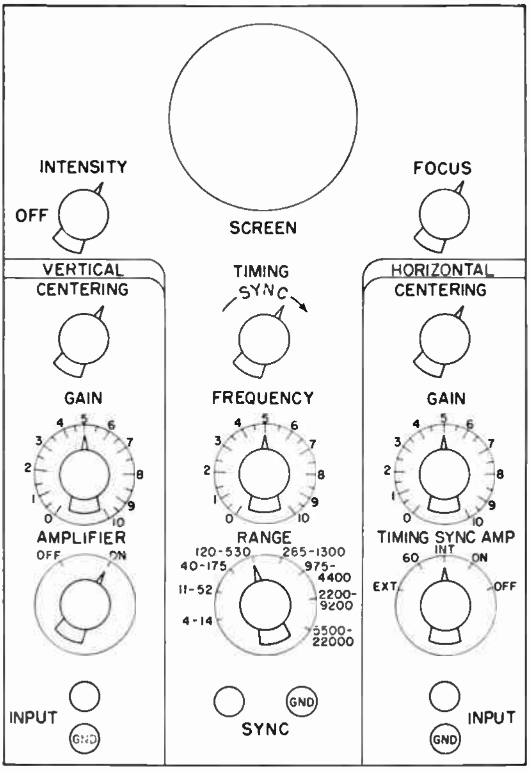


Fig. 13-8. Front view of an oscilloscope, showing controls

Turning on the Oscilloscope. Begin by setting all controls in their extreme counterclockwise positions. Then insert the line-cord plug and turn the INTENSITY control in a clockwise direction until you just hear a click. Sometimes, the on-off switch may be associated with another control. This operation turns on the oscilloscope power. Wait about one minute and turn up the INTENSITY control until a spot appears on the screen. This INTENSITY control is a potentiometer which varies the voltage fed to control grid No. 1 of the C-R tube. The spot on the screen may not be sharp, but rather may be fuzzy. Turn the FOCUS control in a clockwise direction until the spot is sharp. The FOCUS control is a potentiometer which varies the d-c voltage applied to anode No. 1 of the C-R tube.

CAUTION: *Never allow a bright spot to remain stationary on the screen, because this will burn the screen. If necessary, turn down the intensity control.*

Next center the spot on the screen by varying the vertical and horizontal CENTERING controls. These are potentiometers which feed positive or negative voltages to the ungrounded vertical and horizontal deflector plates of the C-R tube.

Vertical Gain Controls. You have now completed the preliminary adjustments necessary for any study made with oscilloscope. Let us now investigate the vertical controls. Down at the bottom of the left section of the panel are the input terminals. One of these is labeled GND and is the grounded terminal. Whenever you have a test voltage source with one side grounded, connect this grounded side to the GND input terminal.

Above the input terminals is a switch labeled AMPLIFIER. In its OFF position, the test voltage is fed to the vertical deflector plates directly. In its ON position, the test voltage is fed to the vertical amplifier and then fed to the vertical deflector plates. In radio-service work, you will probably use the oscilloscope with this control in its ON position at all times. Above the AMPLIFIER control is the GAIN control. This latter control is a potentiometer which controls the magnitude of the signal fed to the vertical amplifier, and hence the degree of vertical deflection.

Let us experiment with the vertical controls. Connect the leads from the signal generator producing the 400-cycle signal to the vertical INPUT terminals. Turn the AMPLIFIER switch to ON. You will notice a vertical line produced at the center of the screen, since there is no horizontal sweep. Vary the GAIN control and note how the vertical line increases and decreases in size. Remove the leads from the vertical INPUT terminals.

Horizontal Controls. Now consider the horizontal controls at the right. At the bottom are the horizontal input terminals. These are similar to those you encountered for the vertical input. Above the input terminals is a control labeled TIMING SYNC.—AMP. The two extreme right positions of this switch control are similar to the AMPLIFIER control for the vertical input. In the OFF position, any test voltage fed to the horizontal input terminals is fed directly to the horizontal deflector plates of the C-R tube. In the ON position, any test voltage will be fed to the horizontal amplifier and then fed to the horizontal deflector plates of the C-R tube. Above this control is the GAIN control, which is a potentiometer that controls the magnitude of the signal fed to the horizontal amplifier, and hence the degree of horizontal deflection.

Let us experiment with the horizontal controls as described up to this point. Connect the signal generator with its 400-cycle signal to the horizontal INPUT terminals. Turn the AMP switch to its ON position and notice the horizontal line at the center of the screen. Vary the GAIN control, and note how the horizontal line increases and decreases in size. Remove the leads from the horizontal INPUT terminals.

Synchronizing Controls. Now let us examine the TIMING SYNC positions of the TIMING SYNC—AMP switch control. Note that there are three positions for this portion of the switch. When you use an external synchronizing voltage fed into the SYNC input terminals at the bottom center of the panel, you set the switch to its EXT position. If your test signal has a frequency of 60 cycles per second or any harmonic value of 60 cycles (e.g. 120, 180, 240, 300, etc. cycles per second), you may set the switch at its "60" position. This furnishes an internal synchronizing voltage at 60 times a second. Most often in radio-service work, you will set the switch to its INT position. This position furnishes an internal synchronizing voltage at any frequency properly locked to the frequency of the test signal fed to the vertical input terminals.

Once you set the switch mentioned above to its INT position, you must use the timing or sweep controls in the center of the front panel. Above the SYNC input terminals is the RANGE switch. You set this switch at the range position, which includes the frequency of the test signal fed to the vertical input. To get closer to the proper sweep frequency that will produce a stationary image on the screen, you must adjust the vernier potentiometer control labeled FREQUENCY. The image on the screen may still drift slowly. To make it absolutely stationary, you turn the SYNC control above the FREQUENCY control in a clockwise direction until the image just stands still. This SYNC control is a potentiometer used to control the amount of synchronizing voltage fed to the sweep oscillator. It locks the test signal and the sweep oscillator frequencies. Do not turn the SYNC control up more than necessary, since oversynchronization may distort the screen image.

Connecting the Oscilloscope. Now let us complete the procedure. Connect the signal generator and its 400-cycle signal to the vertical INPUT terminals. Set the TIME SYNC—AMP control to its INT position. Set the RANGE switch to its "120–530" position, since this includes the 400-cycle frequency. Then vary the FREQUENCY control until the image on the screen just about stands still. Then turn up the SYNC. control just enough to make the waveform image remain stationary. You should see the a-c voltage waveform. If you wish, you may turn up the INTENSITY control for a brighter image.

There is one precaution which you must keep in mind. Stray voltages may be picked up by the oscilloscope input leads, particularly in the neighborhood of power machinery. Spurious unwanted waveforms will appear on the screen. A helpful procedure in such cases is to use shielded input leads.

Service Measurements with the Oscilloscope. There are many checks and measurements which you may make with the cathode-ray oscilloscope. As you become more and more familiar with this versatile instrument, you will find many ways in which to use it to save your servicing time. We will confine the remainder of this chapter to a study of some of the more important uses which you will make of this service instrument.

As a preliminary learning procedure, make the checks to be described on a receiver that is known to be in good operating condition, so that you will learn to recognize normal oscilloscope waveform traces. Then when you see abnormal traces, you will readily recognize them and will know where to look for defects.

Servicing a Receiver That Hums. Hum originating within a receiver is either of the 60-cycle type or of the 120-cycle type, as would result in a full-wave rectifier. It is obvious then that you may set the TIMING SYNC. control to its "60" position, and set the FREQUENCY and RANGE controls to 60-cycle sweep frequency. You then tune the receiver to a non-station position, and apply the vertical input prod to various test points in the receiver. If at one stage you find one cycle on the oscilloscope screen, you know that 60-cycle hum is entering that stage. If you find two cycles on the screen, you know that 120-cycle hum is entering that stage.

Hum in the Power Supply. Let us make a few specific tests. Turn on the receiver. First check your power supply for the origin of hum. Figure 13-9*a* shows a typical a-c power supply. Set your oscilloscope to the 60-cycle sweep and the 60-cycle synchronizing position. Connect the ground prod of the oscilloscope to point 1 of the power supply and the other prod of the vertical input to point 3.

If input condenser C-1 and filter choke L-1 are in good shape but condenser C-2 is open or has lost considerable capacitance, the waveform trace on the screen will be similar to that of Fig. 13-9*b*.

If the input filter were open or had lost considerable capacitance and the choke and output filter condenser were all right, the waveform on the screen would be similar to that in Fig. 13-9*c*.

If the filter condensers and choke were all good, you would obtain a waveform on the screen similar to that shown on the oscilloscope in Fig. 13-9*a*. You may have to turn the vertical gain control all the way up to see this waveform. Note that a faint residual hum is still present even in a good power supply. In each of these checks, the greater the vertical height of the waveform trace, the greater the magnitude of the hum voltage.

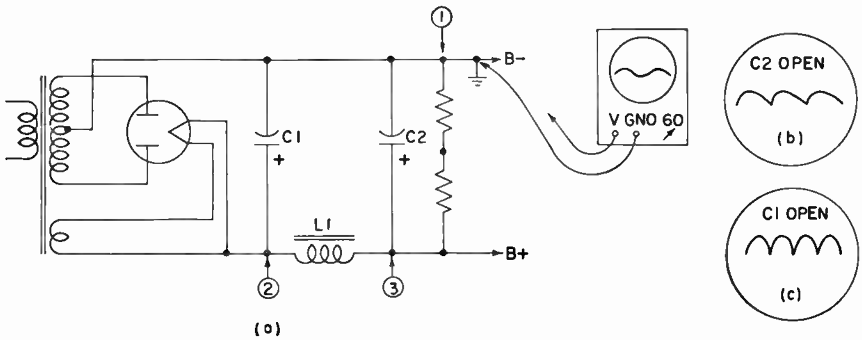


Fig. 13-9. Checking the power supply for hum

To gain experience, you should try these tests on a good receiver and then open the various filter condensers by disconnecting a lead. Observe the effect on the oscilloscope screen. There is nothing like seeing the normal and abnormal traces yourself.

Having cleared the power supply of any hum-producing effects, you then turn to the signal chain of the receiver proper. We will begin with the audio-frequency section of the receiver.

Hum in the A-F Section of a Receiver. To check the a-f section for hum, you must silence the stages before it. If the receiver is of the a-c type, remove the last i-f tube; if it is of the a-c/d-c type, short out the grid of that tube. Several procedures may now be followed, but we will study a simple one. The preliminary steps may be listed as follows:

1. Turn on the INTENSITY switch and center the spot.
2. Adjust the FOCUS control for a clear spot.
3. Turn vertical AMPLIFIER to its ON position and set the vertical GAIN control to midway position.

4. Set the TIMING SYNC switch to its INT position.

5. Adjust the horizontal GAIN control to give a horizontal line across the entire screen.

6. Set the RANGE switch to its "40–175" position.

7. Feed about 8 volts (a-c) from a transformer shunted by a 25,000-ohm/1-watt resistor into the vertical INPUT.

8. Adjust the timing FREQUENCY control until you get one cycle on the screen.

9. Lock the screen trace by adjusting the timing SYNC control.

10. Readjust the vertical GAIN control to get a good amplitude for your trace.

11. Disconnect the vertical input.

Your instrument is now set to give a 1-cycle trace if 60-cycle hum shows up in the test and a 2-cycle trace if 120-cycle hum appears. Let us proceed with the check. Turn on the receiver. Remember that no signal will appear at the a-f section, since you shorted out the signal at the i-f stage. All that appears on the oscilloscope screen is the horizontal line. Now connect the GND terminal of the vertical input to either terminal of the switch on the volume control of the receiver (or B-minus). Connect the shielded test lead and prod to the other terminal of the vertical input.

Begin by touching the test prod to various key points in the a-f signal chain. Touch the arm of the volume control. Then touch, in succession, the control grid of the first a-f amplifier, then its plate, and finally the voice coil of the speaker. If no hum is present, the horizontal line will appear constantly. However, the moment you touch a point with a hum voltage, a single cycle will appear on the screen if it is 60-cycle hum, 2 cycles if it is 120-cycle hum. You have then located the hum-producing stage. A routine inspection of components will then disclose the cause. Just keep in mind when making this test that a certain small amount of tolerable hum will always be present. Look for extremes.

To gain experience in locating hum in the a-f section of a receiver, you might try introducing 60-cycle hum by connecting a 1,000-ohm, 2-watt resistor between cathode and either heater terminal of the a-f tubes. You will readily learn to recognize this hum trace, which simulates cathode-heater leakage.

Servicing the Receiver with Amplitude Distortion. The cathode-ray oscilloscope is an extremely useful service instrument when a receiver with a distorted output is encountered. It furnishes a quick and efficient means for seeing a distortion effect wherever it exists. The technique, in brief, is to view the signal waveform on the oscilloscope screen at the input and the output of the stage under test. Any variation in this procedure is made in the interest of reducing the number of connection changes in order to save time. The defective stage that introduces the distortion is located when a waveform is seen at the output of a stage that is *considerably* different from the waveform seen at the input of the stage. Let us see how you can approach the procedure from a practical point of view.

Audio Connections. To check the a-f section of the receiver, use an audio signal generator. Feed a signal of about 400 cps into the input of the audio section after turning on the receiver. Connect the ground terminal of the test oscillator to the receiver chassis or common negative and the hot terminal to the ungrounded end of the volume control. Be sure to reduce the input from the generator, so that you do not overload the stages, and set the receiver volume control to below its halfway position.

Getting an Audio Waveform. Turn on the oscilloscope. Adjust the INTENSITY, FOCUS and CENTERING controls so as to obtain a clear, centered spot on the screen. Turn the vertical AMPLIFIER switch to its ON position. Turn the TIMING SYNC switch to its INT position. Set the RANGE switch to the "120–530" position. Connect the ground terminal of the vertical input to the receiver chassis and the hot vertical input terminal to the ungrounded end of the volume control. Adjust the FREQUENCY control so as to obtain about 2 cycles of the generator signal on the screen. Lock the waveform trace, so that it does not drift, by adjusting the SYNC control. Finally, adjust the horizontal and vertical GAIN controls to obtain the desired size of waveform picture. Now observe this picture to see its form. It might be advisable for you to make a copy of this waveform by placing tracing paper over the screen and *gently* tracing the picture.

Now observe the waveform at the output of the a-f section of the receiver. Transfer the vertical input leads so that they are across the voice coil of the loudspeaker. Adjust the vertical GAIN control so that the waveform picture is the same size as previously. Compare the two pictures. Any marked variation between the two images on the screen indicates that distortion is being introduced into the a-f section.

If distortion is evident, shift the hot lead of the test oscillator to the plate of the first a-f amplifier tube, and adjust the vertical GAIN control of the oscilloscope to obtain a waveform of the same amplitude as before. If now no distortion is evident, the defect lies between the plate of the first a-f amplifier and the loudspeaker. If, however, distortion is observed, the defect lies between the volume control and the first a-f amplifier tube.

Examples of Distorted Waveforms. Harmonic or amplitude distortion may produce waveforms of various types. Common forms are those shown in Fig. 13-10. Figure 13-10*A* shows the normal sine waveform of the undistorted signal. Figures 13-10*B* and 13-10C show distorted waveforms where either the upper or lower peaks are flattened. Such conditions would

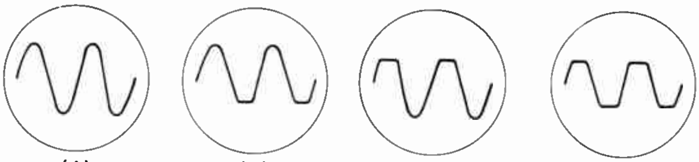


Fig. 13-10. Harmonic distortion waveforms

result in a tube where the bias was too great or too low, or where plate voltage was too low, or where a tube with weak emission existed. In Fig. 13-10*D*, the distortion results in all peaks being flattened, indicating an overloaded stage. A poor tube or improper bias and plate voltages could produce such an effect.

R-F Connections for Oscilloscope. Most often, the cause for distortion will be found in the audio section of the receiver—usually in the output stage. If the audio section does not produce the distortion, then you must hunt the source in the r-f section of the receiver. Perform this check in the following manner. Use a signal generator with a 400-cycle audio modulation. Connect it across the antenna input of a receiver that is known to give good undistorted output. Connect the vertical input of your oscilloscope across the voice coil, and adjust the controls as you have just done to obtain 2 cycles of the 400-cycle modulation note. Make a tracing *gently* of the waveform on the screen. This is your input waveform. If it is slightly distorted, you may attribute this fact to the inability of the signal generator to give a pure sine waveform.

Now feed a 400-cycle modulated note from your signal generator at a non-station position at about 1,000 kc into the antenna input of the defective receiver. Set the volume control of this receiver at its halfway position. Place the vertical input terminals of the oscilloscope across the voice-coil terminals of that receiver. Tune the receiver to the same r-f frequency as the signal generator. Adjust the vertical GAIN control of the oscilloscope until the amplitude of the waveform on the screen is the same as that of the waveform you have just traced. If the image is considerably different, that is, distorted, feed the signal from the signal generator into the signal grid of the converter. Again adjust the GAIN control to get a waveform of the same amplitude as before.

If the waveform is not distorted, the defect lies between the antenna and the signal grid of the converter. If the waveform is distorted, feed a 400-cycle modulated signal at the intermediate frequency of the receiver into the signal grid of the i-f amplifier tube. Adjust the vertical GAIN control of the oscilloscope to obtain a waveform of proper amplitude. If this waveform is not distorted, the defect lies between the converter signal grid and the i-f amplifier grid. If the waveform is distorted, shift the hot prod of the signal generator to the diode detector plate and again adjust the vertical GAIN control. A waveform that is not distorted indicates a defect between the i-f amplifier signal grid and the detector plate. A distorted waveform on the screen indicates a defect between the diode detector plate and the volume control.

Some Distortion Is Normal. The oscilloscope is thus seen to be a service instrument that can readily locate a defective stage that results in receiver distortion. You have to use judgment in making interpretations of the waveform on the screen. A certain amount of distortion is to be expected and is normal. The degree of distortion is the important factor for you as a serviceman. Experience will guide you in this regard. After you have located the defective stage, you may proceed with further isolation procedures.

Servicing the Receiver with Frequency Distortion. The a-f section of a receiver should have a frequency response which is flat at all audio frequencies in order to reproduce faithfully the audio signals which it is required to amplify. If different audio-input frequencies are amplified to different extents, the receiver is said to suffer from frequency distortion. The oscilloscope is an extremely useful instrument for making this check.

The output from an audio oscillator is fed direct to the vertical plates of the oscilloscope—bypassing the vertical amplifier which might throw off the indications. Starting from the low audio-frequency end, the frequency of the audio oscillator is slowly advanced to the high audio-frequency end. During this frequency swing, any deviation in the amplitude of the signal as shown is noted with the frequency at which the deviation occurs. You have thus recorded the output characteristics of the audio oscillator.

Then connect the audio oscillator to the input of the audio stage or section to be checked. Connect the output of the stage to the vertical plates of the oscilloscope, as was done previously. Again swing the audio oscillator from low to high frequency. You are now checking the a-f stage, or section, for frequency response. Note again any deviations from the deflection obtained at the start of this check. If the deviations do not occur at the same frequencies as were obtained previously from the output of the audio oscillator, frequency distortion is present. If this frequency distortion lies outside the limits specified by the manufacturer for the audio section, the section should be investigated for the source of the trouble.

Example of Frequency Distortion. Let us see how to apply the check specifically to a receiver. Turn on the oscilloscope and obtain a clear, sharply focused spot at the center of the screen. Set the RANGE switch to its "40–175" position; set the TIMING SYNC switch to its INT position. Set the vertical AMPLIFIER switch to its OFF position. Then connect the ground terminal of the audio oscillator to the vertical GND terminal of the oscilloscope. Connect the hot terminal of the oscillator to the hot vertical input terminal.

Now turn on the audio oscillator and the oscilloscope, and set the audio oscillator at the low-frequency end of its range. Adjust the FREQUENCY and SYNC controls to obtain several cycles of the sine wave, and note the deflection produced on the screen. The deflection of the sine wave may be measured from peak to peak. Increase the frequency of the output from the audio oscillator, and note the frequency at which any deviation in the deflection occurs. Adjust the RANGE, FREQUENCY, and SYNC controls as required during the oscillator frequency sweep.

Turn off the audio oscillator and connect its ground terminal to the chassis or common negative of the receiver. Connect the hot terminal of the oscillator to the grid of the input stage of the audio section. Then connect the vertical input terminals of the oscilloscope across the voice coil of the loudspeaker of the receiver. Turn on the audio oscillator, the receiver, and the oscilloscope. Set the oscillator to the low-frequency end of its range. Adjust the RANGE, FREQUENCY, and SYNC controls of the oscilloscope to obtain the same number of waves on the screen as in the previous steps. Adjust the attenuator of the audio oscillator to give the same vertical deflection as that obtained from the oscillator alone in the previous check. Swing the oscillator to the upper end of the frequency range, and note any deviation in deflection as well as the frequencies at which they occur. During this swing, adjust the RANGE, FREQUENCY, and SYNC controls as required.

If wide deviations occur at different frequencies from those obtained from the audio oscillator alone, trouble within the audio section is indicated. To localize the defective stage, connect the vertical input GND terminal to the chassis or common negative of the receiver. Connect the hot vertical input terminal to the signal grid of the output stage, and repeat the check. If the frequency distortion disappears, the trouble is in the output stage. If the trouble still appears, the defect lies before the output stage.

Aligning I-F Stages. Perhaps the greatest advantage of the oscilloscope to the serviceman is for receiver alignment, particularly i-f stages. The normal procedure for receiver alignment is that of peaking the response, as indicated on an output meter, by adjusting the trimmer condensers. A typical set of response curves is shown in Fig. 13-11. The intermediate frequency is at the center of the response curve.

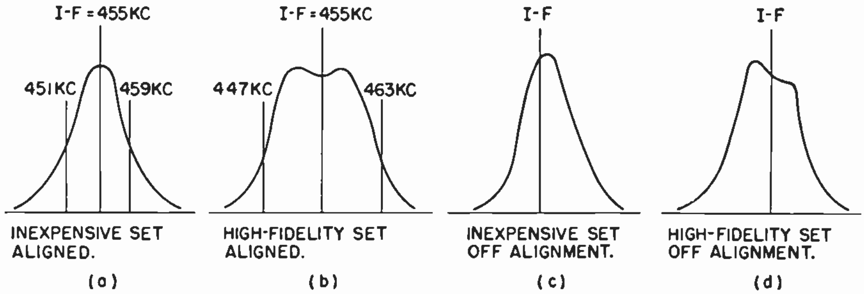


Fig. 13-11. Examples of i-f response curves as seen on screen of cathode-ray oscilloscope

For an inexpensive receiver of high sensitivity and high selectivity but relatively poor fidelity, as shown in Fig. 13-11*A*, the response curve is a single peak with sidebands of about 5 kc on each side of the intermediate frequency.

For a high-fidelity receiver, as shown in Fig. 13-11*B*, the response curve is a double peak with sidebands of about 10 kc on each side of the intermediate frequency. For both cases, the curve is symmetrical on both sides of the center intermediate frequency.

Therein lies the difficulty of aligning the i-f stages with an output meter. You may obtain a peak response on the output meter without having symmetrical response curves. Fig. 13-11 C and *D* shows such unsymmetrical curves which would give a peak response. Nevertheless these conditions would indicate misaligned stages.

The oscilloscope has the great advantage in such alignment because it not only shows peak response but also shows symmetry or lack of symmetry. The procedure is known as visual alignment. Let us see how to use the oscilloscope with a sweep-frequency generator in making such a visual alignment.

Connecting the Sweep-frequency Generator. The technique involved is simple if proper test equipment is employed. You must have an f-m or sweep-frequency signal generator capable of sweeping through 20 or 30 kc of frequency around the intermediate frequency (455 kc) of the receiver. The output from such a generator is of the saw-tooth waveform, as shown in Fig. 13-12. The frequency sweep repeats itself 60 times a second. Or one sweep occurs in $\frac{1}{60}$ of a second.

If this sweep frequency is now fed into the input of an i-f stage, the gain of the stage would tend to be greatest at the resonant or intermediate frequency and to fall off as the test frequency shifts further from the resonant frequency. This condition results from the fact that the i-f stage is fixed-tuned to the intermediate frequency.

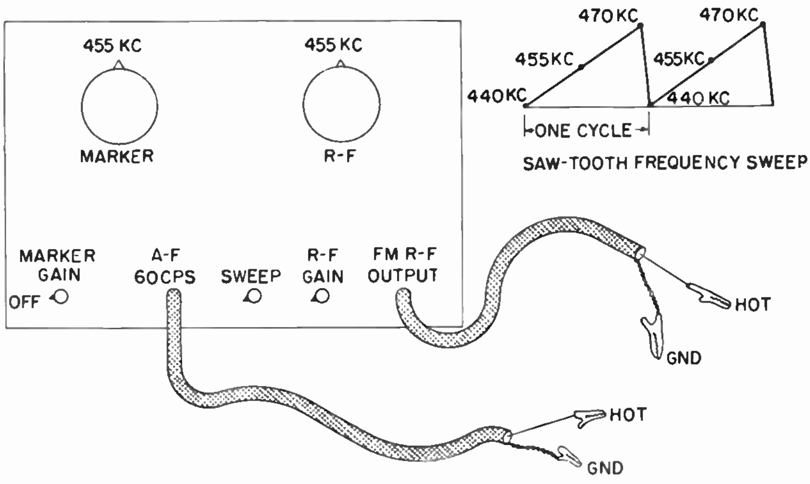


Fig. 13-12. A typical sweep-frequency signal generator and its controls

Let us examine the main controls of a sweep-frequency signal generator, as seen in Fig. 13-12. In the upper right-hand corner is the R-F control, which will be set around 455 kc. The SWEEP control will be set to produce the 30 kc sweep—15 kc on either side of 455 kc. Near this latter control is the R-F GAIN control which determines the strength of the generator signal. The signal from the generator is taken from an output cable connected to the jack labeled FM R-F OUTPUT. To the left of the SWEEP control is a jack labeled "A-F 60 CPS." The cable attached to this jack delivers

60-cycle voltage which will be used to trigger the horizontal sweep of the oscilloscope at 60 cycles per second. Above the jack is a switch that produces the 60 frequency sweeps of the generator per second when in the ON position. For the time being, forget the other controls.

Connecting the Oscilloscope. Where can you measure the gain of the i-f stage in response to the various frequencies of input signal? The detector load, which is the volume control, turns out to be the best point. For a diode detector, when there is no signal to the i-f stage, the d-c voltage across the detector load is zero. When the sweep frequency signal from the generator is fed to the signal grid of the i-f stage, there is some definite d-c voltage across the detector load. If now the generator feeds its frequency-varying signal to the i-f stage, the d-c voltage across the detector load will vary in accordance with the response of the i-f amplifier to the various frequencies. If you connect the outer terminals of the volume control to the vertical plates of the oscilloscope and provide a horizontal sweep to the oscilloscope which is repeated at the same rate as the repetition rate of the generator (60 times a second), you will see the response curve on the screen. The complete connection of the sweep-frequency signal generator and the oscilloscope to the receiver is shown in Fig. 13-13.

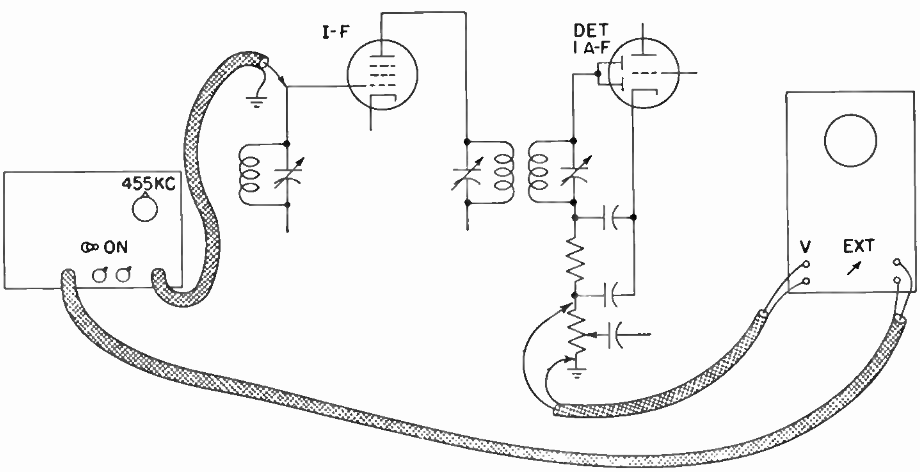


Fig. 13-13. Connection of test instruments for i-f alignment

Where a diode detector is not used, the oscilloscope is connected to the resistor that serves as the detector load.

Let us now get back to the oscilloscope. The vertical plates are receiving the varying d-c voltages developed across the detector load, which result from the frequency sweep from the signal generator which occurs in $\frac{1}{60}$

second. If a saw-tooth linear time sweep is applied to the horizontal plates of the oscilloscope, occurring in 1/60 second, you will get a waveform on the screen which represents the response curve for the i-f stage. Figure 13-14 shows this relationship.

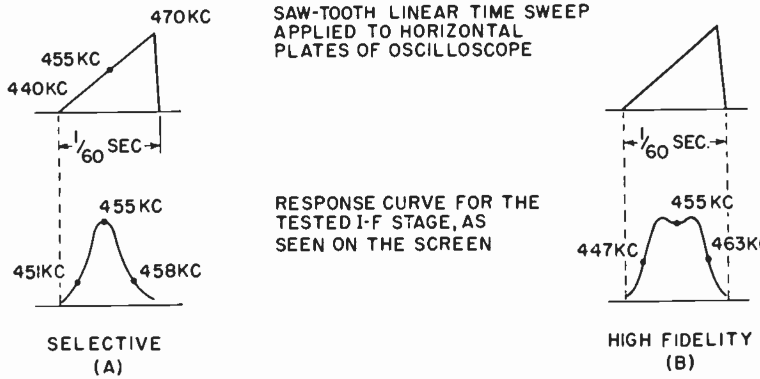


Fig. 13-14. Response curve with a saw-tooth sweep

Alignment Procedure. Let us now examine the exact procedure for aligning the i-f stages of a superheterodyne receiver. If there are several i-f stages in the receiver, begin with the one nearest the detector and work back. Begin by joining the antenna and ground terminals of the receiver with a 0.001-mfd capacitor. Connect a shorting wire between the stator and rotor plates of the oscillator section of the gang tuning condenser. You can readily locate this section by tuning to a station. The oscillator section is the one where the signal disappears or you get a new station when you touch the stator plates with your finger. Connect the output of the sweep signal generator so that its hot lead goes to the signal grid of the last i-f stage and its ground lead goes to the receiver chassis or common negative.

Now turn on your oscilloscope and adjust the controls for a sharply focused and centered spot on the screen. Set the TIMING SYNC control to its EXT position. Set the vertical AMPLIFIER control to its ON position. And finally, connect the vertical input terminal of the oscilloscope across the detector load resistor.

Turn on the signal generator, the receiver, and the oscilloscope. Now connect the hot lead of the r-f output from the sweep-frequency signal generator to the grid of the i-f tube whose stage is being aligned. The shield lead of the r-f output from the generator goes to the receiver chassis. Then connect the hot lead from the "A-F 60 CPS" jack to the ungrounded horizontal input terminal of the oscilloscope. The shield lead from this jack goes to the grounded horizontal input terminal of the oscilloscope. Set the RF control of the generator at 455 kc, and set the SWEEP control at 30 kc. Finally, set the MOD switch to its ON position. Set the RANGE switch of the oscilloscope to its "40–175" position. Then adjust the FREQUENCY and SYNC controls to obtain a stationary i-f response curve on the screen. Adjust the horizontal and vertical GAIN controls to obtain waveforms of suitable size.

Peaking, Symmetry, and Bandwidth. Now adjust the i-f trimmers in the i-f output transformer until you obtain a resonance curve on the scope screen similar to that shown in Fig. 13-11*a*. There are three factors that you must keep in mind: maximum amplitude or peak of the curve, symmetry of the curve, and proper bandwidth of the curve. Let us see how these factors are handled.

Peaking means that you adjust the trimmer condensers of the i-f transformer until the scope curve rises to its greatest height and appears to be symmetrical.

To be sure of the symmetry of the curve centering around the intermediate frequency, you use the marker controls on the sweep-frequency signal generator. Set the MARKER control at 455 kc and turn on the MARKER GAIN control. When you do this, a little hash mark will appear on the scope curve at the 455 kc position. If alignment for peak and symmetry is correct, the scope waveform will appear like that in Fig. 13-15*a*. If the hash mark is not in its correct position, readjust the trimmers until it is, even though the peak goes down.

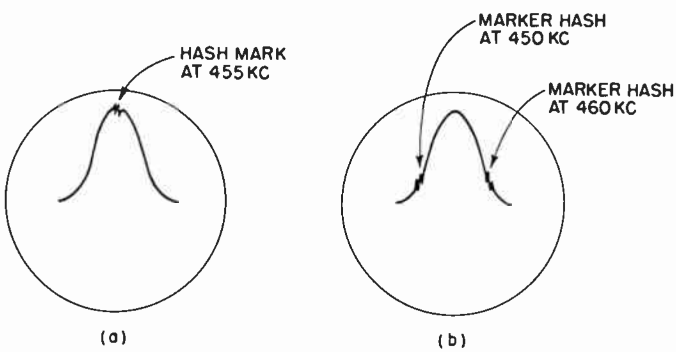


Fig. 13-15. How a marker signal aids in checking i-f alignment and i-f bandwidth

Bandwidth is checked also with the marker signal. After symmetry has been established, set the MARKER control at 450 kc and 460 kc. The hash marks should appear about half way up the slopes of the curve as in Fig. 13-15*b*.

To align the i-f input transformer, repeat the procedure. However, this time you feed the generator signal to the converter signal grid. If there are two i-f stages, be sure to feed your generator signal to the grid of the tube ahead of the transformers you are aligning.

With high-fidelity sets, you follow the same procedure but adjust for a two-peak resonance curve and for greater bandwidth.

Precautions. You must avoid an output from the sweep-frequency signal generator that is too strong, because it may overload the last i-f stage. Such an input may flatten the peaks of the i-f response curve to an excessive degree. If you obtain such a trace on the oscilloscope screen, reduce the output from the signal generator, and increase the setting of the vertical GAIN control of the oscilloscope to get the same size of response curve on the screen as before. You must also avoid too low a signal output from the generator because this condition will make circuit noises visible and result in ripples on the response curve.

If the waveform of the trace on the screen appears thickened and blurred instead of clear and sharp, it may indicate a defective r-f filter in the detector stage which permits r-f voltages to appear across the detector load resistor.

Checking AVC Circuits in a Radio. The operation of the avc circuits may also be checked with the oscilloscope. The procedure is as follows:

1. Connect the ground lead of a standard signal generator with good sine-wave output to receiver ground.
2. Connect hot lead of the generator to antenna of receiver, and turn on the receiver.
3. Tune the receiver to 1,000 kc.
4. Set the generator to give a 400-cycle modulation at 1,000 kc, and adjust for low output.
5. Connect GND terminal of vertical input of the oscilloscope to avc bus (grid return of i-f stage is easy point to locate).
6. Connect the hot terminal of vertical input to ungrounded end of volume control. Vertical input is then connected across avc load resistor.
7. Set the RANGE and FREQUENCY controls to about 400 cycles.
8. Set the SYNC control to about its halfway position.
9. Set the TIMING SYNC switch to its INT position, and turn on the oscilloscope.
10. Adjust controls to get a clear stationary image on the screen of sine waveform.

11. Increase output from the signal generator.

12. Image on the screen should continue to increase in vertical direction up to a point.

13. Increase output from the signal generator.

14. Image on the screen should not increase in size. Be sure not to turn the generator up too high.

15. Distortion of the image indicates a defect in the avc condensers.

Evaluation of the Oscilloscope as a Service Instrument. As a service instrument, the oscilloscope is an extremely useful instrument. Its high-impedance input enables you to connect the instrument into any circuit of the receiver without loading any of them. Further, it gives you a picture of what is going on in the receiver and thereby eliminates in part the necessity of interpreting what a particular reading on a meter signifies. Truly, one picture is worth a thousand words.

For the a-m receiver, however, you can service defects with other service instruments. However, in the alignment of high-fidelity receivers, the oscilloscope finds its most important use. In one other way the oscilloscope is of great value to the serviceman. The customer will enjoy seeing the results of your servicing techniques on the screen. He will understand, as from no other method of explaining, your skill in service techniques and in the use of a complex instrument. Your service charge will be accepted more readily.

14

Glossary of Receiver Complaints

Value of a Glossary of Complaints. Up to this chapter, you have been told how to tackle various receiver defects. Enough explanation of service theory has been presented to enable you to approach radio-servicing problems with intelligent understanding. That approach is probably the best one, because it will enable you to think through the usual as well as the unusual type of defects. As a result, you will find yourself reasoning at every step of your procedure, directing every one of your checks and tests and properly interpreting the indications on your test instruments.

The glossary presented in this chapter is a summary of all the understandings you got from preceding chapters. It does not tell you how to use your service instruments. But it does point up the way in which various conditions may produce receiver defects. As such, the glossary is valuable in that it directs you in the checks and tests to be made. Wherever possible, the defects which occur most frequently will be listed at the head of a table of possible causes for each defective condition. The glossary will be especially valuable after you have localized a defective stage.

There are many ways in which a service glossary may be presented. Troubles may be presented by their manifestations in various stages or sections of the receiver. Or, the troubles may be presented in a classified system according to the manner in which they manifest themselves in the total output of the receiver. Another way is to present troubles as they might result from improper operation of component parts. In this chapter we shall try to present various systems of classification.

How Components Become Defective. The broadest approach to a glossary for a servicing book is a description of how the various components of a receiver may become defective. Such a glossary will give you a lead after you have localized a defective stage. Use it only in that manner.

Tubes. Tubes become defective in various ways. Elements within the tube may open from their connections. As a result the tube would become inoperative. A similar effect would result when some of the tube elements short to each other within the tube. Sometimes the tube ages and the electronic emission from the cathode or filament decreases to a level much below normal. The resulting effect would be weak tube output, as well as a distorting effect with respect to the signal. At other times, leakage may develop between the cathode and the heater of a tube. As you already learned, this condition may result in hum from the receiver. Again, loose elements within the tube may vibrate mechanically and set up a microphonic howl. Tubes may also be the cause of noise. Poor internal connections or momentary contacting of elements or gas within a high-vacuum tube would cause such a condition. In the case of an oscillator tube, circuit conditions could result in critical oscillation, where the tube would fail to oscillate at the low-frequency end of the broadcast band.

Tuning Condensers. Many defects may result from defects in tuning condensers. Conductive dust between the rotor and stator plates could produce noise or even produce a dead receiver. Bent plates would cause contact between stator and rotor plates at certain points and produce a dead receiver at certain points of the tuning range. A similar effect would be caused by a loosened nut holding the rotor or stator plates in proper parallel alignment. Sometimes, the rubber supports for a tuning gang harden. As a result the gang may vibrate and produce microphonic howls. Another possible source of trouble is the wiper contacts to the rotor plates. Corrosion at those points or dirt between the contacts could produce weak output, noise, or oscillation squeal.

Paper, Mica, and Ceramic Condensers. These condensers are known as *solid dielectric condensers.* The effect that would result when they became defective depends on the function that they serve within the receiver and should be analyzed from that point of view. Sometimes, the leads of these condensers separate from the foil plates. The condenser is then said to be open and acts as though it were not present at all. At other times, a short develops between the condenser plates. The condenser then fails to act as a condenser and serves merely as a conductor, passing direct and alternating currents through it. Or the condenser may become leaky, serving both as an ineffective condenser and as a fairly high-resistance conductor.

Electrolytic Condensers. Electrolytic condensers are used in the power supply and as the cathode bypass condenser for the output tube of the receiver. They are polarized condensers and must always be connected with the positive terminal to the positive side of a line. They are always used in circuits passing alternating currents with d-c components.

Sometimes, as a result of too high a voltage, a short develops within an electrolytic condenser. The condenser then becomes a good conductor for both alternating and direct currents. In the power supply, this defect shorts out the B supply with possible damage to the rectifier tube and the power transformer, if present. As the cathode bypass condenser, it would short out the cathode bias resistor and result in receiver distortion.

A somewhat similar effect would occur when electrolytic condensers become excessively leaky, although not quite a short. Of course, a normal leakage current of about 0.3 milliampere per mfd of capacitance in electrolytic condensers is not to be considered as a sign of a defect.

At other times, electrolytic condensers may dry up. When this occurs, they overheat and lose capacitance, thereby failing in their normal functions. As filter condensers in the power supply, such condensers result in hum, distortion, and lowered B voltage. As the cathode bypass condenser, they produce low gain as well as poor low-frequency response. Very rarely will electrolytic condensers open and act as though they are not present.

Trimmer Condensers. Trimmer condensers are usually semivariable condensers used with resonant circuits. One may be found in the wave trap if the latter is present. Trimmer condensers may be found with the input tuning circuits to the r-f stage and the mixer portion of the converter tube. These condensers are found on two sections of the tuning gang assembly. Trimmer condensers are also found in the tuning circuit of the oscillator portion of the converter. And finally, trimmer condensers may be found in the input and output i-f transformers.

Trimmer condensers are fairly rugged and rarely develop defects. Sometimes dirt gets in between the two plates and causes noise. More often, however, the setting of these condensers vary for one reason or another. The resulting condition is a misalignment of the tuned circuits of which they are a part. As we saw previously, misalignment may make the receiver insensitive and weak, may cause poor selectivity, may cause distortion or oscillation whistle, and may throw off the tuning-dial calibration of the receiver.

Volume and Tone Controls. Volume and tone controls are continuously variable resistors whose resistive element is usually of the carbon-composition type. Because the contacts in these controls are of the sliding type, various defects occur. Sometimes the resistor strips become worn and cracked. The variation in control resistance is no longer smooth and even. Noise or intermittent operation may result. At other times, dirt accumulates between the sliding arm and its contact ring, producing poor contact and noise. And sometimes the volume control may open because of a break in the resistor element or no contact between the sliding arm and its contact ring. The resulting effect would depend on the circuit in which the control is a component. Similar defects may occur to such controls utilizing a wire-wound resistor.

Carbon Resistors. These are the color-coded fixed resistors that are extensively used in all receivers. They do not develop defects too frequently. Sometimes they crack and create an open circuit where a resistive path normally should have been. The effect produced in the receiver depends on the function served by the resistor. At other times, as a result of overheating, the carbon particles in the resistor fuse together, and the over-all resistance of the resistor decreases. As a result, the resistor passes more current than it was designed to do. The condition of overheating could result from various conditions, like placement near a hot component, or use of a resistor whose wattage rating is too low, or passage of too much current because of the breakdown of some associated component.

Wire-wound Variable Resistors. These resistors are usually used as voltage dividers and have either fixed or adjustable taps. They usually pass large currents and develop considerable heat. Sometimes adjacent turns make electrical contact and short out part of the resistor. The resistance goes down, the amount of current passed increases as does the amount of heat produced. The life of the component is shortened. At other times, an open develops in the wire resistor, and a portion becomes nonfunctional. If arcing occurs across a gap in the wire or between adjacent turns, noise results. And finally, poor contacts may develop between the tap and the resistance wire. As a result, that contact overheats and may open the contact completely.

Coils: Air-core and Iron-core. Coils of wire are used throughout the receiver. They may be air-core coils like r-f coils, antenna coils, oscillator coils, and i-f coils. Or they may be iron-core coils like power transformers, filter chokes, speaker fields, a-f transformers, and output transformers.

Many of the defects that such coils develop are common to both types. Shorts may develop between the turns of wire in the coil, thereby reducing both the resistance and inductance of the coils. If arcing occurs between turns, noise results. This condition may be particularly bad in iron-core coils where shorts may develop between adjacent layers of wire.

Another fairly common defect is corrosion of the contact between the coil wire and its lugs, giving a poor noisy contact or a completely open condition. Corrosion may also create a partial or complete open anywhere along the wire coil. This condition is more common in the air-core coils with their thin wire. With air-core transformers, the primary winding is more likely to develop corrosion difficulties.

Iron-core coils develop other difficulties. Sometimes the wires short to the iron core, which is usually connected to chassis. Shorting out of high B voltages may result. And finally, the laminated iron-core plates may become loose and set up a mechanical hum in the receiver as a result of an induced vibration.

Loudspeakers. Loudspeakers may develop many defects. As with iron-core coils, the speaker field may open, short to its iron core, or develop shorts between turns and layers. The resulting effect would be determined by how the field is used in the receiver circuit. The voice coil may open and produce a dead receiver. If the cemented turns of the voice coil break apart, they produce buzzes and distortion from the receiver.

Distortion may result from a defective voice coil in other ways. A bent voice coil form, a loose spider, an off-center pole piece, or dirt between the voice-coil form and the center pole piece would produce rubbing and distortion or noise. Also, a torn paper cone or a warped paper cone or a cone loose from its basket support would produce receiver distortion or noise. Loose loudspeaker bolts could produce annoying rattles.

Switches. Sometimes switches produce receiver defects. Dirt collects on the contacts, or the contacts corrode. Improper connection is made and noise results. In extreme cases, the contacts open and the switch becomes completely inoperative.

Tube Sockets. Tube sockets may become a source of trouble. Spring clips in the sockets grip and make good contact with the tube pins. Sometimes, after numerous removals and replacements of tubes, the clips make poor contact or even no contact with the tube pins. Noise or an inoperative tube would be the result. Furthermore, the tube pins are close together in the socket. Collection of dirt at the socket or charring of the socket material could produce a high-resistance conductive path between tube pins where no connection is desired. All types of receiver defects could be caused by this defective condition.

Line Cord and Plug. Defects produced by the line cord and plug are often considered to lie outside the receiver, but their effect is readily heard in the receiver. A plug, loosely set in the power outlet, would produce considerable disturbing noise. A similar defect would occur if a fuse were loosely set in its screw receptacle or if the line cord were poorly connected to the screw contacts of the plug. If the line cord contained a line-cord resistor, a break often could occur in the resistance wire. As a result, the tube heaters would not light. Sometimes a customer cuts this type of line cord and resistor and burns out a tube when he plugs into the power socket, because not enough line voltage is dropped over the shortened resistance wire.

Antenna. The antenna may be a source of defects, especially when an outdoor antenna is used. A poor connection between the flat-top and lead-in wire, or between the leadin and window strip, or between window strip and receiver, or between receiver and ground would produce noise. A grounding flat-top or lead-in wire would also produce noise. A definite break would produce an inoperative receiver. Defective lightning arresters could produce similar effects. A loose swinging flat-top could produce fading.

Connections. Most connections within the receiver are soldered connections. They may corrode in time and make poor connections or even result in open connections. Sometimes sparking occurs at the joint with resulting noise. Another aspect of connections are those made by shields. They may make poor mechanical contacts with the receiver chassis with resulting noise or other defects.

Cabinets. Cabinets are often responsible for noise. Loose or broken parts or loose dial windows might vibrate and produce annoying buzzes and rattles. The remedy, of course, is to damp these mechanical vibrations by tightening down on the loose part.

Tuning Dials. In the case of indirectly driven tuning dials, several defective conditions might result. The driving cord might slip on its pulley and prevent you from tuning easily to a particular station. Sometimes the driving cord breaks, and you then are unable to tune the receiver at all.

Vibrators. In vibrator power supplies used in auto radios the vibrator may be a source of trouble. Pitting of the contact points may give extremely irregular operation or prevent any vibrator action. The usual remedy is vibrator replacement.

Batteries. In battery receivers or three-way portable receivers, the batteries are a frequent source of trouble. Energy drain from the batteries is

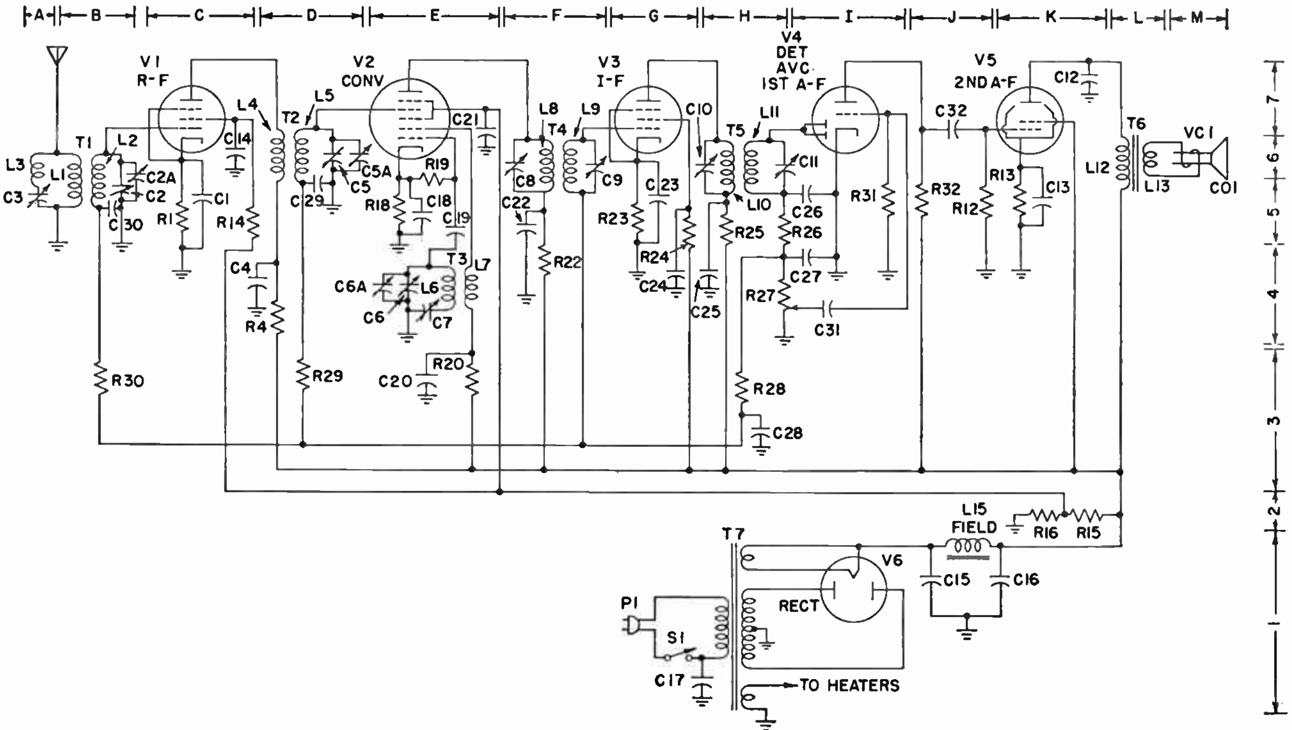


Fig. 14-1. Schematic diagram of a typical a-c receiver used for analysis

rapid, and their voltage soon drops below the required level. Weak output and distortion frequently follow as a consequence. Another defective condition is corrosion of the battery terminals producing high-resistance contacts. Or corrosion across the battery plug may short the battery.

Receiver-circuit Analysis. Another system for organizing a glossary is that of analyzing a typical receiver—stage by stage, circuit by circuit—to determine how component failures could produce defective receiver operation. The hope in such a glossary is that such a systematic analysis could furnish clues for other receivers with similar circuits.

Figure 14-1 is the schematic diagram of a typical a-c receiver. It will serve as the basic receiver for analysis. For speedy and effective location of parts to which you may have to refer, markers are indicated at the top and right side, as on a road map. For example, volume control *R-27* would be located by using the markers 4*H*. Move down column *H* and left of section 4. Where the two sections intersect, you will find the component mentioned. The most frequent defects will now be tabulated.

Tabulation of Defects and Effects. The component defects for each section of the typical a-c receiver of Fig. 14-1 are tabulated in Tables 1 through 8. These cannot, of course, include conditions like bad connections, poor sockets, and similar conditions. However, you must not overlook their existence in practical servicing.

Table 1. Power-supply Defects

Component	*Location*	*Defective Condition*	*Accompanying Effects*
P-1	1G	1. Open line cord or plug. 2. Poor seating of plug in socket.	1. Tubes do not light. 2. Noise or intermittent operation.
S-1	1G	1. Open switch. 2. Poor switch contact.	1. Tubes do not light. 2. Noise or intermittent operation.
T-7	1*H*	1. Open transformer primary. 2. Shorted h-v secondary.	1. Tubes do not light. 2. Overheated transformer; weak output.
C-17	1*H*	1. Open condenser.	1. Modulation hum; noise.
V-6	1*I*	1. Low emission. 2. Gassy.	1. Weak output. 2. Glows with purple light. Dead receiver or hum.
C-15	1*J*	1. Dried out; low capacitance. 2. Open. 3. Shorted.	1. Weak output plus hum. 2. Weak output plus hum. 3. No B voltage; plates of rectifier red hot.

Table 1. Power-supply Defects (*Continued*)

Component	Location	Defective Condition	Accompanying Effects
L-15	1J	1. Open. 2. Short to speaker pot. 3. Open, but arcing. 4. Shorted turns.	1. Receiver dead. No B voltage. 2. Receiver dead. No B voltage. Damage to power supply. 3. Noise and weak reception. 4. Hum.
C-16	1K	1. Dried out; low capacitance. 2. Open. 3. Shorted.	1. Hum. 2. Hum, squeal, or motorboating. 3. No B voltage; receiver dead. Overheated rectifier.
R-15	2K	1. Open. 2. Decrease in resistance.	1. No screen voltage. Receiver dead. 2. Screen voltage rises. Possible oscillation or fading.
R-16	2K	1. Open. 2. Decrease in resistance.	1. No voltage divider action. Screen voltage high. 2. Low screen voltages. Possible oscillation and distortion.
C-15/C-16	1J/1K	1. Leakage between condensers in a block.	1. Hum.

Table 2. Loudspeaker Defects

Component	Location	Defective Condition	Accompanying Effects
L-15	1J	1. Open. 2. Short to speaker pot. 3. Open, but arcing.	1. Receiver dead. No B voltage. 2. Receiver dead. No. B voltage. Damage to power supply. 3. Noise and weak receiver.
VC-1	6M	1. Open. 2. Rubbing voice coil caused by: a. Warped coil form. b. Loose spider. c. Grit around V-C form. d. Off-center pot. 3. Loosened voice coil wires.	1. Receiver dead. 2. Rattle, weak receiver, distortion. 3. Buzzes, distortion.
Paper cone	6M	1. Torn. 2. Loose from basket. 3. Warped.	1. Rattles. 2. Rattles. 3. Distortion.
Mounting screws	6M	1. Loose.	1. Rattles.

Table 3. Output-stage Defects

Component	Location	Defective Condition	Accompanying Effects
R-12	5*J*	1. Open.	1. Distortion. Low plate voltage. Motorboating.
C-13	5*K*	1. Dries out, loses capacitance. 2. Short or high leakage. 3. Open.	1. Weak reception. Poor low-frequency response. 2. Distortion. Low plate voltage. 3. Distortion. Weak output.
R-13	5*K*	1. Open. 2. Lowered resistance.	1. Dead receiver. High plate voltage. C-13 may short. 2. Distortion.
C-12	7*K*	1. Short. 2. Open.	1. Dead receiver. No plate voltage. Overheated rectifier. 2. Weak output. Distortion. Oscillation.
T-6	6*L*	1. Open primary. 2. Shorted turns in primary.	1. Dead receiver. No plate voltage. Red-hot screen. 2. Weak output.
V-5	7*K*	1. Low emission. 2. Loose elements. 3. Cathode-heater leakage. 4. Grid emission. 5. Open heater.	1. Weak reception. Distortion. High plate voltage. 2. Microphonics or noise. 3. Hum. 4. Distortion after a few minutes. Positive grid. 5. Dead receiver. Tube doesn't light.

Table 4. First A-F Stage Defects

Component	Location	Defective Condition	Accompanying Effects
R-27	4*H*	1. Open. 2. Internal dirt. 3. Cracked resistive element.	1. Dead receiver. 2. Noise, intermittent operation, fading. 3. Noise, intermittent operation, fading.
C-31	4*I*	1. Open. 2. Leakage.	1. Dead receiver. 2. Distortion.
R-31	5*I*	1. Open.	1. Distortion. Low plate voltage. Motorboating.
V-4	7*I*	1. Cathode-heater leakage. 2. Low emission. 3. Open heater. 4. Loose elements. 5. Grid emission.	1. Hum. 2. Weak output. Distortion. 3. Dead receiver. Tube doesn't light. 4. Microphonics or noise. 5. Distortion after a few minutes. Positive grid.

Table 4. First A-F Stage Defects (Continued)

Component	Location	Defective Condition	Accompanying Effects
R-32	5J	1. Open.	1. Dead receiver. No plate voltage.
C-32	7J	1. Open. 2. Short or leaky. 3. Intermittent open.	1. Dead receiver. Voltages normal. 2. Distortion. Positive V-5 grid. 3. Intermittent reception, fading.

Table 5. Detector-AVC Stage Defects

Component	Location	Defective Condition	Accompanying Effects
C-11 or C-10	6H	1. Improper setting. 2. Dirt inside. 3. Short.	1. Misalignment. 2. Noise. Misalignment. 3. Dead receiver.
L-11	6H	1. Open. 2. Corroded coil.	1. Dead receiver. 2. Noise. Coil resistance high.
L-10	6H	1. Open. 2. Corroded coil.	1. Dead receiver. No plate voltage for V-3. 2. Noise. Coil resistance high.
V-4	7I	1. Defective.	1. Hum, weak output, distortion, or dead receiver.
R-28	3H	1. Open.	1. Dead receiver. Possible hum.
C-28	3H	1. Open. 2. Leaky.	1. Weak output. Oscillation. Motor-boating. 2. Distortion on strong signals. Low avc voltage.

Table 6. I-F Amplifier Stage Defects

Component	Location	Defective Condition	Accompanying Effects
C-9 or C-8	6F	1. Improper setting. 2. Dirt inside.	1. Misalignment. 2. Noise. Misalignment.
L-9	6F	1. Open. 2. Corroded coil.	1. Dead receiver. 2. Noise. Coil resistance high.
L-8	6F	1. Open. 2. Corroded coil.	1. Dead receiver. No plate voltage for V-2. 2. Noise. Coil resistance high.
R-23	5G	1. Open.	1. Dead receiver. High cathode-to-ground voltage.
C-23	5G	1. Open. 2. Intermittent open.	1. Weak reception. 2. Intermittent fading.

Table 6. I-F Amplifier Stage Defects (Continued)

Component	*Location*	*Defective Condition*	*Accompanying Effects*
C-24	4G	1. Open. 2. Short.	1. Oscillation. 2. Dead receiver. No screen voltage. Damage to *R*-24.
R-24	5G	1. Open.	1. Dead receiver. No screen voltage.
C-25	4*H*	1. Short. 2. Open.	1. Dead receiver. No plate voltage. Damage to *R*-25. 2. Oscillation. Voltages normal.
R-25	5*H*	1. Open.	1. Dead receiver. No plate voltage.
V-3	7G	1. Open heater. 2. Low emission. 3. Loose elements.	1. Dead receiver. Tube does not light. 2. Weak reception. Distortion. 3. Noise. Microphonics.

Table 7. Converter Defects

Component	*Location*	*Defective Condition*	*Accompanying Effects*
L-5	6*D*	1. Open. 2. Corrosion.	1. Dead receiver or weak reception plus hum and distortion. 2. Noise. Weak reception. Broad tuning.
L-4	6*D*	1. Open. 2. Corrosion.	1. Dead receiver. No plate voltage for V-1. 2. Noise. Weak reception.
C-5 or C-6	6*D* 4*E*	1. Drive cord slips. 2. Drive cord broken. 3. Poor wiper contact. 4. Dirt between plates. 5. Short between plates. 6. Hardened rubber supports.	1. Difficult tuning. 2. Cannot tune. 3. Noise. Intermittent operation. 4 Noise. 5. Noise. Dead spots on tuning dial. 6. Microphonics.
C-5A	6*D*	1. Short.	1. Receiver dead.
C-29	5*D*	1. Open. 2. Leaky. 3. Short.	1. Weak reception. Oscillation. High noise level. 2. Distortion on strong signals. 3. Distortion. No avc voltage.
R-29	3*D*	1. Open.	1. Distortion. Weak reception. Possibly dead receiver.
L-7	4*E*	1. Open. 2. Corrosion.	1. Dead receiver. No voltage on oscillator anode. 2. Noise.
L-6	4*E*	1. Open. 2. Corrosion.	1. Dead receiver. 2. Noise. Oscillator instability.

Table 7. Converter Defects (*Continued*)

Component	Location	Defective Condition	Accompanying Effects
R-20	3*E*	1. Open.	1. Dead receiver. No voltage on oscillator anode.
C-20	3*E*	1. Short. 2. Open.	1. Dead receiver. No oscillator anode voltage. Damage to *R*-20. 2. Dead receiver. Inoperative oscillator. Low oscillator anode voltage.
C-6A	3*E*	1. Misaligned. 2. Dirty.	1. Tuning dial does not track. Possible dead receiver. 2. Noise. Possible dead receiver.
C-7	3*E*	1. Misaligned. 2. Dirty.	1. Tuning dial does not track. Possible dead receiver. 2. Noise.
V-2	7*E*	1. Cathode-heater leakage. 2. Open heater. 3. Critical oscillation. 4. Loose elements.	1. Modulation hum. 2. Receiver dead. Tube does not light. 3. Receiver dead at low-frequency end of band. 4. Noise. Intermittent operation.
R-18	5*E*	1. Open.	1. Receiver dead. High cathode-to-ground voltage.
C-19	5*E*	1. Open. 2. Changed resistance.	1. Dead receiver. 2. Dead receiver.
C-18	5*E*	1. Open.	1. Weak reception.
C-22	4*F*	1. Open.	1. Weak reception. Squeals.
C-21	6*E*	1. Open.	1. Oscillation squeal.

Table 8. R-F Amplifier Stage Defects

Component	Location	Defective Condition	Accompanying Effects
L-1	5B	1. Open. 2. Corrosion.	1. Dead receiver or noisy and weak. 2. Noise.
L-2	5B	1. Open. 2. Corrosion.	1. Weak, noisy reception. Possible hum. 2. Noise.
C-2	5B	1. Drive cord slips. 2. Drive cord broken. 3. Poor wiper contact. 4. Dirt between plates. 5. Short between plates. 6. Hardened rubber supports.	1. Difficult tuning. 2. Cannot tune. 3. Noise. Intermittent operation. 4. Noise. 5. Noise. Dead spots on tuning dial. Voltage normal. 6. Microphonics.

Table 8. R-F Amplifier Stage Defects (Continued)

Component	Location	Defective Condition	Accompanying Effects
C-2A	6B	1. Short. 2. Dirty.	1. Receiver dead. 2. Noise.
C-14	6C	1. Short. 2. Open.	1. Dead receiver. No screen voltage. Damage to R-14. 2. Tunable oscillation squeal.
C-4	4D	1. Short. 2. Open.	1. Dead receiver. No plate voltage. Damage to R-4. 2. Weak reception. Possible oscillation.
C-30	5B	1. Short. 2. Open.	1. Distortion. No avc voltage. 2. Only strong stations come in. High noise level.
R-4	4D	1. Open.	1. Receiver dead. No plate voltage.
R-1	5C	1. Open.	1. Dead receiver. High cathode-to-ground voltage.
R-14	5C	1. Open.	1. Dead receiver. No screen voltage.
C-1	5C	1. Open.	1. Weak reception.
L-3	6A	1. Open.	1. Station interference.
C-3	5A	1. Wrong setting.	1. Misalignment. Station interference.
V-1	7C	1. Low emission. 2. Loose elements. 3. Open heater. 4. Cathode-heater leakage.	1. Weak reception. Distortion. 2. Noise. Microphonics. 3. Dead receiver. Tube does not light. 4. Hum.

Of course, a glossary of component defects based on a typical circuit cannot be equally useful for all receivers. It cannot possibly cover all the variations of receiver circuits and types. But it can develop a skill in circuit analysis which may be extremely useful for any receiver. The least usefulness of the glossary just presented is found in the a-c/d-c power supply, the auto-radio power supply, and the three-way portable receiver. A brief glossary will now be presented covering those variations.

A-C/D-C Power Supply. Figure 14-2 shows the schematic diagram of a typical a-c/d-c power supply. Common component defects for this are listed in Table 9. For the balance of the receiver, component defects are very similar to those presented for the a-c receiver above.

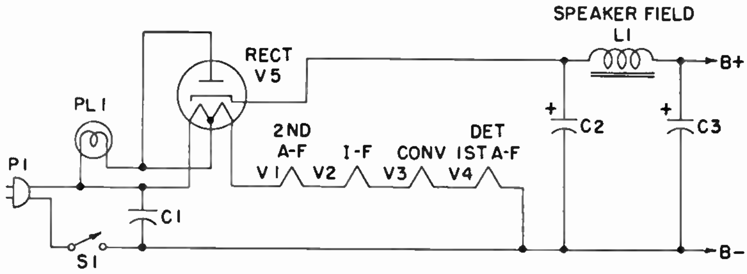


Fig. 14-2. Schematic diagram of a typical a-c/d-c receiver power supply

Auto-radio Power Supply. Figure 14-3 shows a typical auto-radio power supply, and Table 10 gives the component defects. For the rest of the receiver, defects are similar to other receivers, except for the possibility of a grounded antenna or improper shielding.

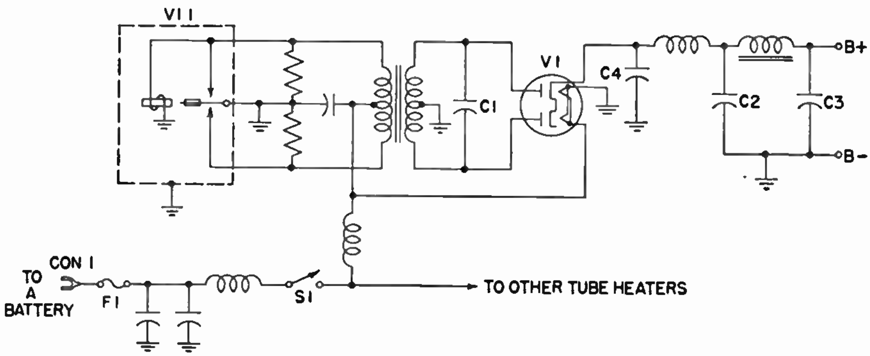


Fig. 14-3. A typical auto-radio power supply

Table 9. A-C/D-C Power-supply Defects

Component	*Defective Condition*	*Accompanying Effects*
P-1	1. Plug poorly seated in outlet. 2. Plug wires poorly connected to screws. 3. Plug incorrectly polarized in d-c outlet.	1. Noise. Intermittent operation. 2. Noise. Intermittent operation. 3. Dead receiver. Tubes light.
PL-1	1. Pilot lamp loose in base. 2. Pilot lamp keeps burning out.	1. Noise. 2. Open half of V-5 heater. Shorted receiver B supply.
S-1	1. Open switch. 2. Poor switch contact.	1. Receiver dead. Tubes do not light. 2. Noise or intermittent operation.

Table 9. A-C/D-C Power-supply Defects (*Continued*)

Component	Defective Condition	*Accompanying Effects*
C-1	1. Open. 2. Short.	1. Modulation hum. 2. Blows house fuse.
V-5	1. Weak emission. 2. Open cathode lead. 3. Open heater.	1. Weak reception. Distortion. 2. Dead receiver. Tubes light. No B voltage. 3. Dead receiver. No tubes light.
C-2	1. Open. 2. Short. 3. Leaky. 4. Dried out, lowered capacity.	1. Hum. Low B voltage. Distortion and weak reception. 2. Dead receiver. Ruined V-5. No B voltage. 3. Hum. Distortion. Overheated V-5. 4. Hum. Distortion.
C-3	1. Open. 2. Short.	1. Hum, motorboats, or squeals. 2. No B voltage. Overheated V-5. Hum.
L-1	1. Open. 2. Shorted turns. 3. Corroded turns. 4. Short to speaker pot.	1. Dead receiver. No B voltage. 2. Hum. Noise. 3. Noise. 4. Dead receiver. Ruined V-5.
V-1, V-2, V-3, V-4, V-5	1. Cathode-heater leakage. 2. Intermittent heater open. 3. Open heater. 4. Internal short. 5. Loose elements.	1. Hum. 2. Receiver goes on and off intermittently. 3. Dead receiver. All tubes out. 4. Some tubes do not light, others overheat. 5. Microphonics. Noise.

Table 10. Auto-radio Power-supply Defects

Component	Defective Condition	*Accompanying Effects*
CON-1	1. Disconnected battery lead.	1. Dead receiver. Vibrator not buzzing. No B voltage.
⏚	1. Poor ground connections.	1. Excess hash.
VI-1	1. Defective vibrator. 2. Worn vibrator.	1. Dead receiver. Vibrator not buzzing. No B voltage. 2. Intermittent operation. Fuse F-1 may blow out. Hash.
F-1	1. Blown out fuse. 2. Poor fuse contact.	1. Dead receiver. Vibrator not buzzing. No B voltage. 2. Noise. Weak reception. Intermittent operation.
S-1	1. Open switch. 2. Poor contact.	1. Dead receiver. Vibrator not buzzing. No B voltage. 2. Noise. Overheated switch. Weak reception.

Table 10. Auto-radio Power-supply Defects (Continued)

Component	Defective Condition	Accompanying Effects
C-1	1. Shorted buffer condenser.	1. Dead receiver. No or low B voltage. Heavy battery drain.
V-1	1. Internal short or open heater. 2. Low emission.	1. Dead receiver. Heavy battery drain. 2. Weak reception.
C-2	1. Open. 2. Short. 3. Leaky.	1. Hum. 2. Dead receiver. Heavy battery drain. 3. Weak reception. Hum. Low B voltage.
C-3	1. Open. 2. Short. 3. Leaky.	1. Hum. Oscillation. 2. Dead receiver. 3. Hum. Low B voltage.
C-6	1. Open. 2. Short.	1. High hash level. 2. Dead receiver.

Three-way Portable Radio Power Supply. Figure 14-4 shows a typical power supply for a three-way portable receiver, and Table 11 gives its component defects.

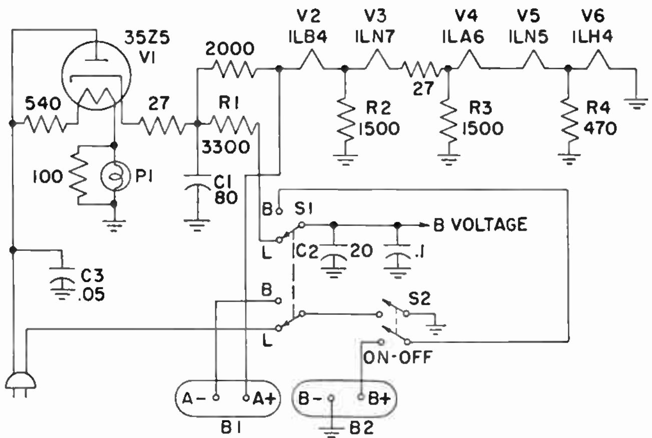


Fig. 14-4. A typical power supply for a three-way portable

Table 11. Three-way Portable Power-supply Defects

Component	Defective Condition	Accompanying Effects
R-2, R-3, R-4	1. Open.	1. Tube heaters burn out. Dead receiver.
V-2, V-3, V-4, V-5, V-6	1. Open heater.	1. Receiver dead.

Table 11. Three-way Portable Power-supply Defects (Continued)

Component	Defective Condition	Accompanying Effects
B-1, B-2	1. Batteries weak. 2. Dead batteries. 3. Poor battery plugs.	1. Weak reception. Distortion. Oscillation. 2. Dead receiver on battery operation. 3. Noise. Intermittent operation.
S-2	1. Open switch. 2. Dirty corroded contact.	1. Dead receiver. 2. Noise. Intermittent operation.
S-1	1. Poor contacts.	1. Intermittent operation. Failure to switch from battery to line operation.
C-3	1. Open. 2. Short.	1. Modulation hum on line operation. 2. Dead receiver.
V-1	1. Open heater. 2. Low emission.	1. Dead receiver on line operation. Tubes do not light. 2. Weak reception on line operation. Distortion.
C-1	1. Open. 2. Dried out, low capacitance. 3. Short.	1. Audio howl. 2. Audio howl. Weak reception. Distortion. 3. Dead receiver. Ruined V-1.
R-1	1. Open.	1. Dead receiver on line operation; no B voltage.
C-2	1. Open or lowered capacitance. 2. Short. 3. Leaky.	1. Hum, oscillation, or motorboating. 2. Dead receiver. 3. Hum on line operation.
P-1	1. Pilot lamp poorly seated.	1. Noise.

Defective-receiver-operation Analysis. Still another system for arranging a servicing glossary is that of listing the main reasons for defective receiver operation. These will now be listed below.

Dead A-C Receiver. For an a-c receiver, no program is heard. The tubes may or may not light, and hum may or may not be present. Causes are as follows:

1. Defective rectifier tube.
2. Shorted filter condensers.
3. Open heater in any tube.
4. Shorted B supply in the receiver.
5. Open power-transformer primary or secondary.
6. Defective wall outlet.
7. Open filter choke (speaker field).
8. Filter choke shorted to chassis.

9. Open connections in the receiver.
10. Open coupling condensers.
11. Open voltage divider resistors.
12. Open voice coil.
13. Open winding in the output transformer.
14. Break in the receiver line cord.
15. Internal short in tubes.
16. Open line fuse.
17. Open self-bias resistors.
18. Defective receiver line switch.
19. Open audio transformers.
20. Open plate loads (resistors or transformers).
21. Shorted line filter condenser.
22. Open volume control.
23. Shorted signal paths.
24. Open air-core coils.
25. Shorted trimmer condensers.
26. Shorted tuning condensers.
27. Great misalignment of i-f transformers.
28. Critical oscillator stage.
29. Grounded antenna.
30. Break in antenna, leadin, or window strip.
31. Short in lightning arrester.
32. Defective band switch.
33. Open plate decoupling resistor.
34. Disconnected grid caps.
35. Reversed antenna and ground leads to the receiver.

Dead A-C/D-C Receiver. For an a-c/d-c receiver, the same conditions as those listed above may cause a dead receiver, with a few exceptions related to the power supply and a few additional factors. Of course, item 5 above is not applicable. Additional factors are:

1. Open line-cord resistor.
2. Defective ballast tube.
3. Open heater voltage-dropping resistor.
4. Open filter resistor in the power supply.
5. Shorted selenium rectifier in the power supply.
6. Reversed line plug in a d-c wall outlet.

Dead Portable Receiver. For the three-way portable receiver, you have the same defects as for the a-c/d-c receiver with these additional causes:

1. Dead A or B batteries.
2. Defective battery plugs.
3. Open or overheated heater equalizing resistors.
4. Open mode-of-operation switches.

Dead Auto Radio. There are many causes for a dead auto receiver. For the most part, they are the same as those for an a-c receiver, except for the power supply. These additional causes are listed below:

1. Grounded auto antenna.
2. Defective vibrator unit.
3. Open battery fuse.
4. Open line switch.
5. Shorted buffer condenser.
6. Open or shorted power transformer.
7. Wrong polarity of synchronous vibrator.

Weak Receiver. Weak response from a receiver may be caused by factors listed below:

1. Low tube emission.
2. Receiver misalignment.
3. Weak field excitation of loudspeaker.
4. Open or leaky input filter condenser (plus hum).
5. Open cathode bypass condenser in a-f section.
6. Short in filament winding of a-c receiver.
7. Open coupling condensers (for strong locals only).
8. Open grid circuit in output stage (plus hum and distortion).
9. Poorly seated tubes (plus noise).
10. Gassy tubes (plus distortion).
11. Leaky coupling condenser (plus distortion) in a-f section.
12. Jammed or rubbing voice coil of loudspeaker.
13. Open antenna-coil primary.
14. Poor tuning condenser wiper contacts.
15. Open avc bypass condenser.
16. Shorted secondary of antenna, r-f, and i-f transformers.
17. Shorted turns in output transformer.
18. Shorted turns in a power-transformer secondary winding.
19. Corrosion in tuned circuits (plus noise).

20. Damp tuned circuits.
21. Open secondary of antenna, r-f, and i-f transformers.
22. Leaky screen bypass condensers.
23. Open plate bypass condenser in output stage.
24. Dirty tuning or trimmer condensers.
25. Open plate bypass condenser in a-f section.
26. Low line voltage.
27. Break in antenna.
28. Altered resistance of cathode self-bias resistor.
29. Weak batteries (plus distortion or oscillation).
30. Worn vibrator in auto-radio power supply.
31. Open or leaky buffer condenser in auto-radio power supply.
32. Defective volume control.

Receiver Hum. Humming in a receiver may be caused by these conditions:

1. Open power-supply filter condensers.
2. Lowered capacity or leaky output filter condenser.
3. Cathode-heater leakage in tubes (usually the audio section).
4. Open grid circuit (plus distortion).
5. Poor lead dress.
6. Poor grounding of shields.
7. Defective volume control.
8. Open line filter condenser (tunable hum).
9. Leakage between condensers in a filter condenser block.
10. Shorted turns in the power-supply filter choke.
11. Gassy rectifier tube.
12. Weak tubes.
13. Open cathode bypass condenser.
14. Unbalanced tubes in a push-pull stage.
15. Open decoupling filter condenser.
16. Overbiased tube.
17. Leaky screen bypass condenser.
18. Antenna pickup from nearby power lines.
19. Mechanical vibration of transformer or choke plates.
20. Poor grounding of a receiver.
21. Reversed loudspeaker hum-bucking coil.
22. Shorted turns of a hum-bucking coil.
23. Open half of high-voltage secondary winding in a full-wave rectifier.

24. Reversed plug in outlet receptacle.
25. Corroded contacts.
26. Misalignment.
27. An oscillating stage.
28. Shorted secondary winding turns of power transformer.
29. Open filament center-tap resistor.

Receivers that Squeal and Motorboat. Common causes for squeals and motorboating in a receiver are:

1. Open or low-capacitance output filter condenser.
2. Poor shielding.
3. Open screen bypass condenser.
4. Open cathode bypass condenser.
5. Open plate decoupling condenser.
6. Open or shorted grid decoupling condenser.
7. Open screen voltage-dropping resistor.
8. Misalignment.
9. Poor lead dress.
10. Poor grounding.
11. Corroded or poor connections.
12. Open grid circuit.
13. Low tube bias.
14. Open secondary of antenna, r-f, or i-f transformer.
15. Poor grid-cap connection.
16. Improperly grounded tuning condensers.
17. Poor wiper contact in tuning condensers.
18. Gassy tubes.
19. A microphonic tube (loose internal elements).
20. Poor rubber mounts.
21. High line voltage.
22. Weak batteries.

Noisy Receiver. The defects listed below may account for a noisy receiver:

1. Pickup from power lines.
2. Pickup by the antenna and ground.
3. Poor shield grounding.
4. Poor seating of the line plug in the wall outlet.
5. Corroded soldered connections within the receiver.

6. Intermittent shorting of leads within the receiver.
7. Worn volume and tone controls.
8. Intermittent shorts within a tube.
9. Corroded windings in r-f, i-f, and a-f coils.
10. Conductive dust on tuning condensers.
11. Intermittent shorting of stators and rotors of tuning condensers.
12. Poor seating of tubes in their sockets.
13. Poor tube grid-cap connections.
14. Conductance around a tube base.
15. Dirty wiper contacts of tuning condensers.
16. Loose hardware or parts in the receiver.
17. Poor internal tube contacts.
18. Intermittently open condenser.
19. Loose fuses in the fuse box.
20. Defective switches.
21. Intermittently grounding antenna or leadin.
22. Break in antenna leadin.
23. Cracked carbon resistors.
24. Intermittently shorted turns of wire-wound resistors.
25. Rubbing loudspeaker voice coil.
26. Dirt between voice coil and center pole piece.
27. Torn loudspeaker cone.
28. Loose loudspeaker spider.
29. Loose voice-coil wires (broken cement).
30. Corroded battery connectors.
31. Weak batteries.
32. Weak gassy tubes.
33. Loose pilot light.
34. Leaky condensers.
35. Dirty lightning arrester.
36. Dirty contacts in auto vibrator.
37. Poor grounding bonds in auto receiver.
38. Missing auto static-collector springs.
39. Open hash filter in an auto radio.
40. Defective buffer condenser in an auto radio.
41. Open line filter condenser.

Receiver That Distorts. The causes for distortion in a receiver are listed below. The defect is usually found in the a-f section of the receiver.

1. Leaky coupling condensers.
2. Open output filter condenser (plus hum).
3. Weak tubes.
4. Misalignment.
5. Grid emission.
6. Cathode-heater leakage (plus hum).
7. Lowered capacitance of output filter condenser (plus hum).
8. Shorted cathode bypass condenser.
9. Cathode bias resistors whose resistance has changed.
10. Incorrect tube bias.
11. Shorted turns in the primary of the output transformer.
12. Open grid circuit (plus hum and weak output).
13. An oscillating stage.
14. Rubbing voice coil.
15. Leaky avc filter condenser.
16. Warped loudspeaker cone.
17. Unbalanced push-pull tubes.
18. Defective tone control.
19. Weak field excitation for loudspeaker.
20. Weak batteries.
21. Location too close to a powerful station.

Intermittent Receiver. Conditions within the receiver that may cause intermittent operation are listed below. Fading of station signals is included in this defect. Remember that any form of defective operation may be intermittent.

1. Intermittently open fixed condenser (rarely shorts).
2. Defective tubes:
   a. Intermittently open heater.
   b. Intermittent internal shorts.
   c. Intermittently open electrodes to their leads.
   d. Gassy tubes.
   e. Grid emission.
3. Intermittent open coils.
4. Defective volume controls.
5. Internal cracks in fixed resistors.
6. Dirty wiper contacts in tuning condensers.
7. Intermittent shorts in tuning condensers.
8. Poorly soldered joints.

9. Poor antenna-ground joints.
10. Intermittently grounding antenna and leadin.
11. Broken window strips.
12. Poor seating of tubes in their sockets.
13. Poor seating of line plug in wall outlets.
14. Loose shields.
15. Intermittent shorts within the receiver.
16. Leaky filter condensers.
17. Poor tube grid-cap connections.
18. Defective switches.
19. Iron-core coils shorting to chassis.
20. Fixed resistors that change in value.
21. Extreme line-voltage variations.
22. Leaky coupling condensers.
23. Weak batteries.
24. Worn-out vibrators in car radios.
25. Critical oscillator stage.
26. Intermittent shorts in trimmer condensers.
27. Faulty taps in wire-wound resistors.
28. Poor seating of pilot lights.
29. Poor fuse contact in car radio.
30. Swinging antenna flat-top.

Receiver Exhibiting Station Interference. Some station interference effects are inherent in a low-cost receiver. Those listed below are interference effects in receivers where service adjustment may improve the condition.

1. Wave trap out of adjustment.
2. Wrong i-f alignment.
3. Wrong antenna orientation.
4. Too long antenna.

Receiver with Broad Tuning. A receiver that exhibits broad tuning is said to have poor selectivity. The possible causes are listed below:

1. Improper r-f and i-f alignment.
2. Tubes with weak emission.
3. High resistance and corroded contacts in tuned circuits.
4. Dirty wiper contacts in tuning condensers.
5. Poor seating of tubes in sockets.

6. High-resistance contacts in grid circuits.
7. Corroded tube-grid clips.
8. Weak batteries.
9. Low line voltage.
10. Disconnected ground connection.
11. Too long an antenna.
12. Poor shielding.
13. Inexpensive receiver.
14. Too close to a strong station.

15

Getting Servicing Experience

Experience in Servicing. You have no doubt heard the old saying that there is no substitute for experience. And it is quite true! At the present moment, you probably feel that you have been fed a tremendous amount of service information that is bursting forth, ready to be tested. All that you need is experience in radio servicing in order to feel sure of your procedures. It is like the fellow who reads how to swim, but is never a swimmer until he gets into the water.

Experience is not obtained by reading, watching, or even by aimless servicing. It is the intelligent application of information to the job you wish to perform—radio servicing. Normally, this is a process which develops over the years. You do not want to enter the radio-service field 5 or 10 years from now but rather as soon as possible. Therefore, your experience getting must be carefully planned and speeded up. In this chapter, you will be given a plan for just such a result.

Do not try to get servicing experience by constructing a receiver. Your customer does not wish you to build a receiver for him. He wishes you to repair a receiver that is not functioning normally. He wants you to diagnose the defect, track down the cause, and make the necessary repairs—all in a fairly reasonable amount of time and at a reasonable cost. Your practice must therefore be in those skills, not in construction, which is an entirely different skill.

Some instructors suggest that you apprentice yourself to a neighborhood servicing shop and observe the trained technician at work. This method comes closer to what you want, but is still not the best and quickest means of building up your experience. The reasons are obvious. First, the technician is not going to have the time to explain to you all the thinking that enters into his procedures. Second, the types of defects that are brought into the shop may limit your experience to only a small number of differrent defects. What you want is as broad an experience as possible in a short period of time.

Finally, your guide may be inefficient in his methods. It is like the fellow who never became a good ice skater because he practiced doing the wrong things for years. You will never become efficient watching an inefficient technician, even if you observe his methods for years.

Well, then, what must you do to get a broad, efficient experience in a short time? The method that we suggest is the one used by the more progressive radio schools. It is based on the theory that to get experience in fixing defective sets, you must practice with receivers that have every type of defect. Of course, you cannot find receivers with every defect. Therefore, your only alternative is to secure a perfectly good set and *deliberately* introduce defects of all types, observing the resulting effects.

Experience by Servicing Receivers. This method that you follow is that of getting experience by actual receiver servicing. As you introduce various defects, you should refer back to the service theory presented in the previous chapters. In that way the information will take on more meaning. You should use your nose, eyes, and sense of touch in the search for external clues.

In addition, you should make all sorts of ohmmeter and voltmeter measurements on the receiver. It is advisable first to make measurements on the receiver while it is still normal, then repeat the measurements after you have introduced the defect. In this way, you will be able to determine what resistance and voltage changes your defect has produced.

You should also practice injecting signals into the normal receiver with a signal generator and listening for the generator note in the receiver loudspeaker. If available, you should also practice using a vacuum-tube voltmeter and cathode-ray oscilloscope on the normal receiver and then on the receiver with the defect that you have introduced.

And also, you should try making stage-gain measurements on the normal receiver. Then try misaligning the receiver, and observe the effect in the loudspeaker and in the output meter. Finally, try re-aligning the receiver to get it back into normal operation.

But we are getting a little ahead of ourselves. The manufactured experience listed above must be approached slowly and in definite order. The following description gives the precise way of approaching the problem. Remember at all times to refer back to the information in the previous chapters.

Preparatory Steps. Before manufacturing defects in order to build up your experiences, you must first lay the groundwork for proper understanding. Obtain a receiver—new or old—that you know is in good shape. Do not become overambitious at the start. A midget, broadcast-band, a-c/d-c radio is probably as good a receiver as any. Try to get one with an r-f amplifier stage, if possible.

But you are not yet ready to begin. Trace all leads, locate all components, and make a schematic diagram of the receiver; then write to the manufacturer for a copy of the receiver schematic diagram and other relevant service data. These are usually free of charge. If you cannot get the diagram, see if you can get hold of it in Riders' Manuals or Sams Photofacts. Compare your diagram with the manufacturer's. Practice this skill until you are perfect at it.

Then learn to trace through the signal circuit from the antenna through the loudspeaker, using the schematic diagram. Check the B-supply circuit from the power supply to the tube electrodes. Check the A-supply circuit from the power supply through the tube heaters. Trace the special circuits, like the avc circuit, the tuning-eye circuit, if present, and similar circuits. Be sure that what you see conforms to the knowledge you have about the various stages and circuits.

Do not proceed until what you see makes sense to you. Examine the schematic diagram for ohmic values of components, as indicated by the manufacturer in his diagram. Notice the indicated capacitance for each condenser. Determine which tuning condensers are ganged. See if there are any ganged switches. Finally, notice the test points at which the manufacturer recommends that you make voltage measurements. See if you can tell why those test points were chosen.

Another important point to remember is to look through the complete circuit on the diagram for variations from the typical circuit that you have in mind. Each manufacturer introduces variations from this typical circuit into his receiver to obtain varying results. You must understand each circuit completely in order to understand how circuits may have defects. Of course, this does not imply that you must be able to calculate all values mathematically as an engineer would do. But you should know what each part in the receiver is doing.

Going from the Diagram to the Receiver. Now, you may turn to the receiver itself. It is important for you to recognize in the receiver those stages and parts indicated in the diagram. Locate each stage indicated on the schematic diagram. See if you can identify the i-f coils. Find the r-f coils and the oscillator coil. Locate the oscillator section of the ganged tuning condensers. Look for all special switches and controls in the receiver. Locate the filter section of the power supply. Find the avc bus and trace it to the controlled stages. Look for all trimmer condensers. Locate all other parts.

After you have done this for a while, you will have the feeling that you know the receiver in relation to its schematic diagram. You will be able to move from any part in the diagram to the corresponding part in the receiver without wasting valuable time. Do not underestimate this type of experience. When you finally establish yourself in the actual business of servicing receivers, this skill will constantly be used; and too much time cannot be devoted to it at this stage of your training.

Becoming Familiar with the Normal Receiver. You are still not ready to train yourself in the diagnosis of defective receivers. Like the doctor who must first know the characteristics of a healthy person before he can diagnose a sick person, you must first be familiar with a normal receiver before you can go to work on a defective one. You must first make various tests and measurements on the receiver which you know is good.

The first series of measurements is made with your ohmmeter. Be sure that the receiver power is turned *off*. Connect the ohmmeter from all tube screens and plates to B+. Find a convenient B-plus point, so that you may keep one probe of the ohmmeter on that point for all these measurements. Connect the ohmmeter for all tubes from the signal grid to the receiver chassis or common negative. Measure across other continuous circuits. In each case, first try to estimate from the schematic diagram what the resistance value should be. Be sure to look for parallel circuits when estimating resistance values. And finally, measure the resistance of coil windings, of electrolytic condensers, and resistors. Remember to reverse the probes after measuring the resistance of electrolytic condensers; the highest reading is the true value.

Now you are ready for voltage measurements. Turn on the receiver and measure the tube electrode d-c voltages with respect to the chassis or common negative. If the service notes furnish voltage values for certain test points, be sure to verify them by actual measurement. Measure B voltage from the appropriate point in the power supply to the chassis or common negative. If your voltmeter has a sensitivity of about 20,000 ohms per volt, or if you have a vacuum-tube voltmeter, measure the avc voltage from the avc bus to chassis. In each case, be sure to use your voltmeter with due regard for polarity and proper range.

Service Procedures on a Normal Receiver. The next step is to perform several over-all service procedures on the normal receiver. Refer back to previous chapters of the book if you have forgotten any of the details. Turn on the receiver and listen for the normal hum level. Turn the volume up high and listen for the smooth, noiseless increase of volume. Manipulate any other special controls and observe the effects produced. If there is an external antenna and ground, disconnect each and observe the effect on the receiver output.

Then practice making stage-gain measurements on the normal receiver with the volume turned up full. Connect an output meter across the primary coil of the output transformer. Remember that you then feed a modulated r-f signal from a signal generator into the *input* of the r-f amplifier, the converter, and the i-f amplifier at a level to obtain standard output on your output meter (approximately 16 volts). Then feed a modulated r-f signal into the output of those stages at a level to obtain standard output once again on the output meter.

The gain of each stage is found by dividing the level of voltage of the signal generator at the output of the stage by the level of signal generator voltage at the input of any one stage. In the a-f section of the receiver, you will feed an a-f signal into the test points of the receiver and then calculate the gain of each stage in the same manner. Record the attenuator settings for your signal generator which give standard output.

The measurements just made will give you practice in the important task of injecting a signal-generator signal into the various stages of the receiver to produce a note in its loudspeaker. This skill should be thoroughly mastered by you, so that you may actually use it in practice with speed and assurance. Recall the different types of receiver defects which are found by means of the signal generator, and you will realize the importance of being adept in the use of this test instrument.

The next technique to practice on the normal receiver is the circuit-shock procedure. As you recall, you must cause a surge of current in one of the circuits in the signal chain. The result will be a click, thump, growl, hum, or squeal from the loudspeaker. Begin with the output stage and work back to the loudspeaker. The simplest circuit-shock method is that of momentarily shorting the control grid to the tube cathode. Check the audio section of the receiver by touching the movable arm (center terminal) of the volume control. You should hear the typical growl of hum when the control is at mid-position or farther on.

You have now completed the preparatory work before actually examining a defective receiver. These are the techniques that are absolutely necessary for any real service work. Only when you feel sure of the behavior of the normal receiver should you begin to concentrate on defects.

Service Analysis. You must still keep away from the actual receiver. Modern schools have found a very interesting technique to be quite effective. Place the schematic diagram before you. Imagine each condenser to be open, leaky, or shorted. Try to figure mentally what the effect would be on the receiver operation, on the various tube electrode voltages, on other receiver components. Record your answers so that you may verify them later on the receiver itself.

Similarly, mentally imagine open resistors, resistors that have changed in resistance, an open coil, a short in a coil, a defective tube, corroded connections, various speaker defects, and other abnormal conditions. In each case, again record your answer for future verification.

For example, assume that a plate load resistor opens. Ask yourself several questions. What will be the over-all effect on the receiver? How will tube electrode voltages be affected? Working back from the loudspeaker, at what point will a signal from the signal generator fail to be heard in the loudspeaker? How will resistance measurements be affected? By what procedure can you quickly localize the defect? These are typical questions.

Do not perform this exercise carelessly. It is probably the finest way to review all the information. As a further part of this mental servicing, figure out the procedure you would use for isolating the defective stage and the defective component. Visualize the test instruments that would be necessary and the method by which you would use them. You are now ready to practice with the receiver itself.

Defective Resistors. Normally, when a receiver is brought to you for servicing, a defect will be present. But in this experience-getting exercise, you will introduce the defect yourself. To profit most, observe the over-all effect on the receiver output. Check voltages in the stage where you have introduced the defect for any significant change from the voltages obtained in the normal receiver. Try to locate the defect by your section-, stage-, and component-isolation techniques. Compare actual results with those you mentally figured out previously. When you are completely sure of yourself, restore the receiver to normal, introduce a new defect into the receiver, and proceed in a similar manner. Be sure to turn off the receiver when introducing defects.

You can begin introducing defects by altering the fixed resistors. In the normal course of events in a receiver, fixed resistors open or change in resistance value. Your job then is to open and change the value of each fixed resistor by replacing with other resistors in your experimental receiver and to proceed as explained in the paragraph above. Generally, fixed resistor defects develop in circuits which carry fairly large currents, like the plate load, screen-grid load, and cathode resistor. Therefore, try playing first with those resistors. They are opened simply by unsoldering one end. When you wish to simulate a resistor that has become lower in resistance, unsolder one end and solder a resistor of lower value into its place. Usually you will have to reduce to about half the original value or at least double the resistance value before any change can be noticed.

Be sure that both resistors are rated at the same wattage. Another method of simulating the same effect is to connect in parallel a resistor of the same resistance and wattage as the one in the receiver you wish to reduce in value. This will drop the resistance value to half its normal value. See what happens to the general operation.

Before you introduce any resistor defect, look at the schematic diagram and see if the simulated defect would cause any other component to go bad. Remember that an open cathode resistor might easily cause the cathode bypass condenser to break down because of the rise of voltage across it. Be prepared to replace that condenser when restoring the receiver to its normal condition.

Defective Condensers. The next group of defects to introduce are concerned with fixed condensers. Paper condensers either short, open, or become leaky. Electrolytic condensers become defective in the same way but, in addition, may lose capacitance. You should simulate these defects with all the fixed receiver condensers. Here, especially, you must determine in advance whether the defect you introduce will destroy other associated components. If the damage is too extensive you can skip that test. For example, do not short filter condensers in the power supply, or plate and screen bypass condensers which would short the B supply.

An open condenser might be simulated by unsoldering one lead of the condenser. A shorted condenser is simulated by connecting a wire across the condenser terminals. You can simulate a leaky paper condenser by connecting a 1-watt resistor of from 50,000 to 100,000 ohms across the terminals of the condenser. Electrolytic condensers in the power supply should not be shorted, because of the extensive resulting damage. These filter condensers may be made to behave like a leaky condenser by connecting a 10-watt resistor of about 1,000 ohms across the condenser terminals. To simulate a condition of lowered capacitance in the electrolytic filter condensers, connect an electrolytic condenser of approximately similar capacitance and voltage rating in series with it, or even open one lead of the condenser.

In the case of the variable tuning condensers short the rotor and stator plates of each section. In addition, introduce some dirt and dust under the wiper contacts of each section and observe the effect. If possible, remove the rubber supports from under the ganged tuning condensers and replace with fiber washers. See if the receiver output is affected.

Defective Tubes. The next components with which you experiment are the tubes. Two common defective conditions are cathode-heater leakage and low emission. Cathode-heater leakage is simulated by connecting a resistor of about 1,000 ohms from the cathode to one of the heater terminals of the tube.

A tube may be made to behave weakly, as though its emission were low, by decreasing the heater voltage. This is accomplished by connecting a filament rheostat of about 25 ohms in series with the heater of the tube. By turning up the rheostat, you decrease the heater voltage, thereby decreasing the electron flow from the cathode.

Defective Coils. The most common defect of coils in receivers is a short or an open. You can easily simulate these conditions. To create an open, simply unsolder one terminal of the coil. To produce a short, jump a wire across the terminals of the coil.

The shorting procedure is all right for r-f and i-f transformers or any transformers carrying comparatively weak signal currents. Do not use this procedure on power transformers, since the larger currents available will burn up the transformer.

You will on occasion find an r-f or i-f coil that suffers from a lowered Q factor. You can also simulate that condition by connecting a resistor of about 10,000 ohms across the coil. Note the effect on the over-all response of the receiver.

Defective Loudspeakers. The loudspeaker may introduce defects in the receiver in many ways. Simulate each of those loudspeaker defects and listen for the receiver response. Simulate a broken spider by loosening the spider screws. Open one voice-coil connection. If a hum-bucking coil is present, try reversing its connections. If the receiver has an electrodynamic loudspeaker, open the field coil, and observe results. Then repeat with a shorting wire across the field coil. Remove the paper cone, if possible, and work the voice-coil form. Replace the cone and note the effect. Remove the cone, and break the voice-coil cement so that the turns become loose. Replace the cone and note the effect this time. Remember that, after each defect, you must restore the receiver to normal operation. Some of these experiments will permanently ruin your loudspeaker. Determine if the experience is worth the cost of a new one.

Service Defects. Up to this point, you have been checking a normal receiver and have been introducing defective components. Actually, you will be given a receiver that is defective in such a manner that it will produce an over-all effect in the output, such as hum, weak output, oscillation, or similar effects. You should therefore logically practice on a receiver that is defective in such a manner that the defects produce an over-all receiver effect, like those listed above.

The simplest procedure is to begin with the dead receiver. Review all the possible ways in which your test receiver could go dead. In each case, introduce the defect in your receiver and observe that you have no output. Then plan a method for localizing the defective section, the defective stage, and the defective component. With all the service instruments that are available to you, carry out the localizing procedure until you isolate the defective component. Restore the receiver to normal operation.

If you have available a fellow learner or someone familiar with radio receivers, have him introduce a defect without your being told what the defect is. Then use your isolating procedures to discover the defect. This last exercise actually is the type of work you will encounter in a service shop. Do not forget to time yourself in these exercises. Make every isolation procedure a race with time against your previous records. Remember that the ultimate goal is correct servicing in the shortest possible time. Do not be discouraged if you consume much time at first. In time you will proceed more rapidly. Get the right procedure first.

In a similar manner, review all the possible ways in which receiver defects produce weak output. Introduce those defects and plan your isolation procedures. Then use your available test instruments to carry out your plans. In each case restore the receiver to its normal operating condition.

Similarly, introduce hum, motorboating, oscillation squeals, noise, man-made interference, distortion, intermittents and interference. Plan your isolating procedures and carry them out. In each case, listen to the way the receiver sounds as each defect is introduced, and try to remember the sound. These external clues may often guide you in approaching the problem.

Alignment Exercises. Although you will have gone through alignment procedures in practicing with service defects, it will be worth your while to make receiver alignment a separate exercise. The need for re-alignment will often arise, especially after you replace some receiver components, and it must be done properly with speed. Review re-alignment of receivers before beginning the exercise.

Connect an output meter across the primary winding of the output transformer. Feed a modulated r-f signal from a signal generator into the receiver antenna at such a level as to produce standard output on the output meter when the receiver is tuned to the same frequency as the generator. Now vary the various receiver trimmers, and note the effect on the output meter as well as the effect on the modulation note from the loudspeaker. Restore each trimmer to its original position after throwing it off.

As a final alignment exercise, turn each alignment screw of each trimmer about two full turns in either direction. This step throws the receiver completely out of alignment. It is now probably worse than a receiver that will be when brought to you for servicing. Use your signal generator and output meter, and see how quickly you can re-align the receiver so that it operates normally once again. Get the correct procedure first. Then time yourself repeatedly for improvement in speed.

Replacement Exercise. A frequent job encountered in radio-service work is the replacement of defective parts. The replacement of tubes, fixed resistors, and condensers are relatively simple tasks. However, the replacement of other components often is complicated and time-consuming.

Practice the replacement of these parts, and try to reduce the time to a minimum. Replace the volume control. Remove a tube socket and replace it with a new one. Disconnect an r-f coil and an i-f coil and replace with new ones. If the receiver has a loop antenna, replace it with a new one and recheck the receiver alignment. Take out the loudspeaker and insert a new unit. If the receiver has a multicontact switch, disconnect it and replace with a new one. If a unit has several connections to it, be sure to mark those connections to it carefully, so that you can quickly make the proper connections to the replacement unit.

Practice with Many Service Instruments. Most of your previous exercises have been performed with a multimeter and a signal generator. However, if you have other service instruments, try to use them to carry out your isolating procedures. Review instructions for the use of the vacuum-tube voltmeter, the oscilloscope, and other instruments. See which ones do the job for you in the shortest possible time. Familiarize yourself with the use of the ones that make you most efficient.

Finally, see if you can get hold of a variety of receiver types—multiband receivers, auto receivers, battery portable receivers, three-way portable receivers, and receivers with phonograph attachments. Go through the same exercises as you did with your simple test receiver.

The Air Check. After the serviceman repairs a receiver, he usually puts it through the air check. His purpose is to be sure that the receiver is normal in all respects. You should practice making the air check yourself. After you have restored the test receiver to its original condition by removing the defect, check it for perfect operation. Tune for all major stations. See that they come in at their proper positions on the tuning dial. Operate all switches, and see that they are performing their required functions. Turn the volume control up high, and see that distortion does not set in or that it operates without noise.

Finally, prepare the receiver as though it were being returned to a customer. Blow out all dust. Remove small bits of solder that may have fallen into the chassis. Clean up the outside cabinet. This last step is important because many customers will judge your ability by the over-all external appearance of their receivers.

Where Do You Stand? If you have carried out the previous suggestions in this chapter, you should know where you stand. Normally, you will feel sure of yourself and will be raring to get started. Of course, your experience will continue to grow with your work, but you will have built up plenty of experience to succeed on the job. If you still do not feel sure of yourself, do not throw in the sponge. Repeat the recommended procedures in this chapter several times, and you cannot miss. Just remember that each of us has his own rate of learning, and the fact that you took longer to catch on does not signify that you will be inefficient in a shop.

16

Case Histories

Value of Case Histories. An essential part of any training course in radio servicing must take into consideration the fact that skill increases as you build up actual experience on the job. But real experience is something that will consume long periods of your time. A proper approach to the problem is the case-study approach. Here, you do two things: First, you make a record of all your service jobs—listing the brand and model of the receiver, the service complaint, your external observation, your controlled tests and checks, the defective components, and the result of your servicing.

Let us look at a specific case as recorded by an experienced serviceman:

1. Hudson Model 1088 a-c receiver.
2. Set goes dead about once a month. Customer states that each time he must replace the type 5Y3G rectifier tube.
3. Customer reported that set began to misbehave after a burned-out power transformer had been replaced by another serviceman.
4. Checked filter condensers of power supply with ohmmeter. They were good.
5. Checked for short in B supply from tube electrodes to chassis with ohmmeter. No shorts.
6. Put in a new 5Y3G tube and turned on the receiver. The set played.
7. Made a routine voltage check. Found the hot A line measured 5 volts. Checked rectifier filament and found it measured 6 volts. Apparently previous serviceman interchanged the transformer windings.
8. Connected 5-volt winding to rectifier heater and 6.3-volt winding to other tubes.
9. Called customer 4 months later. Set still playing.

The second thing that you must do is to read about actual defects on specific receivers and about how they were handled by skilled radio servicemen. Make brief notes on these reports, and file them in a convenient container with your own service notes. As you read and digest these case studies, they become part of your own experience very quickly.

The actual case studies listed below have been grouped according to the defects encountered. The list is by no means all-inclusive. It is merely orientation. Begin collecting these records from here on. Sometimes the data will be presented very briefly, other times in more detail. Record as much data as you can.

Dead Receiver. 1. An a-c receiver was dead with the input filter condenser shorted. The cause was found to be loose plug contacts in the plug-in loudspeaker which opened the filter choke (speaker field).

2. The receiver was dead. The cause was found to be shorted leads in the i-f transformer. Remove the i-f can and insulate the leads properly.

3. A three-way portable receiver failed to play in the power-line mode of operation. The cause was found to be an open filter resistor. Replace the resistor.

4. The receiver was dead, although the tubes lit and all voltages were normal. The cause was found in the second detector, which had a grid-cap connection. Someone had run the grid lead under the tube shield and along the outside. When the shield was pressed down, it cut through the grid-lead insulation and shorted it to the chassis. Tape up the break in the insulation, and run the lead up inside the tube shield.

5. The a-c/d-c receiver was dead, and the tubes did not light. All the tubes checked all right in a tube checker. The trouble was found to be in the i-f tube socket. The center hole of the bakelite socket was chipped and permitted the tube to be inserted in an incorrect position. Replace the defective socket with a new one.

6. The a-c/d-c receiver used 5 tubes whose heaters were in series with a wire-wound 90-ohm, 2-watt line-voltage dropping resistor. The set repeatedly went dead and a tube heater burned out. The defect was found to be the result of the dropping resistor. Several turns of this resistor were shorted, so that insufficient voltage was dropped. Replace the resistor with a new one.

Weak Receiver. 1. The receiver was dead at the low-frequency end of the tuning dial, and weak at the high-frequency end. The cause was found to be an open oscillator coil.

2. The receiver was very weak, with low voltages and more than normal

hum. The cause was found to be an input filter condenser which had dried out and lost capacity.

3. The receiver was weak, although tubes checked all right and voltages were correct. When i-f trimmers were loosened the signal increased in volume. The cause was found to be wet trimmers.

Hum in the Receiver. 1. The receiver hummed. The cause was found to be leakage between the filter condenser can and chassis. The insulation was cleaned and coated with mineral oil to remedy the defect.

2. The receiver had a small hum. The cause was found to be reversal of the terminals of the hum-bucking coil of the loudspeaker caused by previous faulty servicing. Reverse the leads.

3. The receiver hummed as though a filter condenser was open. The cause was found to be shorting of the pilot light leads to the chassis through worn insulation. Replace the leads with new ones.

4. The receiver hummed badly. The defect was removed when the metal container of the filter condensers was directly soldered by means of a wire lead to the chassis.

5. The receiver defect was tunable hum plus distortion. The trouble was removed by dressing the grid lead of the i-f tube away from a nearby r-f amplifier tube.

6. The receiver had a bad hum. Investigation showed that some of the grid leads were shielded by a metal shield, the latter being connected to common negative and being insulated from the chassis by means of spaghetti tubing. It was found that high-resistance leakage had developed from the shield to chassis through the tubing. The defect was corrected when new spaghetti tubing was used.

Noisy Receiver. 1. Receiver noisy. Defective dial lights. These lights are turned on and off by the band switch. Change lamps, and be sure contacts are good.

2. The receiver was found to be noisy when jarred. The cause was found to be poor grounding of the i-f shields, which are grounded through an eye bolt on the can. Solder jumper from the shield can to the chassis.

3. The receiver was noisy, particularly when changing the volume manually. The cause was found to be a worn volume control. Replace with a new control.

4. The receiver emitted a sputtering noise, even when the volume control was turned all the way down. The cause was found to be a slight heater-to-cathode leakage in the output tube. Replace with a new tube.

5. The auto receiver had excess vibrator hash. The cause was found to

be poor grounding of the gang tuning condenser frame. Solder a jumper from the frame to the chassis.

6. The receiver was noisy when the tone control was adjusted. The cause was found to be a leaky condenser in the tone-control circuit. Replace the tone-control condenser.

7. The receiver was found to be noisy at the extreme end of the tuning dial when turning the tuning condenser counterclockwise. The cause was found to be the driving pulley on the tuning shaft. It caught one of the leads to the tuning eye which passed through a hole in the chassis. By doing so it caused the chassis to cut through the insulation of the lead, thereby grounding the lead.

8. The receiver was noisy in operation. The trouble was found to be a short from B-plus to ground inside the speaker-cable plug. Clean the plug to avoid the intermittent grounding.

9. The receiver emitted a noise whenever it was jarred. No loose connections were evident. The defect was found in the power transformer. A loose rivet, not very evident, was found to be the cause. Try bonding the rivet to the chassis.

10. The receiver emitted microphonic noise when a loud signal came through. The defect was found to be due to dried and hardened rubber washers on the loudspeaker mounting. Vibrations were transferred to the tubes. Replace the washers with new rubber washers.

11. The receiver was noisy, and no obvious defect was visible. The cause was found to be a defective pilot lamp, even though the lamp seemed to make good contact in its socket. A curious fact was that the lamp produced noise when tried in several other good receivers.

Intermittent Receiver. 1. The receiver was found to be intermittent. The cause was a poor ground connection from the volume control to the chassis. Resolder the connection.

2. The receiver developed an intermittent hum. The cause was found to be in the filter condenser, which is of the plug-in type. The prongs of the socket lose tension, and filter action is intermittent. Squeeze the prongs together for better contact or solder the connections.

3. The receiver intermittently squealed and howled. The cause was found to be a loose i-f tube shield. Clean the shield, and bend it so that it makes firm contact with the chassis.

4. The receiver went dead intermittently. The trouble was found in the metal-sheathed wires running to the volume control. The metal sheath was soldered to the chassis. The heat during soldering had burned the

rubber insulation of the enclosed wire, permitting the wire to short to the sheath intermittently.

5. The receiver played normally and then suddenly dropped in volume. The trouble was found to be in the oscillator coil, where a connection broke contact on heating. The defect can be made to show more quickly by operating the receiver in a closed carton. Resolder the lead securely.

6. The receiver operated normally for about 10 minutes and then decreased in volume until only strong local stations could be heard. All tubes checked all right in a tube checker. However, the condition was cured when the i-f tube was replaced in the receiver with a new one.

7. A receiver was intermittently noisy at about 15-minute intervals during a day. Investigation disclosed a factory nearby which had an air compressor with a defective motor. The motor sparked excessively under heavy loads, producing the noise. The plant manager cooperated by having the motor repaired.

8. The a-c/d-c receiver was intermittent, going on and off periodically. Tubes went out whenever the receiver cut off. The defect was found to be an intermittently thermal opening of the heater of a 12BA6 tube. Replace with a new tube.

9. The receiver would intermittently go dead or become weak. The defect was the result of a condition in the antenna coil contained within a shield can. Vibration of the chassis caused the coil lugs to short to the shield can. The condition was corrected by bending in the lugs away from the can.

Distortion. 1. Receiver is an a-c/d-c set. It distorts after about 10 minutes of operation. Defect found to be grid emission in the output tube.

2. The receiver tone was raspy and distorted. The cause was found to be a leaky coupling condenser between the first a-f tube and the output tube. Replace with a new condenser.

3. The receiver had severe audio distortion after 10 minutes of operation. The cause was found to be a gassy first a-f tube. Replace the tube with a new one.

4. The receiver was distorted and had weak output. The output tube checked all right in a tube tester. The defect, however, disappeared when a new output tube was placed in the receiver.

5. The receiver produced distorted output on strong signals. The output stage was a push-pull stage. The cause was found to be opening of one section of the primary of the output transformer. Replace with a new output transformer.

6. The receiver delivered a badly distorted output. The defect disappeared when a new volume control was used to replace the one in the receiver.

7. The receiver defect was distortion and fading. The cause was found to be a defective electron-ray tuning indicator tube which had apparently become gassy. The trouble was completely removed when the tube was replaced with a new tuning indicator tube. Apparently, the gassy tube had upset the operation of the avc system.

8. The receiver defect was distortion that had been localized in the audio section. Removing either of the push-pull output tubes improved the receiver tone. An ohmmeter check revealed the fact that corrosion had produced high resistance in one half of the primary winding of the output transformer. The defect disappeared when a new output transformer was used to replace the old one.

Squeals and Motorboating. 1. The receiver displayed oscillation squeal. The cause was found to be misaligned i-f transformers. Re-align these transformers.

2. The receiver displayed motorboating. The cause was found to be an open output filter condenser. Replace with a new condenser.

3. The receiver produced motorboating at the low-frequency end of the dial. The condition was remedied when the leads running to the grid caps of several tubes were replaced with shielded leads. The shields were grounded to the chassis.

4. The receiver uses 1.4-volt tubes. The defect was microphonic hum. The condition was improved by placing rubber spacing washers between the loudspeaker and the baffle.

5. The receiver emitted a whistle after the set was in operation for a while. The defect was found in the plate decoupling resistor of the i-f tube, which changed its resistance to a lower value as the receiver warmed up. Replace the resistor with a new one of 1 or 2 watts.

6. The receiver whistled over the entire range of the tuning dial. No station could be received. The defect was found in the i-f amplifier stage involving a 6K7 metal tube. Its No. 1 pin (the shield) was ungrounded. The condition was cleared up by soldering a jumper from the No. 1 pin to the chassis.

7. The receiver faded regularly and whistled at the same time. The defect was found to be due to the decoupling condenser from the low side of the antenna-coil secondary to ground. This condenser opened intermit-

tently. The defect was removed when a new replacement condenser was used.

Broad Tuning. The auto receiver had very poor selectivity and low volume on weaker stations. The condition improved on damp days. The cause was found in the antenna matching unit at the base of the antenna. The unit showed very high resistance from the antenna to the leadin at the receiver. The coil in the matching unit had corroded severely because of weathering. Replace the coil.

17

Starting a Television and Radio Servicing Business

Start Slowly. Did you ever see the little fellow who, after several days of coaching, works up enough courage to lift his feet off the ground and swim a stroke or so? He feels so proud of himself that he assumes he mastered the complete skill of swimming and strikes out with intent to swim considerably more than his beginning ability warrants.

Complete success comes slowly. If you are like most of us fellows, your first impulse will be like that of the little fellow. You have learned a new fascinating skill and have the urge to strike out. But take it easy. There are more bridges to cross than that of being highly trained in television and radio servicing. A business must be run on sound business principles. If you strike out into the field too rapidly, you may find yourself very soon in the graveyard of the many failures—not a technical failure but a business failure.

The purpose of the remaining chapters of the book is to give you pointers on the business aspect. It will be assumed that now or later you will handle television servicing along with radio work; hence, the instructions given apply to both types of work. Master these business rules fully as you mastered the technical aspects. Do not be the fellow about whom they say, "He was a good man but could not make a go of it."

Setting Up Your Business. At this stage of the game, you are a fairly good technician. However, you will still find that you are feeling your way. Some defective receivers will still stump you. Your speed at work, although ample for a start, is still not your most efficient speed. Furthermore, your community reputation as a serviceman is unestablished. To invest a fairly large sum in a business will strain your finances to the breaking point. This launching of your business must be carefully planned if you want to survive.

Keep your expenses down. The most relentless drain on your funds is the monthly rental. Each month, if you are located at a choice site, you will receive a rent bill which must be paid regardless of what your income has been during the previous month. The best advice to you is to avoid that item at the start. How can you do it? Make your servicing business a part-time business. Hang on to the job that is at present buttering your bread. Begin servicing on a small scale in the evenings and during your spare time. True it will put a drain on your energies, but your interest in beginning will make it seem like fun. Since you still have your old job, there will be no worry about the volume of business at the start.

Locating Your Shop. Where are you going to work if you have no shop? Well, if you have a home of your own, the basement can easily be fixed up as a service shop. Try to set up a separate entrance to the basement so that people may come and go without parading through a private home. Strangers will shy away from entering the private domain of a person, particularly if he is not an acquaintance of theirs.

The basement is a good location for another reason. When concentrating on your work, you will not want members of your family around. They will break your train of analytical thinking, divert you from your checks and measurements, and perhaps annoy you with unfounded suggestions.

If you do not own a home, you have another alternative. Perhaps one of the large shops, showrooms, or even a large garage in town will let you have a corner for a nominal fee or even gratis if their owners are friends of your family. Community contacts will be useful in finding such a site. Perhaps raising the point at a church function will find you a good neighbor. Or perhaps a lodge brother will feel kindly disposed. A little imagination applied to the problem should resolve it fairly easily.

You cannot do efficient television and radio servicing work out of a closet onto the kitchen table. Working space simply must be found. Tackle that problem first, and do not begin until you have it solved. People will have more confidence in the man who shows his seriousness by setting aside space for a job. They will feel that you are in business, not working off a shoestring.

Your Basic Equipment. By now you know that you need equipment if you are going to do an efficient job. Certainly, equipment is expensive, but there is no choice about getting it. Again, you will need to keep expense down. Do not cut corners by purchasing cheap equipment that will not stand up over the years. Instead, buy the minimum amount of basic equipment; but by all means get good equipment put out by reputable and reliable manufacturers.

Do not try to save money by designing and building your own service equipment. It doesn't pay. You need finished commercial equipment that you can rely on year after year.

As a good start, write to the equipment manufacturers and tell them that you are setting up a servicing business and want literature on their equipment. Compare the capabilities of the rival instruments and their cost. Purchase the one that gives most for your money. Contact a parts jobber for advice if you can.

Since service instruments are costly, begin by buying the two basic ones first. These are a signal generator and multimeter. If you can afford it, get a tube tester in addition.

If you have on hand a fairly complete stock of new tubes, you can get along without a tube checker at the start. For service work, tubes may be tested by replacing the questionable ones with others known to be good and noting the effect. This is actually the best way for television work, anyway. You can add the tube checker when you open your shop and have a number of people coming in to have tubes checked. Then get the largest and showiest tube tester that you can afford.

Your Multimeter. Choose a multimeter that is capable of being used to make several different measurements. It should be so designed as to measure several ranges of a-c and d-c voltages, several ranges of current, and several ranges of resistance. The ranges of one useful multimeter on the market are listed below:

DC	*AC*
0/5/50/250/500/2,500 volts	0/10/100/500/1,000 volts
dc-ma	*ohms*
0/1/10/100/1,000 ma	0/500/10,000/1 meg/10 megohms

Such an instrument will serve you well. Some instruments, in addition, have an output terminal so that you can use it as an output meter for stage-gain measurements and for receiver alignment. The voltmeter should have a sensitivity of anything between 5,000 and 25,000 ohms per volt.

Your Signal Generator. The signal generator should be capable of delivering a modulated r-f signal at any frequency that you may encounter in your service work. Keep in mind that you will handle short-wave and multiband receivers with frequencies measured in megacycles. A switch should be provided for removing the a-f modulation note from the r-f signal at will. An additional feature in some instruments is a pair of terminals from which to get an a-f signal, usually at 400 cycles. You will find it a useful output in your service work.

Keep a Tin Box. As you go ahead with your work, your low overhead should enable you slowly to build a money reserve. Since you are still working at your old job and earning your keep, you would be wise to place the profits from your servicing work in an untouchable tin box. When the funds become sufficiently large, buy other service instruments which will enable you to perform your work more quickly and efficiently.

Remember, also, that the accumulation of test equipment *now* will eliminate that major item of cost when you strike out in a full-time servicing business. At the same time, practice with the more intricate service instruments while you are still a spare-time technician will give you that much more experience as a background for your full-time work.

Future Trends. When purchasing service equipment, try to keep this thought in mind: In the field of television and radio, design changes relatively quickly. Try to determine trends, and avoid buying expensive items that will shortly thereafter become obsolete. It is not too easy to foresee all future trends, but give the matter some thought nevertheless. Also, be customer-conscious when buying instruments. Try to get good equipment that looks impressive. Your customer will often judge your ability by the appearance of your equipment. It is worthwhile pleasing him as well as yourself.

You will also need various shop tools to do your job well. Do not improvise: Do not use a knife instead of a screwdriver; do not open screw nuts with a pair of pliers. Just remember that the good carpenter is the fellow with the good carpentry tools. Get good servicing tools! Their cost is relatively small; their utility and efficiency is great.

And finally, you will need a stock of parts with which to replace defective components in the sets which you service. Of course, you cannot anticipate every one of your needs, but there are certain basic items which you can keep on hand with full assurance that you will soon use them. Having them on hand will save you the time required to purchase the part from your supplier.

As you use up these parts, replace them at your convenience when business takes you near your supplier. Experience and time will show you more specifically the parts to keep on hand to service your community. Do not lean over backwards and store up large quantities of various parts. Remember that parts represent money but cannot be used to purchase other needs. Do not tie up your cash.

In the last analysis, your basic stock will be determined primarily by the requirements of your community. Keep a weekly inventory of parts that you actually use on servicing jobs. You will find certain items that move more rapidly than others. Stock up with those parts. Until you establish your needs, you can gain valuable aid from the wholesaler who supplies your parts. He can readily tell you the parts most frequently supplied to other servicemen. You will find him quite ready to help, because he wants your trade.

Television and radio tubes present a problem in stocking. The Sylvania Electric Products Company reports that there are over 400 types of tubes in current demand. However, about 75% of your service requirements will use about 66 types of tubes; about 90% will use 123 types.

At the start, you may prefer to stock up on the 66 types of tubes. If you need any of the others, you can make a special trip to the wholesaler. The company suggests that you keep on hand about three times the monthly sales of any one of those tubes.

An interesting leaflet, put out by the Radio Corporation of America, is entitled *Tube Movement Inventory Guide*. It is based on careful study of service-dealer requirements nationally and is designed to develop an accurate inventory guide for your tube stocks through a study of tube movements. Write for a free copy.

With batteries, you have another peculiar problem. You must be prepared to furnish the proper battery for a battery receiver when necessary. Once again, consult your wholesaler on the types most frequently purchased by other servicemen. A visit to surrounding shops that sell battery receivers will indicate the types of batteries you will probably need. The Radio Corporation of America furnishes a *Battery Comparative Chart* which shows you the proper RCA battery for interchangeability. If you then deal with an RCA distributor, you can get the proper battery for any set and keep an inventory similar to that for tubes. Other battery manufacturers may furnish similar data.

When stocking batteries, be sure to consider their shelf life. Batteries deteriorate even though they are not in service and are resting on your shelf. Don't be stuck with half-dead batteries. Stock them fully in the spring, when customer demand is at its peak. Allow the stock to dwindle around midsummer. Battery and three-way portable receivers are used on the battery mode of operation primarily during the spring and summer seasons—rarely during the winter.

And now a final word on the stocking of electrolytic condensers. Avoid overstocking! These condensers deteriorate on the shelf in about a year. There is no profit in stock thrown away. Be sure that you have on hand electrolytic condensers that will turn over fairly rapidly.

Your Source of Supplies. Where shall you get your supplies? Obviously you are not going to purchase directly from the manufacturer. Go to your local classified telephone book and look up the names and locations of the nearest wholesale parts distributors. Select one and pay them a personal visit. Talk your problems over with them and get their advice. Arrange to get a trade discount for all the purchases you make, and perhaps have them extend credit to you.

You may live in a small community where there is no wholesale parts distributor. It is then necessary for you to deal with one of the mail-order supply houses. The names and addresses of these latter companies can be found in the advertisement section of a television and radio magazine.

Working in close contact with your wholesale dealer will result in a saving of time, money, and efficiency on your part. The distributor can make it possible for you to see and examine new test equipment prior to the actual purchase. Your distributor will provide you with trade literature of all kinds—descriptive material on new equipment, tube literature, manufacturer's house organs, and much other useful information.

Some distributors have realized their debt to the servicemen who patronize them and have published monthly surveys of great use to their customers. Others have from time to time sponsored a town-hall meeting for servicemen, where experts deliver service lectures to the assembled technicians. Newest developments are constantly brought before alert and progressive servicemen. Attend such meetings whenever it is possible for you to do so. Meeting other servicemen will teach you plenty of the technical and business know-how. So, establish yourself with your wholesale distributor for your own advantage.

Try to work with one wholesale dealer for the furnishing of most of your supplies. In that way you can build up a cooperative business relationship. The wholesaler will keep you informed of new developments, be more likely to extend credit to you, and take back defective parts without too much argument.

Service Bench. Efficient radio servicing depends to a great extent on the facilities for working. Your service bench is either a help to you or an unattractive cluttered-up hindrance. It must be planned with great care. But this consideration is not the only one. Remember that your customers, at the start, may not know you well. After meeting you, their eyes will size up your surroundings. A sloppy, unattractive workbench will create the impression that your work is of the same quality. Of course, that may not necessarily be so, but do not argue with human nature. Let your workbench advertise your ability.

If you wish to get started without delay and do not have the time or ability to plan a personal service bench, you can avail yourself of one of the standard benches on the market. A good bench was sold at one time by Sylvania Electric Products Company, and may still be available. This was 7 feet long and 32 inches deep, with six drawers and two large storage cabinets. The top of the bench was covered with heavy, tough linoleum. Masonite panels at the rear served for mounting test instruments. Such a bench should be adequate for your start.

As your volume of business increases, you will probably want to design a bench for your own needs. The description that follows will give you a few ideas along that line. Keep your eyes open for the service benches of other successful servicemen, and you may get other worthwhile ideas, in addition.

Example of Service Bench. Two views of a good television and radio service bench are shown in Fig. 17-1. Dimensions and construction details given in this description are, of course, subject to revision where your available space and your individual preference require such revision. However, regardless of other considerations, you should plan to have a minimum table-top area for work of about 2 feet by 4 feet. This bench top should be made of wood or other insulating material. Avoid any metal trim which might result in a short circuit.

Behind and above the working area, you can install shelving and panels for meters, manuals, tools, supplies, and replacement parts. On one side of the working area place your soldering iron, on a stand, and a small bench vise. If space permits, a bench grinder is another useful tool to have available. Place the vise and grinder sufficiently far from the work area to avoid getting metal filings into the receiver.

The height of the working area from the floor should be such as to be comfortable for you. A height of about 40 inches is a good average. Test instruments should be mounted at your eye level when you are seated at the bench.

Below the working area, there should be suitable knee space. Flanking this space, you can construct drawers for tools. At the back of the knee space, you can build a shelf for storing such equipment as a storage battery and charger. The tool drawers should be set back about 4 inches from the

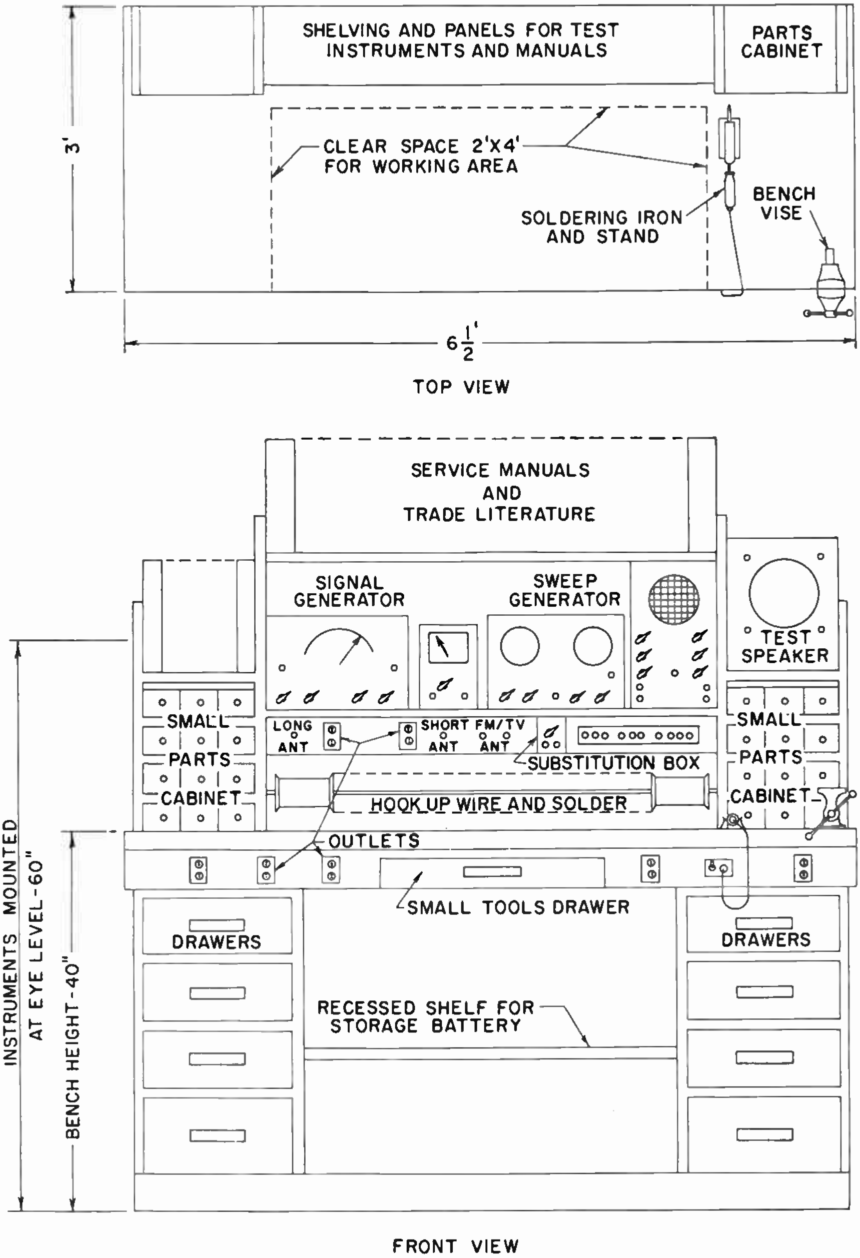


Fig. 17-1. Top and front views of a professional work bench

front of the bench top. Directly beneath this top, in the knee space, mount a strip of wood containing electrical outlets. This same strip can have a small drawer in it for frequently used small hand tools and test leads.

A good place for more outlets is directly below the meter shelf. This outlet strip can also contain connections for your shop antenna and test speaker. A shelf above the meter panel can accommodate manuals and trade literature.

Below the test instruments is a convenient place to mount spools of hookup wire and solder. These spools can be mounted so as to unwind on a dowel rod.

Naming Your Business. The first thing you must do when you are technically equipped to begin is to give your shop a name. Your customer must know your business by some business name, perhaps if only to recommend you to some other friend. Do not go fancy and select a name that will either make people laugh at your misnomer of a newly established serviceman or chase away others who do not know you well and fear a high cost on their little radios. Do not choose an overimpressive name like "Electronics Industry" or "Radio Engineering Laboratory." Select a conservative and descriptive name like "Smith's Television and Radio Service Shop" or "Jeffersonville TV–Radio Repair Shop" or "George's TV and Radio Hospital." A stranger in your community would immediately size up the nature of your business from its name.

Business Signs. The next step is to hang out a shingle. Simple as this seems, you must still give the matter ample thought. People will see the sign from two angles. Some will see it while walking down the street. Others will see your sign as they face directly toward your house or store window. Meet them at both angles. Have one sign on your establishment that runs parallel to the street. Have another sign, suspended by a chain or from a rod, which is perpendicular to the street. Catch the eyes of people from all angles. If you are operating from a house in which you are a tenant, be sure to get your landlord's permission to hang out the sign.

In addition, be sure that your signs are professional ones. A sloppy homemade sign will immediately destroy the confidence of your prospective customers. Take a walk down some street in your city and observe how you react to the various store signs. You might not feel so strongly in this matter about a vegetable shop, but note your reaction toward a shop which involves work as skilled and complex as radio servicing.

Free and low-cost display material for your service window can be obtained from various companies. The Sylvania Electric Products Company furnishes or sells window decals, a weatherproof service banner, an electric-clock sign, and a stand-up electric sign. A similar electric sign may also be purchased from RCA and Philco Corp. Give yourself as much of that attractive publicity as you can.

Choosing a Business Car. The third step is to get yourself a car to pick up and deliver sets. Investment in a low-cost jeep or a secondhand car or small truck will prove ample.

If you are purchasing a secondhand car, try to get a two-door sedan, because the door is wide and permits easier loading and unloading. If the old car has two separate seats in front, so much the better! Remove the seat alongside the driver's seat. This makes loading even simpler. Have a professional sign painter place a large, neat sign on the vehicle. The sign will be a good investment in advertising. If you cannot afford the investment in a car at this time, get some friend to cooperate by permitting you to use his car for calls. Nevertheless, plan to get your own sooner or later. It is indispensable.

Telephone. A fourth important item is a telephone. If you are operating out of your own home, you can readily use your own home phone. But you will find it advisable, if you can afford it, to have an auxiliary business phone installed. It will extend to you the important privilege of having yourself listed in the classified section of the phone book of your city.

If you are operating out of someone's business establishment, you should certainly get a business phone of your own to avoid tying up your patron's phone. Another important detail is to be sure that someone is always on tap to take a telephone message. Do not lose service calls or exasperate an anxious customer by having him call in vain. At home, a member of the family can handle it. At a business establishment, the regular office girl may be induced to take messages.

Business Stationery. The last important prerequisite item is your business stationery. You will need neat letterheads and envelopes, business cards, stickers for tubes, job-record cards, business-record cards, and similar items. Your local printer can set these up for you. But valuable low-cost materials are furnished by several manufacturers. Write to the Sylvania Electric Products Company and to the Philco Corporation Service Division, for such material and prices. You are now equipped and ready to go.

Getting Your First Customers. You have invested a fairly large sum of money in equipment and business materials before you have even begun to earn money. The temptation to strike out for any and every customer becomes overwhelming. Resist it at this time! You're just a fledgling learning to fly. There still remains the task of feeling your way on the actual job.

While learning, your failure to repair any defect was chalked up to experience. Out in the business world you cannot afford overlengthy delays or failures that occur too often. Too many displeased persons at the start will clip your ambitions in the bud. The report will go the rounds that you are a good serviceman to avoid.

Try to keep the servicing time down to a professional minimum. Do not, in the name of friendship, keep repaired sets around your service laboratory for days after they have been repaired. Return the sets to their owners, in good repair and neatly cleaned. Do not be too ready to give up on any one job. Sweat it out if necessary.

And most important of all, make your charges comparable to those of an established serviceman. If the time consumed was too long, do not charge a high fee to pay partially for your beginner's lack of efficiency.

Avoid being the good-time Charley who does free servicing for friends or relatives. First, such a practice will give the impression that you work for nothing because your ability is worth nothing. And second, your friends will get into the habit of expecting free or negligible cost for servicing long after you have proved yourself.

When you feel that you have achieved a high enough efficiency, you are ready to broaden out the territory to be exploited. But be absolutely sure of yourself. This is important because it is bound to affect your manner and tone of speech when meeting the new customer. You must absolutely ooze natural confidence in your capability. Do not expand your coverage until you can at least match in all ways the ability of the average serviceman who is already established.

Business Procedures. In order to keep yourself financially above water, you will have to seek out new customers continually. In the next chapter, business-getting techniques will be described in great detail. Use all of them, and others if you can think them up. This build-up campaign is crucial. If you put it across, you can think of a full-time television and radio repair business. But if it flops, you might just as well throw in the sponge before you invest hard-earned money in a blind-alley business. The remainder of this section will give you some other important tips on how to carry on. Master them!

Shop Calls. As a part-time serviceman, you will have many problems. Many sets, especially the small portable ones, will be brought to your service shop. You may not be present because you are out on another service call or because you are at your regular place of employment. At all times, have someone present to receive the customer and his set. This individual should courteously explain that the regular serviceman is out and request that the receiver be left at the shop. The name and address and phone number of the customer should be recorded with the statement that you will discuss the defect with him just as soon as you return. Then, when you arrive at your bench, be sure to phone or call upon that customer just as soon as you possibly can. Avoid customer irritation because of undue delay.

Home Calls. On other occasions, you will be called to the customer's home to inspect the set. At such time, you may repair the set in the customer's home if the job is simple, or you may take it to your shop if a complex defect is indicated. This latter procedure is desirable for many reasons. First, it keeps the customer from being a service superintendent peering over your shoulder. Second, it keeps the customer from seeing any bungling on your part. And last, if the repair is very simple, it may avoid the customer's balking at a price which not only covers the price of the parts but also your labor, your time, and your know-how. So if the repair is fairly extensive, do it on your workbench.

When receiving a call to come to a customer's home, avoid the situation if the customer tells you no one will be home but the key is under the doormat. You will otherwise be letting yourself in for responsibility for any household articles lost, misplaced, or stolen by someone else. When such a call comes in, politely suggest another time for the call.

Efficiency. At all times, carry a small notebook with you. In it record every item about all service calls. Note how much time you take in travel. List the amount of time spent in the home making minor checks. Just remember that your customer is going to pay for your time as well as for other service items.

From time to time, call your shop when out on a job. Perhaps there is a pickup job near the place where you now are located. It would be silly inefficiency to return to your shop only to come back to the place you just left. But under no circumstances, call from some customer's home. Although you may receive permission to call, most people resent such calls. It is a small item of expense. Use a public telephone!

How to Handle Customers. Meeting a new customer, whether in his home or at your shop, is an art in itself. It includes every phase of personal relations. You must be prepared to sell yourself as the best man for the job. You must act dignified, professional, and as if your ability will keep you in business for the next hundred years. And yet, do not be so aloof that your customer feels like a fool for not being able to repair the receiver defect himself.

Listen attentively as the customer relates the sad tale of woe about his set. Jot down a note about all the facts. When he is through, ask a few questions of your own. Get him to feel that even if he does not know how to repair the defect, he has been very helpful with his excellent observation and description of what has happened.

Try to remember your customer's name. During your talk with him, he will feel much more friendly if you insert "Mr. Smith" here and there during the conversation. Later, if you meet him on the street, greet him by name. He will reciprocate with yours, and your name will become fixed in his mind when he thinks of a radio serviceman.

How to Answer Questions. During your conversation, the customer may ask you many questions—especially as he observes you making various tests. Many of them may be silly to you, the trained technician. Act as though they are intelligent questions worthy of a considered answer. Do not laugh at them. Your sincere reply in a nontechnical manner will convince him that you are the best man he could have called in. Answer in such manner that he will feel that you are already on the road to making a proper diagnosis and repair.

A simple proverb should always be kept in your mind: "Talk is silver, silence is gold." Do not be so talkative about your service plans that you practically give away the solution of the service problem. First, your wild guess as to the cause of the defect may not be accurate, and you will have to call back later and report other defects. Psychologically, that labels you as incompetent. Second, the customer may feel that if the defect can be found so simply, service work should be done cheaply.

Lastly, if you give away the cause of a receiver defect, an unethical but capable customer may call off your services and do a simple replacement job himself. So, just talk enough to give the impression that you can find out what is wrong. By the way, if you limit your talking, you will find the customer doing likewise. This is an important consideration if you are making repairs in someone's home. You do not want another person chattering at you while you are performing tests.

Speak No Evil. If your customer asks you—as many do—if he bought a good set in the first place, try to suggest that he did. Remember that a negative answer criticizes the customer's choice as well as the set. If the receiver is a poor one, tell him that his choice for the money was good, but gently indicate the shortcomings of such a low-priced receiver.

Do not criticize any previous service work that may have been done on the set. The temptation is great to enhance yourself by belittling the other fellow. Such a practice degrades the whole profession of radio servicing in the customer's eyes. He will feel that all servicemen are incompetent thieves—and possibly you also. Say nothing! If a previous serviceman did a poor job, redo it and add the cost onto the bill.

Handling Estimates. Inform your customer that you will check his set and let him know the cost of repairs *before* you actually repair it. Never do a job until your customer gives you the green signal to go ahead. In that way, you will avoid complaints.

Women. There is one way especially in which you can sell yourself as the regular radio serviceman. Cater to the women! For the woman, the receiver is not only a source of entertainment but a piece of furniture that falls within her province. She will expect you to treat it as you would a piano or a cabinet. If you cannot sell yourself to her, you will probably lose the business of the whole family.

When you call at a home, be extremely neat and immaculate. Women appreciate that. They go for uniforms, so get yourself a clean laboratory coat with your name neatly sewed on. Your tool kit should reflect the orderliness of your mind. Place a clean canvas on the floor and do all work on it. The lady will not appreciate your dirtying her rug or scratching her floors.

If you must move any furniture, do so with extreme care. First remove all movable items like vases from the top. Compliment her for not trying to clean the inside of the set. Suggest that she could have damaged parts by trying to clean. Recommend that you be permitted to take out the set for a complete and careful cleaning at your shop. She probably will be more than willing.

When you take the set or chassis with you, wrap it carefully and neatly as though you were removing a piece of prized China. Remember, it is a part of her prized furniture. If screws and other parts must be left behind, store them in the cabinet neatly. Restore everything exactly as you found it and as the housewife wants it.

At your workbench, of course, you will repair the set. But in addition, clean up everything—chassis, dial plate, dirt in cabinet grooves (if you have the cabinet). Make all knobs secure, and be sure no minor defects, like a slipping dial cord, are evident. If you have the cabinet, give it a high polish with plenty of elbow grease. Otherwise, polish it carefully in the customer's home, after reinstalling the chassis.

When returning the set, again wrap it carefully and neatly. In some way, get the lady of the house to look at how clean the chassis is now. Replace the set and ask her where she wants it. Do not become irritated if she drives you to tears by asking you to shift or turn it here and there an inch or so. That is part of your service. Keep smiling! Finally, ask her to try the set, and ask if she is pleased with its operation. Almost invariably, she will say it sounds much better.

Don't Be Too Friendly. Above all, be reserved at all times and treat the woman of the house as a grand lady. Some women, noticing your name on your car or laboratory coat, soon become friendly and call you by your first name. Do not let the gesture cause you to talk to her as though she was an old friend. That can lead to trouble. Be professional and impersonal. When leaving, thank her for her kindness in calling you.

How to Handle Complaints. If your customer is dissatisfied and writes or calls you to tell you so, get to see him personally and *immediately*. The longer he stews in his anger, the more it will grow. Listen to his angry outpouring in silence. When the storm is spent, do not begin with a rebuttal. First apologize for his having been inconvenienced. Then either humbly admit that an error was made and offer to make amends or give an unemotional, sincere explanation of what your side of the question is. If mutual anger does not develop, any difficulty can be reasonably settled. Your customer is angry. It is up to you to remain calm.

From various surveys, it has been found that most customers like to remember you as:

1. A pleasant, likeable, friendly fellow.
2. A neat fellow with a neat shop.
3. A polite fellow.
4. An efficient, confident fellow.
5. One whose charges are absolutely fair, honest in all ways.
6. A straightforward, dependable fellow.
7. A fellow interested in his craftmanship.

Shall Work be Guaranteed? The average customer expects you to stand behind your decision that his defective receiver has been properly repaired. Of course, no one can compel you to guarantee your work. But it is advisable that you do so if you want to win customer confidence, which is so necessary for your business. Do not look for an out for your lack of complete experience.

The practice varies widely among servicemen. Some guarantee nothing. Most servicemen guarantee the specific defect which they repaired for a period of 60 or 90 days. Others guarantee the entire receiver for a similar period of time. Still others guarantee the entire receiver for a short period, except for the tubes. They will, of course, guarantee any new tubes they place in the set for the usual guarantee time that the tube manufacturer places on them.

Which procedure should you follow? Size up your situation. You are a part-time serviceman who has yet to build up a broad experience. You have not yet learned to recognize all components that are failing and likely to cause trouble in a short time. At this stage, therefore, you had better guarantee only your own specific work and any new tubes for the normal tube guarantee period. It is not the best policy with respect to the customer, but it is the one least likely to bankrupt you at the start.

When you feel sufficiently skillful at detecting failing components, you should change your policy. Explain to your customer that you will guarantee only your work for about 90 days. But, for a slight extra charge, you will make a complete check of his receiver and indicate incipient defects. If he then approves your replacing the necessary components, you will then guarantee the entire receiver for 90 days, except for the tubes.

Some customers will suspect that you are trying to build up a large service deal. However, when your prediction of breakdown comes true a short time later, their confidence in your ability will be increased. They will be much more likely in the future to take your advice. Other customers will permit you to do a complete overhaul job on the receiver in order to obtain the complete receiver guarantee. Such a policy pursued by you may actually increase your business.

You Must Keep Records. Any business that is carried on with the expectancy of surviving must be carefully planned. Sound plans can be based only on records of past experience. You just have to keep records that are systematic and not haphazard. Their purpose is to guide your business in the following manner:

1. They record business increase or decrease.
2. They record payments still due to you.
3. They record payments you must make.
4. They serve as a record of your progress for credit purposes.

5. They aid you in filling out your income tax form.
6. They aid you in controlling your buying and selling.
7. They aid you in determining service charges.
8. They indicate radio-receiver trends.
9. They will help you to associate specific receiver defects with specific receiver conditions.
10. They will enable you to keep a listing of your customers for advertising campaigns.

Customer Record Card. Let us begin with the simplest records. These are records of the name and address of customers who call upon you for service, plus other pertinent data. They may be kept on library cards,

Name ______________________ Date __________
Address ______________________
Telephone ______________________
Manufacturer & Model ______________________
Complaint ______________________
Parts Replaced ______________________
Service Work ______________________

____
Charge $ ______________ Date Paid ______________

Fig. 17-2. A typical service-record form

alphabetically arranged in an appropriate box. A typical card is shown in Fig. 17-2. Keep a separate record card for each time the set is brought in for servicing. This system will serve many purposes:

1. It will help you if you get a repeat call for the same defect.
2. It will give you a continuous record of what is happening to the receiver with the passage of time.
3. It will aid you in servicing similar defects in the receivers of other customers.
4. It will help you determine what tubes and parts to bring when called to the customer's home.
5. It will indicate a design defect by the manufacturer for any particular receiver model number.

Job Record Tag. The second important type of record is known as the *job record.* Most servicemen use a tag type of record for this purpose. The tag is perforated so that it may be readily divided into three parts. Each of the three parts has a similar number printed on it. One small stub section is the customer's claim check. The main section contains the customer's name, address and phone number; the make, model, and serial number of the receiver; the complaint; and the promised date of return. On the back of this section is a chart for indicating the cost of materials and labor. You will file this section in a suitable box for future reference. It will guide you in making future charges on the same receiver.

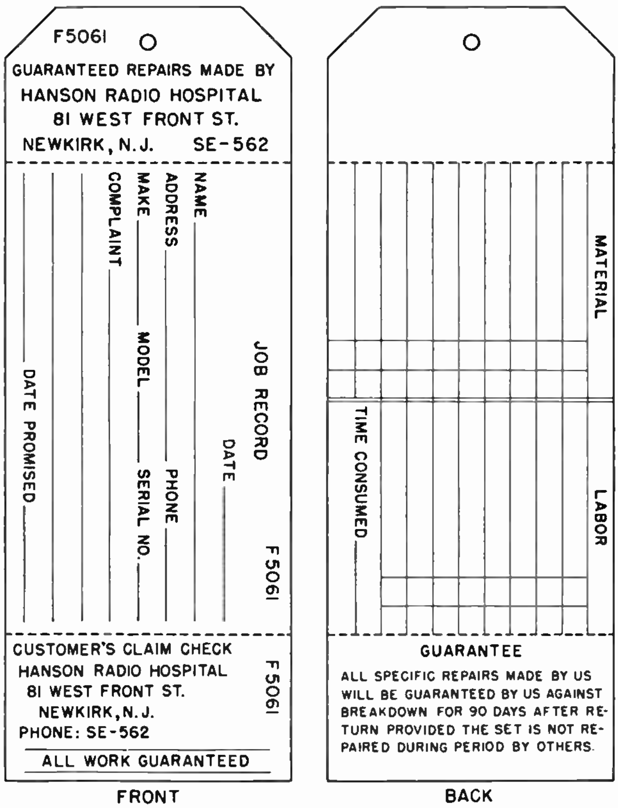


Fig. 17-3. A typical job record card

The last section of the job record simply lists the number of the job record for identification purposes. As soon as you receive a set, fill out the job record and attach it to the line cord. A typical job record is shown in Fig. 17-3. As stated previously, several tube and receiver manufacturers furnish job-record forms to servicemen at a low cost. Avail yourself of these forms, because the cost of having a local printer make them up would be prohibitive.

Business Record. Still another important type of record is the *business record*. It is designed to serve several purposes:

1. It furnishes a day-by-day record of money taken in.
2. It furnishes a day-by-day record of money spent.

As a part-time serviceman, your business records will naturally not be very complex. As your business grows, your records will also become more complex and more systematic. At this early stage, just get a hard-covered notebook. Rule the first two facing pages as shown in Fig. 17-4. Every item of income is listed on the left page. Every item of expense is listed on the right page. After each week income and expenses are added up.

2 INCOME					EXPENSES 3			
DATE	JOB NO.	SOURCE	AMT. REC'D.	WEEKLY TOTAL	DATE	PURPOSE	AMT. PAID	WEEKLY TOTAL
5/3	224	Mr Smith	8.50		5/3	Advertisement	1.60	
5/3	225	Mr. Brown	3.60		5/4	Cab fare	.80	
5/4	220	Mr. Elliot	4.50		5/5	Parts	15.90	
5/4	227	Mrs. Hubbard	12.00		5/8	Phone bill	5.00	
5/5	226	Mr. Muldavin	15.90		5/9	Electric bill	4.75	
5/7	228	Mrs. Wilson	19.00		5/10	Profit withdrawn	25.00	
5/10	229	Mr. Hood	16.00					
				79.50				53.05
5/11					5/11			

Fig. 17-4. A form for keeping business records

Our illustration shows that, at the end of the given week, your business has a capital reserve of $26.45. If you wish a financial statement of your business at the end of any week, simply add up the weekly totals of income and the weekly totals of expenses and subtract the latter from the former figures. This simple record will show the trend of your business—upward, downward, or unchanging.

Drawing Your Salary. Several things should be noted in this record. You act as though you were employed by your business and remove from the business a weekly salary. Never treat all the profits as your particular booty. Every business has its up and downs. In order for you to survive, you must have a business reserve to meet the periods of slowing up of customers. Furthermore, you must be prepared at any time to purchase new equipment that is necessary. The reserve fund is the source for payment. The larger the reserve fund, the better the financial strength of your business. As this fund grows larger, you profit from it by increasing your salary withdrawal.

There is an old saying that business and pleasure do not mix. Your salary withdrawal, which serves your pleasures, should not be mixed with your reserve fund, which serves your business. Keep separate bank accounts for each one.

Set Up a Petty Cash Fund. From time to time, you will have to pay cash in small sums. These payments should not come out of your reserve funds, since that would upset your record system. Instead, list as one of your weekly expense items the words *petty cash*. Pay yourself out of the weekly income a small sum of money to meet those small bills. Keep that petty fund money in your shop where it is always readily available for small payments. Remember, however, that you do not enter into the expense columns payments made from the petty cash fund since you originally listed all petty cash as an expense item. To do so would merely enter the petty cash twice in the expense columns. From time to time, renew the petty cash fund.

As your business grows, you might try other established systems. Several manufacturers furnish business record forms at a low cost. The Sylvania Electric Products Company at one time sold a fine business-record form for $1; see if it is still available. This is designed primarily for the full-time service-shop owner. It also contains tax information of value. Although you may use it in your part-time work, your low volume of work at the start can be handled just as efficiently by the simple record that was previously presented.

Going into Full-time Servicing. Your proving ground is your part-time service work. At that stage, your bridges are still intact. You may go forward, or if you choose, you may continue as is, or retreat. The carrying on of sound business practices and the keeping of accurate records should furnish you with the answer to the question of how to proceed. Before you make that fateful decision, be sure to ask yourself some serious questions:

1. Do you like the type of work you have been doing as a part-time serviceman?

2. Are you sufficiently trained and experienced a technician so that you can compare favorably with established servicemen?

3. Has your volume of business grown to a point where it can support you in a full-time business?

4. Is your capital reserve enough to finance you in establishing yourself during the first few months?

You would be wise to answer these questions cautiously. The danger lies in the fact that a positive and strong answer to the first question will make you say "yes" to the other questions too readily. It is wiser to be a bit pessimistic about the answers. Give yourself every opportunity to succeed. Remember that you lose doubly if your decision is wrong. You lose your business and your old job. But if you are certain that now is the time, strike out mightily with all your means to put your business across. Just feel reassured by the fact that thousands before you are now successful shop owners.

Locating Your New Shop. When you are absolutely certain that you are going to make radio servicing your full-time work, your first major problem is the determination of your shop location. Of course, you may continue to operate from the same shop where your part-time work is performed. However, sooner or later, you will have to blossom into full bloom if you want to develop fully. Psychologically, you will impress your customers better if you have your own independent shop.

Where shall your shop be located? The wise answer to this question may make the difference between success and failure. Give it serious thought. The first consideration is people. Obviously, the more people who pass your shop, the greater the likelihood of capturing their trade. Try to locate your shop where large numbers of people do their buying. Good locations are near drugstores, grocery shops, department stores, banks, hardware shops, theaters, chain stores, and similar businesses.

The best plan is to have people pass in front of your shop in going to those other businesses. The next best plan is to be across the street from the mass movement of these people. Least desirable is to be located around the corner from the line of passage. A good idea is to be located near a bus or trolley station, so that people may look into your shop window while waiting for transportation. Plan to provide service to about a minimum of 1,000 families if you wish to survive.

Shop Rent. An important item that will enter into your consideration is the rent you will have to pay. In order to survive, you should pay an annual rental of about 4 to 5 per cent of your gross income. If you plan to do $5,000 worth of servicing business, your annual rental should be about $200 to $250. Of course, if you plan to sell radios and other items, you will probably be able to pay a bit more.

Remember that the farther you are away from heavy sidewalk traffic, the more you will have to advertise to make people come to you. Now that practically every family has a car, however, advertising can bring them to locations heretofore considered worthless for a servicing business.

The Neighborhood. Another consideration is that of the income bracket of your prospective customers. The higher the income bracket of a neighborhood, the better your chances of survival. Wealthier people are more likely to demand perfect operation from their sets. They have the money to pay for perfection and will patronize your services more frequently with less complaint about price. They also are more likely to buy if you sell sets and equipment. Size up your people, therefore, before you rent the shop.

Competition. A further consideration is that of the number of competitors you will face in a neighborhood. Obviously, the thinner you spread the trade of a community, the less each serviceman is going to earn. Do not be afraid of one competitor. People like to juggle their trade back and forth. You will capture some of your competitor's trade and profit from his presence. But avoid a neighborhood saturated with service shops.

If possible, avoid a shop off the street level. People do not like to go up steps or down steps to get into a shop. You may feel that little effort is required to walk that step, but people just do not wish to do it. Cater to their wishes.

You may wish to specialize in car radios. Then locate your shop near a garage, where cars will constantly be entering. Provide sheltered drive-in space, so that cars may come right into your shop for service. In other words, be near the place where your specialty trade comes, and provide for its convenience.

A final consideration is purely a technical one: Try to avoid locations that will make your shop antenna inefficient in operation. Avoid areas that feed noise into your set. Avoid areas that will block signals from your antenna. Be sure that no restrictions are placed on the construction of an outdoor antenna.

No doubt, you will rarely find the perfect location. Do not expect it! Weigh all the factors carefully, make the necessary compromises, and select your shop. Once the die is cast, strike out vigorously to build up your trade. If you find that you have made an error, do not despair. Plan on changing to a better location when your lease is up.

Just one final word! Your community may have special regulations for television and radio servicemen. Inquire at the offices of your local government. Be sure that you are not violating some local regulations by opening a shop in a particular area.

Planning Your Shop. Having rented the shop, your next job is to set it up for business. Your workbench and equipment should be at the rear of the shop, where people will not be stumbling over, and interfering with, your work. A good idea is to have a showcase in front of your workbench and to place a tube checker on that showcase.

Accident Hazards. Another important factor is to size up all accident hazards. A law suit can rob you of the profits of a year or more. Just do not let that happen. Anticipate all possible hazards and remove them. Remember that if a customer is hurt as a result of any negligence on your part, you must pay the damages. It will be useless for you to claim in court that your clerk or helper created the hazard or that the customer was careless in failing to avoid a known hazard. You are still liable.

Replace all floor boards that are loose or rotted or have holes in them. They can cause serious injury. Keep stock items and tools off shelves where they may accidentally topple on someone's head. Keep boxes and other stored items off the floor, where customers may stumble over them and fall. Enclose power tools and electric terminals so that no one can accidentally be injured. Especially, watch out for children, whose natural curiosity may cause them to explore your shop. Believe it or not, mother or daddy is not responsible for their injuries in your shop. You are! Be sure your store is well lighted. Although you are responsible under any circumstances, fewer accidents will occur in a well-lighted shop.

There is one further point. Your responsibility is not confined to the inside of the shop. It includes all walks, ramps, steps, and other approaches. You simply must train yourself to size up possible hazards each day as you begin your work. If you can afford it, contact your local insurance company and see if they will sell you liability insurance for any accidents for which you are liable.

Shop Decorations. Another vital consideration is the decoration of your shop. You simply cannot present a customer with a hole-in-the-wall appearance and expect to hold him. Psychologically, he will expect shoddy work from such a serviceman. The successful shop attracts the attention of the customer, invites him to enter, and impresses him with a sense of modern efficiency once he is inside.

How do you accomplish this minor miracle? A prime consideration is adequate lighting. There is nothing so depressing and discouraging as dingy lighting. It gives the impression of imminent business failure. And there is nothing that gives the impression of success and modern methods as a well-lighted shop. It is worth the extra investment.

The Sylvania Electric Products Company has furnished some interesting information about good lighting. They recommend that lighting fixtures be spaced no further apart than the distance from the floor to the ceiling. As a general rule, they suggest that one 40-watt fluorescent lamp (corresponding to approximately a 100-watt incandescent lamp) is required for every 80 square feet of shop space. Or a four-lamp fixture may be used for every 160 square feet. Show cases may be illuminated with long-slim fluorescent lamps, which are ¾ inch to 1 inch in diameter and have lengths up to 8 feet. The shop window must also be adequately illuminated.

The inside of your store must be clean and neat. The walls should be attractively painted and free of smudges, cracks, and hand marks. Floors should not be soiled and splintery. Have them scraped and neatly shellacked. Much better, lay down a simple linoleum or inlay, if you can afford it. Avoid the feeling of artificial ornateness. Give the sense of simple, modern efficiency.

Window Display. Your front-window display is probably one of your most productive forms of advertising. Many people will pass your shop if it is properly located. The window display must be such as to cause them to stop and look. Then it must invite them in. Begin with a clean window. Your customers do not want to peer through a smoke screen. Make it easy for them to see.

Your trade name should appear neatly and professionally on the window or on a sign over the shop. Make it bold, so that it will be remembered. Have an electric sign if you can, perhaps operating through a blinker button that makes it go on and off. A clock in the window will make many a person stop at your shop. Neat window decals furnished by such manufacturers as Sylvania, GE, RCA or Philco will attract attention.

An interesting tube display, neatly set up, is a good idea. The chassis of a set showing the underside may cause the curious to stop and look. The potential customer will be impressed by its complexity and be more prone to respect your ability in servicing it. Placing the chassis on a rotary turntable is even better. Neat tags connected by tapes to various parts can be effectively used to explain the functions of various parts of the set. A loudspeaker display can also be effectively used.

Special Promotions. If you are selling receivers, records, and electrical items, place a few in your window. Save these displays for later repeated showings. Some servicemen have an extension speaker in the window operating from a set in the shop. Musical and other programs may thereby be heard on the outside. Recordings may be similarly advertised. Give the matter a little thought, and you probably will think up many other ideas. Do not keep one window display until the colors of displays fade and dust and cobwebs give your establishment the appearance of an antique shop. Change it regularly.

On the opening day, have a large sign in the window offering a come-on gift: a free service checkup, souvenirs, a special sales offer. Maintain this policy until you are successfully launched. Then settle down to normal service and sales work.

Signs and Posters. In addition to the customer attraction items, your window should have sales appeal. Neat and professional posters should clearly advertise your sales and service policies. Prices of sales items should be neatly indicated. If you have an unusual sales or service offer, let your public know by means of attention-getting, colorful signs. Make every poster and display in your window serve a useful purpose.

On the outside of your shop, have large and neat professional signs which advertise your business name and your service. Place them so that they may be seen from every angle of the street. Signs with large attention-getting thermometers can often be purchased from tube manufacturers. One may be hung outside your shop to good advantage.

Arousing Curiosity. Opening day can also be a form of window display. Do not set up your shop and fixtures with curious eyes supervising. Coat the window with whitewash and proceed in privacy. People will wonder what is going on. When completely ready, burst forth by removing the whitewash, and give a special offer like small souvenirs or a free service checkup for a short period of time. This sudden bursting forth is always a good attention getter.

Points to Check When Preparing for the Opening. Many of the thoughts mentioned in preceding sections will enable you to get off to a flying start. No doubt, as you think about the grand day, more ideas will enter your mind. Give the matter careful thought. Below are listed a few questions in a checklist to guide you.

1. Is your workbench set up for immediate work?
2. Do you have the necessary tools and service stock?
3. Is your window set up neatly and attractively?
4. Is the shop neat and professional-looking?
5. Is an attractive sign and shingle neatly hung?
6. Are counters and fixtures neatly placed?
7. Have you planned for customer comfort?
8. Do you have a cash register or cash drawer? Cash?
9. Have you provided space for serviced sets?
10. Do you have record forms?
11. Is the telephone installed, electricity turned on?
12. Have you purchased necessary insurance?
13. Have you wrapping paper, string, gummed tape?
14. Do you have a duster, broom, mop, pail, etc., to keep the shop clean?
15. Have you informed as many persons as you can about the opening?

18

Business-getting Ideas

The Go-getter. Have you ever stopped to realize that the word *business* is related to the word *busy?* Too many fellows in business forget that. Remember that your customers are not going to keep busy hunting you out. Rather you have got to hunt your customers out, no matter how efficient you may be. If you are going to sit and wait, that is how you will be found when they count ten and out of business. You simply must match your ingenuity as a service technician with your ingenuity as an attracter of customers.

In this chapter we will present a few ideas that successful servicemen and businessmen have found to work well. Keep your eyes open for more of such ideas used by other tradesmen. Think up new wrinkles yourself. You will be surprised at what comes out when that thinking cap is on.

Window and Interior Display. It pays to advertise! That expression has come to be recognized as true as "Don't count your chickens before they're hatched." Large companies spend hundreds and thousands of dollars each year on advertising their products and services. You simply must do likewise in your own little way.

The least expensive type of customer stopper or advertising is your own shop window. If it looks like any one of the 20 or more stores that a passerby has just passed, he will go merrily on his way. You must make it so different that it commands attention. But remember, it must not only command attention, but it must also command respect for the one who set it up and a curiosity to come in and see more.

What is your customer appeal? A survey was made some time ago as to the manner in which people gain impressions. Naturally, all impressions are made through the five senses. But on which one ought we to concentrate? The survey listed the percentage of impressions gained through these senses. Here they are:

Seeing	87%
Hearing	7%
Smelling	3½%
Touching	1½%
Tasting	1%

Obviously, your best appeal must be made through seeing. It follows then that if your shop window has no eye-appeal, it is not going to stop many persons. Do not simply put anything in the window. Give the matter considerable thought. It is worth that at least.

Traffic Stoppers. There are three main ways of making people stop to see. The first is through the medium of dramatic lighting. You may focus a spotlight on an object that is meant to be outstanding. Or, you may use a blinker to illuminate a sign or an object periodically. Blinkers are obtainable in any good electrical or hardware shop.

The second method of eye-appeal is through the wise use of color. Think of winter and the color that comes to mind. What colors do you visualize when you think of Christmas? Colors to match the season or a special holiday usually attract attention. Why not take advantage of the fact?

The third method of catching the eye is by means of motion. For example, a radio may be made to rotate slowly on a raised platform. Or, you may use an animated sign or figure. You probably can think of others. As a rule, do not use devices that are entirely unrelated to the field of television and radio. They will attract attention but will arouse no further curiosity.

Changing Your Display. Did you ever see a child with a new toy? He plays with it for 2 or 3 days and then yells for a new one. Well, adults are not much different. For them, too, variety is the spice of life. You simply must concentrate on a regular schedule of new attractions.

Do not allow one attractive display in your window to shade into antique gray with age and dust. The passerby will subconsciously assume that your methods are about as archaic as your display. It is a good idea to concentrate on a new display about once a week. If the volume of your business presses in on your time, then it is certainly worth your hiring a professional decorator once every month or so. He can do a professional and attractive display for you.

Window Lighting. A window with no light looks like a business that has failed. A window with dim lights looks like a business that will soon fail. You can afford neither. Get the lights to go to work for you. It has been estimated that there should be about 150–200 watts of light for each foot of store frontage.

You must be wise in how you use these lights. Provide even distribution throughout. And avoid glare. Where possible, have the lights recessed in a false ceiling. Even better and cheaper, you should try to use fluorescent lights. They are softer, more diffused, and come in a variety of colors.

Should you keep lights on all night, or should you shut them off when you close the shop at night? Obviously, it is both costly and partly wasteful to keep the lights on during the wee hours of night, when no soul is around. Since the window display is a form of advertising, you must at least have a potential audience. On the other hand, it is silly to stop advertising simply because you have called it a day. It is suggested that you keep your window lit up until there are not enough people passing by to make it worthwhile. You will have to decide that hour yourself. The matter can be handled with a timing switch after you have left.

What to Put in Your Window. The things you place in your window must attract attention and invite the customer into the store. It might be an exhibit of a variety of radio tubes with a neat sign offering to test tubes without charge. Or it might be an inverted chassis of a radio, with neat ribbons and labeled cards going to various parts of the set. An accompanying poster might say that a radio is a complex device; do not let a hammer-and-screwdriver technician toy with it. Exhibits of that type will, no doubt, make the passerby pause. Now, the bait to come in!

We said above that you might offer to test tubes without charge. You must also use other devices. Perhaps, you may offer a free log of surrounding radio stations. Or you might offer a printed log and time schedule for symphonic music, dance music, entertainment, literary discussions, etc. Or you might offer free demonstrations of how some new device, like a wire recorder or a line-noise eliminator, works. You will think of many schemes if you consider the idea important enough to think about.

Window-display Signs. In addition, you should include signs which many dealers and manufacturers will send you on new developments in radio. Often, you will get to know a new customer for the first time when he comes in not for service but for information. If handled politely and correctly, you may sell him then and there on your services.

At all times, have a neat sign in the window on your business policies. If tubes are tested free, say so. If you guarantee your work for any period of time, let all who pass by know it. If you are featuring a special temporary offer, put it on a sign and place it in a conspicuous spot in the window. Nothing pleases a potential customer more than knowing what to expect before he enters your shop. And nothing drives customers away—especially undecided ones—so much as the uncertainty of what to expect after he crosses your threshold. So, advertise yourself in your window.

Vary the emphasis on your window display. Always have some reference to your servicing and sales. But when spring comes, make a larger display of three-way portables for outdoor use. During the summer, emphasize auto-radio work as well as batteries for portables. In the fall, center on a display calling for receiver checkup to get good football reception. Push those items which you wish to sell.

It is a good idea to keep your eyes open, when you can, for ideas and to make notes on them. Whenever you see a newspaper photo of an interesting store window, make a note of it and try to adapt the idea for yourself. Do the same for windows you drive past. The other fellow is giving the same matter some serious consideration himself. And he may be using highly trained window decorators. Remember that a good plan is always worth borrowing.

And one final bit of advice! Keep notes on your various window displays. Notice which ones are on the ball and which ones let them go by. Nothing succeeds like success. Produce variations of any displays which seem to bring the customer in. Avoid the flops!

Outside Advertising. Up to this point, your advertising has been relatively free of cash. You might be tempted to let it go at that. Don't! It is not enough. Many successful servicemen make it a policy to use about 5 per cent of their expected income for advertising. You simply must do likewise if you want to reach out for customers.

There are many ways in which you can spread your name and reputation beyond the immediate vicinity of your service shop. Each of these will be considered in turn. Of course, it is not necessary to engage in all of them at once. But have at least one of them going at any one time. Keep thinking of new ways all the time. And expand on those which seem to be working for you.

Direct-mail Advertising. One of the most direct methods of advertising is by mailing postal cards or sales letters to persons in your territory. In small towns, you may wish to take in the entire community. In a large city, you will probably concentrate on a number of blocks surrounding your shop.

How do you get a list of persons to whom you will write? It is important to reach as many people as you can in the area in which you are working. The first source of names is the list of your own customers. Do not take your customers for granted! They may be pleased with your service but must always be gently reminded that you are ready to serve them further. Keep your name in their minds at all times. Get them to think of you automatically, when service is needed, by contant tactful reminders. These customers will in turn tell their friends about you.

Your local postmaster is another source of names. Make an appointment with the postmaster and explain your problem. He may be able to suggest where you can get the desired list. For a small charge, he will also furnish the correct address of anyone you can no longer locate. It pays to cultivate the friendship of these who handle your mailing.

You can sometimes get names from various lodges, organizations, societies, and church groups. Write to one of the officers—or better, go to see him—and explain why you want the list. In most cases, the list is yours for the cost of getting it copied.

No. 606
Name ______________________
Address ______________________
Make of receiver ______________________
When purchased ______________________
How many times was it repaired? ______________________
If you have additional television and radio sets, give information below:
____
____
____

Fig. 18-1. Copy of potential-customer information card

Phone directories can also furnish names and addresses. These are readily available in all communities. Select those who live in the area which you intend to cover, and keep in postal contact. Remember, however, not everyone has a phone. So use other sources as well.

Whatever your source of names, you have to keep plugging away at writing if you want it to pay off. Do not stop because the first results seem barren. Keep the mail going at regular intervals. Give your prospects the idea that you constantly have them in mind. They might retaliate by keeping you in mind.

Keep your lists up to date. Do not waste time and money on those who have moved to distant parts. If you definitely find out that someone does not have a receiver, why offer him service? When you find that someone has moved, change his address on your file of names.

Wherever possible, make a note of the brand and age of the receiver of each person on your list. One serviceman got this information by running a contest in which he offered a free service call to the one with the winning number on a card. These cards were left in surrounding groceries, drugstores, garages, and cigar stores. Certain information had to be furnished. Figure 18-1 is a copy of one of the cards with the information required. The cards were dropped in a box outside the service shop. Such information may point out your most likely customers. Concentrate on them more frequently.

What to Place on Postal Material. No one likes a long-winded story—especially from a stranger. Make your mailed cards or letters say their messages quickly and clearly. If you are making a free offer, say so in a few words. Do not give the idea that you are a desperate near-failure making a last attempt by offering everything. Give the impression that this is a once-in-a-lifetime opportunity to get something free from a topnotch technician.

If you are simply soliciting service trade, make the cards or letter impress the prospect with the fact that you are interested in his set. It is fatal to give the impression that your only interest lies in picking up a quick dollar. Did you ever hear someone say, "He sounds too glib"? Do not make your communications give that effect.

There are many ways to do this. One way is to include with your major message a bit of technical advice. You might include some information about the effect on reception of aging tubes. Or, you might call attention to a particular station that is poorly received in the community. Tell them either what can be done or that nothing can be done.

Where a postal card is of the double-size variety, you might include station logs, program listings, etc. In this way, you will induce the person who receives it to save it with your name and phone number on it. Thus, your name will be readily available at all times.

Other Ways of Advertising. There are many other ways of advertising. Many people seek their services and products by means of the classified telephone directory. When they need television or radio service, they look for a neighborhood shop in that way. The cost is not great. Purchase a small listing. It is not a dramatic appeal. It does not advertise special offers and inducements, because it is static. So make it a general statement of policy like "Work Guaranteed," "Speedy Service," "Television and Radio Servicing," or "Specialized Radio Servicing." If you are a member of a recognized servicemen's organization, state the fact.

Another way to get your name around is by means of an advertisement in your local newspaper. This is a more dynamic form of advertising. Be brief and clear. Again state your policy and organization membership. In addition, state any special offer or service. It is a good idea to include a little cartoon cut if you can. This device has more appeal than mere words. You might also add interest by using larger letters for special emphasis, as on a free offer. Change the format of the ads regularly. You'll probably get many good ideas by looking through the newspapers at how others do their advertising.

As another means, have your local printer make up several poster signs—preferably in more than one color. With the cooperation of the owners, you can get them placed neatly in garages, etc. One serviceman went even further: For a small percentage commission, he had these merchants receive any defective sets in their places of business. At regular intervals he picked them up, serviced them and delivered the sets to their owners.

Advertising can often be done through good-will functions. If a church or organization is running a special affair, offer them the free use of a radio, a phonograph, or a public address system. Have a neat placard near the equipment with words to the effect that it was loaned through the courtesy of your shop—listing your name, address, and radio services.

One serviceman had a clever idea. He wrote a signed article on radio regularly in his local newspaper. No charge was made. In these articles he discussed reception problems, new developments in radio, the advantages of regular radio rehabilitation, etc. It paid off.

Another form of advertising is particularly effective in a smaller community where there is a more personal contact between the servicemen and those he serves. This is the direct phone call. Do not waste time in aimless chatter. Without high pressure, be businesslike. Prepare in advance what you wish to say. Write it down on a card and follow it. Efficient conversation gives the impression of efficient workmanship.

A final, but effective way to get your name into the minds of people is by the simple expedient of sticking a label with your name, address, and telephone on the back of all sets repaired by you or on new tubes that replace old ones.

Which is the best way to advertise? You must determine that for yourself. Whenever a new customer comes in, ask him how he heard of you. Record that information. Eventually you will know where best to invest your advertising funds.

Apartment-house Servicing. One serviceman had another good idea which might work for you. His shop was located in a large city with many large apartment houses. He contacted the landlords of several houses, one at a time, and requested permission to contact every tenant in the building. In return, he offered to remove old and obsolete antenna masts and wires at no cost, if the tenant desired this.

Every tenant was met in person. The serviceman explained that he was doing a job for the landlord. Then he asked how many sets each tenant had. Were there any in need of repair? Since he was contacting the entire house, he offered a special reduced servicing rate. Where all was well, the serviceman simply left an attractive card with his name, address, and phone number. He got many jobs on the scene and eventually had to hire an assistant to handle the volume. The idea is worth a try.

Tie-in Servicing. Many servicemen use another technique that pays off. They make an arrangement with the local garage or auto-service shop whereby a large sign is displayed stating that auto radios are repaired at that place of business. A percentage of all fees is then given to those tie-in businesses.

Of course, definite arrangements must be made for this type of cooperation. Either the cooperating party must be trained to remove the car radio and to hold it for the serviceman, or the serviceman must arrange to be at the garage or car-service shop at specific hours of the day. If you try this idea, you will have to determine which arrangement is most satisfactory for you. Auto-radio installation may be handled in a similar manner.

The Serviceman's Attitude. Last, but far from least important in your attempt to increase business, is your own attitude in your relations with customers. Unless accomplished successfully, you will choke off the influx of customers which your other ideas might have created. What this discussion refers to is a consideration entirely apart from your technical skill and service charges.

What do customers like in a television and radio serviceman? What should you avoid in your customer relations? First, customers like a friendly but businesslike fellow. They like you to greet them in a friendly manner, often by name if you know it. When they bring in a receiver, they appreciate a simple, nontechnical explanation of what is wrong. Do not talk so much that you give the impression that all you will do is talk the receiver back to normalcy. Be brief and businesslike.

Don't Make Jokes. Don't be a buffoon! There are some fellows who clown around while working, apparently enjoying the sensation of keeping the customer, who may be watching, in laughing happy spirits. As a comedian you may be a great success. But who would trust a comedian for a serious job?

Answer Questions Briefly but Clearly. Don't ignore questions by a customer peering over your shoulder while you are at work. Answer as simply as you can without acting too superior. Customer curiosity is normal. If the customer fires too many questions at you, you can discourage him by the simple expedient of making your answers very brief, while slowly continuing with your work. Avoid discouraging him by saying he would not understand.

Be Professional. Another trait to avoid when a customer is around is that of thinking out loud. You wouldn't think much of a doctor who came to diagnose what was wrong with you on the basis of your symptoms and thought out loud. Here is what he would probably say: "It might be . . . or . . . or . . . or . . ." That is what the average doctor does mentally, but when stated out loud, it sounds as though he is unsure and incapable. You will be judged similarly. Learn to talk to yourself in silence.

Don't Criticize. Avoid knocking a competing serviceman. Too many fellows belittle the other fellow in order to enhance their own reputations. But that is a double-edged sword. The effect of knocking is to create the impression that the field of servicing is shot through with incompetent, gouging fakers. By association with the trade, you will be held under similar suspicion. Treat the receiver, not the previous serviceman.

Repetition Pays. Customers like an aggressive, friendly serviceman. Keep after old customers; go after new ones. Be persistent without being a nuisance. Give the folks the idea that your constant reminders are symptoms of interest in their having pleasurable television and radio entertainment.

Give Prompt Service. Don't keep a customer waiting. When he calls for service, he obviously is missing his entertainment. Every day's wait adds to his irritation. Try to get to his set as fast as you can. And, for your own sake as well, try to get it repaired and returned equally fast. Some servicemen, where possible, leave an old receiver at the customer's home if the defective set is taken to the shop, so that the customer will be able to enjoy programs in the interim period.

Tell the Customer Beforehand. Don't spring surprises on your customer. Let him know what your service policy is right at the start. Stick to any promise you may have made to him. Avoid the reputation of being a "gyp outfit."

Smile. And finally, keep smiling at all times. If the customer argues or comes in with a chip on his shoulder, be the great conciliator. For if he leaves your shop in a rage, you have lost him for good as well as those whom he can prejudice against you. It is a good idea never to let a customer leave your shop without a smile, even if you must reduce the margin of your profit with him.

Serviceman-customer relations are only a matter of good-will and common sense. Yet they spell the story of success or failure. Be alert at all times for ways to improve them. They are as important as technical know-how.

Remember always that a customer is the most important person ever in your shop, whether in person, on the telephone, or by mail. A customer is not dependent on you—you are dependent on him. A customer is not an interruption of your work—he is the purpose of your work. Therefore, you are not doing him a favor by fixing his set; instead, he is doing you a favor by giving you the chance to fix it. A customer is a part of your business, not someone to argue with or match wits with. You can never win an argument with a customer because you lose him if you win.

Adding Sales to Service. There is another way in which you can expand your business. That is through the sale of television and radio sets. However, one must never jump unthinkingly into this related business. It contains the germ of a medium that can either swell your income tremendously or that can smash your well-established servicing shop. Before you jump to that area of activity, you must think the problem through very carefully and plan the groundwork in more detail than previously.

Do not attempt too quick an expansion at the start. You had better begin with a few models and add to your stock as business conditions and consumer demand direct.

One of the primary requirements when you start on your plans for growth is provision for adequate capital. A survey by the U.S. Department of Commerce showed that lack of capital was responsible for about one-third of all business failures. It is true that in the radio business you can operate on less capital than other business, because credit arrangements are easier and more available. But do not ride on credit alone, because the temptation is to expand beyond what you can safely carry. Pay your bills as rapidly as you can.

It is advisable that you talk the matter over with your banker. Many advantages to you will ensue. The bank can be helpful in extending credit, in advising you on business trends, in discounting notes, and in many other ways. Many a business has weathered a business storm through the aid of a bank.

Another angle that you must consider is the new responsibility that you are now assuming. Consultation with a lawyer might pay off in the end. If you continue as you have been in individual ownership, conditions may arise which require that you satisfy your creditors. At such time, they are legally able to seize all your property—personal as well as business. However, if you incorporate your business, you will not be personally liable for the debts of the corporation over the amount invested. The disadvantage is the cost of incorporation and corporation taxes. Get good legal advice for your decision.

The next major step is a survey of consumer demand. An easy way is to note what people entering your store ask for. Another method is to observe what models your successful competitors are carrying.

Do not stock up too much. If the wholesaler is easily reached and you can replenish stock quickly, you should carry one or two of each larger set. But if your wholesale supplier is at a distance and there is a time delay in restocking, then you must naturally carry a larger inventory.

When restocking your store, you must always keep in mind the fact that models change. Manufacturers regularly change the design and appearance of their products in order to increase sales. People constantly go for modern design. Don't be stuck with obsolete stock. Keep constant contact with the manufacturer as to the dates for change of model, and act accordingly.

Principles of Salesmanship. Don't take sales for granted. You simply must plan and train yourself for the job. Know your products intimately. Know why the construction is superior. Be sold on its virtues yourself. However, concentrate on customer use. In the last analysis, the use is the primary interest to the purchaser.

Know people. Women are especially influenced by fashion and color. They go along with a latest mode. Men, on the other hand, are more responsive to an appeal to their technical understanding. They will be flattered by an emphasis on construction and operation. Meet each person where a favorable response is most likely. Do not use high pressure, but emphasize at all times the advantages in style and service of your product. Be armed with trade literature to make a convincing presentation. And above all, do not rely on extemporaneous salesmanship; plan your sales talk in advance.

And the last item of importance is the knowledge of the principles of salesmanship. Size up the prospective customer. Is it a single man or woman or a married couple? Are they young people or elderly folks? And then determine your sales appeal.

Don't be aloof. Put human interest into your sales talk. Tell the personal advantages of the product. Try to get the prospect to talk by asking questions. In this way, you will be able to ascertain his feelings on the subject. Then tie your talk in with his feelings. Answer his questions simply and with interest, but keep up your own prepared appeal. Make the appeal stronger and stronger as you go along. And know when to stop. It is silly to keep up your attempt to sell when the customer is ready to buy. Overtalking may arouse new doubts.

1. Be stable and professional in your poise.
2. Meet the customer's needs.
3. Know how to talk and when to stop. Talk distinctly and slowly.
4. Be self-confident and courteous.
5. Be neat.
6. Be enthusiastic about your product.
7. Listen attentively to the customer.
8. Keep smiling through; keep cool.
9. Respect the customer's viewpoint.
10. Keep all your promises.
11. Avoid knocking rival products and services.

Fig. 18-2. A few important salesmanship traits

Carry out faithfully every commitment made during the sales talk. Have confidence in your ability. No one is a born salesman. We all learn if we attempt to improve ourselves intelligently. In Fig. 18-2 are listed a few of the important traits to develop. Concentrate on developing them.

19

Service Charges and Policy

Operating at a Profit. Well, you're in the servicing business and you want to stay there. However, regardless of what the volume of service may be, you will have to make a profit out of each job in order to stick. There is the silly story of the man who bought electric fans at $12 apiece but sold each one at $11.98. When asked how he could remain in business he replied that he lost 2 cents on each fan but sold so many that it made up for the minor losses. It simply does not work that way.

There are many factors that you must keep in mind which will spell profit or loss. If you overlook any of them, your career will soon end. All of them add up to the price you will charge your customer for services rendered. So we can reframe the question: How much shall I charge for any servicing job?

Factors Involved in Estimating Servicing Charges. One factor that affects your charge is the competitive price. You can assume that some nearby serviceman is just as competent as you are. If he is underpricing you by a considerable margin, you may have trouble building up your business. Don't worry too much about this, though, because it is very hard for anyone to compare prices for service work when almost every job is different. Also, your competitors may not know their true costs and may not be charging enough to stay in business. There is no point in meeting competitive prices if you all go broke as a result.

The key to lower prices is increased volume of customers. If you improve your servicing technique so as to reduce labor time and if you carry on an active go-getter campaign, the increased business will sustain you even at a lower net profit per service job.

Where there is no competition, you can increase the per cent of net profit. But even here you must conform to fair business practices. It can prove fatal to the confidence of your customers if they feel that you are charging unfair excessive fees for no other reason than that there is no one else to whom to turn. It will set up a backlog of bad will that might ruin you if a competitor enters the area of your coverage.

Parts. The first factor to consider in a service charge is the cost of replacement parts. No doubt you will stock up on parts that have been purchased by you at wholesale prices. Obviously, there is no profit in charging the customer exactly what you paid for the parts. How much above cost must you charge? It is customary to bill your customer at list prices for any parts. You are entitled to such a price, because you have bought in quantity and stocked parts and are selling one unit at a time.

Labor. Another factor that enters into your service charge is labor cost. If you simply make a small profit on replacement parts and consider that your charge, you might as well get out of the service line and become a parts jobber. No, you must charge for the labor involved in the repair work.

Hourly Rate. If you were employing a serviceman to work for you, you would have to cover his salary by including it in the fee. You could easily determine the labor charge by dividing his weekly salary—let us say $80—by the 40 hours that he works each week. That gives a labor cost of $2 an hour. If he worked for 1½ hours, his labor would be worth $3. You are selling your employee's labor as a commodity and are entitled to a fair profit on it. Such a fair profit is about 20 per cent, or one-fifth, of the labor cost and is added on to the customer's labor charge. In our example, the labor cost is $3, your profit is ⅕ of $3, or $.60, and the customer's labor charge is $3.60. If you do your own servicing with no employee assistance, the labor charge would then be the same, or $3.60. Simply assume that you are employed by yourself.

Final Charge. The $2 hourly rate is used here only as an example. The actual rate that you use for yourself may be higher or lower, depending on your locality, experiences, ability, and competitive rates. Start a little low, so you can give yourself a morale-boosting raise now and then, just as if you were working for someone else.

Many servicemen adopt a policy of adding the list price to the labor charge, and letting that be roughly 60 per cent, or three-fifths, of the complete customer bill. To find the complete charge, divide the charge for parts and labor by 0.6. This is the same as multiplying parts and labor charges by ⁵⁄₃. Take the example of a part that lists for $.80. If it took you

$1\frac{1}{2}$ hours to find the defect and repair it, the labor charge would be $3.60. Therefore, the parts and labor charge is $4.40 ($3.60 + $.80), which is 60 per cent of the total charge. The latter is found by multiplying $4.40 by $\frac{5}{3}$. This turns out to be $4.40 × $\frac{5}{3}$, or $7.33, which you would round off to $7.50.

Overhead. No doubt, you are wondering what the 40 per cent of the total charge covers. Too many young and enthusiastic servicemen just starting out tend to make the service charge cover parts and labor with a little markup for profit. But they are forgetting that there are costs to be met which seem unrelated to the job. These invisible items are called overhead costs. There are expenses like rent, heat, phone charges, lighting, car equipment, taxes, advertising, lost time, vacation, insurance fees, accountant's fees, and many others, which must be paid for. In addition you must show a net profit at the end for expansion, replacement, and other incidentals.

Where can you cover overhead expenses and net profit if not in the service charge? Overlook these items and you will soon be out of business. Usually, the 40 per cent is divided into 35 per cent for overhead and 5 per cent for net profit.

The formula just presented is not a rigid one. It is simply a guiding principle around which to operate. On small jobs, multiplying the parts-labor cost by 2 instead of $\frac{5}{3}$ will be fairer to you, since it costs just as much to get a small repair job as a big one. You will have to study your own setup carefully and keep exact records to work out a successful solution. Figure 19-1 shows graphically the main factors that influence your

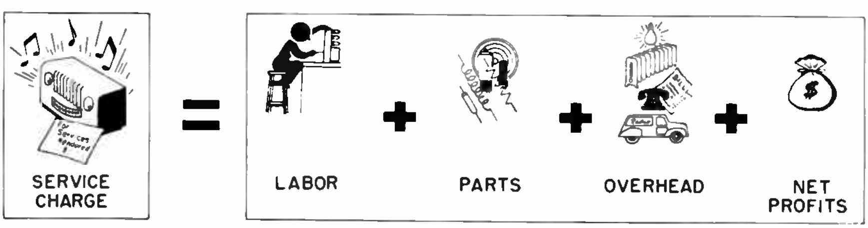


Fig. 19-1. What goes into service charges

charge. These may be affected slightly by the extent of competition and by the volume of work you do. The more jobs you handle per day, the less overhead there is to charge against each one. Your job is to work out a successful formula with these factors for your own shop and your community.

Before You Begin Service Work. Never start a job before the customer knows approximately what the charge will be. Do not become the victim of a customer who refuses to pay, after services rendered, because he considers your bill excessive. The prior estimate will help to eliminate such an eventuality.

Of course, many servicemen feel that the quotation of a price will immediately have the effect of driving away the customer. There is a certain element of truth in that. But there are ways to overcome the complaint that you are bleeding the customer. First and foremost is the fact that you have built up a reputation for efficiency and honesty. That is your strongest argument.

However, there are other ways. It is unfortunate, especially with small table-model radios, that the potential customer cannot see how a large bill can be applied to a small piece of equipment. The same bill applied to the repair of a car would meet little or no objection.

Your job is to explain to the customer in simple and dignified terms the facts about a successful business. Point out to him how low the repair cost is when compared to the number of years of uninterrupted pleasure he got from his radio receiver. Briefly explain the basis on which you determine your estimate. Tell him that he may obtain the services of a competitor who may quote a lower price, but he must do so by using inferior parts or lower-priced and less skilled labor. Unless your customer deliberately intends to cheat you, he will recognize and accept the fairness of your point of view.

There is nothing wrong in losing a job because your price is too high for the customer. You should expect this and not feel bad about it. Reducing your charge lowers your prestige; furthermore, too low a price means that you are working for nothing or even taking a loss. Let the price chiselers go to your competitors.

Accuracy of Estimates. The estimate must never be permitted to become a strait jacket. It is impossible to hit the actual charge squarely on the nose every time. You may find that the time consumed in locating a defect turns out longer than you had at first imagined. Or after replacing an obviously defective part, you may find that other previously undetected conditions show up. Therefore, you must make sure that both you and the customer realize that the quoted estimate is a rough one. Of course, if the charge runs appreciably higher than the estimate, you will want to call the customer and get his approval before completing the job.

It is a good idea to have a sign posted where the customer can see it like the one shown in Fig. 19-2. Be sure to call the attention of the customer to this policy. It is also advisable to establish a reputation for fair practices by extending any savings on the estimated price to the customer. But be sure that you are not overlooking some item of your own cost in this regard.

OUR POLICY

1. Our estimates are based on our first analysis of possible defects and are not necessarily final.
2. If the service charge exceeds our estimate by more than 10%, we shall notify our customer and ask for authorization to proceed.

Fig. 19-2. A typical policy sign

Handling Those Who Shop Around. There is another condition which you must avoid. Some customers have a habit of taking their set to several servicemen for estimates. You spend your valuable time locating defects in order to make an estimate, only to find that it was all in vain. Some servicemen meet such occurrences by charging a flat rate of a nominal sum for estimating the cost of a repair job. If the customer then leaves the set for such repair, the estimate charge is dropped. To a certain extent, such a policy will be determined by competitor policy. You determine what is right for your own location.

Tagging the Repair Job. It is a good idea to give your customer an indication of your fairness by attaching a tag to the set, itemizing his cost. State the cost of labor and overhead involved. If then the customer has a gripe, you can explain and justify the breakdown of items, provided your charge has been an honest one.

To Guarantee or Not to Guarantee. The question of guaranteeing your service work definitely affects the factor of overhead. The customer expects his repaired set to give normal operation for an indefinite period of time. And he has a right to feel that way. However, you know that there are many parts in a set which can go bad. To make matters worse, these parts do not all go bad at the same time. You may replace a defective condenser and get a set working fine, only to have a different condenser go bad a month or two later. Are you to be held responsible for this new defect? Obviously not!

Yet the customer has a right to be assured that the first repair job performed by you was a satisfactory one. He must also realize that your replacement condenser will not last until the end of time, but also has a life of its own. You cannot be held responsible for its indefinite good behavior. Herein lies the basis of your guarantee policy.

The least that you can do is guarantee your own service work and parts to the same extent as your competitors. To avoid frequent making good on your guarantee and thereby increasing your overhead, use the best parts that you can purchase and do first class workmanship. It'll pay off in the end.

It is a good idea to have a guarantee statement on the back of your itemized bill. A typical statement used by one successful serviceman reads as follows:

GUARANTEE

The parts used by us are of the best quality. We guarantee our workmanship and parts against breakdown for 90 days after installation by us. If within this period of time a part installed by us becomes defective, we will replace said part with a similar new part at no charge to the customer, provided that no one else has tampered with any parts within the set or that no one has subjected the receiver to other than normal use.

We do not guarantee this receiver against breakdown of parts other than those replaced by us. We do not guarantee this receiver against breakdown of parts other than those replaced and listed on this bill.

As a little booster for yourself, if you feel that the parts you use are of the finest quality, you can even extend this guarantee to a period of 6 months or more. Do not argue with your customer if he comes in to make you stand behind your warranty. Show good faith by following through. You will be establishing a steady customer as well as a walking advertisement.

Some servicemen have worked out another angle. They give a guarantee similar to the one stated above. But they inform the customer that this repair job was like plugging a leak in a weakened dike. It will hold for a while, but a new leak or defect can be expected soon. With the customer's permission, they will overhaul the entire set, replacing all bad and weak parts. Then they follow through with an unconditional guarantee of the entire receiver for a period of 1 year. This policy is especially desirable to the customer when the receiver is a large, expensive piece of equipment with a definite furniture value.

Cash or Credit. As a serviceman whose profit margin is small, you will need cash at all times to take advantage of special contingencies and special purchasing opportunities. To have that available cash, you should avoid doing service work on a credit basis. Like many others, you will be tempted to capture trade from competitors by an overextended credit policy. But better beware. Many a serviceman has gone on the rocks with large outstanding unpaid debts. Your success is measured by profit collected.

Aside from the risk of loss, there are many other accompanying headaches. When the customer gets his prized set back without paying, he is much more likely to gripe about the repair job you did. Some hope thereby to get you to reduce your charge in a compromise gesture. A customer readily forgets his previous willingness to pay a fair price to get the set fixed.

Further, even if eventually you are paid by a reluctant customer, you will waste time in collection procedures. Wasted time, as you remember, increases your overhead costs. It is time devoted to a customer for which you will not be paid. And where you call in the services of a collection agency, there will be even more tangible costs to you.

So, if possible, try to confine yourself to a cash business. Be firm in maintaining it. Place a sign in large letters over your interviewing counter, like "ALL SERVICE FOR CASH."

Unfortunately, such a 100 per cent cash policy is often impossible to follow. Special marketing areas, the nature of your customers, unique situations like a set received by a maid when the customer is not home, and the policies of your competitors may compel you to carry on a certain amount of credit business. When such is the case, you simply must have a definite credit policy.

First, you should know the name and address of the person to whom you are granting credit. In addition try to determine his credit status. From neighborhood stores or the local bank, find out how he has met previous obligations. Does he own property or is he a tenant? Has he been long in the community? Decide how great the risk is and act accordingly.

A second important point is that you obtain a dated receipt for itemized work done from the customer seeking credit. But where the claim goes to court, you must have real evidence of services rendered. Such a receipt will minimize the tendency of unethical persons to deny that you did any work for them. They will be less likely to withhold eventual payment.

A third important thing to remember is that credit must not be left indefinitely outstanding. Avoid the situation where the customer promises to pay you later, again and again. Where credit is granted, set a precise date or dates for payment. You will then know all the sooner who is stalling.

Collecting Delinquent Accounts. You're bound to run into delinquent accounts if you are setting up a credit system. Here, especially, you must have a definite policy that is prompt, regular, and tactful. More is needed than a hope and a prayer. The longer you delay action, the less likely you are to be paid in full.

Do not assume immediately that the delinquent customer is a cheat. Many of us, who are extremely honest, develop Freudian subconscious blocks, especially when it comes to paying bills. We intend to pay but put the painful task off until the last moment.

So go easy at first. Drop a couple of form cards in the mail, reminding the customer of payments due. If this brings no response, keep cool. Write a letter similar to the following:

> Dear Mr. Jones,
>
> Did you receive our bill of June 6, 19—, for radio service work rendered? The balance due is $8.60. An addressed envelope is enclosed for your convenience in making the payment.
>
> Very sincerely,
> John Doe

Wait for about two weeks. If payment is not made, be friendly but a bit more firm. Send a second letter:

> Dear Mr. Jones,
>
> Two weeks ago we called your attention to the unpaid balance of $8.60 for servicing your radio.
>
> If you need more time or would like to pay it in two installments, won't you get in touch with us at once?
>
> If failure to remit payment has been a matter of oversight, we would appreciate your taking care of the matter as soon as possible.
>
> Very sincerely,
> John Doe

Wait about a week or two more. If payment is still not made, you must tactfully threaten your man. He is still a customer, so do not let fly with insulting remarks. Send a third letter:

> Dear Mr. Jones,
>
> This is our third letter to you regarding our bill for $8.60. Please settle the claim in the same good faith as we extended credit to you.
>
> We know that you are anxious to avoid legal steps, just as we are. But we have no alternative unless we hear from you within one week.
>
> Very sincerely,
> John Doe

Do not lose your head if payment is still not forthcoming. Call the man on the phone. He may lose resistance in voice-to-voice conversation, whereas a letter could be tossed unopened into the garbage pail. And finally, pay a personal call upon him. Failure to settle now is the final assurance that he is not minded to do so at all. Firmer action is needed.

You may take the customer to the Small Claims Court. There is a small cost for such action. But if judgment is granted to you by the court, this cost will be added to the receiver-repair charge. Court actions waste a lot of your own valuable time, however.

Sometimes, you will turn the matter over to a collection agency rather than to the court. Although the agency takes a cut on the collection, they will spare you wasting time in court action.

Keep one thing in mind at all times. Do not be tempted to take legal action or collection-agency action too soon. Sincere wishes to pay coupled with embarrassing financial circumstances may have created your delinquent customer. Save him further humiliation, if you can. Give him any face-saving method to pay off his debt honorably. Such consideration may endear him as a good customer at later times. Where hardship is evident, give consideration to marking the bill paid and presenting it to the customer as a good-will gesture; you lost nothing, and may gain a lifetime friend and booster.

The Storage Problem. A problem remotely related to delinquent accounts is that of the customer who brings in a set to be repaired and then seems to forget about picking it up. You have the headache of storing it, perhaps in cramped quarters. Then, perhaps long after you have disposed of the forgotten treasure, the customer turns up for it and demands payment.

Do not become the victim of such a mishap. Establish a definite policy on this score at the start. Place a large neat sign over your customer-interviewing counter reading as shown in Fig. 19-3. Of course, it is usually

STORAGE POLICY

We assume no responsibility for anything left beyond 30 days after pickup.
After 30 days, uncalled-for items are subject to storage charges of 25¢ per week.
After 6 months, uncalled-for items will be sold or otherwise disposed of.

Fig. 19-3. A typical storage-policy sign

advisable to set a date for the customer to pick up his set or to have it delivered to his home. If on that date he fails to show up or fails to be at home to receive it, drop him a card restating the storage policy.

Check That Check. In this modern day and age, many payments will be made to you by check. If the customer is relatively unknown to you, ask him to make the check out to *Cash* rather than to you or your shop. The reason for this precaution is that checks made out to cash are usually collectible with the aid of the law. Checks made out to you or your shop name that do not clear through the banks must be handled through time-consuming collection methods.

Sometimes, the check is already made out to you or the shop. If it is returned with "insufficient funds" on it, do not return it to the customer. This invalid check is your evidence of payment due to you. Return the check to the bank. When funds are deposited by the customer, the bank will honor the check.

Where the customer gives you a part payment by check for services, be sure to get a signed statement from him that payment is in part for the full amount (stated and dated). Do not write "payment for radio service" on the check. If anything, write part payment for full stated sum.

SUMMARY STATEMENT

The field of radio service is a much-maligned one. Many customers have prejudgments that you are out to "do" them. Combat that attitude by being friendly, professional, and honest in your dealings.

But do not let skeptical customers drive you into unsound business policies to attract them. Be firm in your policies. Explain your position to those who question you. The fair and honest ones will understand and go along with you. As for the others, it is better to lose them sooner.

20

Record Keeping

The Need for Keeping Records. Your business success, like all business, depends on your ability to do those things which will terminate in a net profit for you. Similarly, your success will depend on your avoiding those things which lead to excessive loss. It is as simple in principle as that. The trick, however, is in conducting your practical affairs from day to day so as to achieve that goal.

To do so requires constant and alert planning. And to plan in an orderly, mature way requires that you keep records—daily, weekly, monthly, annually. Of course, the keeping of records must not be an end in itself. It would be ridiculous for you to spend hours on records for a small, growing business. The records should be only so detailed as to help you plan. Naturally, the greater the volume of your business, the more records you must keep.

Generally, there are about five good reasons for keeping records: First and foremost is the record of profit and loss in order to guide your future activity. A second good reason is to control your buying, stocking, and selling of parts and materials. A third reason is to have at all times a record of payments due you as well as a record of your own credit debts. A fourth reason is to have information immediately available for making your annual income tax statement. And finally, you must have systematic records for survey when applying for credit extension.

You cannot succeed without records, but you can make them as streamlined as possible, so that they are useful without being burdensome.

Kinds of Records. You will have to keep records of your customers, their sets, and repairs made for them. By doing so, you will be prepared to some extent when called by an old customer. You will have a history of what has been happening to the set. You will know what tubes and parts to bring.

Another record that is essential is the individual service tag and guarantee. This record enables you to keep track of whose set is on the shelf, among many others, and finally serves as a reminder to the customer of you as the serviceman who repaired his radio.

A third type of record is the financial record. This may be kept daily, weekly, monthly, and annually. It is designed to inform you of payments made to you, payments owing to you, payments made by you, and payments you still must make. In this way, you can tell the financial degree of success with which you are operating. Related to these records is your checking account record which you must examine monthly when your bank statement arrives.

Another series of records essential to wise planning is the inventory record, checked monthly. Here, you keep tabs on parts that you have used up during the month, the parts that you still have on hand, and the parts that you must reorder. This must be a live inventory, up to date. The natural tendency is to delay in making the record. As a result, time is lost in waiting for some needed part, and a customer is annoyed by the delay.

A fifth record that must be kept is the one that will enable you to make out your income tax statement at the end of the year. If kept properly, the latter chore is easily handled. If not, look for a headache and a nightmare.

You may find other records useful in your planning. Use them if they aid in that purpose. But do not keep records for their own sake. Let us look more closely at those briefly described above.

It is a good idea to keep repair records on file in alphabetical order by last name of customer, for ready reference. They will enable you, among other things, to avoid responsibility for someone else's service work and to meet the challenge of being blamed for repair work previously done by you when a new defect develops.

The second record is the service tag and guarantee. This too, should be filed, since it gives the breakdown of parts and labor for the service charge. These tags can also serve to aid in making your monthly entries of income.

Financial Control Records. Let us now direct our attention to the keeping of a financial record. Everything that you do will depend upon how you keep and interpret this information. This record is the pulse of your business. It will dictate what changes in policy are necessary. It will point up areas in your work that need new emphasis. And yet, the record itself is fairly easy to keep—particularly at the start. When your business has grown very large, you will need an accountant for a double-entry system. But let us begin slowly.

The monthly profit-loss sheet, shown in Fig. 20-1, is recommended as a

Profit-Loss Statement

Period from March 1, —— to March 31, ——.

SALES AND SERVICE INCOME		$2,200.24
COST OF GOODS SOLD:		
(1) Cost of materials on inventory	$3,600.98	
(2) Purchases	600.63	
	4,201.61	
(3) Cost of materials left	3,600.44	
(4) Cost of goods sold	601.17	601.17
GROSS PROFIT		$1,599.07
EXPENSES:		
(1) Rent	125.00	
(2) Electricity	20.10	
(3) Heat	11.23	
(4) Telephone	31.12	
(5) Car expense	60.00	
(6) Advertising	29.72	
(7) Insurance	36.25	
(8) Wages	600.00	
(9) Depreciation	60.00	
(10) New equipment, etc.	60.00	
(11) Taxes	4.80	
(12) Lost time, bad debts, etc.	16.00	
Total	$1,054.22	1,054.22
NET PROFIT		$544.85

Fig. 20-1. A typical monthly profit and loss statement for a two-man service business. Item 8 includes your own regular wages drawn for the work you do as head of the business

typical way to watch your financial health as you go along. The sales and service income represents the total money intake for the month. The net profit that you can credit to your business is going to be the sales and service income minus all your expenses incurred during the month.

The first deduction from your gross income is the cost of materials and items used. However, during any one month, you will not only purchase new supplies but will use up materials carried on your inventory during previous months. To get the cost of materials for the month, add the cost of materials purchased previously but still on inventory to the cost of materials purchased during the current month. Then subtract from this total the cost of materials left on inventory at the end of the month.

The other expenses to be deducted from the gross income are rent, operating costs, taxes, etc. These are listed in Fig. 20-1. Your net profit is the difference between the gross income and all costs and expenses.

Some of the expenses are not paid monthly. For example, taxes and insurance are paid annually. However, you should break them down to monthly figures. This procedure will enable you to evaluate your business at shorter intervals.

The profit and loss statements show how your business is going. But it does not tell the story of the value of your business. To show your assets, liabilities, and net worth of your shop, an annual balance sheet should be made up. You may have to show such a statement if you should seek a loan for expansion or some other purpose. A typical annual balance sheet is shown in Fig. 20-2.

Assets				Liabilities and Net Worth	
Current Assets:				Current Liabilities:	
Cash on hand and in bank		$1,800		Accounts payable	$1,200
Accounts receivable		250		Notes payable	500
Merchandise and parts inventory		1,740.42		(B) Total current liabilities	$1,700
Total current assets			$3,790.42	NET WORTH (A — B)	$4,800.42
Fixed Assets					
Furniture and fixtures	$930				
Less depreciation	140	$790			
Shop equipment	$1,500				
Less depreciation	300	$1,200			
Delivery equipment	$1,000				
Less depreciation	280	$720			
Total fixed assets			$2,710		
(A) Total assets			$6,500.42		

Fig. 20-2. Typical annucl balance statement for a business

The balance sheet may serve another important function: It can indicate the manner in which you have been investing the profits from your business. In that way, you can tell where a change of business policy is necessary. Your business is on a sound basis, without doubt, when your monthly net profit and your annual net worth is maintained or grows. If it does not, analyze your monthly profit and loss statement for the source of decline, and give that your immediate attention.

Inventory Control. The control of inventory is most important in the success of your business. To give efficient service, you must have materials on hand at all times. Yet you cannot overstock, because that would mean you were tying your assets into items that did not of themselves produce profit. Overstocking would also prevent your taking advantage of periodic price reductions.

To have a wise control of inventory stocking, you must know how many items of one kind you have on hand at any time, how many are on order, and how rapidly they are being used up. The simplest method to achieve this information is by means of an inventory card that is kept live at frequent intervals. In Fig. 20-3 is shown a typical inventory card for this purpose.

Item	Condensers—0.1 mfd/400v	Unit	one	Unit cost	$.12
Supplier	Steuben Distributors	Minimum	8	Maximum	35

On order	3-10 27	3-16 19					
Cost	3.24	2.28					

Date	In	Out	Bal.	Date	In	Out	Bal.	
3/11	27		35					
3/12		2	33					
3/13		4	29					
3/14		7	22					
3/15		6	16					
3/17		8	8					

Fig. 20-3. A typical material inventory card. After "Unit," indicate if sold one at a time, by the foot, quart, pound, etc.

The inventory card shows the maximum and minimum number of items to keep on hand. The indication of unit cost will indicate when to take advantage of a materials price reduction. At all times, you will know when and how many items have been ordered and the total cost. In our figure, it can be seen that 27 condensers were consumed in 6 days. Perhaps that would indicate a need for increasing the maximum and minimum figures.

If you have an employee, it is a good idea to have one person in charge of inventory control. To have more than one person in charge is to invite error, forgetting, and other breakdown experiences.

Where sales items such as receivers are concerned, inventory control is very important. Generally, you must make a drive to push stock that has been around for 60 days. Of course, if it is an item that will give you a heavy gross profit, you can wait a bit longer. But remember, no profit is derived from inventory. Profit results from sales. Push sales hard!

Income Tax Information. As a result of profit from your business, you will have to pay Federal and state income taxes. The tax laws have been changed and amended from year to year. Your job is to keep abreast of the laws. Good advice can save you many dollars. The proper maintenance of the financial records just described will be of invaluable assistance to you.

It is suggested that you invest in the services of a good accountant in filing your tax returns. There are many legitimate savings that you can make but about which you will not know. Let the expert give advice.

There are many things that you can do to assist in making a wise return. First, find out which forms you must fill out. Sometimes making out an alternate form will save you money.

Do not wait until the last minute to make out your return. Failure to take advantage of some tax-saving item in one fiscal year is lost forever. You cannot make the claim in the following year.

Be sure to deduct for depreciation of your equipment, your business car, and your property—if you own it.

Keep an accurate live record of your inventory. The government permits you to figure the value of your inventory at cost or market value, whichever is lower. Proper use of the inventory card suggested in Fig. 20-3 will aid you in deciding which one to choose.

Keep records of repairs and maintenance as a deductible yearly expense. The government will allow this, but improvement costs must be apportioned over a number of years. Keep separate records of each item.

Keep records of petty cash. In themselves, they are small and insignificant. However, they become sizeable over a year. Take advantage of these petty cash expenses.

Do not wait for a bad debt to be paid. Deduct it during the year in which it occurs. Otherwise you may lose it as a deductible item.

Try to pay all current bills during the fiscal year so that you may deduct them from the year's income. It will reduce your tax for that year.

And finally, keep all records—invoices, canceled checks, receipts, etc.—in a systematic way. You may be challenged to prove statements made on your tax form. Be ready with substantiating data to avoid a headache.

FINALE

We have explored the field of radio servicing from both the technical and business angles. Sufficient information has been given to launch you and help you over the pitfalls that have trapped others. You will no doubt use the information in your own way for your own local needs. The emphasis has been on problems generally encountered.

Have faith in what you are trying to do. Move slowly and think your way through. The prize is worth the effort. Think in terms of training yourself further and expanding into the field of television. Much of the information given will be of use in that endeavor. Good luck and happy days!

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