THE ABC'S OF SERVICING

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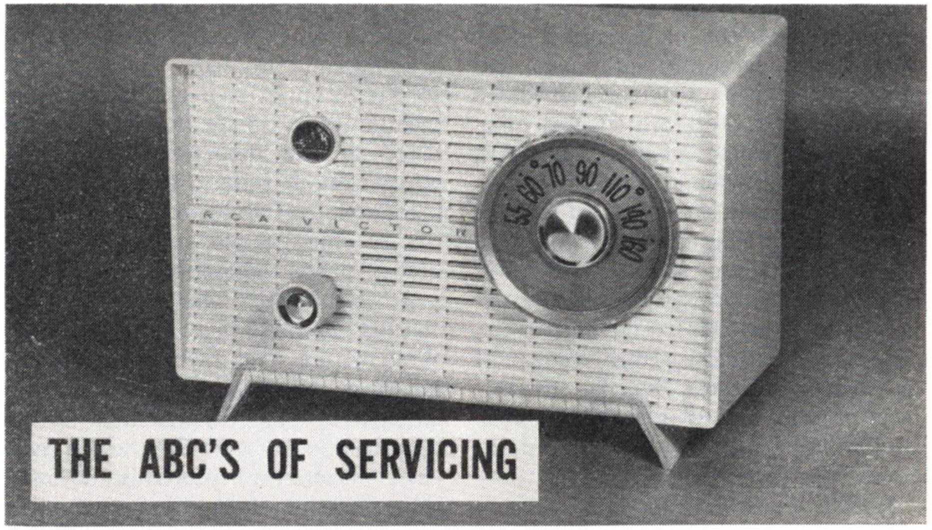

THE ABC'S OF SERVICING

REGARDLESS of what type of electronic career you are planning you will unquestionably deal with radio receivers at least part of the time. Obviously, if you decide to go into radio and television service work you will receive many radio receivers to repair.

If you are planning to go into radio and television communications, you will still have to repair a radio receiver occasionally. For example, practically every radio or television station keeps one or two receivers around.

There may be one or more radios in the offices of the station executives. You would feel very embarrassed indeed if you had to call in a serviceman to fix one of these receivers.

The two-way radio communications stations used on airplanes, on boats, and on railroads as well as by police and fire departments are other examples of radio receivers a technician may be called in to repair. Even if you decide to become a technician in an industrial plant, you will still find occasions when you will be called on to service radio receivers. Furthermore, the fundamental ideas used in servicing radio can be applied to any piece of electronic equipment. Therefore, regardless of what type of work you expect to go into in your electronics career, you should spend a certain amount of time learning to service radio receivers.

PURPOSE OF THIS LESSON

First, as a beginner you must learn how to identify the various parts used in electronic equipment. One of the simplest pieces of electronic equipment is a radio receiver and therefore this is a good place to start.

The second and perhaps even more important purpose of this lesson is to start teaching you a systematic procedure that you can use to service all electronic devices. Most modern radio receivers have only 5 tubes if they are vacuum-tube receivers and somewhere between 5 and 7 transistors if they are transistorized receivers. We call each tube, or each transistor, and the parts associated with it, a stage. The average stage has five or six parts besides the tube or transistor. In a five-tube receiver, this would mean about 25 or 30 parts in addition to the tubes, and in a transistorized receiver maybe as many as 40 parts. However, let's consider a more complex piece of electronic equipment. The average television receiver has about 20 stages and therefore several hundred parts. Some complex pieces of electronic equipment have thousands of parts. Needless to say, if one of these parts breaks down, it would be an almost endless task to try to find the defective part by checking each part, one at a time. You must have some systematic procedure that will lead you from the effect that the defect produces to the cause of the trouble. We call this procedure *effect-to-cause reasoning.*

Before going ahead let's take a quick look at what we mean by effect-to-cause reasoning.

EFFECT-TO-CAUSE REASONING

The successful use of effect-to-cause reasoning in servicing electronic equipment depends upon dividing the equipment into sections. For example, consider a television receiver. The average TV set has about twenty tubes. However, the set itself can be divided into about five or six sections. Some of the sections have only one stage, others have three or four stages. Each section has a definite job to perform.

If a defect develops in the receiver, the way in which the receiver performs will usually indicate the section in which the defect has occurred. Therefore by noting carefully the performance of a receiver, you can usually isolate the defect to one section immediately. Now, if the section of the receiver in which the defect is located happens to be a small section with only one or two tubes, the job of finding the defective component will be fairly simple. However, if it is in a larger section with three or four tubes, finding the trouble may still present some problem. Then, the next step is to apply professional servicing techniques to isolate the defect to one stage in the defective section. In other words, if there are four stages in the defective section, you isolate the trouble to one stage. Once you have isolated the trouble to one stage, you concentrate on the individual circuits in that stage. There may be three or four circuits; by taking a few measurements with a voltmeter or an ohmmeter, you can usually isolate the trouble to one circuit. In each circuit there are probably no more than a few parts. It is a simple matter to test these parts one at a time if necessary to find the defective one.

You can see how much simpler it is to service a 20-tube TV receiver by using effect-to-cause reasoning than it would be to start servicing the set by checking one part after another.

The successful use of effect-to-cause reasoning in servicing electronic equipment is based on the technician's understanding of how the equipment should work and how a defect in one circuit will affect the operation of the equipment.

You will find this lesson extremely important in your electronics career. Here you learn something about effect-to-cause reasoning. You will learn how to identify the major parts in a radio receiver. You will see that receivers using transistors are not very different from receivers using tubes, and that the major parts used in the two are similar. In the following lessons you will study in detail how the various parts found in electronic equipment work and in later lessons how they are used together to form stages.

Analyzing the Modern Radio Receiver

In order to use effect-to-cause reasoning in servicing a radio, you must understand what happens to the signal from the time it is picked up by the antenna to the time it comes out as sound from the loudspeaker. This is what we will study in this section.

Most of the first radio receivers built were comparatively simple devices. The incoming modulated rf signal was amplified by one or more rf amplifiers, the signal was then fed to a detector stage that separated the audio from the modulated rf carrier. The detector was followed by a number of audio stages, which increased the amplitude of the audio or sound signal before it was applied to the reproducing device, which was either headphones or a loudspeaker.

This type of receiver is called a tuned-radio-frequency receiver, abbreviated "trf." Modern radio receivers are somewhat more complex than the trf receiver. The trf receiver will not give satisfactory performance today in the crowded broadcast band where there are many high-power stations operating.

Modern receivers use a circuit called the superheterodyne circuit (pronounced Soo-pur-het-ur-o-dine and often abbreviated superhet or super). The superhet has many advantages over the trf receiver as you will see.

BLOCK DIAGRAMS

Frequently it is convenient to study the operation of a piece of electronic equipment by using block diagrams rather than detailed schematic diagrams. You already know that a schematic shows all the electrical connections in a piece of electronic equipment. A block diagram, on the other hand, is much simpler. The various stages are simply represented by a square. By using this type of diagram we can study the piece of electronic equipment and consider the general purpose of each stage in the equipment, and learn how the equipment operates, without going into the details of each circuit used in each stage.

The block diagram of a superheterodyne receiver is shown in Fig. 1. Let us follow the signal through the receiver from the antenna to the loudspeaker.

THE BASIC SUPERHETERODYNE RECEIVER

In an earlier lesson, you learned that the radio waves sent out into space by the radio transmitter are made up of two signals—a carrier signal and an audio signal. The frequency of the carrier is very high; we say it is a "radio frequency." This is abbreviated rf. The audio signal has a lower frequency, corresponding to the actual sounds being produced at the microphone. The audio signal is combined with the rf carrier at the transmitter. We say the rf carrier is "modulated" by the audio signal.

This modulated rf carrier is picked up by the antenna of the radio receiver. The antenna feeds it into a stage called the mixer-first detector. Another signal is also being fed into the mixer first-detector. This is another rf signal, which is generated right in the receiver. The stage that generates this second signal is called the "rf oscillator" stage. (Any stage that generates a signal is called an oscillator.) This stage is also called the "local" oscillator, because it generates the signal at the receiver, or "locally."

These two signals, the modulated rf carrier signal and the rf signal from the local oscillator, are fed into the mixer where they are mixed together. When you mix two radio signals in a stage such as this, you will have four signals in the output of the mixer. These are: the original modulated rf carrier, the signal from the rf oscillator, one signal having a frequency equal to the sum of the two frequencies, and another signal having a frequency equal to the difference between the two frequencies. Both the sum and difference frequencies will be modulated with the original audio signal. In the output of the mixer is a circuit which rejects all signals except the one having a frequency equal to the difference between the two signals. This difference frequency signal is a radio frequency signal which is modulated by the original audio signal. The difference signal is called the intermediate frequency signal, which is usually shortened to i-f signal.

This first stage is also sometimes called a "converter" because it converts the incoming signal into an i-f signal.

The modulated i-f signal is then fed to a stage called the i-f amplifier. There it is strengthened, or amplified. The modulated i-f carrier signal is then fed to a second detector where the audio signal and the i-f carrier are separated. At the output of the second detector we will have only the audio signal. The audio signal is then fed through two audio stages where it is amplified further. The first of these audio stages is called the first af stage, and the second one is called the audio output stage or simply the output stage. The signal from the output stage is used to drive the loudspeaker, which converts the audio signal into sound.

The big advantage of the superheterodyne receiver is that it has much better selectivity than a trf receiver. For example, suppose there are two broadcast-band stations, one operating on a frequency of 1000 kc, and the other operating on a frequency of 1010 kc. This 10-kc separation between the two stations is a frequency difference of only 1%. It would be extremely difficult to design tuning circuits that could separate the two signals. However, when

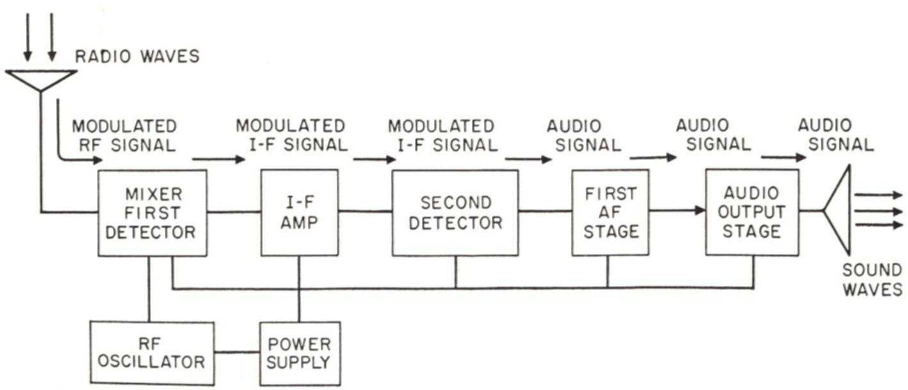

FIG. 1. Block diagram of a superheterodyne receiver.

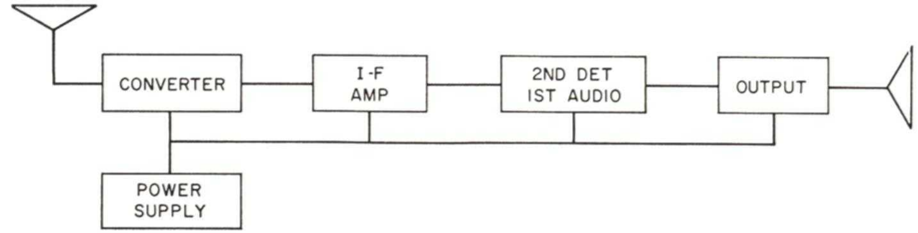

FIG. 2. Block diagram of a modern 5-tube receiver.

these signals are mixed with the signal from a local oscillator, the carrier frequencies are converted to a lower i-f carrier frequency. If the i-f frequency is a 100 kc, the 10 kc difference in frequency between the two signals, is now a difference of 10%. It is much easier to separate two signals differing in frequency by 10%, than it is to separate signals differing in frequency by 1%.

The superheterodyne has another big advantage. It is made so that the mixer stage and the oscillator stage are tuned at the same time. When we say a stage is "tuned" we mean it is adjusted for a particular frequency. Since these two stages are tuned at the same time, it is possible to keep the difference frequency constant regardless of which frequency the receiver is tuned to receive.

For example, they can be adjusted so that there is always a 100-kc difference in frequency between them. If the mixer is receiving a modulated rf signal having a frequency of 500 kc, the local oscillator will be generating a signal of 600 kc. The difference frequency will be 100 kc. Then, when the mixer is receiving a signal of 1500 kc, which is at the other end of the broadcast-band, the local oscillator will be generating a signal of 1600 kc. The difference frequency will still be 100 kc.

Since the output of the mixer-first detector in this case will always be 100 kc, the i-f amplifier, which is the next stage, can be designed to operate at one frequency. An amplifier that is designed to operate at a fixed frequency can be built with higher gain than one that must be tuned over a wide range of frequencies. Therefore the i-f amplifier in a superheterodyne receiver will have much more gain than the r-f amplifier in a trf receiver could have. Because of this fact it is possible to get a much higher gain in a superheterodyne with the same number of tubes. We have used 100 kc for the i-f frequency in this example because it is an easy figure to work with. Different i-f's have been used by receiver manufacturers, but a frequency of about 455 kc is used in most modern receivers.

THE MODERN VACUUM-TUBE RECEIVER

The block diagram shown in Fig. 1 has seven different stages. However, modern superheterodynes designed for broadcast operation usually have only five tubes in them. Manufacturers have designed tubes that perform more than one function in order to reduce the number of tubes required in the set from seven to five.

The mixer-first detector and oscillator are usually combined in one tube. Thus in Fig. 2 we see the first stage where only one tube is used to perform two separate operations, that of generating the local rf signal which is produced by the oscillator section

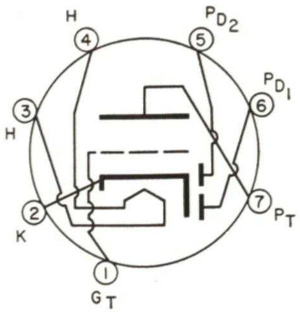

FIG. 3. Schematic symbol of the 6AT6 dual-diode-triode tube.

of the stage and the job of mixing the locally generated signal with the incoming rf signal which is performed by the mixer. This stage is usually called the converter.

The second detector in most superheterodyne receivers is a diode type of detector. The first af stage is usually a triode tube and these two tubes are usually combined in a single envelope. As a matter of fact, most tubes used in this stage are dual-diode-triode tubes. This simply means that there are two diodes and one triode in the same envelope. (Actually only one of the diodes is used in this type of circuit.) The schematic symbol used to identify the type of tube is shown in Fig. 3. Notice that the tube has a single heater, and a single cathode. It has three plates marked PD1, PD2, and PT. The letter P stands for plate and the letter D for diode. The triode plate is marked PT. This plate is drawn larger than the two diode plates.

TRANSISTOR RECEIVERS

Many modern radio receivers, particularly portable receivers, use transistors in place of vacuum tubes. Because transistors are small, rugged, operate on very low voltages and consume very little power, they are particularly suitable for use in portable receivers because the battery life will be much better than it would be in a vacuum tube receiver. In other words, the battery will last longer.

A block diagram of a transistorized portable receiver is shown in Fig. 4. Compare this with the block diagrams shown in Figs. 1 and 2. Notice that in general the block diagrams are similar. As a matter of fact, if you examine the block diagram of a receiver it would be difficult to tell whether it used vacuum tubes or transistors. This is the way it should be, because actually the stages perform the same functions. In other words, the oscillator in a receiver using transistors generates a local rf signal and the mixer mixes this signal with the incoming signal, just as it does in a vacuum-tube receiver. The general purpose of each stage is the same whether the stage uses a transistor or a vacuum tube. The circuit details are different. However, the purpose of a block diagram is not to show the circuit details, but rather to convey only general information about each stage and what it is designed to do. The transistor radio shown in Fig. 4 has all the stages found in the vacuum tube receiver except the power supply. The power

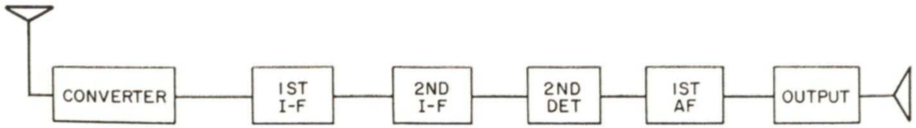

FIG. 4. Block diagram of a portable receiver using transistors in place of vacuum tubes.

is obtained from a battery. The set does have more i-f and audio stages, because a transistor does not have as much gain as a tube.

SUMMARY

At this point in your lesson you should have a general idea of what happens in the various stages of the superheterodyne receiver. You should remember that the incoming signal is mixed in the mixer stage with an rf signal generated by a local oscillator in the receiver. At the output of the mixer there are four separate signals: the original incoming modulated signal, the signal from the local oscillator, a signal equal to the sum of the two frequencies, and a fourth signal equal to the difference between the two frequencies. A special circuit in the output of the mixer selects the difference frequency signal and rejects the others. The difference frequency signal, which is modulated just as the incoming rf signal is modulated, is amplified by the i-f amplifier and fed to the second detector where the audio signal is removed from the rf carrier. The audio signal is amplified by the first audio amplifier and by the audio output stage. From the audio output stage the signal is fed to the loudspeaker. The loudspeaker converts the audio signal back into sound. The general purpose of each of the various stages in the receiver is the same whether the receiver uses vacuum tubes or transistors. Only the individual circuit details are different.

Now that you have studied in general the stages found in a radio receiver, let's see how a serviceman would look over a set.

Removing the Set for Servicing

A typical modern receiver is shown in Fig. 5. This type of receiver is called an ac-dc receiver because it can be operated from either an ac or a dc power line. Although most homes are supplied with ac power, some parts of a few large cities in the country are supplied with dc power.

The receiver shown in Fig. 5, like most modern table model receivers, is housed in a plastic cabinet. The back of most receiver cabinets is closed with a masonite or cardboard frame. On the masonite or cardboard a loop antenna is usually wound or stamped. The back of the receiver shown in Fig. 5 is shown in Fig. 6. Notice that the receiver is rather completely enclosed so that it is impossible to perform even such a simple service operation as replacing a tube without at least removing the back from the receiver. In many cases, the back is fastened securely to the receiver chassis so it is necessary to remove the entire chassis from

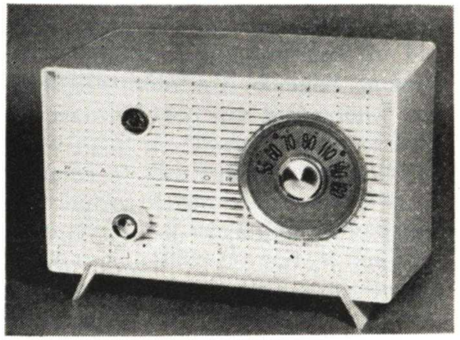

FIG. 5. An ac-dc table-model receiver, the RCA 8-X-5E.

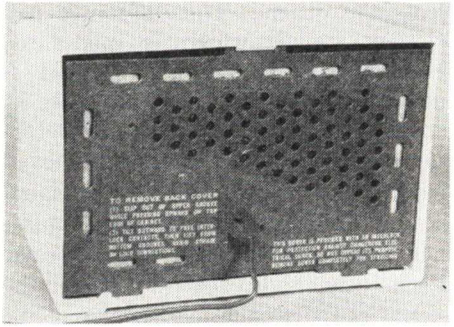

FIG. 6. The back of the receiver is enclosed by a masonite board on which the loop antenna is wound.

the cabinet before any work at all can be performed on the receiver.

In this section of the lesson we will discuss the removal of this receiver from the cabinet.

REMOVING THE KNOBS

All receivers have at least two knobs. The large knob on the receiver shown in Fig. 5 controls the dial, the smaller one is the volume control and on-off switch. Some receivers have a third knob, which is a tone control, and still others have a fourth knob, which is a band-change switch used to switch from the broadcast band to one or more short wave bands.

There are two different types of knobs commonly used on receivers. Practically all of the modern receivers use knobs that simply slip on and are held in place by a spring clip or by friction. Some of the older receivers have knobs that are held in place by a set screw.

Perhaps the easiest way to identify the two types of knobs is to look for a set screw in the knob. If there is a set screw, then the obvious way to remove the knob is to first loosen the screw by turning it in a counterclockwise direction. When loosening the set screw it is important to use the right size screwdriver. If you use too large a screwdriver, the sides of the blade will hit the sides of the screw hole. This may prevent you from getting the blade of the screwdriver into the slotted head of the screw, and also it can damage the threads in the knob itself. If you use too small a screwdriver, the screwdriver may not have sufficient bearing surface and you may destroy the slot in the screw. In either case, once you damage the set screw you may have considerable trouble loosening it and may have to replace the knob. This usually means that you have to replace all the knobs on the receiver because it is often impossible to find one that will exactly match the other knobs on the set.

If there are no set screws then the knobs are the slip-on type. This type of knob is removed simply by pulling it off.

In some cases it is impossible to get a slip-on type of knob off the receiver even though you are able to exert a fairly large amount of pressure. Often this difficulty can be overcome by wrapping a handkerchief

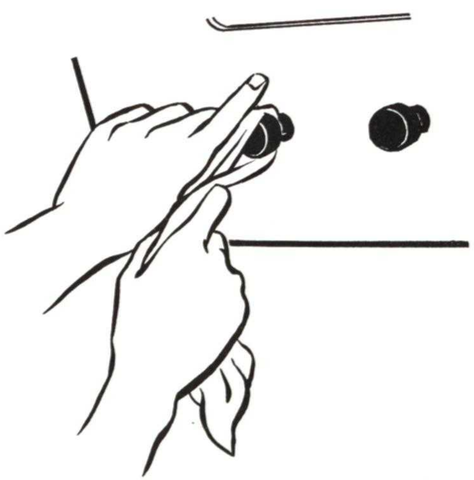

FIG. 7. How to use a handkerchief wrapped around the back of a slip-on knob to remove the knob from the shaft.

around the back of the knob and then pulling out on the knob while holding the chassis as shown in Fig. 7. By using this system you can remove most knobs.

Sometimes even this method of removing a slip-on knob fails. The knob may have been on for a long time and the spring clip in the knob may have rusted to the shaft. Another possibility is that a serviceman who worked on the set previously has glued the knob back on the set. In either case it is usually necessary to get a screwdriver or some similar object in back of the knob to pry it off. If it is necessary to take this step to remove the knob, you should put something between the blade of the screwdriver and the cabinet, to avoid scratching or marring the cabinet. Also, do not pry continually in one place. Either turn the knob or slide the screwdriver around to exert some pressure on first one side of the knob and then the other. This will usually enable you to remove most knobs that are frozen in place. However, sometimes even this fails, and the knob will break.

TAKING THE SET OUT OF THE CABINET

There are many different methods used to hold radio receivers into the cabinet. In some sets three or four self-tapping screws are put through the bottom of the cabinet into the metal receiver chassis. In other receivers, two screws, one on each side of the set, are screwed through the back of the receiver chassis into a molded flange in the cabinet to hold the chassis in place. Many other different schemes have been used. Usually you can discover the method by inspecting the set, looking for screws that hold the chassis in place.

In many receivers self-tapping hex

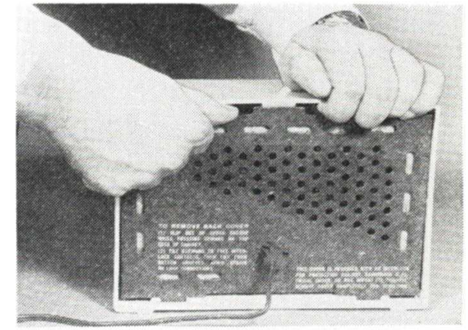

FIG. 8. The top of the back is removed from the grooves holding it in place by pressing up on the rear of the top of the cabinet and then tilting the top of the back out of the groove.

screws are used to hold the chassis in place. These screws, instead of being made like an ordinary wood screw, have a six-sided head. Some of the screws have a slot in them so they can be removed with a standard screwdriver, but others have not. Hex-head tools, which are often called nut drivers are available and are extremely handy in removing the screws.

The receiver shown in Fig. 5 uses still a different scheme for holding the set in place. To get this set out of the cabinet, you first remove the knobs from the front panel. Instructions for removing the back are printed right on the back. The first thing to do is to press upward on the top of the cabinet, then you slip the back out of the groove on the top of the cabinet, as shown in Fig. 8. You then tilt the back of the receiver back to free the interlock contacts. This is simply two prongs that plug into a socket on the end of the line cord. The back must be tilted back far enough to disconnect these. Then, you can lift the back up out of the slots that have been molded into the receiver cabinet. This frees the back, and it can be moved out a little. However, you can't pull the back out

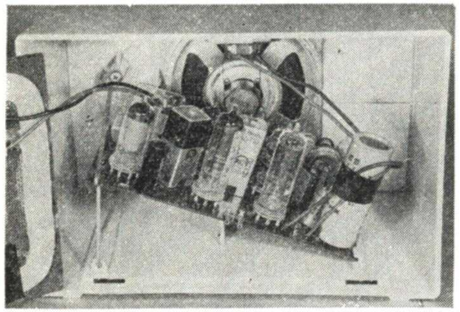

FIG. 9. The back of the receiver cabinet can be moved out of the way to replace any defective tube without removing the receiver from the cabinet.

too far, because the loop antenna is mounted on it, and you may break the connections connecting the loop antenna to the receiver.

Once you have the back removed, it can be turned out of the way as shown in Fig. 9. With the receiver back in this position, the tubes can be reached, and any defective tubes can be replaced without dismantling the receiver further.

Up to this point no serviceman should have any trouble, since he can read the instructions on the back of the set. However, there are no instructions given as to the exact method of removing this set from the cabinet. The serviceman confronted with this problem must inspect this receiver to see how the chassis is held in place. Upon close inspection you will notice a bent metal rod holding

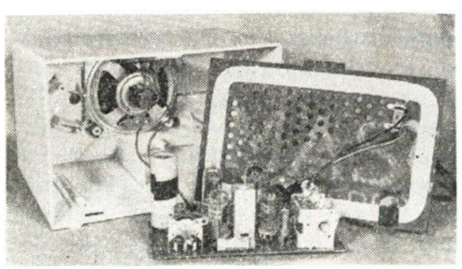

FIG. 10. Once the two Phillips screws have been removed, the chassis can be removed from the cabinet.

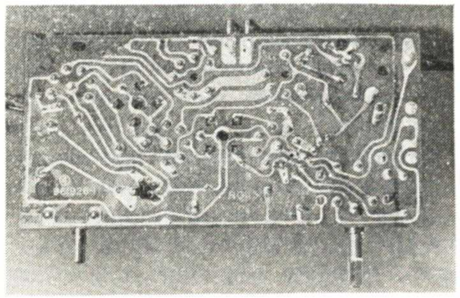

FIG. 11. A bottom view of the receiver showing the printed wiring.

the chassis on the left side of the receiver as shown in Fig. 9. This metal rod fits into a hole in the bottom of the cabinet and the other end of the rod is held in place by a Phillips-head screw, fitting into a hole molded into the front of the receiver cabinet. Also, on the right side of the set, there is another Phillips-head screw holding a tab on the volume control. To remove the set, these two screws must be removed.

Once the screws holding the set in place have been removed, the receiver can be taken out of the cabinet as shown in Fig. 10.

This receiver, instead of using a metal chassis, is built on a board made out of a plastic substance called phenolic. The top of the board can be seen in Fig. 10. Notice that

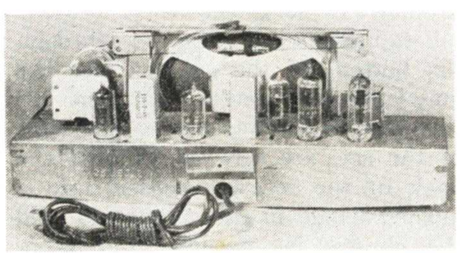

FIG. 12. Top view of a typical ac-dc receiver built on a metal chassis, the Motorola 52X11U. The speaker is mounted on the chassis instead of in the cabinet as it was in the set using a printed-circuit board.

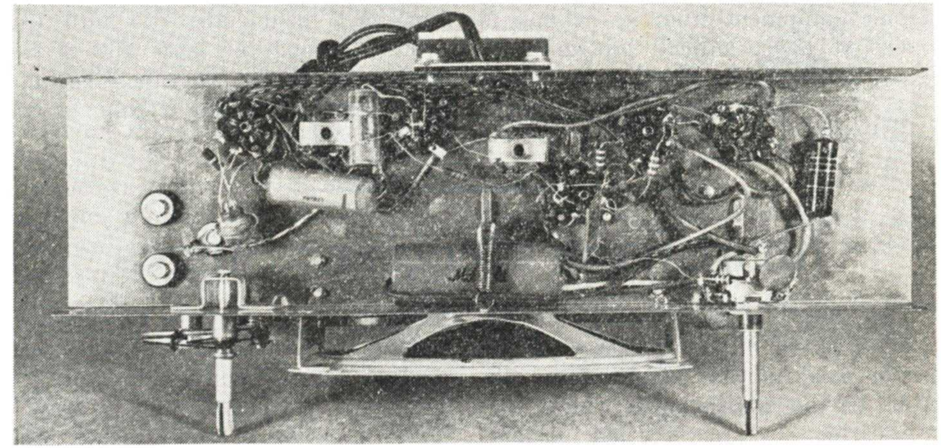

FIG. 13. Bottom view of an ac-dc receiver using conventional wiring.

the tube sockets and miscellaneous parts are all mounted on the top of the board. There is little or no wiring on the top. From this top view it is possible to identify many of the parts used in the receiver.

A bottom view of the wiring board is shown in Fig. 11. Notice that there are no wires. Instead, the connections between the various parts are made by copper strips that are attached directly to the board. This type of wiring is called *printed wiring.*

Many receivers are still manufactured on a metal chassis with wire used to make the various connections. These receivers are generally a little larger than sets made on printed circuit boards, but nevertheless the electrical circuits are very similar. A photo of the top of the chassis of a typical receiver made on a metal chassis is shown in Fig. 12. Fig. 13 is a bottom view of the receiver chassis showing the wiring. Notice that in Fig. 13 there are many more parts than in the bottom view shown in Fig. 11. This is because many of the parts mounted on the top of the printed circuit board in the receiver shown in Fig. 10 are mounted on the bottom of the metal chassis in the receiver shown in Figs. 12 and 13.

Many of the parts are mounted on the top of the chassis look the same in both receivers. The tubes used in the two receivers are the same. Both receivers are five-tube receivers, using the same five tubes.

SUMMARY

In general, manufacturers do not give detailed instructions on how to remove a receiver from the cabinet. However, this seldom presents any difficulty to the serviceman because he can almost always see how to remove the receiver after studying the set for a few minutes.

The first step is to remove the knobs from the front of the set. Two types of knobs are found, the slip-on type and the type held in place by a set screw.

Once the knobs have been removed, take off the back of the receiver cabinet. This may be held in place by set screws, by clips, or by molded grooves in the cabinet as it is in the receiver we are studying in this lesson.

Once you have the back removed, you can find the screws holding the chassis in the cabinet.

The job of removing a piece of electronic equipment from its cabinet is more of a mechanical job than an electrical one. Usually it's a simple task, but sometimes you do run into equipment that presents quite a problem. All technicians run into this problem sooner or later and it can only be solved by experimenting until you discover how the equipment can be removed.

Identifying Receiver Stages

The heart of each stage in a receiver is the vacuum tube or transistor used in that stage. It is the tube or the transistor in which amplification or rectification occurs. The parts in the stage are used in conjunction with the tube. Thus, if you can identify the various tubes or transistors in a receiver you can very quickly break the receiver into stages.

TUBE LAYOUT DIAGRAMS

Manufacturers of most modern receivers make it easy for the serviceman to identify the various tubes in a receiver by printing a tube layout diagram on the bottom of the set, on the back of the loop, or sometimes right on the chassis of the receiver. This type of diagram shows the layout of the various tubes and generally gives the purpose of each tube in the equipment. In the receiver that you are studying in this lesson, a small printed sheet, shown in Fig. 14, is glued to the bottom of the cabinet. On this sheet the position of each tube in the receiver is shown along with the purpose of that tube in the receiver. If you refer to Fig. 2 showing the block diagram of a typical modern superheterodyne receiver, you will see that you can quickly draw a block diagram of this receiver and identify the tube used in each stage of the set from this layout diagram.

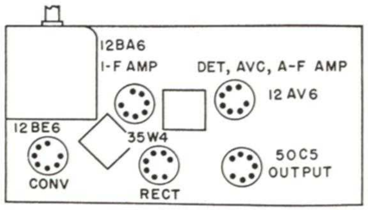

FIG. 14. Tube layout diagrams such as this are found on most receivers.

Most receiver manufacturers print diagrams of this type so that the set owner can remove the tubes and take them to the service shop to have them tested and put them back in the correct socket in the receiver. However, sometimes this diagram has been removed or it may be unreadable. In this case you can identify the various stages in the receiver by referring to a tube manual. A tube manual can be purchased from any large radio parts wholesaler for about a dollar.

USING A TUBE MANUAL

To use a tube manual to identify the various stages of a receiver, write down the numbers of the various tubes in the set and then start looking them up in the tube manual. For example, one of the tubes used in the receiver we are studying is a 12BE6. If you look for the 12BE6 tube in a tube manual you will find it listed in the tube manual as a pentagrid converter. The information on the tube says that it is used as a converter in ac-dc receivers. The 12BA6 tube is called a remote-cut-off pentode. It is used as an rf amplifier in ac-dc receivers. The only rf amplifier in this receiver is the i-f amplifier, so you know that the 12BA6 must be the i-f amplifier.

Another way of identifying the i-f amplifier tube is by spotting the two i-f transformers. Look at the diagram shown in Fig. 14 or the top view of the receiver shown in Fig. 10. Notice the two square cans. These are the i-f transformers. There is a tube between these two transformers. This tube is the 12BA6 tube, and it is the i-f amplifier. Sometimes this tube is more in line with the transformers than it is in this receiver, but in any case it is usually not too difficult to find.

Each stage in this receiver could be quickly identified by looking up the purpose of the tubes in a tube manual, even without the information given in Fig. 14. The tube type number is printed on the side of the tube. This is enough to enable you to find the tube in the tube manual.

Actually, once you start doing any service work, you soon learn what tube types are used in the various stages of a receiver and so it's only a very short time before you can identify all the stages of a receiver simply by taking a quick look at the set. This is also true of TV sets and most other pieces of electronic equipment.

REMOVING TUBES

To remove a tube for testing or replacement, pull it straight up while wiggling it slightly from side to side. Tube sockets are purposely made to grip the tube pins tightly in order to assure a good connection between the tube pins and the socket. If the tube fits too loosely into the socket an intermittent connection may result, and this may result in noise in the receiver or complete failure of the receiver intermittently. This simply means that the receiver might play

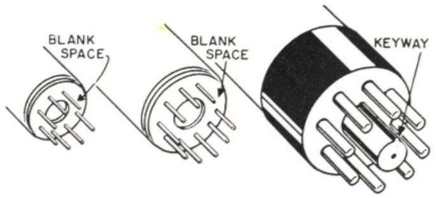

FIG. 15. Most tubes in modern electronic equipment have one of the three bases shown above.

for a while, stop playing, and then after a while when the set cools down, start playing again.

TUBE BASES

The tubes in this receiver all have what is called a miniature 7-pin base. Looking at one of the tubes from the bottom you will see that there are 7 pins. The pins are arranged in a circle near the outside of the base. They are spaced so that there actually could be eight evenly positioned pins mounted on the base of the tube; however, one is omitted. This pin is omitted so that the tube can be put in the socket in only one way.

The pins are identified by counting from the space. Looking at the tube from the bottom, the first pin in a clockwise direction from the space is pin 1, the next is pin 2, the next pin 3 and so on until the last pin you reach, which will be the first pin going in a counter-clockwise direction from the space, is pin 7.

Some tubes that are slightly larger than the tubes used in this receiver have a 9-pin base. Again, the pins on this tube are arranged so there could be ten evenly spaced pins, but one is omitted, and the various pins are identified by counting from the space.

Still another tube base used on many of the older tubes and on some of the large tubes found in modern receivers is the octal base. This base has a total of eight pins and also there is a center stem with a key-way in it so that the tube can be put in the socket in only one way. Some of the pins may be omitted from this type of tube where there is no need for them. However, the standard octal socket will have 8 holes in it so that if the tube has all eight pins the tube will fit into the socket. Pins on this type of base are identified by counting in a clockwise direction from the key in the stem protruding from the center of the tube base. Again, the first pin clockwise from the key is pin 1.

The bases of 7-pin, 9-pin, and octal tubes are shown in Fig. 15.

There are other types of bases found on some tubes, particularly tubes in older receivers. However, you will study more about the tube bases in a later lesson.

HEATER CONNECTIONS

Tubes in electronic equipment may be arranged with the heaters connected in series or in parallel. When the tube heaters are connected in series, the heater voltage required by the tubes may be different, but each tube must have the same current rating. If the tubes are connected in parallel, the tubes must all have the same heater voltage, but they may have different current requirements.

In this receiver all the tubes have the same heater current requirement.

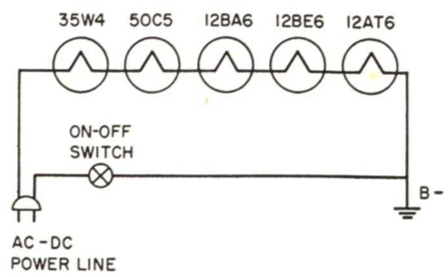

FIG. 16. The series-connected heater string used in the receiver you are studying.

FIG. 17. The NRI Professional filament checker can be used to locate a tube with an open heater in a series string.

The tubes that have 12 as the first two identifying characters require a heater voltage of 12.6 volts. The 35W4 requires a heater voltage of 35 volts, and the 50C5 a heater voltage of 50 volts. The tubes are connected in series as shown in Fig. 16.

Now here is a chance to test what you have already learned about series and parallel cricuits. The tubes in any electronic equipment all get hot when they are operated. Suppose you were called upon to service this receiver and you discovered that when the set was turned on none of the tubes heated. What kind of a defect would you look for?

A quick look at Fig. 16 shows that you have a series circuit and that in order for any of the tubes to heat there must be a complete circuit. Therefore, the series circuit must be open at some point. The trouble could be in the line cord, the on-off switch, or in the connections between the heaters of the tubes, but the chances are that the defect is actually in one of the tubes itself. It is likely that the heater of one of the tubes has burned out, thus opening the series circuit with the result that none of the tubes are heating. You can check the tubes individually in a tube tester, or you can use an ohmmeter to check the heater of each tube in the receiver. If the heater is all right, an ohmmeter will indicate a fairly low resistance, but if one of the tubes has an open heater, the ohmmeter will give no reading at all, in other words it will act as if it were connected to nothing at all. The tube with an open heater should be replaced.

This is a common defect in small ac-dc receivers of this type with the tube heaters connected in series. There are small testers available that can be used for testing the continuity of the heater of tubes connected in series circuits of this type. A typical tester is shown in Fig. 17. You simply plug the tube into the correct socket in the tester. If the tube is good, a small light in the bottom of the tester lights. If the bulb fails to light, the tube has an open heater and should be replaced.

TRANSISTOR STAGES

The heart of the transistorized receiver is, of course, the transistor. Two typical transistors are shown in

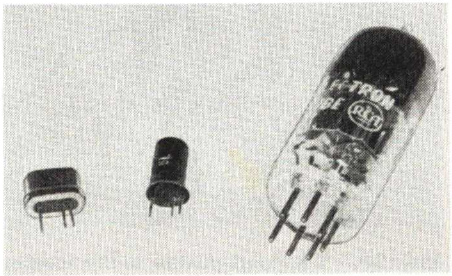

FIG. 18. Two types of transistors compared to a miniature 7-pin tube.

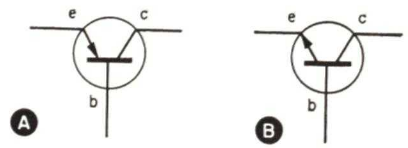

FIG. 19. Schematic symbols for N-P-N and P-N-P transistors.

Fig. 18. They have been photographed beside a 7-pin miniature tube so that you can get an idea of the size of the transistor. Notice that they are both much smaller than the vacuum tube even though this is a small tube. Many tubes are much larger than the one shown.

These transistors plug into small sockets having three holes to receive the three leads from the transistor. In some receivers, the transistors are soldered permanently into the circuit; some manufacturers feel they can do this because transistors last such a long time that they will probably last as long as the receiver itself so there is no need to make provisions for replacing them.

The schematic symbols for two different types of transistors are shown in Fig. 19. The element marked b is the base, the one marked c is the collector, and the one marked e is the emitter. You should try to remember the schematic symbols for transistors because you will see them over and over again in your career as an electronics technician.

There are many different types of transistors in use. Transistors, like vacuum tubes, are designed for specific applications. In the transistorized receiver that we will study in this section of the lesson there are a total of seven transistors. There are three different types of transistors used. There is one type 235, which is used as the converter. This transistor performs the dual function of mixer and oscillator. Two type 234 transistors are used as i-f amplifiers. Since the gain of a single transistor i-f stage is not as high as that of a single vacuum-tube stage, two i-f stages are used in the transistor receiver. The audio stages use type 2N109 transistors. The second detector uses a type 1N295 diode. This diode which is not a transistor is somewhat similar in operation to the crystals used in the early crystal receivers.

SUMMARY

From the preceding you can see that it is comparatively easy to draw a block diagram of a receiver and identify the various stages. At this early point in your course, this may look more difficult to you than it actually is, because the arrangement of the stages in a superheterodyne and even the names of the stages are new to you. However, you will see that these names soon become familiar. You will soon know the stages such as the i-f stage in a receiver so well, that the name of the stage will immediately suggest the circuit used.

You will find a tube layout diagram on most receivers. This diagram will not only give you the location of the various tubes in the set, but in addition in most cases will tell you the purpose of each stage. When the stages are not identified, you can easily identify them by looking up the tubes used in the receiver in a tube manual. The tube manual gives you enough information about the purpose for which the tube was designed to enable you to identify its purpose in the receiver and from this information draw a block diagram of the receiver.

Block diagrams of more complex pieces of electronic equipment such as TV receivers and equipment designed for industrial application can be drawn in much the same way. They are more complex than radio block diagrams, but by the time you have studied the various circuits used in equipment of this type and learned the general principles of operation, you will find block diagrams of complex equipment can be drawn almost as easily as radio block diagrams.

Identifying Parts

Now that we have the chassis out of the receiver and identified the various stages, let us see what the various parts look like. It is important for you to learn how to identify these parts because many of them are similar to the parts found in all types of electronic equipment.

In a receiver constructed on a printed-circuit board, practically all the parts are mounted above the board. In a receiver made on a metal chassis using conventional wiring, many of the parts are mounted beneath the chassis as you saw in Fig.

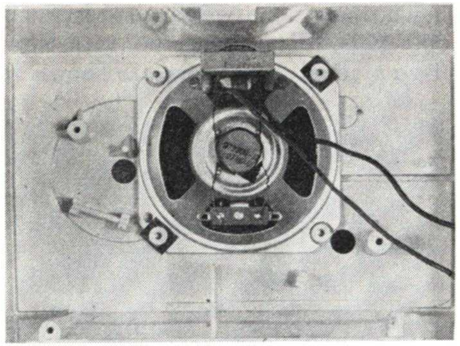

FIG. 20. The loudspeaker in the receiver you are studying is a PM speaker. It is mounted inside the cabinet.

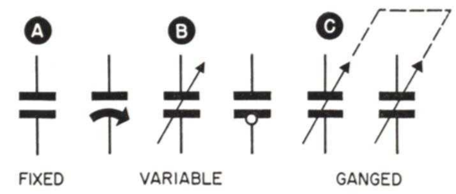

FIG. 21. Schematic symbols for capacitors. A is a fixed capacitor; B shows variable capacitors, and C shows a two-gang capacitor.

13. However, the parts in general look the same in both types of receivers, so you should have no difficulty identifying any components either in receivers using printed wiring or in receivers wired with conventional wire. Let's take our printed circuit receiver as an example and identify the various parts in it.

THE LOUDSPEAKER

The loudspeaker in our typical receiver is mounted on the front of the cabinet. It is held in place by two spring clips, which can be removed by working a screwdriver under the center of the clips and prying first one side and then the other until the clip comes off. It's best not to remove a speaker held in place by this type of clip unless it is necessary because it is difficult to get the speaker out, and in addition after the speaker has been removed several times, the clips may not hold it in place securely.

The loudspeaker is shown in Fig. 20. Mounted on the top of the loudspeaker is the output transformer. This is not part of the speaker, but it is used to couple the speaker to the 50C5 output tube.

The speaker is a permanent magnet dynamic speaker. This type of speaker is usually called a pm speaker. The speaker consists of a permanent magnet of alnico which, as you know, is an alloy of aluminum, nickel, and cobalt.

The speaker voice coil, which is attached directly to the cone, is wound on a light-weight aluminum form. The turns of wire making up the voice coils are insulated from the form.

CAPACITORS

Another one of the basic parts found in most pieces of electronic equipment is the capacitor or condenser. In its simplest form it is nothing other than two metal plates with a space between them. A capacitor will block the flow of direct current but will pass alternating current. You will study them in detail in a later lesson. The electrical size of a capacitor is called its capacity. This may be a fixed value or it may be variable. The schematic symbols for fixed and variable capacitors are shown in Fig. 21A and B.

Capacitors in combination with coils are used for tuning. Let us look at the various capacitors in our set, now. Fig. 22 shows the top of the chassis.

The Tuning Capacitor. The tuning capacitor, or condenser as it is frequently called, is shown in Fig. 22. This capacitor is actually a gang capacitor consisting of two separate capacitors ganged or mechanically coupled together. As you rotate the dial the two capacitors are changed simultaneously. The symbol used to show a ganged capacitor with two sections is shown in Fig. 21C. The dotted line indicates that the two variable capacitors are mechanically coupled together.

A variable capacitor actually consists of two separate sets of plates that mesh together without touching. The plates in one set are stationary and they are called the *stator* plates. The other set of plates turn as the tuning dial turns. These plates are called

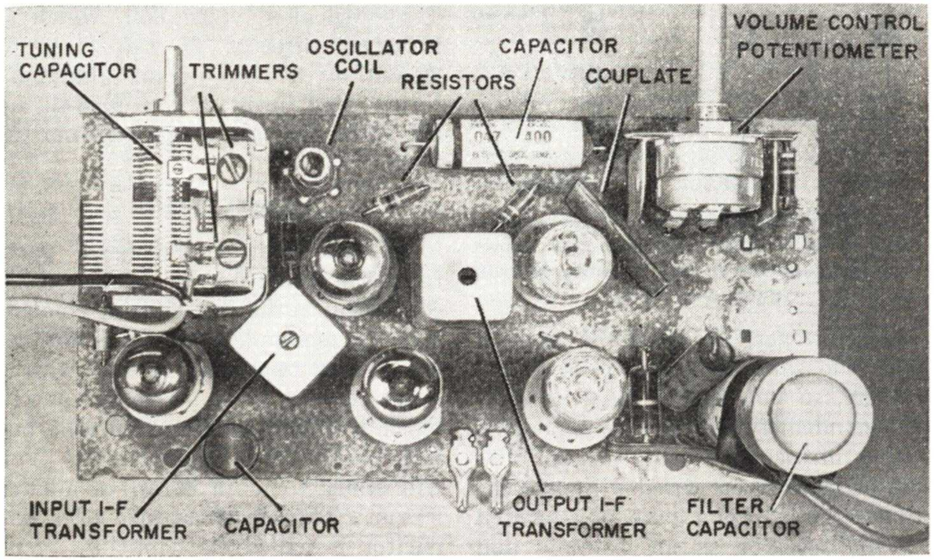

FIG. 22. Parts on top of the printed circuit board.

the *rotor* plates. The capacity of the capacitor or condenser is changed by changing the dial on the receiver. When the plates are completely meshed, the capacitor has maximum capacity and when the plates are open the capacity is at a minimum. Minimum capacity is used when you are tuned to the high end of the broadcast band, and maximum capacity is used when you are tuned to the low end of the band.

Notice that the two capacitors are not the same size. The smaller of the two is used in the oscillator circuit, the larger in the mixer circuit. You learned earlier in this lesson that the mixer and the local oscillator are tuned simultaneously so that the difference between their frequencies is kept constant. This is done by these two ganged capacitors. The signal generated by the local oscillator is higher in frequency than the incoming signal, and at higher frequencies it takes a smaller change in capacity to cover a given frequency range. Therefore, a smaller capacitor is needed to tune the oscillator than to tune the mixer. By making the two capacitors exactly the right size, the correct frequency difference between the mixer and the oscillator can be maintained across the entire broadcast band. When the oscillator and mixer maintain this correct frequency relationship, we say that they "track" properly.

The two-gang capacitor used in this receiver connects directly to the tuning dial. If you rotate the dial one-quarter of a turn the capacitor turns one-quarter of a turn. However, some receivers use a dial-drive mechanism to operate the tuning capacitor. With these systems a reduction gear arrangement is used so that you have to turn the tuning dial several times in order to tune from one end of the broadcast band to the other end. This makes it a little easier to tune the receiver, but many manufacturers are using simpler arrangements such as in our sample receiver in order to reduce the cost of manufacturing the set.

Trimmer Capacitors. Mounted on top of each section of the gang tuning capacitor is a small capacitor called a trimmer capacitor. The trimmer capacitors are used to adjust the two circuits to the correct frequency. The oscillator trimmer is usually adjusted first to make the dial read correctly, and then the mixer trimmer is adjusted for maximum output.

A trimmer capacitor consists of two sets of plates separated by mica sheets. The plates are made of some spring material and compressed by means of an adjusting screw. As the screw is loosened the spring in the metal forces the plates apart and this reduces the capacity or size of the trimmer condenser. As the screw is tightened, the plates are pushed closer together, which adds more capacity to the circuit. Therefore, when setting the oscillator trimmer, if the station comes in too high on the dial, you should turn the dial to the proper setting and then loosen the oscillator trimmer until the station comes in. If the station comes in too low on the dial, turn the dial to the proper setting, and then tighten the oscillator trimmer until the station comes in. Once you have the oscillator trimmer set you simply adjust the mixer trimmer for maximum output.

Fixed Capacitors. In addition to the variable capacitors there are a number of fixed capacitors in the set. The large capacitor in the lower right corner is called the filter capacitor. You already know that a pulsating dc is obtained from a rectifier; this type of dc cannot be used to operate the receiver. This capacitor is used in the power supply to help change the pulsating dc obtained from the rectifier into smooth dc.

COILS AND TRANSFORMERS

Now let's identify the coils and transformers found in this receiver. In physical appearance the various types of coils are quite different.

Output Transformer. As you already know, the small transformer mounted on the speaker shown in Fig. 20 is the output transformer. This transformer consists of two windings wound on a common iron core. One winding has a large number of turns; this is called the primary winding because the sound or audio signal is fed into this winding. The second winding has only a few turns and it is called the secondary winding because the output signal is taken from it.

The purpose of the output transformer is to feed the sound signal from the output tube to the loudspeaker. Later, you will see that it is impractical to connect the speaker directly to the plate of the output tube because there would be very little energy transferred directly from the tube to the speaker.

I-F Transformers. The i-f transformers, which are mounted on the top of the chassis, are the two square cans identified in Fig. 22. Each of these cans has a hole in the center of the top. The one nearest the tuning capacitor is called the *input* i-f transformer because it is used in the input to the i-f circuit between the mixer and the i-f stage. The other transformer is called the *output* i-f transformer because it is used between the i-f tube and the second detector. Some receivers have two i-f stages, in that case there are three i-f transformers. Again, the one between the mixer and the first i-f tube is the

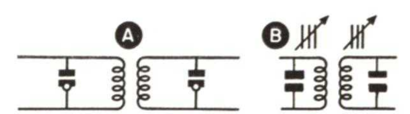

FIG. 23. Schematic symbols for two different types of i-f transformers.

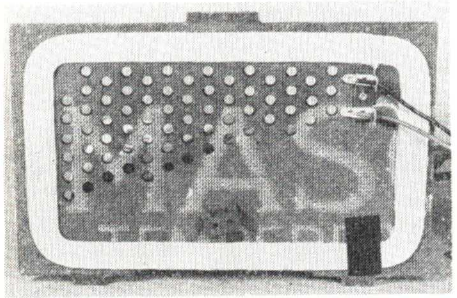

FIG. 24. The loop antenna is mounted on the inside of the back of the receiver as shown here.

input, the one between the second i-f and the second detector is the *output*. The i-f transformer used between two i-f stages is called an *interstage* transformer.

The schematic symbols of two i-f transformers are shown in Fig. 23. Each transformer consists of two coils that are placed close together so that energy from one coil is transferred to the other. The winding into which the signal is fed is called the "primary winding" and the winding out of which the signal is taken is called the "secondary winding." The i-f frequency used in modern receivers is about 455 kc. The primary of the i-f transformer is tuned to 455 kc. Similarly, the secondary is also tuned to 455 kc. There are two ways of doing this.

The i-f transformer shown in Fig. 23A consists of two fixed coils with small trimmer capacitors connected across them. The frequency is varied by changing the capacity of the trimmers. The i-f transformer shown in Fig. 23B has fixed capacities across each winding, but the coils are variable. Each coil has a small powdered iron slug that can be screwed in and out. The i-f transformers used in our sample receiver are of this type. You can see the holes through which one slug can be reached on the top of each transformer. There is also a hole at the bottom of each transformer through which the other slug can be adjusted.

The Oscillator Coil. The oscillator coil is also shown in Fig. 22. This coil is a small two-winding coil. One winding is connected between the cathode of the 12BE6 converter tube and B-. The other winding is used in conjunction with the oscillator tuning capacitor and is connected in the grid circuit of the 12BE6 tube.

Antenna. The loop antenna in our receiver is shown in Fig. 24. It consists of nothing more than a coil wound on the back of the receiver. This coil and the mixer tuning capacitor form a circuit that can be tuned across the broadcast band to pick up signals from local broadcast stations. Because it is wound in the form of a loop, it is usually called a loop antenna.

This type of antenna picks up a signal much better in one direction than it does in the other. When the signal comes from direction A or B in Fig. 25, there will be maximum signal pick-up, but when the antenna is rotated 90° and the signal comes from C or D so that the loop is at right angles to the direction in which the signal is traveling, the pickup by the loop will be at a minimum.

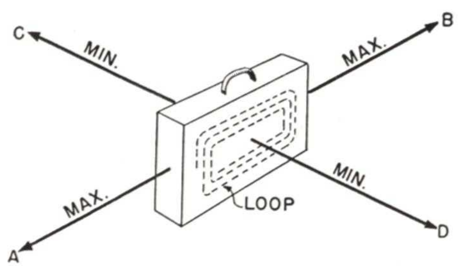

FIG. 25. Maximum signal is picked up by the loop when the signal comes from direction A or B; minimum signal is picked up from C or D.

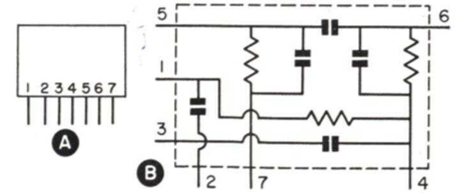

FIG. 26. The couplate shown above actually replaces 5 capacitors and 3 resistors. This part enables the manufacturer to make a substantial saving, not only in the cost of the parts, but also in the labor of assembling the set.

RESISTORS

In addition to the components we have already discussed, there are a number of resistors used in this receiver.

Volume Control. One of the resistors that is the easiest to identify, is the volume control. This is actually a special type of resistor called a potentiometer. There are three terminals or connections to the potentiometer; the resistance between the two outside terminals is constant, but the resistance between the center terminal and either of the outside terminals varies as you rotate the volume control knob on the receiver. The potentiometer can be seen in Fig. 22.

Also notice on the back of the control there are two connections. These are the connections to the on-off switch. The on-off switch is set up so that when the control is turned all the way in a counter-clockwise direction the switch is in the off position. When the control is turned clockwise, the switch is turned on and remains on through the rest of the rotation of the volume control.

Some of the other small fixed resistors are also shown in Fig. 22.

COUPLATES

Another interesting part is the couplate shown in Fig. 22. A drawing

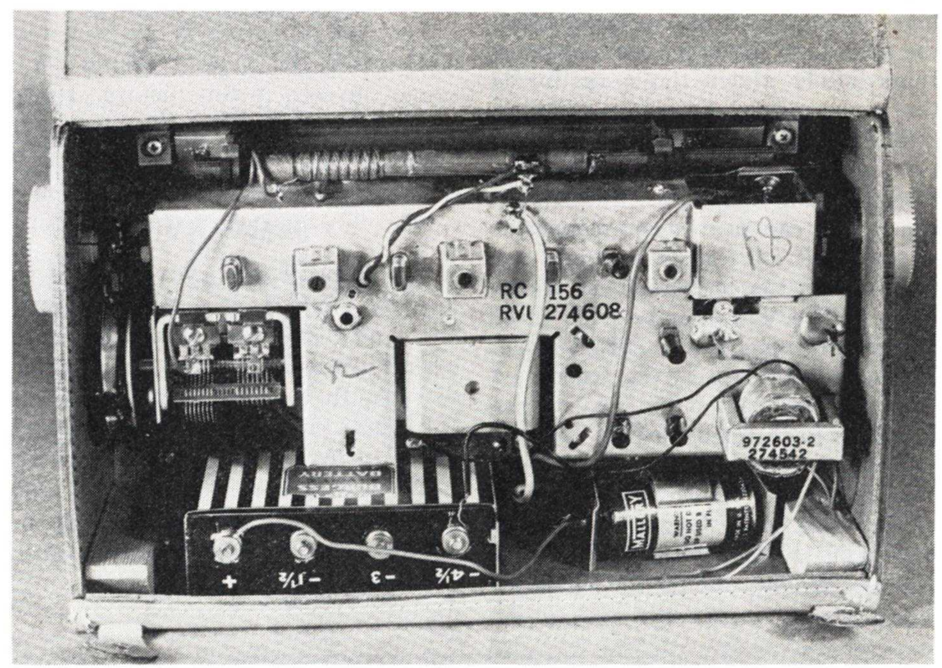

FIG. 27. The RCA 7-BT-10K transistor receiver.

of this part is also shown in Fig. 26A. The couplate is actually a number of parts rather than a single component. The schematic of the couplate is shown in Fig. 26B. Notice that this unit contains 5 capacitors and three resistors. This unit is made by a special manufacturing process and the one part can be used to replace eight separate components.

PARTS IN THE TRANSISTOR RECEIVER

A photograph of the transistor receiver is shown in Fig. 27. From what you have learned in this lesson and the block diagram you can probably identify many of the parts and also a number of the transistor stages that appear in the photograph. Here is a good chance to test yourself—try to identify as many of the stages and parts as you can before reading further in the lesson.

Notice on the left of the receiver near the bottom is the two-gang tuning capacitor. Again, one gang tunes the mixer and the other the oscillator. Immediately above the capacitor is the transistor used as the converter.

The i-f transformers and the i-f transistors are easy to identify. The three transformers are the square cans. The can nearest the converter is the input i-f transformer and the next one is the interstage i-f transformer. The transistor between these two transformers is the first i-f stage. The next transistor is the second i-f amplifier and the output i-f transformer is to the right of it.

The second detector is mounted beneath the chassis where it cannot be seen in this view, but to the left of the output i-f transformer is the first af stage. Slightly below the i-f transformer is a single transistor; this is the driver. The driver is simply an audio amplifier that drives or feeds a signal to the output stage, which in turn drives the speaker. The two transistors beneath the transistor used as a driver are the output transistors. These two transistors drive the loudspeaker in what is called a "push-pull" stage. This type of amplifier has been used in radio receivers using vacuum tubes.

The output transformer in this receiver is mounted on the chassis instead of on the speaker. You can see it in the lower right of the photograph. The leads from this transformer go over to the speaker, the back of the speaker magnet can be seen in the center of the photograph.

On the top of the receiver you'll notice a long coil. This is called a "loop stick," and its purpose is the same as that of the loop antenna such as we found in the receiver we discussed previously.

The rest of the parts are mounted underneath the chassis where they cannot be seen in this picture. However, as you can see, the parts are very much like those used in a vacuum tube set.

SUMMARY

In this section you have learned to identify the parts in a radio receiver, and you have seen that they are essentially the same in different kinds of sets. In the next section we will see what kinds of defects you are likely to find in each of these parts. Learning the various ways in which a part can fail is the first step in learning to apply effect-to-cause reasoning.

Defects in Parts

Let us take up each of the parts we have just identified, and see what can go wrong with them.

LOUDSPEAKERS

You already know how a loudspeaker works, but now let us consider a few of the defects that you might encounter in the speaker.

Damaged Cone. The cone on a loudspeaker is made of a stiff paper. Sometimes the cone will crack because of aging and heat from the receiver. When this happens, the sound is distorted and may sound somewhat tinny. Also the speaker cone can be damaged by punching a hole in it. This often happens in homes where there are children because they may poke things through the front of the receiver cabinet and through the paper cone.

Speakers used in small table model receivers are inexpensive and once the cone is damaged the simplest thing to do is to replace the entire speaker. However, in the case of larger speakers used in console radios, sometimes servicemen have them re-coned. Some radio wholesalers operate a re-coning business themselves or act as an agent for firms that do speaker re-coning. If this service is available in your locality, it is frequently less

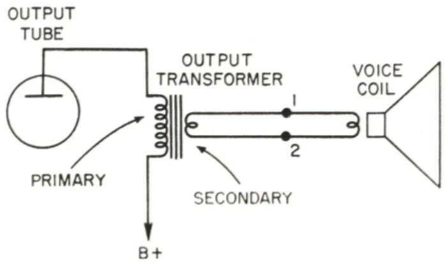

FIG. 28. Schematic showing how the speaker voice coil is connected to the output transformer.

expensive than it is to replace the speaker. However, re-coning a speaker is not a job for the serviceman to attempt himself because it is time-consuming, it requires considerable experience, and the equipment needed to do this type of work is not readily available.

Open Voice Coil. The voice coil of a pm speaker usually consists of somewhere between 10 and 25 turns of wire wound on the voice coil form. A small sized wire is usually used to keep the weight of the voice coil, the coil form, and the cone as light as possible. Because the wire is fine, the coil may open. This may be due to some type of impurity that was on the voice-coil wire, and the moisture in the atmosphere will set up a chemical reaction which will gradually eat through the wire until eventually it breaks.

When the voice coil in a receiver is open, there will be absolutely no sound coming from the loudspeaker. Usually in a dead receiver, you can hear some hum or some type of noise coming from the speaker. If the tubes in a receiver all light, but the set is absolutely dead and there is no sound whatsoever coming from the speaker, it is a good idea to suspect the possibility of a defective voice coil.

The speaker voice coil is connected to the secondary of the output transformer as shown in Fig. 28. When the speaker voice coil opens and you try to check it with an ohmmeter simply by connecting the ohmmeter to the terminals marked 1 and 2, you will get a complete circuit if both the secondary of the output transformer and the speaker voice coil are good, but you will also get a complete circuit if either the output transformer

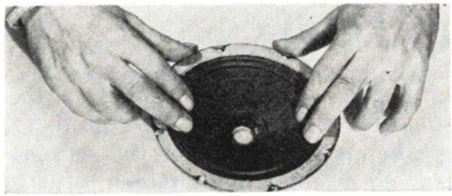

FIG. 29. You can detect an off-center voice coil by gently pushing the cone in and out. If the voice coil is off center, you will be able to feel and hear it scraping.

or the speaker voice coil is open. If the voice coil is open, you will get a reading through the transformer and if the transformer is open you will get a reading through the voice coil. It is impossible to tell from the reading whether both are good or one is defective. Therefore, to check the speaker voice coil you must disconnect one of the leads from the secondary of the output transformer. Then, you can connect the two leads from your ohmmeter directly to the speaker voice coil leads. You should get a reading of only a few ohms. This indicates that the speaker voice coil is good. While you have the lead disconnected, you should check the secondary of the output transformer by connecting your ohmmeter lead to its two leads. Again, if the secondary winding is good, you will get a low-resistance reading.

Off-Center Voice Coil. Sometimes the heat produced in the receiver will cause the speaker to warp, moving the voice coil slightly out of position. The voice coil fits into a small groove between the magnet and a round piece in the center of the voice coil, called the center pole. There is usually very little clearance around the voice coil so that if it changes position only slightly, the voice coil will rub on the speaker magnet. When this happens you will notice distortion, particularly on low-frequency notes. If you notice this type of distortion, you can check the speaker voice coil by laying the speaker flat as shown in Fig. 29 and gently pushing the voice coil in and out. If the voice coil is off center, you will be able to feel it scraping and you will also hear a scraping sound as you push the coil gently in and out. On the other hand, if the voice coil is on-center it will move in and out freely.

Replacing a Loudspeaker. When it is necessary to replace a loudspeaker, the speaker should be the same size as the original. Usually, if you try to put in a different size speaker you may have trouble mounting it in the set.

Speaker Sizes. The size of a speaker is the diameter of the speaker cone. In other words, a 5-inch speaker is a speaker having a cone with a diameter of 5 inches as shown in Fig. 30.

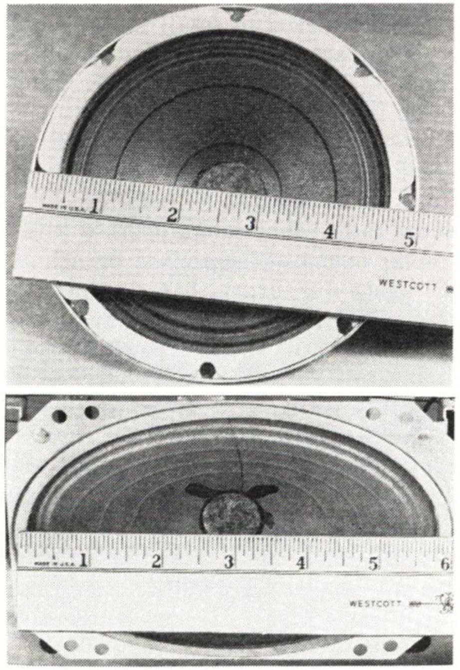

FIG. 30. A 5-inch round speaker, and a 4-inch by 6-inch oval speaker.

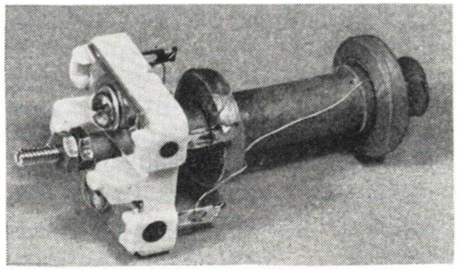

FIG. 31. An i-f transformer with the can removed.

Most table model ac-dc receivers use 5-inch, round speakers. A few have 4-inch speakers, and a few have speakers larger than five inches. You will also find some receivers with oval speakers. These speaker sizes are given by measuring the maximum and minimum diameters of the ellipse formed by the speaker cone. A 4 by 6 oval speaker is shown in Fig. 30. This means that the dimension of the oval is four inches in one direction and six inches in the other.

Large console receivers often use much larger speakers. 12-inch and 15-inch speakers are used in some of the better console receivers and high-fidelity systems.

The job of replacing a loudspeaker in a modern ac-dc receiver is more a mechanical job than it is an electrical job. There are only two connections to be made, that of connecting the secondary of the output transformer to the speaker voice coil. This part of the job is easy enough, but sometimes you run into difficulty mounting the new speaker. Exact duplicate replacements are frequently not available if the receiver is two or three years old and you have to use a standard replacement speaker purchased from a radio parts wholesaler. There may be some differences between the replacement speaker and the original. If the receiver cabinet is made of wood, or if the speaker is mounted on the receiver chassis, this does not present any difficulty, but if the cabinet is plastic, and the speaker is mounted on it you sometimes run into difficulty getting the speaker mounted in place. There is no set rule or procedure to follow, the technician has to improvise and take whatever steps may be necessary to mount the speaker in place.

COILS AND TRANSFORMERS

The most common defect in a coil is an open winding, but there may also be shorts between windings.

Output Transformer. The primary winding of the output transformer has the current from the plate of the tube going through it. The primary opens more frequently than the secondary, because of the fact that it has the plate current going through it and because it is usually wound with finer wire. The primary of the output transformer can be checked with an ohmmeter. Simply turn the receiver off and connect your ohmmeter test leads between the two leads from the primary winding. The exact resistance reading that you should obtain will depend upon the transformer, but it is usually somewhere in the vicinity of a few hundred ohms. If you obtain no reading at all, in other words, if your ohmmeter indicates that the circuit is open, the primary winding on the output transformer is open. On the other hand, if you obtain a zero or practically zero resistance reading, it indicates that the primary winding of the output transformer is shorted. In either case the output transformer must be replaced.

You already know to to check the secondary of the output transformer. Remember, however, that it must be disconnected from the speaker voice coil, otherwise you would get a reading even if it were open.

I-F Transformer. The inside of an i-f transformer looks like Fig. 31. Notice that there are two coils wound of small size wire. Again, due to impurities that may be on the wire, the moisture in the atmosphere may set up a chemical action and eat through the wire. When this happens, the winding will open and the receiver will not operate.

Because the primary winding has not only the signal current flowing through it, but also the plate current of a tube flowing through it, it is much more likely to open than the secondary winding. Open windings can be checked with an ohmmeter. Usually the resistance of an i-f transformer is somewhere between 5 ohms and about 25 ohms. If you obtain a zero reading across an i-f transformer, it indicates that the winding is shorted either due to the leads to the transformer shorting or due to a shorted capacitor. If you obtain a very high resistance reading or no reading at all, the winding is open. In either case, the usual procedure is to simply replace the i-f transformer.

Oscillator Coils. Oscillator coils are wound of a small size wire and as a result they will frequently open. If either winding on the oscillator coil opens, the oscillator will not work and the receiver usually will not pick up any signals. However, occasionally when the oscillator fails to operate you will be able to pick up a station operating near the low-frequency end of the broadcast band. If you can pick up such a station and you find that you pick it up over the entire band or a good portion of the band, it is a good sign that the oscillator in the receiver is not working.

In addition to open windings on the oscillator coil, sometimes an oscillator coil fails and there is no apparent defect. This is due to the fact that the coil may absorb moisture and this in turn results in what is called a low Q. The Q of a coil is simply a figure that tells you whether or not the coil is any good. If the coil has a high Q it is a good coil, but if it has a low Q it usually will not work in an oscillator circuit. Thus when the oscillator in a receiver fails to operate and all the parts in the oscillator circuit appear to be good, it is usually worth while to try a new oscillator coil in the set.

Loops. An open loop is usually quite easy to spot because it causes considerable hum when the receiver is tuned to a local station. When you find this type of defect, you should consider the possibility of a defective loop. This is not the only defect that can cause this trouble, but it is certainly one of the more common. An open in the loop circuit might be in the wires of the loop themselves, but usually it is in one of the leads connecting the loop to the receiver. The loop can be checked for continuity with an ohmmeter.

CAPACITORS

Tuning Capacitors. Tuning capacitors used in modern superheterodyne receivers are almost trouble-free. However, sometimes the rotor plates accidentally touch the stator plates. If this happens, the receiver will not operate. Usually when the rotor plates short to the stator plates, the trouble is noticeable over only part of the band. Therefore, as you tune across the broadcast band, you'll notice that the receiver plays over part of the band, but suddenly you hear a noise or scraping sound and then the receiver is dead. This is usually an indication that the plates of the tuning capacitor are shorting. On examining the plates you can usually find where they are touching,

and then by carefully bending them with a knife or a screwdriver you can eliminate the short, and the receiver will operate again.

Trimmer Capacitors. Trimmer capacitors seldom cause trouble, although sometimes the plates short together or the adjusting screw may short to the stator plates. When this happens, the receiver will not operate. If you find that the receiver operates when the adjusting screw is loosened, but goes completely dead when the screw is tightened, it is usually an indication that the trimmer capacitor plates are shorting together or that the stator is shorting to the adjusting screw.

Filter Capacitors. Sometimes the filter capacitor will short. When this happens, the rectifier tube, which in this receiver is the 35W4, will soon burn out. Filter capacitors may also open or lose capacity. When this happens there will be a noticeable hum in the receiver, and frequently the set will fail to operate or will operate poorly because of the fact that the operating voltages throughout the receiver are somewhat lower than they should be.

A defective filter capacitor is probably the most common defect, other than tube failure, in an ac-dc receiver. The filter capacitor usually fails in about 2 or 3 years of normal operation because the heat that occurs in this type of part causes gradual deterioration.

RESISTORS

Volume Controls. Sometimes the switch on the volume control fails to work. Sometimes it cannot be turned on; sometimes it cannot be turned off. If the receiver fails to go off when you turn the switch to the off position, the trouble is usually due to a defective on-off switch. If the set does not go on, the on-off switch can be checked by unplugging the receiver from the power line and turning the switch to the on position and then checking directly across the switch with the ohmmeter. You should obtain a resistance reading of practically zero ohms.

The volume control part of the potentiometer frequently becomes noisy so that if you change the volume control setting there will be considerable noise in the receiver. Occasionally you will find that at certain settings of the volume control the receiver cuts off and on. This is usually due to dirt inside the control. Sometimes the control can be cleaned by squirting a cleaning fluid inside of the control, but usually it is simpler and better to replace the control.

Fixed Resistors. Several small fixed resistors are used in the receiver. When a resistor is overloaded, it usually changes color. Sometimes the resistor will actually break in two. It is usually not too difficult to spot a resistor that has been overloaded. If the resistor has recently been overloaded, you can generally detect a rather strong unpleasant odor coming from the set.

COUPLATES

Couplates seldom burn out, but when they do, you can sometimes overcome this difficulty simply by connecting a good part across the defective section. For example, if the .006-mfd capacitor connected between terminals 1 and 2 of the couplate shown in Fig. 26B were to open, you could restore operation of the receiver simply by obtaining a separate .006-mfd capacitor and connecting it directly between terminals 1 and 2 of the couplate. However, if the capacitor in the couplate shorted,

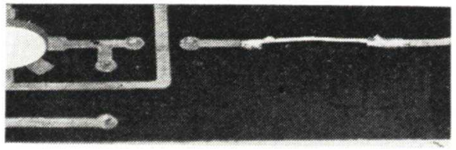

FIG. 32. A break in a copper lead on a printed circuit board can be repaired by carefully soldering a piece of wire across the open circuit.

then you would have to cut the leads from terminals 1 and 2 of the couplate loose and then connect a capacitor into the circuit. You will learn more about how to handle this type of repair later. Actually this presents little or no problem to an experienced technician.

PRINTED WIRING

It is unlikely that anything will happen to the printed wiring as long as the receiver continues to operate. However, sometimes in the process of replacing a defective part you may damage the printed wiring. This can be repaired by carefully soldering a piece of wire across the break. An example of a printed wiring board that has been repaired is shown in Fig. 32. Notice here that a piece of wire has been soldered onto the board. Originally, the printed wiring joined the two points together, but the printed wiring has been damaged and then repaired simply by soldering a short piece of wire across the break in the copper strip.

A great deal of trouble with printed boards can be avoided by using a small soldering iron whenever it is necessary to remove or replace any parts in a receiver using this type of wiring. Small *pencil*-type irons having a wattage rating of about 25 watts are useful when working on this type of circuit. These irons can be purchased from any radio-TV parts supplier. Avoid using large soldering irons sold by hardware stores for radio work. They are too large and often get so hot that you may damage the equipment by using one.

LOOKING AHEAD

In this lesson you have been introduced to a large number of the parts found in a typical radio receiver. You've also been introduced to effect-to-cause reasoning, which is a systematic procedure used to isolate defects in electronic equipment *first* to one section, then to one stage, then to one circuit, and finally to the defective part. By this time you can probably see how important it is to understand how the various parts in a radio receiver operate; you must know what each part is supposed to do and once you've learned how the part is supposed to work you can learn what to expect when one breaks down.

You can probably see the importance of developing a systematic servicing technique so that defects can be quickly isolated in a systematic manner to the defective part. Trying to service a piece of electronic equipment simply by checking one part after another may be successful when you are working on a simple piece of equipment, but it's an almost hopeless task on complex equipment.

In the following lessons you'll begin to study the individual parts used in electronic equipment. You'll study these parts in detail and learn how they are used together to make up complete circuits. The lessons you are about to begin are perhaps the most important lessons in your entire course. Make sure that you understand these lessons before leaving them and going on to more advanced lessons.

Lesson Questions

Be sure to number your Answer Sheet 4B.

Place your Student Number on every Answer Sheet.

Most students want to know their grade as soon as possible, so they mail their set of answers immediately. Others, knowing they will finish the next lesson within a few days, send in two sets of answers at a time. Either practice is acceptable to us. However, don't hold your answers too long; you may lose them. Don't hold answers to send in more than two sets at a time or you may run out of lessons before new ones can reach you.

1. What is the big advantage of the superheterodyne receiver compared to the trf receiver?
2. Draw a block diagram of a modern 5-tube ac-dc superheterodyne receiver.
3. Draw the schematic symbol of a dual diode-triode tube.
4. Give two advantages of a transistor over a vacuum tube for use in a portable receiver.
5. Which *one* of the following three tubes would you expect to find between the two i-f transformers: *the output tube; the mixer tube; the i-f tube?*
6. Draw the schematic symbol of an i-f transformer.
7. If in servicing a receiver you notice distortion, particularly on low-frequency notes, what type of defect would you suspect?
8. If you are going to check the secondary of an output transformer with an ohmmeter because you suspect that the secondary is open, what must you do before you make the check?
9. If you are servicing a receiver that operates over part of the broadcast band, but as you tune toward the low end of the broadcast band you suddenly hear a scraping sound and the set goes dead, what part would you suspect is defective?
10. If the 35W4 tube burns out almost as soon as an ac-dc receiver is turned on, what part may be defective and causing the trouble?

THE VALUE OF COURTESY

A recent survey showed that people complain more about discourteous clerks than about any other fault a business could have. In fact, many people pay extra at higher-priced stores just to get the courtesy and respect they feel entitled to.

Regardless of whether you work for someone else or have a radio business of your own, plain ordinary courtesy can bring many extra dollars to you.

Courtesy becomes a habit if practiced long enough. Be courteous to everyone—to members of your family, to those who don't buy from you, even to the very lowest persons who serve you—then you can be sure you'll be courteous when it really counts.

Give your courtesy with a smile. There is an old Chinese proverb which says, "*A man who doesn't smile shouldn't keep a shop.*" And you're keeping a "shop" even if you are selling only your ability and knowledge to an employer. A friendly smile is itself courtesy of the highest type, bringing you unexpected returns in actual money as well as friendship.

J. E. Smith