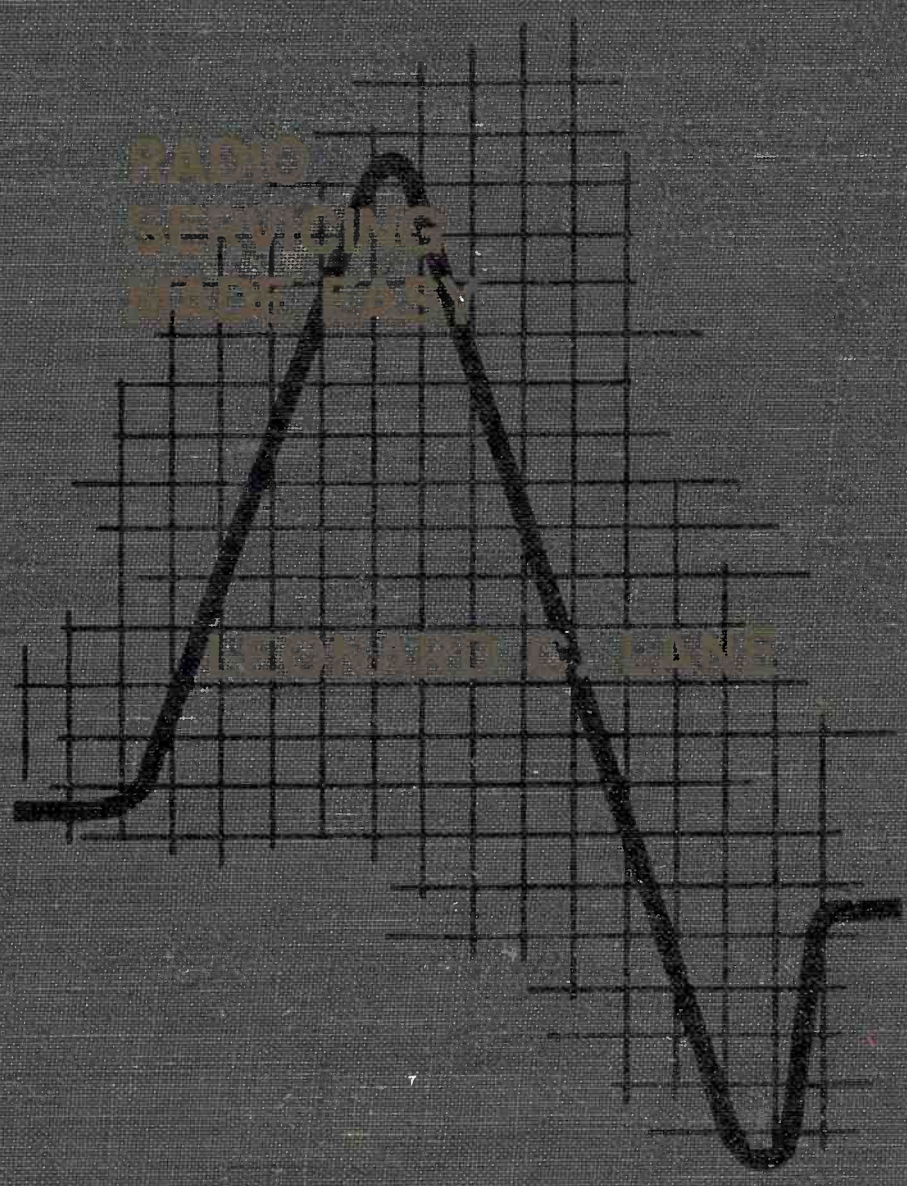


RADIO
SERVICES
RADIO

RECHARD L. LANE



VOLUME 1

radio
servicing
made
easy

LEONARD C. LANE

AUTHOR OF

How to Fix Transistor Radios and Printed Circuits
New Shortcuts to TV Servicing

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To my Father, a gentle
and peaceful man.



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Introduction

WELCOME to the ranks of those who want to earn more by servicing radio receivers.

We could let you jump right in with both feet, give you a complete circuit of a radio receiver and say: "Here. Do this and that . . . and the set will be fixed." That's a cook-book method. A few technicians might think that's good, but what do you do when the chief cook is out . . . and you have a collection of sets with troubles not described in the book?

With our approach you'll be able to look any radio set right in the face and say, "See here. No nonsense out of you or else . . ." What's more, you'll really mean it.

For many years radio service technicians fixed nothing but radios. There were all sorts of radios. Big ones. Little ones. Sets with 15 tubes. Sets with one tube.

But then, along came television and radio took a back seat. Practically all radio receivers were of the 4 or 5-tube ac-dc-type. If you could fix one, you could fix them all. Television was the big thing. People weren't too anxious to spend any money fixing their little sets since they were so cheap to begin with.

People have now become accustomed to television. Many homes have two television sets. And then people discovered radio all over again, after the novelty of television wore off. There is a big demand for radio again.

What sort of radio? All sorts! Clock radios, personal portable radios, short-wave receivers, marine radio receivers, police and airplane receivers, console receivers for the home, FM receivers for the home, FM receivers for use in automobiles. Just in the automobile alone, we have, in addition to AM and FM types, sets that fit into the dashboard, sets that fit into the glove compartment, sets that fit onto the rear-view mirror, sets that fasten to the floorboard (in sports cars).

Radio receivers now come in all shapes and sizes. Some are so tiny that they fit into a vest pocket—or will, just as soon as vests come back into style. Most come equipped with a hearing aid type of earphone so you can walk down the street listening to your favorite program.

And some sets are so big that they need a large console cabinet to hold them.

What does all this mean to you? Just this. These sets are going to break down—get out of order. The time to learn how to fix these sets is now—not when the set is sitting on your bench with the customer breathing down the back of your neck.

The day of the old “know one—know them all” is gone. Today we have such a large variety, that you can’t “pick up your servicing knowledge as you go along.”

Here is one cheerful note. In many cases, if you study one particular circuit, you will find it used in a number of sets, all of which look different. Just as an example, consider a transistor if stage. You will find it in personal portables, in home receivers, in auto radios. There will be some differences but many similarities. You won’t find a *completely* new if stage with every new type of receiver.

We hope we haven’t painted too dark a picture for you. We’re just anxious that you should be fully prepared. Troubleshooting techniques learned here can be used on any electronic circuit. A dead stage will give the same wrong indications in a radio as in an amplifier. Noise interference must be traced with the same procedures and instruments in an automobile radio or an industrial installation. Once the principles are understood the solutions will come much easier.

Just one last word. We have tried to make this book as readable as possible, but that doesn’t mean that you should consider it as a novel. By all means, read both Volumes 1 and 2, and read them often. But keep them around as reference books. The troubleshooting charts were prepared especially to help you. Take advantage of them.

LEONARD C. LANE

CHAPTER 1

working with transistors

WE'RE GOING TO START our work with transistors. There's good reason for our doing so.

Transistors are being used more and more. Some sets have transistors only. Others, known as hybrid receivers, use both tubes and transistors. You may have had quite a lot of experience with tubes, but transistors are different.

Getting started with transistors

Did you ever see a father with a new-born baby? From the way proud papa handles the infant you might get the idea the child is made of glass.

It isn't such a big jump from the nursery to the radio workbench as you might think. Have you watched the way some radio technicians handle a transistor? Right! They're practically afraid to breathe on it.

As you go through these volumes, you will learn that the transistor is not a little namby-pamby. For its size, and what it can do, the transistor is a tough item. It will outlive batteries. It will outlast resistors. You will replace transformers and coils while the original transistors will sit in their sockets waiting for a signal to come along.

Then what are all these stories you've been hearing? Someone having fun at your expense? Not quite! The whole problem lies in the fact that, when transistors were first introduced, technicians decided to handle them just like tubes.

Transistors weren't going to stand for that sort of nonsense.

Transistors wanted to be treated like transistors.

Transistors weren't going to be pushed around.

Transistors are quite willing to amplify and oscillate, but they insist on doing it on their terms.

Our job, then, is to learn what we can and what we can't do with transistors. Once we do that, all we need do is to wait for the receivers to come into the shop. And we don't mean wait and worry, either. We mean wait with confidence!

What is a reference point?

Here's a simple little experiment you might like to try. Stand in the middle of the room and point east, then west. After you have done this, point north and then south (Fig. 101).

What does it mean when you point east? Wouldn't you say that

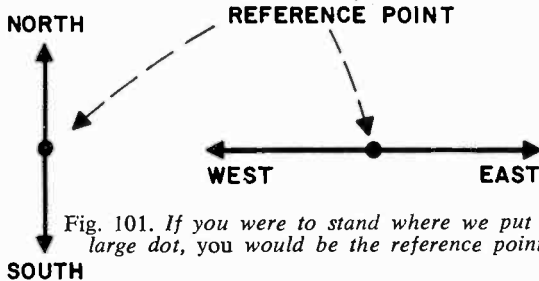


Fig. 101. If you were to stand where we put the large dot, you would be the reference point.

everything in front of your hand is east? But east of what? You're the one doing the pointing, so it must be east of *you*!

Now what happens when you make an about-face and point in the opposite direction? This time, everything in front of your hand is west. Once again, west of what? You're the one doing the pointing, so it must be west of you!

What were you in this little experiment? Since you could point in any direction, wouldn't you say you were a *reference point*?

A practical example

A compass is a good example of a way in which we use reference points. Another very practical device is the ordinary thermometer. Two types are in general use, just as shown in Fig. 102, but they both work the same way.

One type, called the Fahrenheit, has a little mark on it at 32° . We call this the freezing point. At temperatures below 32° water starts to become a solid—ice. Above 32° the ice starts to become a liquid—water. In the Centigrade thermometer, the reference point is at 0° .

In either case, whether we use 32° or 0° , these temperature points are important as a reference.

Other examples

There are many examples of reference points. Your home is a reference point. You leave home in the morning, come back at night. If you travel 3 miles to your job, then the 3 miles is the distance between the reference point (your home) and your job.

The surface of the earth (at sea level) is a reference point. We can either fly above it (as in an airplane) or travel below it (as in a submarine). The plane uses an altimeter to determine how high it is above sea level (its reference point). The submarine uses a

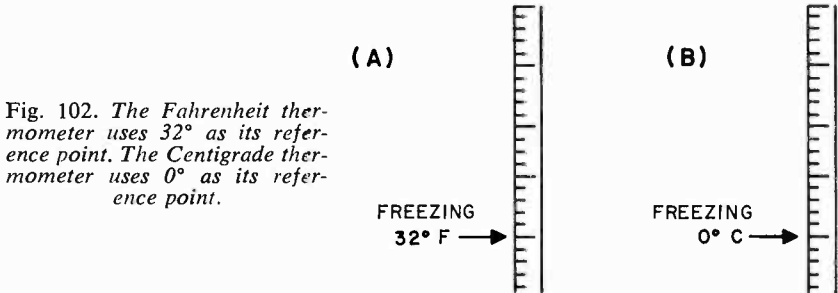


Fig. 102. The Fahrenheit thermometer uses 32° as its reference point. The Centigrade thermometer uses 0° as its reference point.

depth gauge to determine how far it is below sea level (its reference point). Both the plane and submarine (Fig. 103) use the same reference point.

Reference points are used all the time. A graph helps keep track of the progress of a business. You will see graphs almost every day in the business section of newspapers.

When you first learned electronic theory, you probably studied a few graphs like those shown in Fig. 104. In Fig. 104-A we show an alternating voltage.

Note how important the reference line is. We couldn't draw the graph without it. The reference line is the one marked zero. All voltages above zero are plus; all those below it are minus.

Even though our voltage might be all negative (as in Fig. 104-B) or all positive (as in Fig. 104-C), we still need a reference line. The graphs not only tell us whether a voltage is positive or negative (with reference to zero) but also by how much.

Back to radio

In any circuit the chassis or B-minus line is often used as a reference point. In measuring the plate or screen voltage of a tube you connect one test lead to the correct pin on the tube base. The other test lead connects to chassis or B-minus. Just as you could live in a town east of a river (using the river as a reference) or

north of Market Street (using Market Street as a reference), so we measure voltages (Fig. 105) using the chassis or B-minus as a reference.

The ground is all around

Our reference point in a radio set has more than one name. (That isn't too surprising. You have a first and a second name.) The reference point is sometimes called the chassis and sometimes B-minus. But very often it is known as ground. The reason for this is that, in old-time radio sets, the chassis was actually connected to the earth (ground) with the help of a long wire. We don't usually do that any more, but the word ground has remained with us.

Moving the reference point

When we asked you to help with our experiment, you stood in the middle of a room. Suppose, though, that you decide to take a walk. Are you—personally—still a reference point? Couldn't you still raise your arm and point wherever you wanted to?

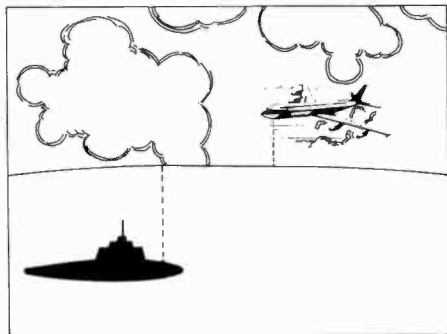


Fig. 103. Both the plane and the submarine have the same reference point.

This can be done with our reference point in a radio circuit. In Fig. 106-A, a 9-volt battery is shunted across a resistor. In Fig. 106-B, a ground is connected at point 2. Have we really changed the circuit? If we use exactly the same parts as in Fig. 106-A, wouldn't the same amount of current flow in both circuits?

In Fig. 106-C the ground connection is moved to position 1 of the circuit. Our reference point is in a different spot, but have we changed the circuit? The same amount of current flows. The reference point could be put right in the middle of the resistor, as in Fig. 106-D, without affecting the circuit.

Bring on those questions

Your first question should be: Why are you doing this? If mov-

ing the reference point around doesn't change the circuit, why bother?

As a start, examine Fig. 106-B. What is the voltage at point 1? Obviously, it's 9 volts. But 9 volts what? Haven't we forgotten something? All voltage has polarity, so our answer isn't really wrong—it's just not complete. In Fig. 106-B, point 1 is 9 volts

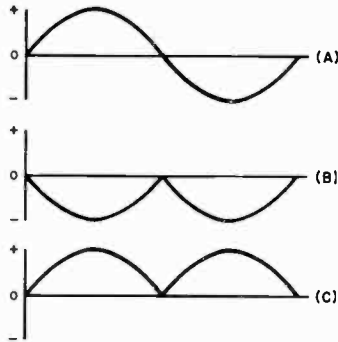


Fig. 104. A graph is often used to show whether a voltage is positive or negative or both. The line marked zero is the reference line.

positive. But with respect to what? Our *complete* answer must be: "Point 1 is 9 volts positive with respect to ground."

In Fig. 106-C, what can we say about point 2? The *complete* answer in this case must be that point 2 is 9 volts negative with respect to ground.

We take a giant step

We hope you have noticed the importance of Figs. 106-B and C. Just by moving the reference point we can have either a positive voltage (with respect to ground) or a negative voltage (with respect to ground).

That isn't all. We can have both polarities, as shown in Fig. 106-D. Point 1 is positive with respect to ground while point 2 is negative.

Now do you see how easy it is, in any radio set with just a single battery, to have both positive and negative voltages?

But is it practical?

Transistor radios use batteries and, although the circuits in Fig. 106 are very simple, they show us exactly what to expect in receivers.

For example, we might not want the full 9 volts supplied by the battery in Fig. 106. We can solve this problem in a nice, easy way: just move the reference point. In Fig. 106-D (if the reference point

is at the exact center of the resistor), our voltages are 4.5 volts positive (with respect to ground) and 4.5 volts negative (with respect to ground).

The reference point can be moved anywhere along the resistor and get any combination of positive and negative voltages that add up to the voltage supplied by the battery.

Follow the arrows

Did you ever see the big white arrows painted on highways to guide motorists? We can use arrows here, and they are just as practical.

Fig. 107 shows what we mean. In this circuit we have two equal resistors whose total value is the same as that of the resistor used

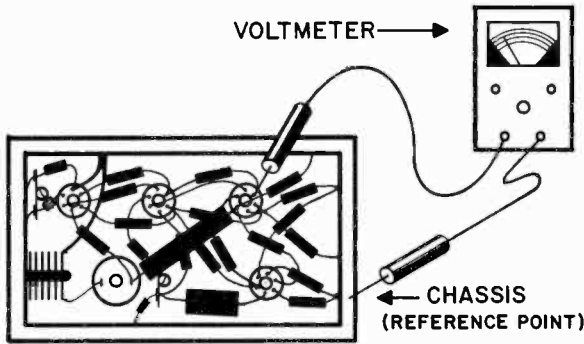


Fig. 105. When making voltage measurements, the chassis is often used as a reference point. Sometimes a wire, running the length of the chassis, is used as the reference point instead of the chassis.

in Fig. 106. We have a voltage drop of 4.5 volts across each resistor.

The arrows tell us the direction of current flow. What good are they? Knowing the direction of current flow tells us the polarity of the voltages across the resistors.

Knowing how to draw the arrows is very simple. An electron current always flows from minus to plus. All we need do, then, is to think of the direction of the current. The head end of the arrow (pointing in the direction the current is moving) is plus; the tail end is minus.

We hope you aren't going to be fooled for one little minute by the fact that this theory isn't difficult. You would be surprised at how many technicians get tripped up by it . . . especially in working with transistor radios, where polarity is so very important.

The common line

If you've worked with vacuum-tube receivers, you are probably accustomed to the idea that B-minus is grounded. Another way of saying the same thing is that you probably always have used B-minus as the common line or reference point.

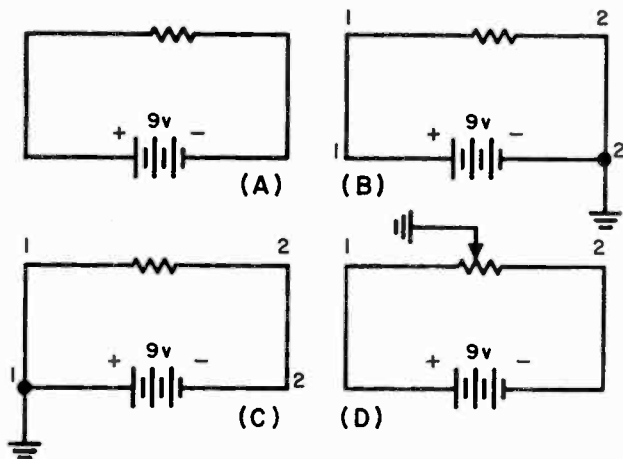


Fig. 106. We can put the reference point anywhere we want. It will not change the voltage, the resistance or the amount of current flowing.

In transistor receivers this isn't always so. In some transistor sets the B-plus of the battery is the common line and the B-plus may or may not be grounded. You may have a bus (a wire) running through the set to which connections are made. This bus is a reference point from which most checks are made.

In Fig. 108-A, note the electrolytic capacitor, C1. In this case the plus side of the capacitor is connected to ground.

Fig. 108-B shows the wiring that you might find in a transistor receiver but which is also very common in vacuum-tube sets. If you will look at C1, you will see that the electrolytic has been turned around.

The great divide

Getting back to Fig. 107, what would you say about the polarity at the junction of the two resistors? Is it plus? Or is it minus? If you're paying attention then we won't be able to trip you up on this one. Aren't we really back to the idea of pointing north and then south?

The polarity at the common point of the two resistors depends

on which way we are looking. It is minus with respect to point 1 and plus with respect to point 2.

The forward-biased diode

With a few basic facts clearly in mind, let's move along to diodes. Fig. 109 shows the two types—semiconductor and vacuum tube.

The semiconductor diode in Fig. 109-A could be germanium or

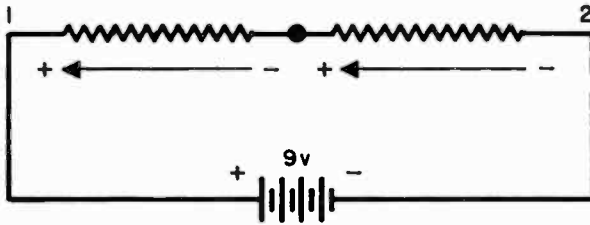


Fig. 107. Note that the connecting point of the two resistors is plus and minus at the same time.

silicon or any other semiconductor material. The supply voltage for the diode is called a bias battery. When we say that the semiconductor is biased, all we mean is that it is connected across a voltage source.

The circuit of Fig. 109-A shows a current flowing, but when we turn the diode around, as in Fig. 109-C, the current stops. Our diode acts like a switch. When the switch is closed, current flows. When the switch is opened, current stops.

Once again we have a few special names. Because the diode in Fig. 109-A is connected to let current flow, we say that it is forward-biased. It lets current move forward. And what is the opposite of forward? Wouldn't you say reverse? That is what we call the circuit of Fig. 109-C—reverse-biased.

If you're a little more familiar with tubes than with semiconductors, don't let it bother you. Fig. 109-A is similar to Fig. 109-B; Figs. 109-C and 109-D are also alike.

Approaching the transistor

Perhaps you are a little worried about transistors and think them strange and mysterious. You certainly don't think about diodes that way because you run across them in every radio set you work on.

What applies to diodes, applies to transistors. The transistor is similar to a pair of diodes placed back to back.

In Fig. 110 we have a p-n-p transistor. The parts we are interested in—the emitter and the base—are just a forward-biased diode. Note the direction of current flow. Wouldn't you say that Fig. 109-A is similar to Fig. 110-A?

A few relations

We now have a p-n-p transistor with the base-emitter circuit forward-biased. That's quite a mouthful to say but, at this point,

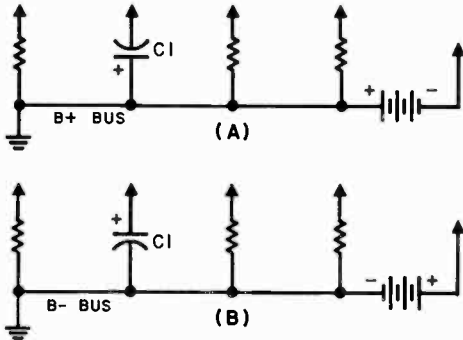


Fig. 108. In some transistor receivers, B-plus is the common return and all measurements are made with respect to the B-plus bus. In other transistor receivers, B-minus is the common line and all measurements are taken with respect to B-minus. In both cases, though, voltage checks are made to ground. Note that in A, ground is connected to B-plus while in B ground is connected to B-minus.

you know what it means. Current is going to flow from the negative terminal of the battery, through the base and emitter connections and back to the plus terminal of the battery. The arrows show the direction of current flow.

*I have an aunt,
an uncle too,
the closest of my relatives, just about
but the brother of the cousin
of the sister of my aunt,
is something I can't
even understand or figure out!*

You have relatives. So do we. But we're not the only ones. Each element of a transistor is related. Lucky for us, though, the transistor has only three elements, so remembering how they are related to each other won't be too difficult to remember.

How are the base and emitter related? Substitute a resistor in the p-n-p transistor, as in Fig. 110-B, and you'll have your answer. The base is negative with respect to the emitter. Another way of saying exactly the same thing is that the emitter is positive with respect to the base.

Let's see just what we know. We're using this resistor in Fig. 110-B as a substitute for the forward-biased diode part of a transistor. Keep in mind what we mean by forward-biasing. The diode is connected so that current flows through it fairly easily. What kind of an answer does this give us? Couldn't we say that the resistance used in place of the diode has a low value?

Suppose we add a few resistors to the circuit, as shown in Fig. 111-A. Our first step is to decide the direction of current flow (it moves the way the arrows point).

We can make life a bit easier by redrawing the circuit as in

Fig. 109. *Semiconductor diodes are just like vacuum diodes. When diodes are forward-biased they conduct. When they are reverse-biased, they conduct very little (practically not at all).*

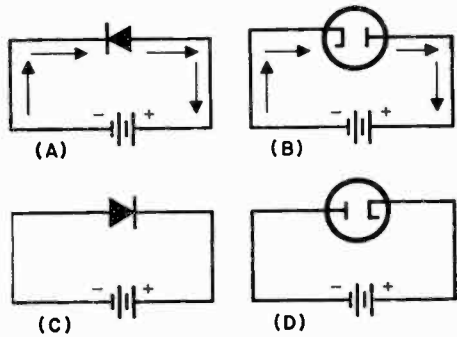


Fig. 111-B. Now what have we got? Three resistors in series! Who said transistors are difficult?

The only difference between Fig. 110 and Fig. 111 is a few added resistors. How will this change the circuit? What effect will it have? Begin with the current. We know that resistors can't change the direction of current flow, but one thing always happens when current goes through a resistor. We get an IR drop. Call it a voltage drop if you like—it means the same.

So we lose some voltage across the resistors. As a result we have less voltage between base and the emitter. However, the direction of current didn't change, the polarity didn't change and we still have a base that is negative with respect to the emitter.

Pairs of diodes

The transistor in Fig. 111-A is a p-n-p unit. Here's how it gets its name:

p (p-type material)	emitter
n (n-type material)	base
p (p-type material)	collector

Look at this carefully. The first letter (p) does two things.

1. It stands for *emitter*.
2. It tells the type of semiconductor material used for the emitter.

That's quite a load of information for just one little letter.

What about the other letters? They work in the same way and just as hard. Examine the second letter (n).

1. It stands for *base*.
2. It tells us the type material used in the base.

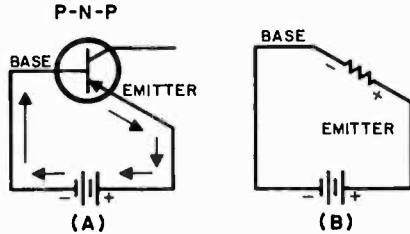


Fig. 110. Note how similar the transistor is to the ordinary diode.

The last letter (p) is the easiest of all. It is made of the same type of material as the emitter. The last letter is always the *collector*.

P-n-p and n-p-n

Do you remember that old brain-teaser about which came first—the chicken or the egg? Maybe we can't answer that one, but if

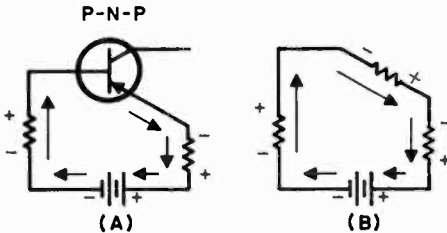


Fig. 111. If we know the direction of current flow, we know the polarity of the voltages across the resistors.

you're ever asked, "Which comes first—P-type or N-type material?" you can answer immediately—both.

Fig. 112 shows this clearly. In Fig. 112-A and Fig. 112-B, we have two diodes. Note that both are forward-biased. One diode is a p-n; the other is an n-p.

How did we manage to get forward biasing, even though the diodes are different? Easy enough: we turned the batteries around.

We could make the same diodes reverse-biased once more by turning the batteries around.

What do we need to remember for forward biasing?

P-type (positive type) germanium or silicon connects to the positive terminal of the battery.

N-type (negative type) transistor element connects to the negative terminal of the battery.

Perhaps you think this is too easy. But just because it is easy

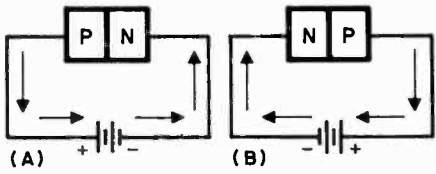


Fig. 112. Current will flow when diodes are forward-biased.

doesn't mean that it isn't important. With this little bit of information, we can have two different types of transistors—p-n-p and n-p-n.

Our first step in getting an n-p-n transistor is shown in Fig. 113. Now compare Fig. 113 with Fig. 110. What is the difference between them? Look carefully, because they are almost alike. If you want a clue, examine the arrows used in the transistor symbols.

In the n-p-n transistor, the current flow is exactly the opposite to that of the p-n-p. But is this such a big surprise? Not if you examine Fig. 112. What we have in Fig. 112 is a pair of forward-biased diodes. But isn't that exactly what we also have in Figs. 110 and 113?

Adding the resistors again

A little earlier, we added some resistors to our p-n-p transistor. Suppose we borrow those resistors and use them again for our n-p-n unit in Fig. 114. Be careful. Watch the direction of current flow. Be sure. Compare Fig. 114 with Fig. 111. It wouldn't be a bad idea if you were to practice drawing both of these circuits. If you know them—really know them—you'll find it a big help in servicing transistor radios.

Polarity again

Did you ever think that a two-way tunnel and transistors have something in common? Every time we drive through a tunnel and keep an eye on traffic moving both ways, we're nearly always reminded of p-n-p and n-p-n transistors. They have currents that move, just like traffic . . . in opposite directions.

Fig. 115 illustrates our diode-current “traffic control” system. Fig. 115-A shows a forward-biased diode. Transpose the battery and current stops (Fig. 115-B).

Fig. 115 shows two types of diodes—n-p and p-n. What is the difference between them? Just a matter of direction of current flow, isn't it?

From the diode to the transistor

We have spent quite a bit of time explaining to you just how we can expect currents to flow in p-n and n-p diodes. If you have the

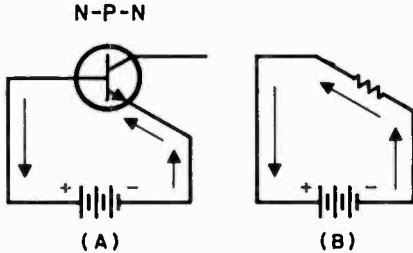


Fig. 113. Current flow in an n-p-n transistor.

slightest doubt about understanding it, go back over the text before going on.

Earlier we told you that a transistor is similar to a pair of diodes. Let's see how we can go about making a transistor out of them.

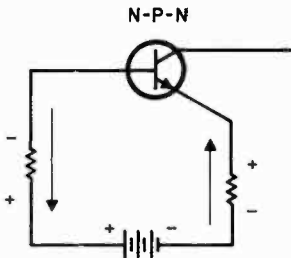


Fig. 114. Note how useful the arrows are when working with circuits.

Fig. 116 shows how we are going to do this. We can begin with Fig. 116-A. Here we have two diodes, connected back to back. How are these diodes biased? Let's make sure we agree. Diode 1 is forward-biased and diode 2 is reverse-biased.

A little summary

Before we go any further, let's talk over some important facts we should have learned by now:

1. Voltages are measured with respect to a reference point.
2. A voltage can be positive with respect to a reference point.
3. A voltage can be negative with respect to a reference point.

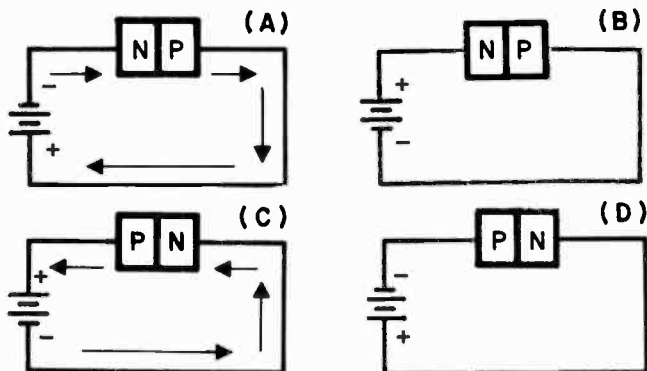


Fig. 115. We can make current flow through n-p and p-n diodes by inserting the batteries the proper way. If we turn the batteries around, current flow will become so small that we can say it practically doesn't exist.

4. In a receiver the chassis or ground is often used as a reference.

The reference can be a bus or some common connection point.

5. Current (electron movement) flows from minus to plus.

6. We can use an arrow to indicate direction of current flow.

The head of the arrow points in the direction in which the current is moving. The head of the arrow is marked plus (+). The tail of the arrow is marked minus (-).

7. Forward-biased means that current moves readily.

8. Reverse-biased means that very little current flows.

9. The elements of a transistor are the base, emitter and collector.

And now let's make the jump from diode to transistor. This is shown in Fig. 116-C. All we did, as you can see quite easily, is to take the two bits of p-type (and also n-type) material and combine them into one.

How could we do this? What gave us the right to do this? Stop for a moment and consider. We had two pieces of germanium or silicon. All we did was to join them. Actually, if you wanted to discuss the point, you might even say that we made no change at all. It's just as though we had two 1-lb weights on a scale and replaced them with a single 2-lb weight. How much difference does it make?

Naming names

The transistor of Fig. 116-C looks like a sandwich. We have two slices of n- and one slice of p-type. The single section in the middle is called the *base*.

Did you ever buy a sandwich, separate the two slices to see if there was anything at all between them? That's the kind of economical transistor "sandwich" we have. The p-type material of the base is extremely thin.

Since the base is now shared by the emitter and the collector the base is a common element. And because it is, wouldn't the base make a good reference point for emitter and collector measurements?

The p-n-p transistor is made in the same way as the n-p-n, as shown in Figs. 116-B and 116-D.

Taking the last step

Ever go on a hike? You can start out full of vim and pep and no distance seems too great. But which are the toughest steps to take? You guessed it. The last few on the way home.

We've been on an electronic hike but home is in sight. You can see it in Fig. 117. Start first with Fig. 117-A. Here we have our n-p-n transistor circuit, complete with batteries and resistors.

Fig. 117 should look familiar to you. Even though we are using the symbol for a transistor, it doesn't fool us a bit. And to make sure that it really isn't hiding any surprises, compare it with the vacuum-tube triode circuit shown in Fig. 117-B.

A closer look

A circuit is like a movie. You have a door to go in and a door

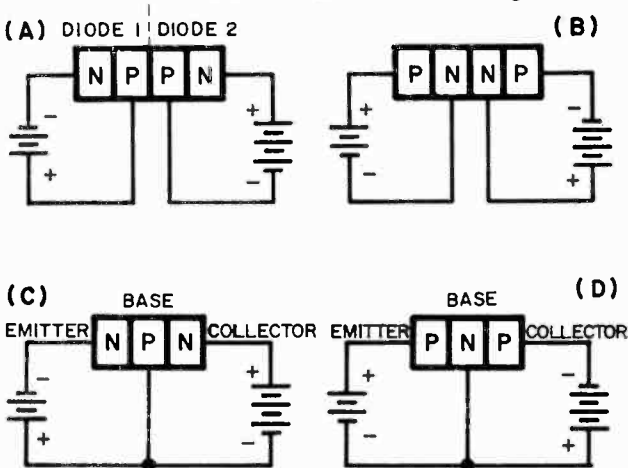


Fig. 116. We can make a transistor from a pair of diodes. If you know how diodes work, you are well on your way to a good understanding of transistors.

to go out. In a radio circuit, we let the signal go in and, if the circuit is working the way it should, we get a signal out.

Getting back to the movie for just a moment, we could eat some

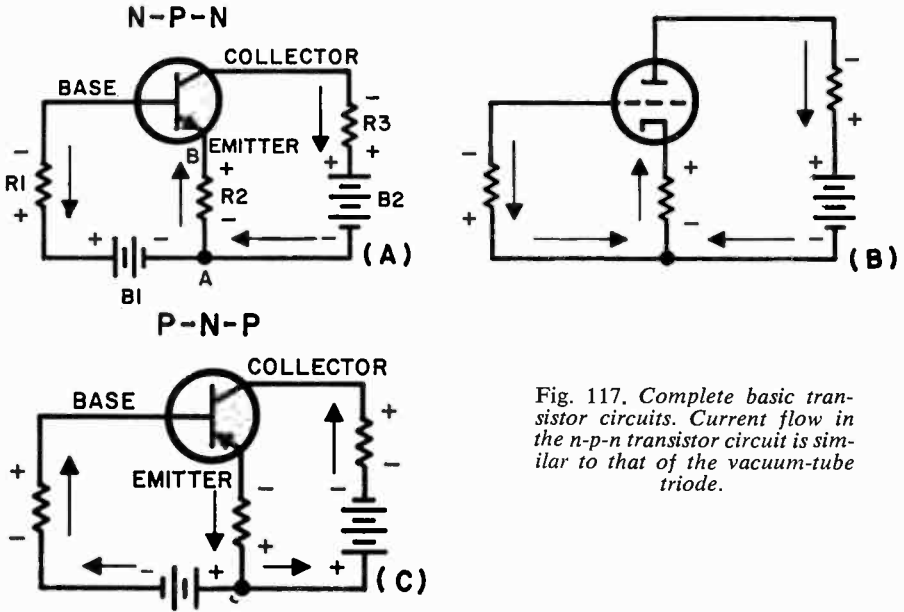


Fig. 117. Complete basic transistor circuits. Current flow in the n-p-n transistor circuit is similar to that of the vacuum-tube triode.

candy or other refreshments while watching, so we come out a bit bigger or heavier than when we went in. In a radio circuit this is what we want. We feed in a signal but we're usually anxious to get out a bigger one.

Fig. 118 shows just how we do this. The signal is injected or fed in between the base and the emitter. The output signal develops across the load resistor connected between the collector and the emitter. It is true that we show two batteries but, with the kind help of a few resistors, we can use just one battery.

Fig. 119 shows the arrangement we have for an n-p-n transistor. Note how much alike Figs. 118 and 119 really are. But are our eyes sharp and our minds clear? What are the differences between the two?

Fig. 118 uses a p-n-p transistor. Note the polarity of the two batteries.

Fig. 119 uses an n-p-n transistor. Once again, note how the batteries are connected.

In certain ways the two circuits are alike. We feed the signal in

the same way to both circuits. And we take the amplified signal out in the same way.

To see how very similar the tube and transistor are, let's set them up against each other.

N-p-n
Transistor
base current
collector current
emitter current

Triode
Vacuum Tube
grid current
plate current
cathode current

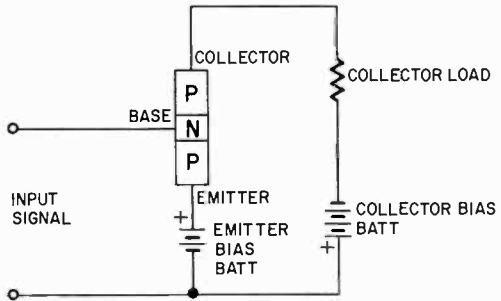


Fig. 118. Just like a vacuum tube, a transistor triode circuit has an input and an output.

Not only that, but the currents in both flow exactly in the same direction. What could be easier to remember!

What about the p-n-p transistor? We can't draw an equivalent vacuum-tube circuit for you because there isn't any we know of that

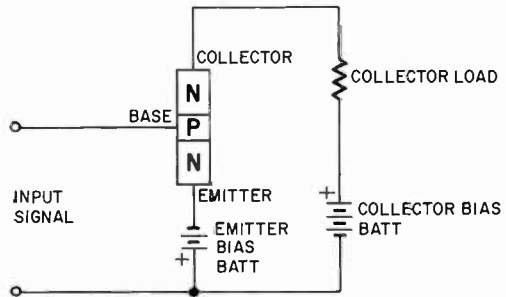


Fig. 119. When working with transistors, be careful about battery polarity. Compare the battery arrangement shown here with that of Fig. 116.

acts like the p-n-p. That won't bother us, though. The p-n-p is like the n-p-n but with currents flowing in the opposite direction.

What about polarity?

We've been telling you this is so easy so often that you probably are beginning to believe it. It is really easy, but don't get the idea that you can know this without doing some working and thinking. Let's work together, then, on the subject of polarity. What about

the polarity of the voltage drops across the resistors shown in Figs. 118 and 119? To help answer that question, let's check off the things we should do when working on a transistor circuit:

1. What type of transistor do we have? Is it p-n-p or n-p-n?
2. What part of the transistor is forward-biased?

To see how we go about answering these questions, take a look at Fig. 117-A. How do we know that it is an n-p-n transistor? In no less than three ways: First, the transistor symbol is marked. Next, the arrow of the emitter is pointing outward. Finally, we note that the emitter is connected to the negative terminal of the battery (B1) and the base to the positive terminal.

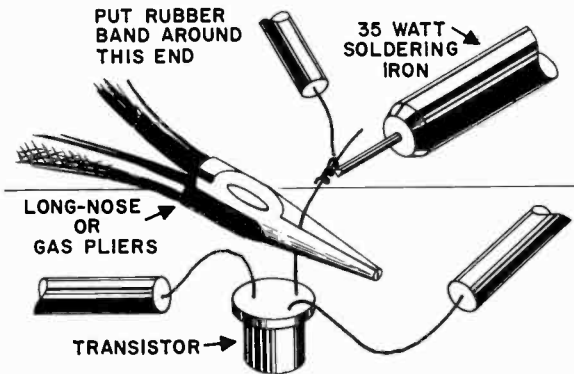


Fig. 120. A pair of long-nose pliers make a good heat sink. Keep the tip of the iron away from the transistor. A rubber band can be used to hold the jaws of the pliers closed, freeing your hands for other work.

Add one more little fact, and we have the whole story. Current flows from minus to plus. With all these clues you should never have any trouble in finding the polarity of the voltage across the resistors.

Finally, if you forget, just remember that in an n-p-n transistor the currents flow exactly as in a triode tube. And in a p-n-p unit the currents flow in the opposite way.

How to handle transistors

All radio components need a certain amount of special handling. You shouldn't mount a wax-filled capacitor right next to a hot rectifier tube—not unless you want a chassis full of wax. You shouldn't connect a power transformer to a dc power line. In the same way, there are certain things we should not do to transistors.

1. Don't use excessive heat for soldering components to tran-

sistor leads. For most work a 35-watt iron is fine. This doesn't mean, though, that you can put the hot tip of a 35-watt iron to a transistor lead and then forget about it. Even with a 35-watt iron, enough heat can accumulate to damage a transistor. It's always best to use a heat sink, as shown in Fig. 120. This can be a pair of long-nose pliers or gas pliers. Kept closed with the help of a rubber band, your hands are free to work.

2. Heat damage is more of a problem with germanium transistors (or germanium diodes and rectifiers) than it is with silicon

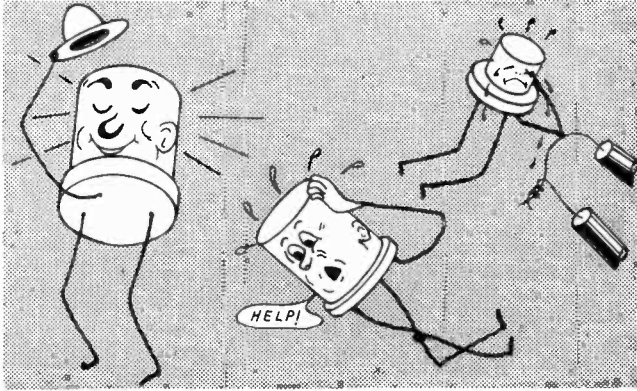


Fig. 121. Make sure transistor leads don't touch each other or exposed wires of other components.

units because of the higher permissible temperatures in silicon devices. The leads normally used are either Dumet or Kovar—either of which is a poor conductor of heat. Hence, if the full length of lead (usually about 1.5 inches) is used, and the solder connection is made within a few seconds, no heat “stealing” will be necessary. If the leads are to be short, or if it is necessary to apply the heat for a lengthy period of time (that is, more than just a few seconds), then it may be necessary to use some means of removing the heat which would be conducted by the component leads. Pliers can be used, as shown in Fig. 120, or it might be more convenient to utilize one of the following:

Dental tweezers which can be locked in place (also useful for holding parts together while soldering).

Alligator clips made of copper. If room permits, the normal clip (such as might be found at the end of a vtvm cable) can be used. Should space be

limited, it might be necessary to “form” the ends of the clip by squeezing them with pliers or vise. A useful tool can be made by squeezing the clip and then bending the flattened portion at right angles. Or, if you don’t wish to bother, you can buy ready-made clips.

Finally, you can wrap the transistor lead in cotton and dampen with water. A slotted felt pad will also work.

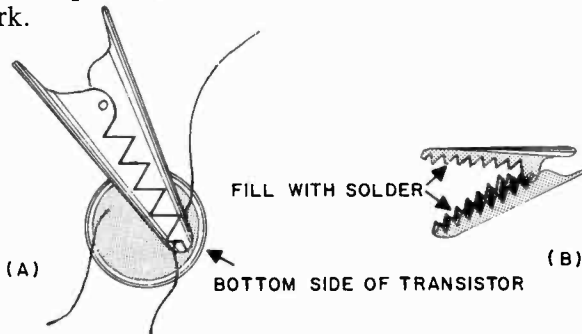


Fig. 122. Ordinary size alligator clips can short transistor leads. The teeth can also bend and cut the transistor leads. Use small size clips. Fill the teeth with solder and then file the solder until it is smooth.

3. When replacing a transistor, (if you cannot get an exact replacement) follow the manufacturer’s recommendations for a substitute.

4. When checking transistor circuits, remove the transistor if it is mounted in a socket.

5. When putting transistors back into their sockets, make sure the receiver switch is off or the battery is disconnected.

6. If you must remove a transistor from a circuit, make sure the switch is turned off or the battery is disconnected.

7. Transistor leads are usually not insulated. Make sure the exposed transistor leads do not touch or short to each other or to other components (Fig. 121).

8. Do not install a battery whose voltage is higher than that of the original. A higher voltage does not mean the set will play louder. It does mean that you may end up with a handful of burned-out transistors.

9. Transistor leads can sometimes be damaged by alligator clips. Some clips have a very strong spring tension. To avoid damage fill the jaws of your test clips with solder (Fig. 122). File the solder until

the jaws can close smoothly. Select small-size clips for this modification. Large clips are often too big to work in the small space inside a transistor receiver. (These modified clips can also be used as heat sinks).

The p-n-p amplifier

We can learn just a bit more about transistor amplifiers by looking at the circuit shown in Fig. 123. In the next chapter we are going to have another circuit, similar to this one, but at that time we will analyze it from a servicing viewpoint.

Unlike the usual vacuum-tube amplifier, this transistor circuit has a low input impedance and higher output impedance.

The input, or base-to-emitter circuit, has two components; one is C1, a 1- μf capacitor. This may seem like a fairly high value for a coupling unit but the reactance of this capacitor must be very low at audio frequencies. Bias voltage is applied to the base through R1.

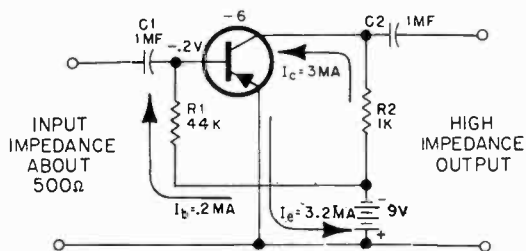


Fig. 123. P-n-p transistor amplifier circuit. The voltage and currents are small. (Admiral Corp.)

The output, or collector-to-emitter circuit has a 1,000-ohm resistor R2 and the output coupling capacitor C2.

What sort of currents can we expect? The base current is 0.2 milliamperes (200 microamperes), while the collector current is 3 milliamperes. But what about the emitter current? This is the sum of the base and collector currents, or, in this case, 3.2 milliamperes.

Voltage measurements

Note the voltages marked on the collector and base in the diagram (Fig. 123). We have -6 volts on the collector. But the battery is rated at 9 volts. Where have we lost 3 volts (the difference between the battery voltage and the voltage on the collector)?

We can find the lost voltage easily enough by using Ohm's Law:

$E = I \times R$. Since the collector current is 3-ma and the collector load resistor is 1,000-ohms the voltage drop across R2 is:

$$E = I \times R$$

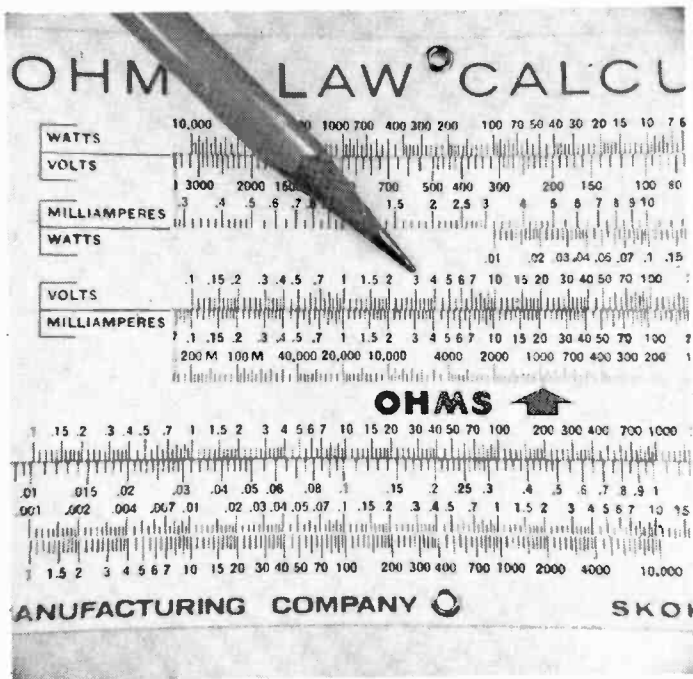
$$E = .003 \times 1,000 = 3 \text{ volts}$$

We can also find the voltage at the base by multiplying the base current by the value of R1.

Now what about the voltage at the emitter? This is usually very close in value to the base voltage, differing from it by just 0.1 or 0.2 volt. For example, the voltage on the base might be -0.1 volt.

Voltage polarity

You've probably noticed that the voltages on the base and collector of this p-n-p transistor are negative. Is something wrong? Aren't we supposed to have a positive voltage on the emitter? Yes,



If Ohm's Law calculations are difficult for you, use a special slide-rule. With any two known values the third can be found easily. Set 1000 over the Ohms arrow and 3 volts is found over 3 milliamperes (ma) as indicated by the pencil point. Wattage for the resistor (less than .01) is found under 3 ma on the next scale above.

(Ohmite Mfg. Co.)

we are. Definitely. But positive with respect to what? Positive with respect to the base. If we have -0.1 volt on the emitter, we have met the requirement! -0.1 volt is less negative than -0.2 volt. Another way of saying exactly the same thing is to say that -0.1 volt is more positive than -0.2 volt.

Actually, though, the voltage on the emitter is zero, as shown in

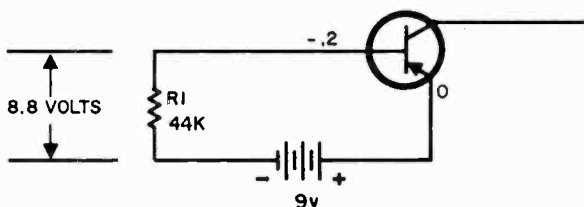


Fig. 124. The base is negative with respect to the emitter by a small fraction of a volt.

Fig. 124. By itself zero is just that—nothing. But we cannot consider it that way. We must consider zero with respect to the base. The base is more negative than the emitter by -0.2 volt. This is the same as saying that the emitter is more positive than the base by this amount.

Fig. 124 also shows how we get 0.2 volt for the base. We drop 8.8 volts across R1, the 44,000-ohm resistor.

QUESTIONS

1. If the direction of current flow through a resistor is known can the polarity of the voltage across that resistor be found?
2. Do the *electron* currents flow from plus to minus within the battery?
3. Is the ground always the reference point in every electronic circuit?
4. Do all voltages have polarity?
5. Should the base-emitter circuit of a p-n-p transistor be forward-biased?
6. Should the base-emitter circuit of an n-p-n transistor be forward-biased?
7. What is the point from which almost all voltages are measured?
8. Do reverse-biased circuits have heavy current flowing through them?
9. Are all voltages positive with respect to the point from which they are measured?
10. What are the names of the three active parts of the transistor to which leads are connected?

CHAPTER 2 **testing transistors and printed circuits**

DID YOU EVER watch a really good magician go through his routine? You know you are being fooled and it looks very mysterious. But to the magician it's old stuff. While he's doing his act he's probably thinking of a dozen different things that have nothing to do with magic.

In the first chapter we tried to take some of the mystery out of transistors. Now that you know how the electron currents flow, and the different polarities at the elements of the transistor, you will feel more confident when working on transistor receivers.

Things to remember

Always remember:

You cannot treat the transistor like a tube.

You must adapt your servicing techniques to the transistor.

You must get used to working with smaller parts in smaller spaces.

Checking transistors

What do you do if you want to test a tube? You can probably think of two ways immediately. Try the tube in a receiver. This is called the tube-substitution method. Or else you can use a tube tester.

Transistors are no different. If you want to know if a transistor is any good, try it in a set. Or else use a transistor checker.

Now all this sounds very nice, but is it practical? Are there any problems in the way? Let's see what they are.

quite a lot of work and could result in some damage. Wouldn't it be easier to make sure by checking the resistor?

We know—and you certainly do—that a resistance test is the easiest check to make. Before we rush ahead with our ohmmeter and its test leads, though, isn't there something we've forgotten? The resistor is in a circuit and up to now the circuit has been connected—it is live. You could argue that no current is flowing through R2 anyway, but why take a chance? Make sure. Turn the battery switch to the off position or else remove at least one lead to each battery.

We now have several possibilities. The resistor could be open or it could have increased to a very high value. In either case, we would have a higher than normal voltage across R2.

Is this the only possibility? Not quite. The resistor could be shorted. Again the answer is simple: replace the resistor.

But what if the resistor is good? What then? All we have left is the transistor. Wouldn't you say that this is exactly the opposite of the way in which we work with tube radios? In a radio set using

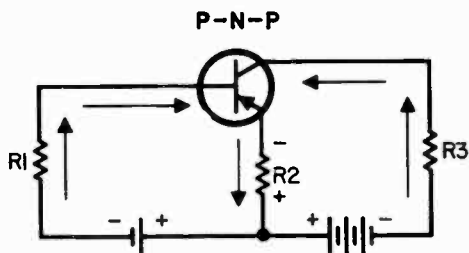


Fig. 203. The *p-n-p* circuit is the same as the *n-p-n*. Note, though, that the batteries have been turned around. As a result, the current flows in a direction opposite to that of Fig. 201.

tubes, the first thing to do is pull the tube out, substitute a new one for it or else test the suspect in a tube checker.

In a transistor radio, though, the transistor is the last item to check. Who would have thought that something that looks so delicate and tiny as a transistor could live longer than the other parts! It just shows you how all of us can make a wrong guess.

Some more troubles

What else could happen to our transistor circuit in Fig. 201? We could have much more voltage across R2 than the schematic calls for if too much current is passing through R2.

Stop and think for a moment. What controls the flow of current in a circuit? Voltage and resistance? Right! We certainly can't expect the battery voltage to increase because dry-cell voltage can go in only one direction—down. Look at Fig. 202. What if the transistor were leaky or shorted from base to emitter? Wouldn't this be the same as a resistor whose value has gone down?

If we replace the base-emitter circuit with a resistor, we can see

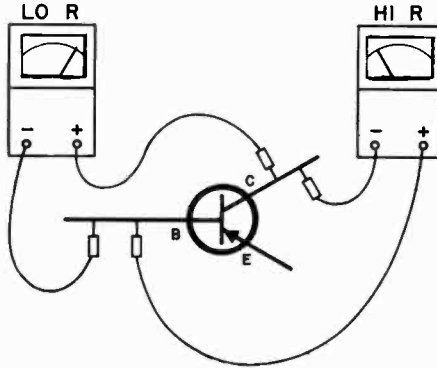


Fig. 204. How to make a forward and reverse resistance check between the base and collector of a p-n-p transistor. Only one ohmmeter is used. It is shown in two different positions.

right away how simple the circuit becomes. We have a battery and three resistors in series. If any of the resistors decrease in value, the current will go up. But if R1 and R2 test good, then what? We could suspect the transistor right away.

Other measurements

While we have our vacuum-tube voltmeter handy, there are other checks we can make. We can measure the voltages across R1 and R3. We can measure the battery voltages under load. We can measure the voltage between base and emitter and between collector and emitter.

Don't be bothered by the fact that we have been working with an n-p-n transistor. The same tests apply to the p-n-p unit shown in Fig. 203. Remember *all* polarities will be reversed.

Checking transistors out of the circuit

Just as we have tube testers, so too do we have transistor testers. But every piece of test equipment has its limitations and this goes for both tube and transistor testers.

Before we use a transistor tester, let's ask ourselves this question, "What do we expect out of a transistor?" You can give the answer in just one word—gain. We could use a larger word—amplification—but it would mean exactly the same. We want to put a small signal into the transistor and get out a bigger one.

What is our problem in working with transistors? Part of the question is a matter of frequency. Transistors work at different frequencies. We are going to want some of them to work at

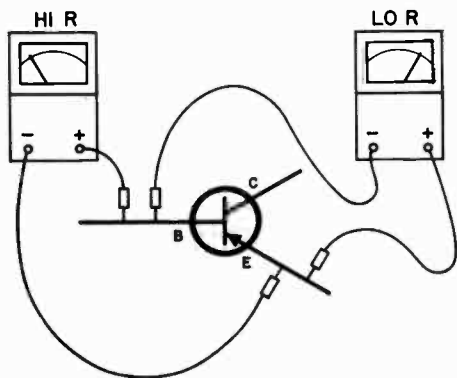


Fig. 205. How to make a test between base and emitter of a p-n-p transistor.

rf-signal frequencies; others to work as local oscillators, some as intermediate-frequency amplifiers and some as audio amplifiers.

Let's be practical! What does all this mean to us? Simply this! The fact that a transistor will work with dc voltages applied to it doesn't mean that it will work at 455 kilocycles. And if it works fine at 455 kc, what guarantee have we that it will do well as a local oscillator at 2,000 kc?

Does this mean, then, that transistor checkers are no good? That we shouldn't waste money on them? Not at all! They are fine if you know, understand and appreciate that, like tube testers, they have their limitations.

Resistance-checking transistors

What have we around the shop that can be put to work testing transistors? How about that old standby, the multimeter? It has a small battery in it that's just about right for the job.

It shouldn't come as a shock that we can check transistors with the resistance section of a volt-ohm-milliammeter. All along we've been claiming that a transistor is nothing more than a couple of diodes.

Figs. 204, 205 and 206 show how to make resistance checks of a transistor. Have you noticed anything unusual or different? What about the base lead in each of the three drawings? Isn't it the only element that always has a test lead connected to it? What's the reason? The base is our reference point and all our resistance measurements—and we mean *all*—are made with respect to the base.

Let's start with Fig. 204. The position of the arrow on the emitter tells us that we have a p-n-p unit on our hands.

Look at the ohmmeter on the left-hand side of Fig. 204. The

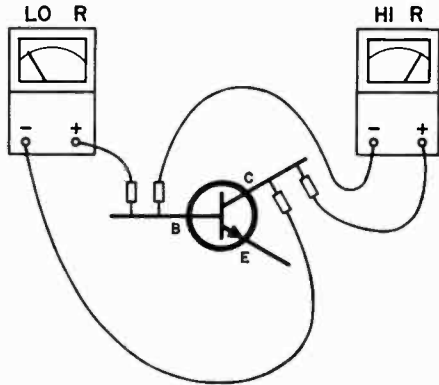


Fig. 206. How to make forward and reverse resistance tests between base and collector of an n-p-n transistor.

plus lead of the meter is attached to the collector and the minus or negative lead connected to the base. (The test leads must be checked to find out which connect to the plus and minus terminals of the battery inside the instrument.) The meter indicates a low amount of resistance.

How much resistance is low resistance? That depends on the transistor. Generally, you can figure on 40 to 50 ohms but please don't throw the transistor away if it reads 100 ohms. In some cases, the forward resistance (which is what we are measuring) will be as high as 500 ohms.

Our next step is to transpose the meter leads, as shown in Fig. 204: *we are not using two meters*. All we have done is shift the test leads.

We now have connected the positive lead to the base and the negative lead to the collector. Because the voltages are "wrong" for this part of the transistor, we are measuring the "reverse" resistance. The amount of resistance will vary from one transistor to

the next, but anything over a megohm (1,000,000 ohms) can be considered good.

The resistance ratio

We don't like to ask you to do arithmetic and we're going to try to avoid it as much as possible. However, just a little bit of it will come in very handy right now.

All you have to do is to divide the reverse resistance by the forward resistance. Suppose the transistor you check has a reverse resistance of 1,000,000 ohms and a forward resistance of 500 ohms. Divide the larger number by the smaller one. In this case we have:

$$\frac{1,000,000}{500} = 2,000$$

If you do the test and then the arithmetic, any answer you get that is above 100 would mean you have a good transistor. The number will usually be much higher than 100, just as in the sample problem.

Now that we've made a check between base and collector, make the same sort of test between base and emitter. This is shown in Fig. 205.

Test n-p-n transistors in exactly the same way (as shown in Figs. 206 and 207).

To help in making these tests, use Table I as a reminder on how to connect the ohmmeter and the results you should expect. The plus and minus signs in the table are same as the plus and minus signs marked on the meters in Figs. 204, 205, 206 and 207.

TABLE I
RESISTANCE CHECKS OF TRANSISTORS

Base	Emitter	Collector	resistance	
			p-n-p	n-p-n
—	+		low	high
+	—		high	low
—		+	low	high
+		—	high	low
	—	+	high	high
	+	—	high	high

We've added just one test to this chart that we haven't mentioned. This is the resistance check between emitter and collector. This shows a high resistance no matter which way we connect the test leads.

The resistance method of testing transistors gives a reasonable assurance that the transistor is good. This isn't quite the same thing as an iron-clad guarantee. All the test does is measure the two diode sections of the transistor.

Just one more word of caution: Some transistors have voltage and current ratings below that supplied by the ohmmeter. The maximum voltage across the test leads should be 3 volts. Make sure you know which is the plus lead and which is the minus lead of the meter.

When making the test, set the instrument on its highest resistance range. If it does not use more than 3 volts, turn the range control knob to a lower range until you get a deflection on the meter you can read easily. It isn't safe practice to go below the $R \times 10$ range.

In-circuit testing

Do you remember the first time you sat behind the wheel of a car?

Didn't it seem to you as though the street had suddenly become crowded with cars? Didn't you wonder whether you were ever going to learn how to read road signs, watch for pedestrians, look

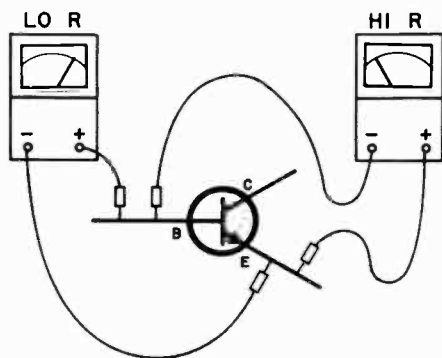


Fig. 207. Connections for forward and reverse measurements between base and emitter of an n-p-n transistor

out for traffic in front of you, alongside you, in back of you, and maybe shift gears too? And didn't you also wonder at other drivers doing all this so easily . . . almost without trying?

Working with radio receivers is like learning to drive. It takes a lot of instruction but, before you realize it, you've managed to pack away all the information, all the advice, all the do's and don'ts, and are busy servicing.

*There was once a technician who cried
"Every test you can name I have tried."
But the man was a boob,
Handled a transistor like a tube
So the transistor curled up and died.*

What is the best way to test a transistor? Right in the receiver with all of the voltages applied. No matter what we do, aren't we going to put the transistor back into the set sooner or later? We'll have to do this if we want the set to play.

We're going to find that transistor testing (and by this we mean circuit testing also) has certain advantages over tube testing. The voltages are low. We don't have to worry about a "hot" chassis or accidentally touching high B-plus voltages.

Does this mean we aren't going to have any problems? We man-

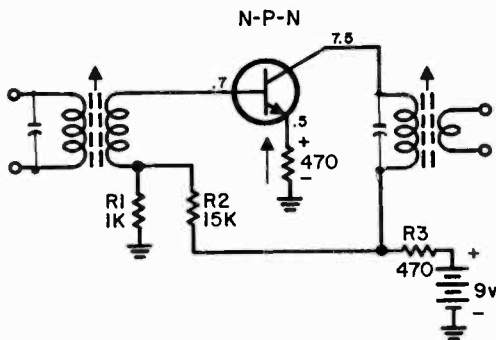


Fig. 208. *Simplified intermediate-frequency circuit of a transistor receiver.*

aged to get quite a few advantages, but we've also managed to bring along a few new difficulties. We're going to be working in tight spots. Most transistor sets are compact. And we'll have to avoid shorting transistor leads to the common B-line to avoid damaging the transistor.

Transistor testers

Just as we have tube testers of all sorts, so too do we have transistor testers. Some are very simple and do nothing more than give you some indication of the forward and reverse resistance of a transistor. Other transistor testers measure gain, shorts, etc.

A transistor tester will measure for leakage much in the same way as your vtvm. It will test both n-p-n and p-n-p transistors at

the flick of a switch. Leakage is indicated as GOOD, FAIR or BAD and not in OHMS as the vtvm does.

Let's get busy

In Fig. 208 we have a basic if (intermediate-frequency) stage. Let's see what measurements we can make. What do we do first? We must decide what sort of transistor we have. Is it p-n-p or n-p-n? Our emitter arrow tells us at once that we have an n-p-n transistor. Next, find the reference point. In this case, the reference point, as shown by the ground symbol, is very clear.

Do you see the voltages marked near the transistor leads? These are very important. The manufacturer is trying to tell us that if we have these voltages, the stage should be in working order.

But what are these voltages? How did we get them and how do we measure them? And what sort of voltages are they—positive or

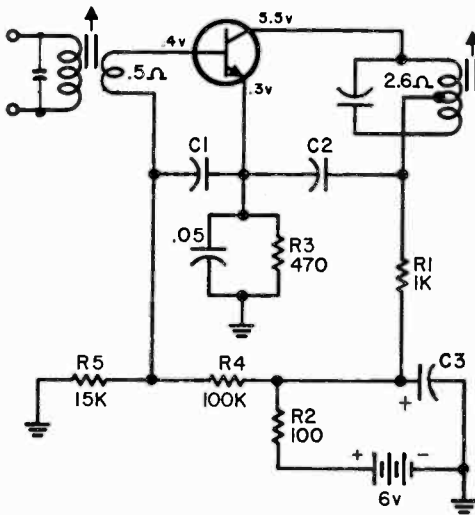


Fig. 209. Ohm's Law can be used just as easily in transistor sets as in vacuum-tube radios.

negative? Now the manufacturer isn't always going to tell us whether these are positive or negative. That may be up to us to figure out.

Look at the emitter. You will see that it is connected to the emitter resistor. Current flows up through the emitter resistor, making the emitter positive with respect to the ground. By how much? The circuit gives you that information. It's + 0.5 volt.

The base is marked 0.7 volt. Is this positive or negative? There are two ways of knowing. First, we are sure it is *positive* because, in an n-p-n transistor amplifier circuit the base is always positive with respect to the emitter.

Now what about the collector? Again we have two ways of knowing the polarity. In an n-p-n transistor amplifier circuit the collector is always positive with respect to the emitter. We can trace the collector circuit back to the positive terminal of the battery.

Let's list what we know about this circuit:

1. The emitter is 0.5 volt plus with respect to ground or the negative side of the battery.
2. The base is positive with respect to the emitter.
3. The collector is positive with respect to the emitter.

Making voltage tests

Suppose we wanted to make some voltage tests, how would we go about it? With the receiver turned on:

1. Set the vtvm to its lowest *plus* dc voltage range. Connect the probe to the emitter and the common lead to the negative terminal of the battery or to ground. You should read +0.5 volt.
2. Keep the common lead of the vtvm connected to the negative terminal of the battery. Connect the probe to the base. You should read +0.7 volt here.
3. Now set the vtvm range selector to a scale that will read about 10 volts full scale. Touch the probe to the collector. This should be +7.5 volts.

Normally the + is not indicated. Any voltage not preceded with a minus (−) sign is positive (+) in relation to the reference point.

And still more tests

You could also measure between base and emitter of the transistor.

4. Connect the common lead of the vtvm to the emitter and the probe to the base. (Remember—the base is positive with respect to the emitter.) You should read the difference between 0.7 and 0.5 volt, or 0.2 volt. (All we did was to subtract 0.5 from 0.7.)

5. You could also measure the voltage between collector and emitter. Put the probe of the vtvm on the collector lead and the

common lead of the meter on the emitter. Here you should get a reading of 7 volts. Note that this is the difference between 7.5 and 0.5 (that is, 7.5 minus 0.5 volt).

Was that too easy?

The circuit in Fig. 208 was stripped for action. We omitted some of the parts to make it easy for you. But now that you have the general idea, let's move on to a complete circuit, such as the one in Fig. 209.

Start with the voltage on the collector. Here we have 5.5 volts. From the collector move along the wire until you come to the if transformer. From here travel through the 1K (1,000-ohm) resistor (R1), through the 100-ohm resistor (R2) until you arrive at the plus terminal of the battery.

What have we learned? The voltage on the collector is plus or

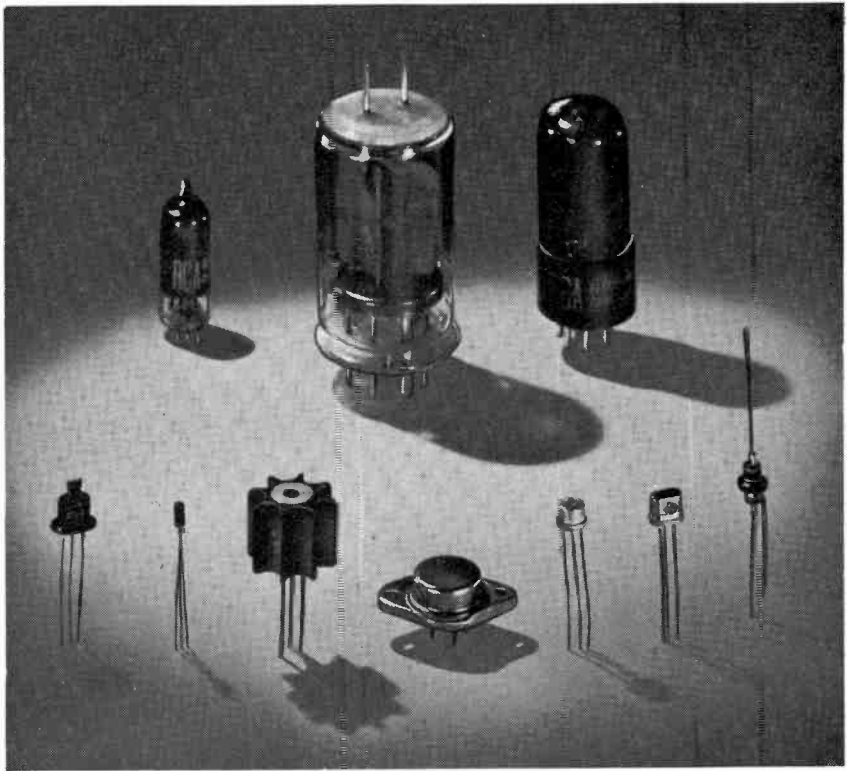


Fig. 210. Because of their size, transistors make very small receivers possible.

positive 5.5 volts. Positive with respect to what? Positive with respect to ground or the minus side of the battery.

Why is it that we have only 5.5 volts at the collector? Isn't the battery voltage 6 volts?

In taking this little trip, you went through R1 and R2. Current flowing through these resistors gives a voltage drop. We've lost half

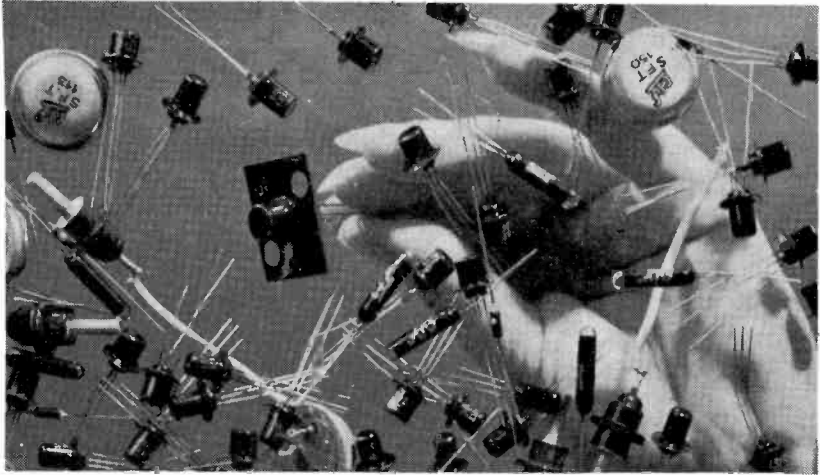


Fig. 211. *These are just a few of the numerous semiconductor types.*
(Intercontinental Electronic Corp.)

of 1 volt. Most of the missing 0.5 volt appears across R1 as a voltage drop.

Practical tests

There are quite a few tests we can make in the collector circuit. We can measure the collector voltage. The collector is 5.5 volts plus with respect to ground. We can check this with a vtvm very easily.

What other tests can we make in the collector circuit? How about measuring the voltage drop across R1? This voltage doesn't appear on the circuit diagram, but it must be very close to 0.5 volt.

Could we measure any voltage across R2? R2 is only one-tenth as large as R1. This means that it will have only one-tenth of the voltage across R2. But R2 has less than 0.5 volt, so do you think we would measure anything across R2? The amount is so small a meter needle will barely move.

Some more "what-if's"

What if you measured the voltage at the collector and found

that it was 6 volts? What then? Wouldn't this indicate no current flowing through the transistor? To check this, make a voltage measurement across R1! We're supposed to lose about 0.5 volt there. Our vtvm across R1 proves what we suspected—that no current is flowing through R1.

Let's follow through. We have a full 6 volts on the collector and no voltage across R1. What is the trouble? Should we replace the battery? Wouldn't that be useless? We are getting a full 6 volts. Should we measure the battery voltage? Again, wouldn't that be a waste of time? We did measure the full voltage at the collector and that should be enough.

Could it be an open circuit somewhere between collector and battery? Again we must rule this out since we're getting voltage at the collector.

It is possible that R1 is completely shorted, but this is not too likely. What about the if transformer? Since this is in series between the battery and the collector, we can rule out the possibility of its being open.

What if C2 were open? That certainly wouldn't prevent current from flowing in the collector circuit. What if C2 were shorted? If that were the case, then we would get no voltage at the collector and almost a full 6 volts across R1.

Where do we go from here? There are two possibilities. The transistor might be biased beyond cutoff. Another possibility is that the emitter resistor, R3, might be open.

This may seem a little odd, so let us consider it for a moment. If R3 is open, all action stops. No current flows to the base or to the collector.

The emitter circuit

In Fig. 209 we show 0.3 volt at the emitter. Where does this come from? By now you're probably reaching for your hat ready to take another trip with us. As usual, when we go on these hunting trips our big "game" is the battery. The easiest path to the battery is down through R3 to ground. But ground is connected to the negative terminal of the battery. That was a short trip.

This still doesn't answer our question about the 0.3 volt at the emitter. The problem is solved, though, when we ask ourselves, "How does the electron current flow?" Always minus to plus. Our current begins at the negative terminal of the battery and moves through R3 to the emitter.

In passing through R3, we get a voltage drop of—you guessed

it—0.3 volt. What the manufacturer is trying to tell you is that, if you make a measurement across R3, you should read 0.3 volt.

What else does Fig. 209 tell us? The base is marked 0.4 volt. If we're going to service transistor circuits quickly and easily, we should know what this voltage is and how we got it.

We can get the answer by tracing the circuit. We start at the base and move through the low-resistance secondary winding



Fig. 212. Printed-circuit boards come in a large variety of sizes and shapes. They are used in AM, FM and TV receivers, test equipment and components like rotary switches, commutators, loop antennas, meter coils and motor armatures. (Keil Products)

(marked 0.5 ohm) down to the junction of R4 and R5. But what have we here? Wouldn't you say that R2, R4 and R5 form a voltage divider connected across the battery?

There is something else. The base lead is "tapped up" on this voltage divider. Since ground is our reference point, the tap at the junction of R4 and R5 is positive with respect to ground. This means that the base is also positive with respect to ground.

Adding up the answers

What have we learned about the transistor's voltages? All of the transistor's voltages are positive. But this is an n-p-n transistor! Isn't the emitter of an n-p-n transistor supposed to be negative? We can answer both questions easily enough. The emitter is positive with respect to ground and it is negative with respect to the base.

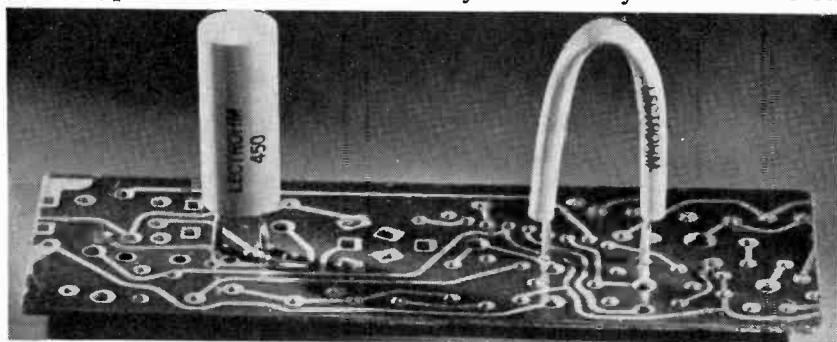
A little comparison

As soon as transistors reached commercial production, there was a rush to manufacture small receivers. This had been tried earlier with vacuum tubes, but even miniature tubes are much bigger than transistors. Together with printed-circuit boards, transistors made a combination that produced radios that could fit into a pocket or purse.

To get an idea of the size of transistors compared to tubes, look at Fig. 210.

How many?

About 40 years ago, there was no such thing as a tube manual. Tube types were so limited that they could easily be remembered.



Special shaped resistors make it easier to bridge portions of printed circuit boards. Wire-wound resistors like these are mounted above phenolic board to prevent possible heat damage. (Lectrohm Inc.)

As time went on, though, so many tubes were developed that technicians just couldn't work without a tube manual.

Today we have the same situation with transistors. There are actually hundreds of types, only some of which are shown in Fig. 211.

Printed circuits

You've probably heard arguments about printed circuits and whether they should be put in receivers or not.

Our job, though, isn't to get mixed into any discussion about it. The fact is that tremendous quantities of receivers are being manufactured with printed-circuit boards—and these will need servicing.

What is a printed-circuit board?

A printed-circuit board consists of a plastic sheet with copper foil bonded to one or both sides. The board replaces most of the wiring in the receiver.

Printed-circuit boards are used in all types of equipment, small and large, transistor and tube. A few of the boards that you may meet in servicing are shown in Fig. 212.

Radio components—tubes, transistors, capacitors, resistors and

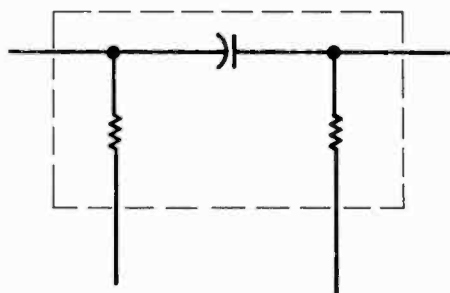


Fig. 213. *Circuit of a printed-circuit resistance-coupled unit. When you see the dashed lines around a component of this type in a circuit diagram, you will know that it is to be handled just as though it were a single component.*

coils—are usually mounted on one side of the board and then soldered into position. Once this is done, the radio part is automatically connected into the circuit by the copper foil molded into the board. We can regard the printed-circuit board as the chassis on which we mount parts. In working with printed-circuit boards (just as in working with transistors for the first time), we must learn special techniques and methods. These aren't difficult. All we need to remember is that there is a big difference between an aluminum chassis and a printed-circuit board. (Even the wired connections, as shown on pages 1-48 and 1-49, are different.) What is good for one will not do for the other.

Printed-circuit components

In some receivers, you will find groups of parts molded into a single unit. For example, we could have the two resistors and capacitor of a resistance-coupled amplifier (Fig. 213). This unit is then regarded as one component even though it contains three parts. Thus, instead of replacing one part, you replace a whole section.

Printed-circuits come with many combinations of components. Some have groups of resistors only. Others have resistors and capacitors (Fig. 214). Some of them even have tubes or transistors.

Soldering

You can replace components on a printed board very easily if you are careful not to use too much heat. Excessive heat will cause the conductor to break its bond to the board. This means that you should avoid the use of large soldering irons. In an emergency you can adapt your present heavy iron to printed-board work by wrapping some heavy copper wire around the metal body of the iron. Tin the end of the copper wire so that it will act as a soldering-iron tip.

If you would rather use your iron without modifying it, put a light bulb in series with it as shown in Fig. 215. Experiment with different sizes of bulbs until you get one that suits. Generally, the heavier the iron (larger wattage rating), the larger will be the wattage of the series bulb. Temperature-controlled irons are also available.

There will be times, though, when the conductive foil on the

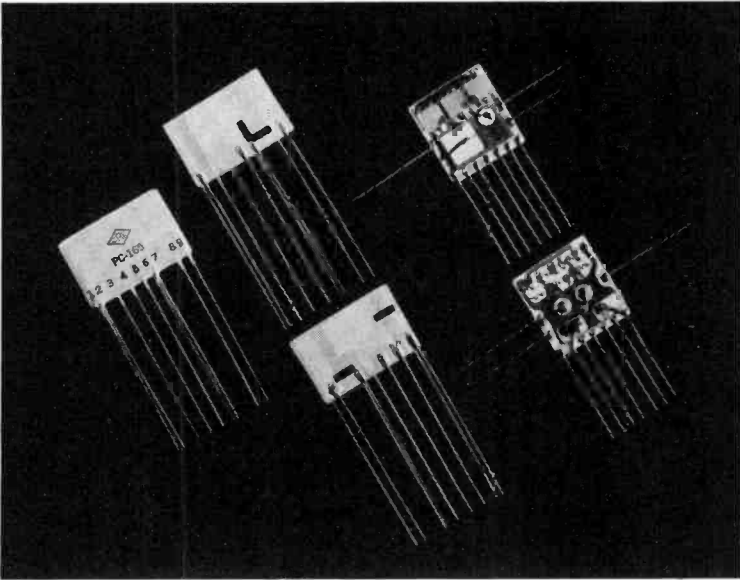
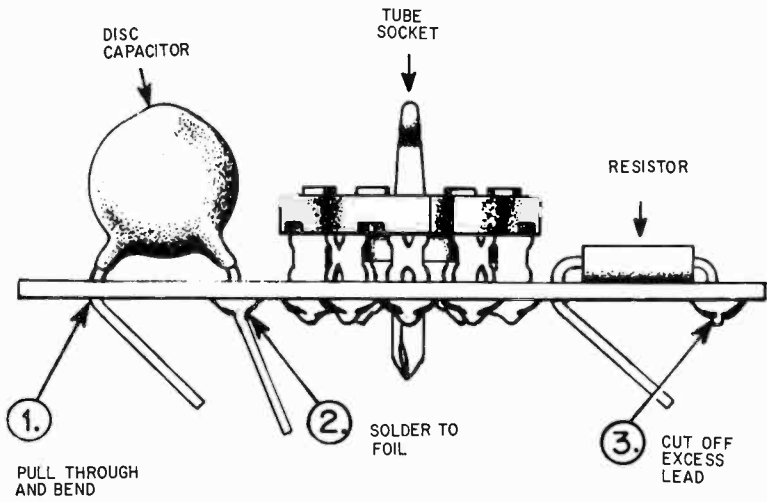
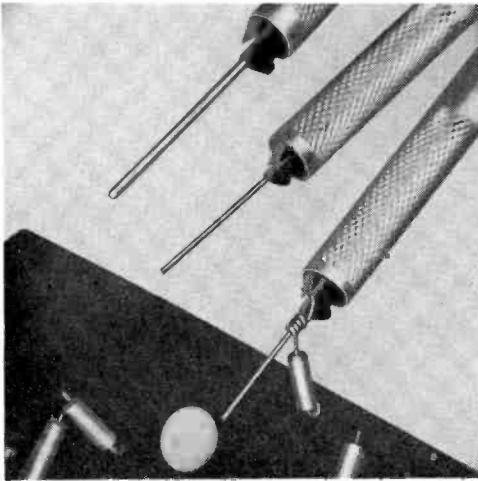


Fig. 214. Some of the component printed-circuit modules have quite a number of parts mounted in them. (Centralab)

printed-circuit board will come loose. You may have a defective board or you may have applied too much heat. When this happens, clip the defective section and replace it with a short section of wire as shown in Fig. 216.



Mounting components on the P-C board is simple and neat when done properly.
(Knight Electronics Corp.)



These special tools are used to form loops in the ends of replacement components that fit over the remaining lead ends when components are cut from a printed-circuit board. Old lead ends are straightened and inserted into center of coiled lead of new components
(Twirl-con Tools)

Replacing resistors and capacitors

If a resistor or a capacitor on a printed board should become defective, don't try to unsolder the unit. Cut the leads as close to the body of the component as possible.

When you do this, you will have two leads soldered into position on the board. Straighten them with a pair of long-nose pliers. These two leads will now act as the supports and connectors for the new radio part.

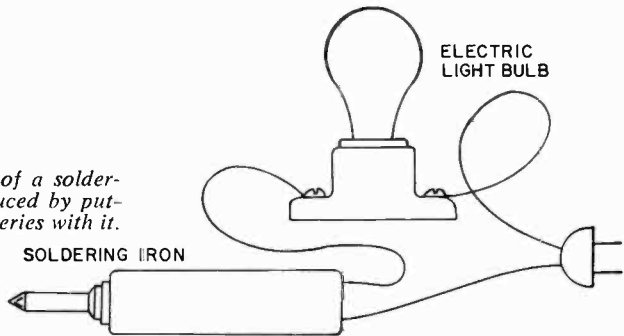
Sometimes the defective component will be mounted so close and so tightly to the board that you will not be able to use this technique. When you run across a problem of this sort, get out your pliers and crush the body of the defective part. After you clean away the pieces, you will have two leads which will be long enough to work with. Straighten these leads and use them as the supports for the new part. (Special tools, as shown on page 1-52, are helpful.)

Mount the replacement component between the two leads, loop the wires and solder, as shown in Fig. 217.

Replacing oscillator coils, if transformers, electrolytics (can type), variable capacitors

These components are similar in that they have a number of connections to the board. Use a 35-watt iron and a brush (a stiff bristle toothbrush will do). Heat each terminal, working on only one ter-

Fig. 215. The heat of a soldering iron can be reduced by putting a light bulb in series with it.



terminal at a time. As you apply the iron, remove the loosened solder as quickly as possible. Try not to overheat.

There is one serious danger in removing solder this way. The conductors on the board are very close together and take to solder the way a 6-year-old boy takes to dirt. In both cases, they're hard

to separate. So be careful. A little bit of solder can make a great big short.

After all the terminals of the component have been unsoldered, rock it back and forth slightly to free it from the board. Unless you have managed to remove all the solder from the terminals, you will find this difficult or impossible to do.

What is connected to where?

When removing any part having a number of connections, always be sure to make a note of which connection goes where. If you don't

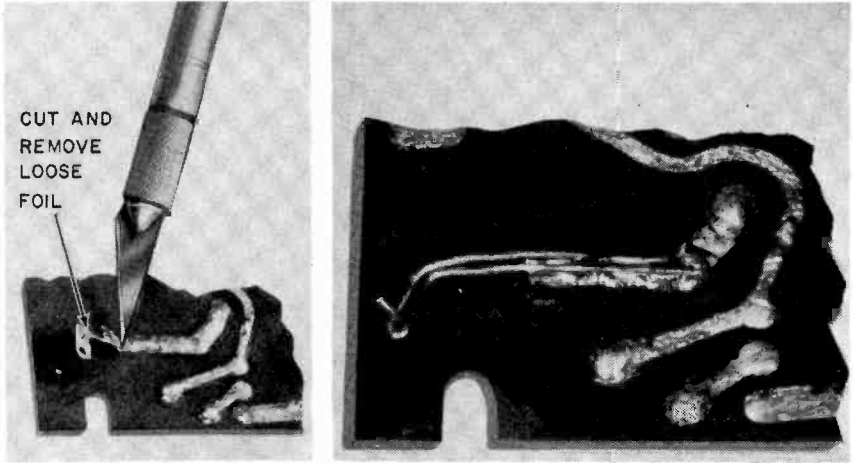


Fig. 216. The foil on a printed-circuit board may pull away. When this happens, clip off the raised part and replace it with wire.

do this, you'll be scratching your head for quite a while. This may be good for your scalp but it doesn't fix radios.

Don't use the manufacturer's numbers stamped on parts as your positioning guide. These can vary from one part to the next. And one final word of caution: keep solder from going into the part itself. You'll soon learn that solder has a habit of sticking best where it isn't wanted and of rolling into places where it has no right to be.

Removing volume controls

You can remove these in the same manner as if transformers. Cut away the connecting leads. Heat the control lugs one at a time and brush away the solder. Straighten the lugs if they are bent. Rock the control back and forth until it comes loose. Don't force it. You are much stronger than the printed-circuit board and you will prove nothing if you break it. If the control doesn't want to

come loose, inspect it to find out why. Fig. 218 shows how a control should be removed.

Removing component boards

In Fig. 214 we showed you some samples of printed-circuit and component modules. Some of these are complete circuits. They can be removed in the same way in which you would remove an inductor or a volume control.

Heat each lug. Remove the solder with a stiff bristle brush. If the component board is long (and some of them are), cut it with a

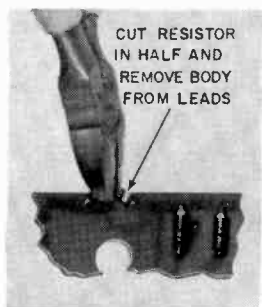
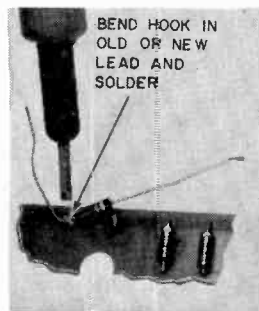


Fig. 217. Removing a defective radio part from a printed-circuit board requires a little care. Cut as closely to the part as possible. Straighten the leads that remain. You will now have a pair of connected supports for the new component.



pair of diagonal cutters (dykes) and remove one section at a time, as shown in Fig. 219.

Testing

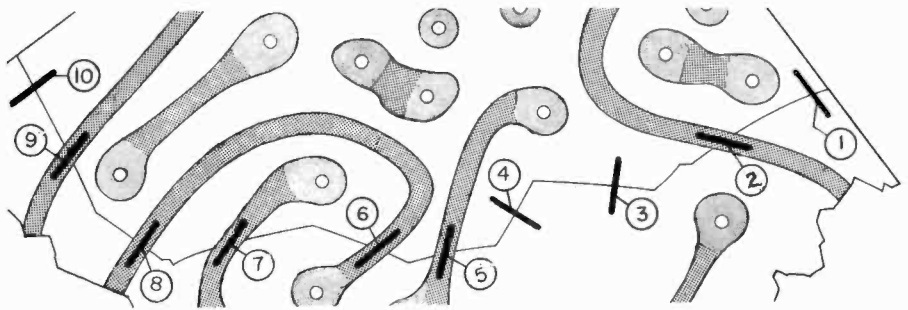
After replacing components on the printed-circuit board, check for in-circuit continuity. To make this test, set the vtvm on a suitable resistance scale and clip one test lead directly to the component. Touch the remaining probe to various points along the conductive foil on the printed-circuit board to make sure that a good electrical connection has been made.

The way in which this is done is shown in Fig. 220.

Cracked boards

Sometimes one of the conductors will crack cross-wise. If the break is complete, you will have an open circuit. This will not be too difficult to check out with an ohmmeter. If the break is incomplete, you may end up with an intermittent or a high-resistance connection.

Sometimes one of the conductors on the board will split or break along its length. The effect will be as though resistance had been added to the circuit.



One method of repairing a broken board consists of drilling holes on both sides of a break, inserting wires through the holes and then twisting the wires to draw the board together at the break. This figure shows how such a board repair would appear upon completion.

First determine where the staple-like wires are to be located. They should span each break in a track (staples 2, 5, 6, 7, 8, 9). Additional staples (1, 3, 4, 10) should be located at those points where more support is needed. Drill the holes $\frac{3}{16}$ " on either side of the break. The holes should be the same size as the wire.

After all holes are drilled apply a non-conductive cement to the break and join the two sections. Insert part of the staples from the top of the board and part from the bottom, so that upon tightening they will draw evenly. Twist only enough to hold the two sections together.

Now solder all staples inserted in broken sections of track (staples 2, 5, 6, 7, 8, 9). This type of repair, while it fulfills all circuit electrical requirements, does not provide mechanical strength equivalent to the unbroken board. To provide a broken board with strength "like new" — or better:

First remove those components which are in the immediate vicinity of the break, leaving a cleared area on top of the board where the strengthening material is applied.

Locate the end of each crack and drill holes to prevent any extension of these cracks in the future.

Strengthening of the board is accomplished by a lamination process. Simply cut a piece of vinyl to fit the cleared area over the break. Coat both the cleared area on top of the board and the opposing surface of the vinyl with cement. Use the cement in the manner recommended by the manufacturer. It is not imperative that the vinyl be clamped to the board while the cement dries. However, clamping will result in maximum strength.

Allow 15 to 30 minutes for the cement to harden and then drill through the vinyl from the original mounting holes. Replace the components in their original locations and solder. All parts should have lead length sufficient to extend through the extra layer of thickness. (*Westinghouse Tech-Lit News*)

In either case, whether the break is cross-wise or length-wise, the trouble can be cured by soldering. Run a small amount of solder along the break. Don't pile on the solder since you will only short to an adjacent conductor.

Handling solder this way calls for some skill. An easier way is to put a length of wire along the break and solder it into place. To

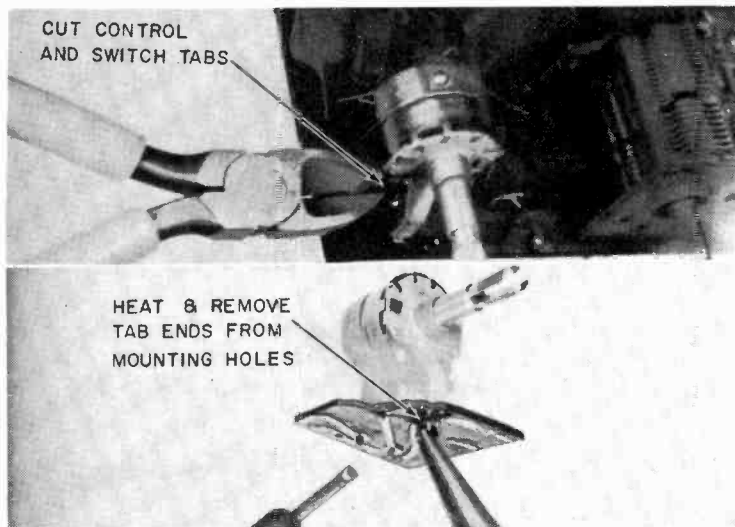


Fig. 218. Method for removing a volume control from a printed-circuit board.

make the job as easy as possible, cut a short length of copper wire to fit. Use bare copper wire. Avoid wire covered with enamel. Do not use very thin or fine wire or wire that is too thick. No. 22 wire should be about right. Wire that has been pretinned will take solder best. (See page 1-58 for more details.)

Lay the wire along the length of the break and solder into position. Use solder sparingly.

Repairing broken boards

Yes — it can be done and it must be done. The only alternative is to junk the receiver. Even slight flexing of a broken board (and this happens all the time with portable transistor sets) means an intermittent or complete loss of sound. Repair details are described on page 1-56.

Removing sockets

Use the same method as for if transformers and volume controls. Clean each socket pin of solder with the iron and a brush. Some

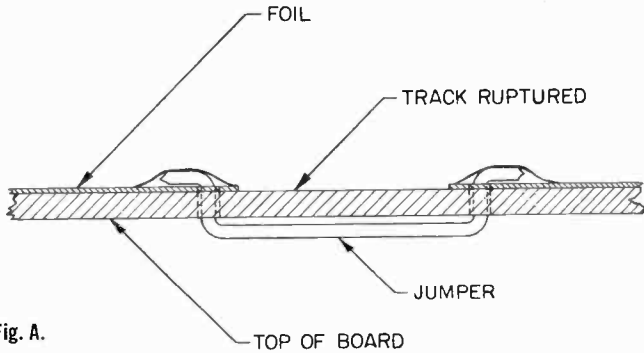


Fig. A.

1. **Fine cracks** — A hairline crack in the copper foil circuit can be located by holding a light source, such as a 60 watt lamp, on the top side and viewing the board from underneath. Flex the board slightly and watch for light to appear through the crack. Resistance measurement is another good method of locating minute cracks.

Flowing solder over these cracks is not a good repair, considering it takes only a few more seconds to solder a piece of bare wire across the break. Use a sharp blade or X-acto knife to scrape the solder resist off the foil. Place a $\frac{1}{2}$ " piece of bare wire directly across the crack and solder down quickly.

2. **Ruptures and large breaks** — Where there is extensive track damage such as might result from a short circuit burning out a section of the track or component burn-out, a combination of repair techniques may be necessary.

Small gaps may be repaired as shown in Figure A. Check first to see if there is space on top of the board for a jumper. Single conductor insulated (B) or bare wire may be used, depending upon the need for insulation in the particular situation. Drill through the board at the two broken ends of the track. Bend the wire as shown in Figure A and insert it into the holes from the top of the board. Hold the jumper tight against the top of the board while soldering it to each end of the broken track. This type of repair will hold the broken ends of the track tightly to the board, thus preventing raising of the track ends and peeling of the foil.

(Westinghouse Tech-Lit News)



Fig. B. Insulated wire is used to bridge the gap after broken or loose foil has been removed.

soldering irons come equipped with circular adapters (circular soldering iron tip) which will permit you to unsolder all the pins at the same time.

Arcing

This isn't a problem in portable transistor receivers but you will encounter it in auto radios and vacuum-tube receivers. The resistors mounted on printed-circuit boards are generally the nonfusible type—that is, they will open when current is excessive, rather than fuse.

Excessive heat, such as that caused by a burning resistor, will

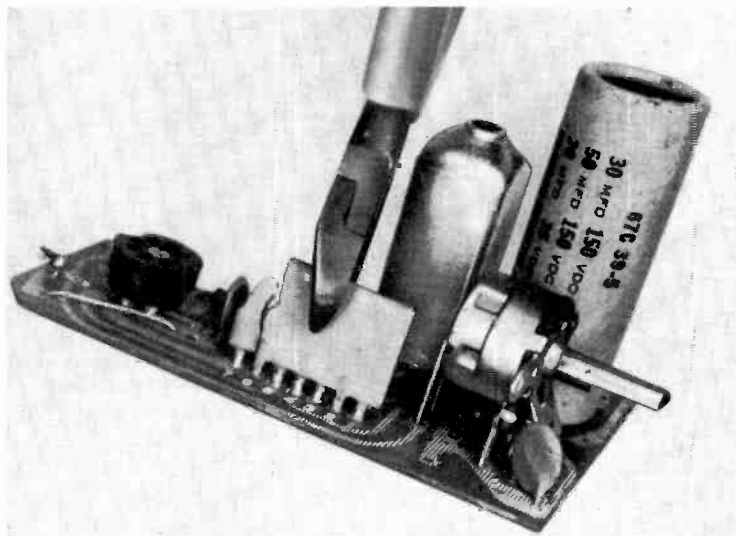


Fig. 219. Removing a component section from a printed-circuit board. The component section is a subassembly and may consist of a complete circuit in itself. The component section is mounted on the main printed-circuit board in the same way as a single component, such as a volume control or an if transformer.

cause the board to carbonize. This changes the board from an insulator to a resistor. Use a sharp penknife to clean away the carbon. Rinse with a non-oily cleaning fluid when finishing.

The final check

More often than not, you will have the receiver out of the cabinet for repair. It really shouldn't make any difference whether the set is in the cabinet or not, but sometimes, in putting the receiver back, some wire or lead may become broken or disconnected. Slide-on clips are often used for speaker connections. These may become

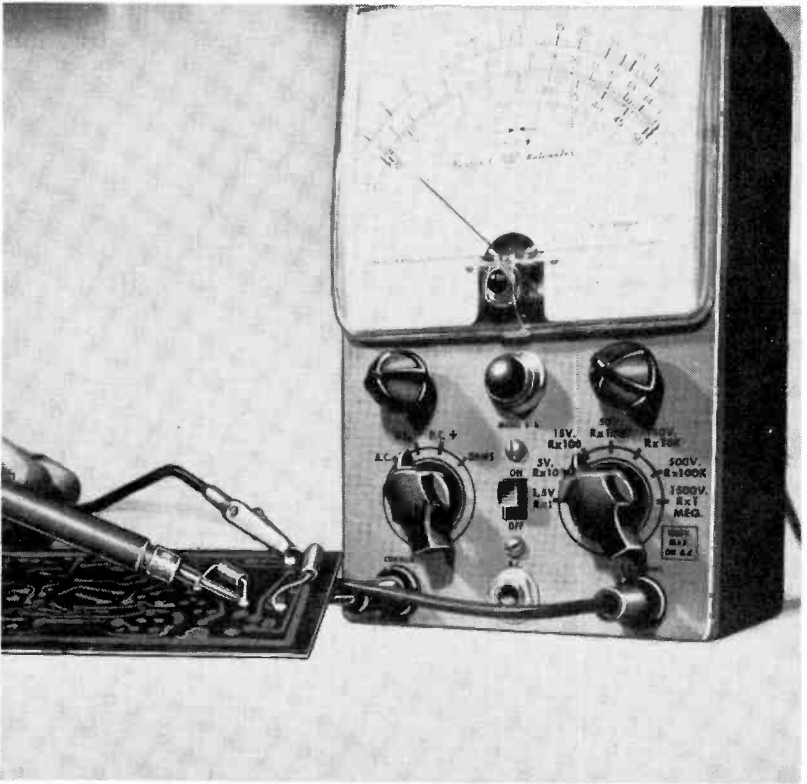


Fig. 220. After replacing components on a printed circuit board check them for in-circuit connections. (Heath Co.)

disconnected. The battery fastener may be loose enough to come off.

Make sure the set will work in its cabinet (Fig. 221). Knobs should be secure—not so loose they fall off the first time the set is played and yet not pushed so far forward that they rub against the cabinet. The dial of the receiver should turn smoothly from one end to the other.

Finally, if the cabinet is dirty, you can achieve miracles with just a damp sponge. You can be sure your customer won't ever remember the condition of the cabinet when he turned it over to you, but he will remember how nice and shiny it was when he first bought it. Try to keep him happy. It's good business!

Back to transistors

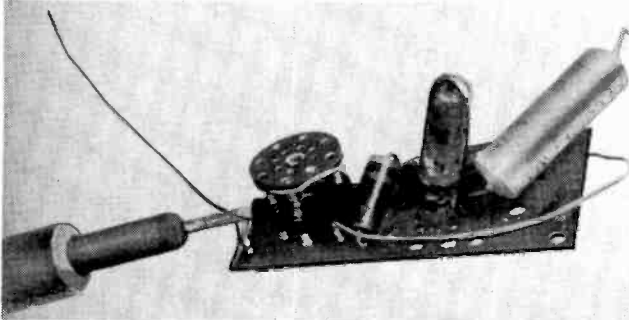
When working with transistor receivers, you will gradually get accustomed to the idea of low voltages and low currents. The voltage between the base and emitter will be less than 1 volt (and often less than 0.5 volt). The amount of current in the base-emitter cir-

cuit will be in the order of microamperes, and not too many of them, at that. A representative value would be approximately $30 \mu a$.

Collector current will vary, depending on the transistor used, the voltage applied, etc. Values of collector current will be about 3 to 5 ma (but not in power output stages).

Transistor types

There are two basic types of transistors, but we will be concerned with only one of them. The two types are the point contact and the junction. The point contact is obsolete (at least as far as radio re-



If there is sufficient "head-room" in the cabinet it is possible to solder replacement socket to old defective socket after removing top wafer. This will prevent possible damage to the printed circuit when removing old socket from board.

ceivers are concerned). The junction transistor is the name used for a large family group, including grown-diffused types, drift, alloy junction, etc. These transistors are all alike in their basic design—they use purified germanium or silicon plus controlled amounts of added impurities. The difference between them is the way in which they are manufactured and packaged.

A transistor is made by joining p- and n-types of material. The area where they join is called a junction—hence the name, junction transistor.

The type of junction is extremely important because it determines the transistor's characteristics—whether it will operate at high frequencies or not.

The frequency at which a transistor will work is determined by the speed with which current moves from the emitter to the collector. This "transit time" of the current is affected by the way in which the junction is made. In drift transistors, transit time is quite small, making this type of transistor suitable for intermediate-frequency stages, for converters and for radio-frequency amplifiers.



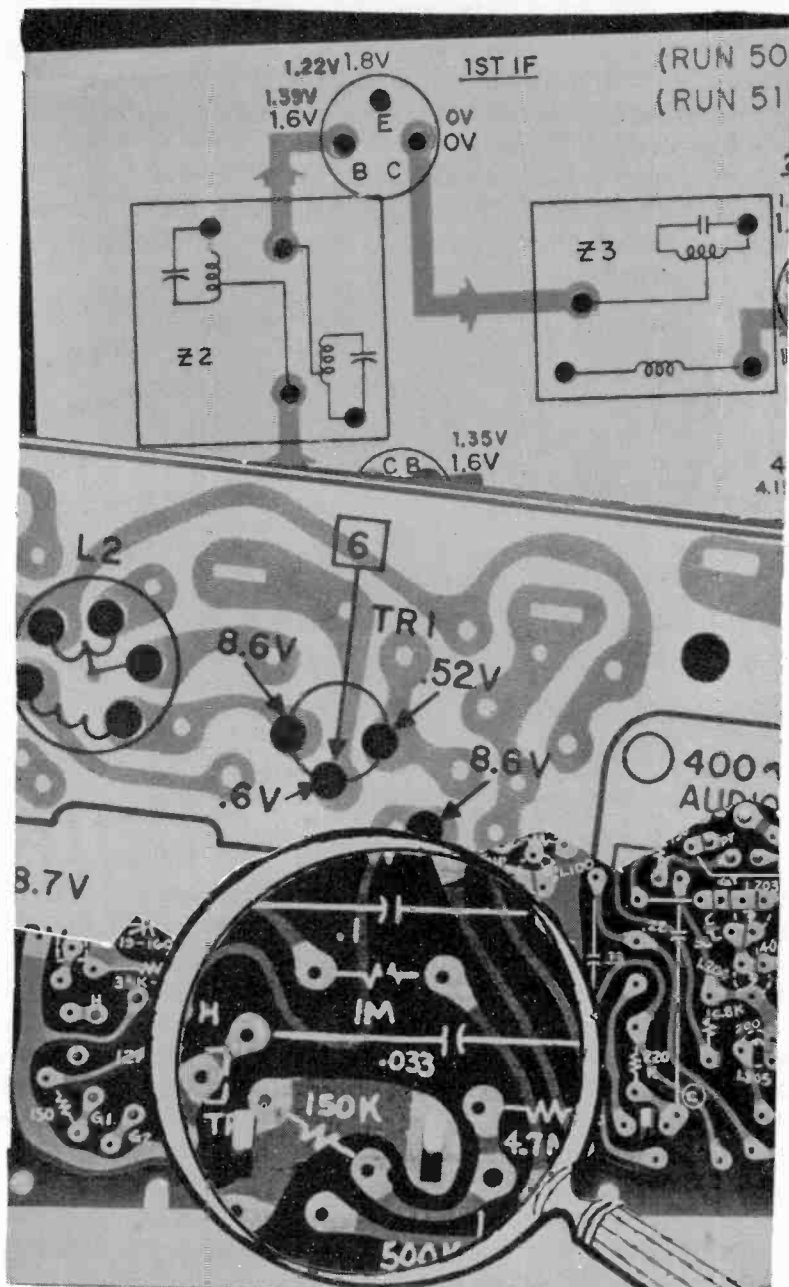
Fig. 221. *The last step in checking a receiver . . . an inspection to make sure the set is ready for the customer.*
(Zenith Radio Corp.)

Servicing do's and don'ts

In the next chapter we are going to start servicing transistor radios. We are going to learn about transistor troubles, stage by stage, circuit by circuit. But before we do, let's go over some servicing "do's and don'ts."

Remember what we have told you about soldering. If you must do any soldering near a transistor socket, it would be best to remove the transistor. If the circuit is the type that doesn't have sockets, put a thermal shunt across the transistor leads. You can make a thermal shunt by filling the jaws of an alligator clip with solder. Make a few of these—they will be very handy.

You will be working with a soldering iron having a low wattage rating. This doesn't give you much choice in the selection of solder. You will need a low-melting point type, such as 60/40. If you aren't sure just what type of solder you have available, connect



Perforated cards (top and center) identify test points and components, are necessary service aids. Additional printing on the circuit board (bottom) serves same purpose. (Philco, General Electric & Westinghouse)

QUESTIONS

1. An n-p-n transistor has a resistor connected from emitter to ground. What is the polarity of the voltage at the emitter with respect to ground?
2. In an n-p-n transistor circuit is the base positive with respect to ground?
3. Does the current flow from the collector, through the load, toward the battery in an n-p-n transistor circuit?
4. Does the entire current flow through the emitter resistor also flow in the collector circuit?
5. Is the emitter of a p-n-p transistor positive with respect to the base?
6. Can collector current be measured by inserting a milliammeter in the emitter?
7. Are transistors only made from germanium?
8. Should the forward-to-reverse resistance ratio of the emitter-base ever be higher than 100?
9. Has the type of junction any effect on the transistor's characteristics?
10. Can printed circuits tolerate high soldering temperatures?

CHAPTER 3

servicing transistor radios

Moving ahead to servicing

*Working for hours and ready to faint,
A service man raised his voice in complaint,
At the transistor set he swore,
I've had it—and more,
Like an ac radio it ain't.*

LET'S LEAVE our poor friend to his misery. What he didn't know was that we just don't treat transistor radios as though they were ordinary radios with transistors substituted for tubes.

Transistor radios have troubles of their own. Let's see what they are! As a start, examine the block diagrams of two typical transistor receivers shown in Fig. 301. The average transistor receiver, like ac-dc sets, is a superheterodyne. It has a few extra added attractions of its own, though.

The block diagrams show us that the transistor receiver has two if stages. (Most ac-dc sets have just one if). The detector stage is a crystal. (In the ac-dc set we use the diode section of a diode-triode.) In the transistor receiver the output is often push-pull, although the cheaper sets have just a single-ended output. (Most ac-dc sets are single-ended.)

Some differences

Most of the transistor receivers you will work on will be the types shown in Fig. 301-A or Fig. 301-B. But you will also find some that will be different. You may work on a set that will have push-

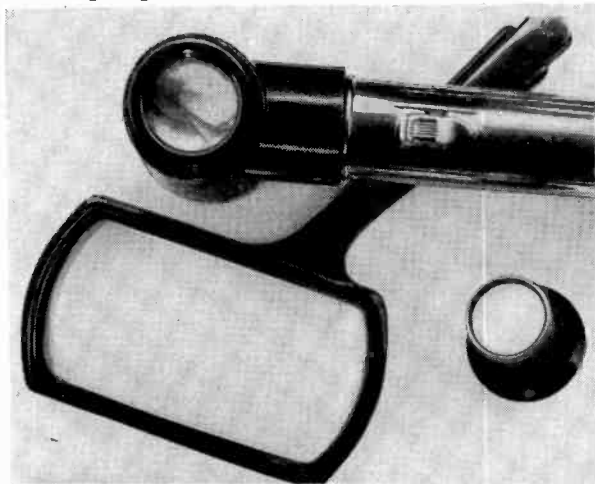
pull output but no radio-frequency amplifier. This means that the receiver will be sort of halfway between that of Fig. 301-A and Fig. 301-B.

Some transistor sets will have added circuits, such as the one shown in Fig. 302. This set features an agc amplifier. The agc control current is amplified and fed back to the input to the first if amplifier. The sets in Fig. 301 will also have agc, but not the agc amplifier.

Servicing the transistor receiver

No two service technicians repair receivers in the same way. You may have your own pet method or approach. If you do have a system, then by all means keep it. You've probably worked it out to your own satisfaction and it's best for you.

Our approach is going to be a little different since what we are doing is learning a general method of servicing. We are going to



Any of these magnifiers can be a help when hunting for printed-circuit board defects or bad connections in miniature receivers.

(Gem Electronics)

cover a few techniques and then work our way through the receiver, starting with the audio output and ending with the rf amplifier. We hope you will adapt what you learn to your own method of servicing.

Look at the circuit

What do you do when you go on a long auto trip? You get out a map and you look over the whole area. Then you narrow your inspection down to the particular route you are going to travel.

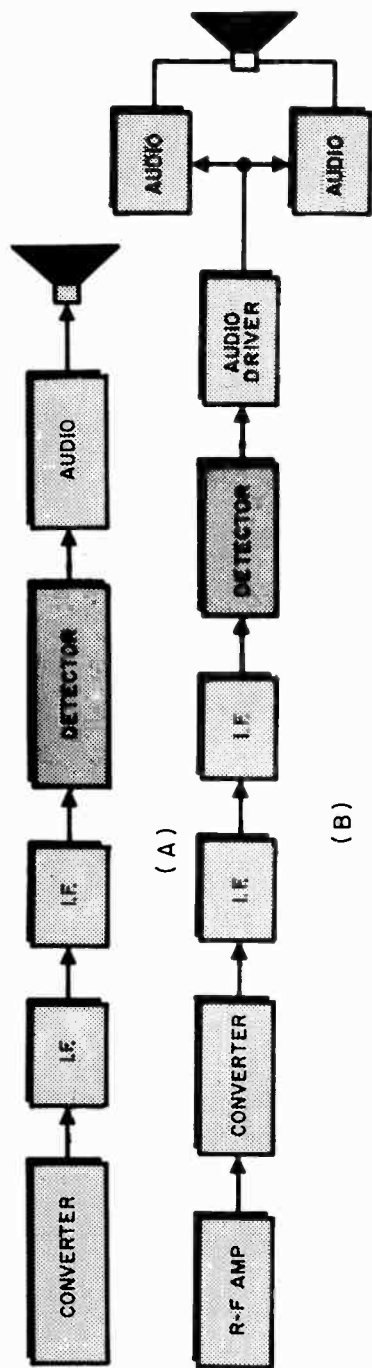


Fig. 301. Transistor receivers can be fairly simple as shown in A or more elaborate as shown in B. The receiver in B is the same as A, except that it has an rf amplifier stage ahead of the converter, and push-pull instead of single-ended audio output.

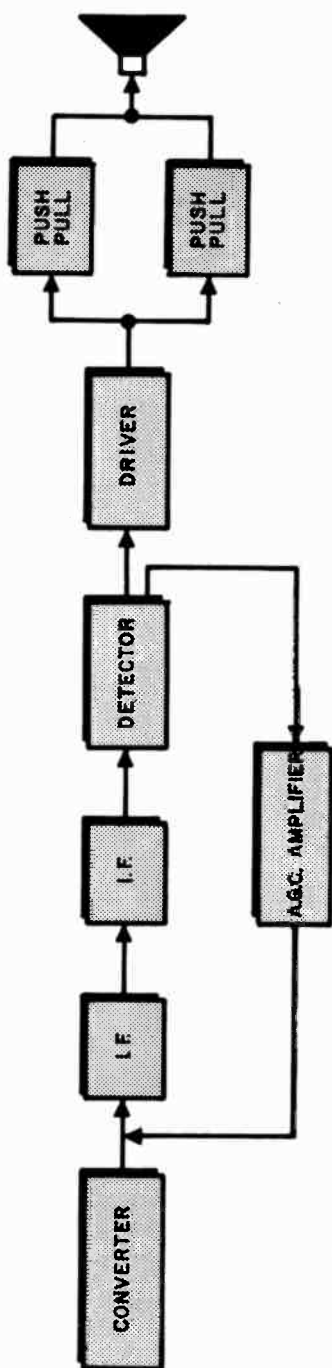


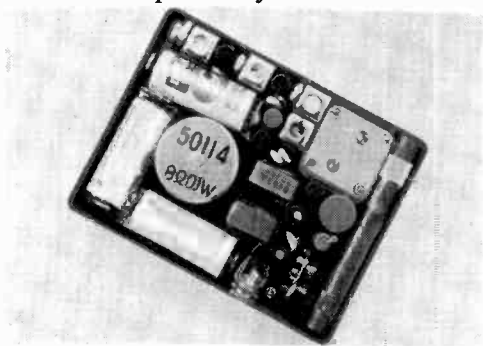
Fig. 302. Not all transistor circuits are alike. This receiver does not have an rf amplifier stage but it does have push-pull audio output. It also has an automatic gain control (agc) amplifier.

Use the same approach here because it's a good one. In Fig. 303 we have the complete circuit of a transistor receiver. This corresponds to the block diagram of Fig. 301-A.

As we examine Fig. 303, we see right away that we have no rf amplifier stage. The signal is picked up by the antenna transformer and, before the signal knows what is happening, it is pushed right into the converter. The converter really works as a combined mixer and local oscillator.

Here is one big difference between tube and transistor receivers. In a vacuum-tube receiver we are accustomed to having either a pentode or a pentagrid converter. But what sort of converter do we have in the transistor set? The transistor converter is a triode.

The if (intermediate-frequency) signal coming out of the converter is fed into the first if transformer, T1. (The if is usually 455 kc.) The signal is then amplified by the transistor and sent along to



This pocket-sized transistor radio has such compact assembly it makes troubleshooting difficult.

the second if transformer, T2. Passing through several if stages, the signal reaches the detector. Note the volume control acting as a diode load across the detector.

Coupling capacitor C12 is generally an electrolytic. If we were working with a tube receiver, this capacitor would be a paper tubular since less capacitance would be needed.

Note the agc feedback circuit. Capacitors C9 and C7 are agc filter units.

Our next inspection point will be the emitters of all the transistors. In all cases, the emitters are connected to resistors which go to ground. These resistors supply self-bias. Where the resistors aren't bypassed, they produce negative feedback.

Capacitors C8, C10, C11 and C13 are rf bypass units.

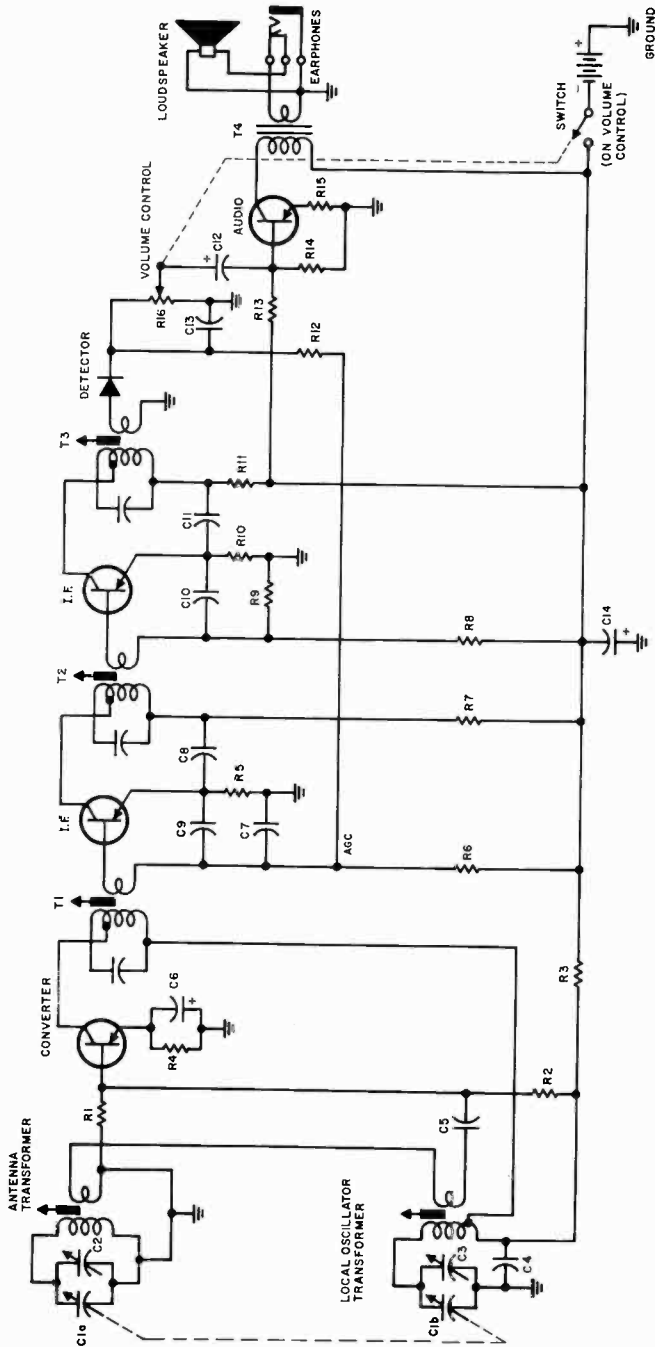


Fig. 303. Circuit diagram of a transistor receiver. This is the type of circuit usually found in less expensive sets.

Another transistor circuit

In Fig. 304 we have another transistor circuit. If you will look at it carefully, you will see that it corresponds to the block diagram of Fig. 302. But there is also another and even more important difference. In this circuit the manufacturer has been very careful to include all the voltages and most parts values.

Note the heavy line marked + bus. All voltage measurements are made with respect to this common line.

The first troublemaker

One component in the transistor receiver is always going to need attention. That component is the battery.

When does a battery start to go bad? The day it is manufactured! This doesn't mean battery manufacturers are cheating you and the public. It just means that's the way batteries behave. Keeping a battery on the shelf and not using it won't save it either. It will last longer that way but, whether you put a battery in the set or just keep it on your bench, it will have a definite life.

When a battery runs down, all sorts of things happen. Probably the first thing you'll notice is that the sound is distorted. Your customer may complain that favorite stations don't come in as nicely. Does the volume control need to be turned all the way up? Then check the battery.

How do we check batteries? Putting a voltmeter across them to measure their voltage isn't too helpful, since even a weak battery may show almost full voltage when the receiver is turned off. If you get distortion and the battery voltage is about 20% below normal (with the set turned on), you can be fairly sure that a new battery is called for.

But why do it the hard way? If you suspect the battery, replace it with one known to be in good condition. That way, you'll be sure!

Battery types

Transistor radios use different types of batteries. The most popular are the zinc-carbon and the mercury. Mercury batteries will last longer but they also cost more. You can often interchange one for the other, but there is a precaution to follow.

The polarity of the center caps on mercury batteries is opposite that of penlight batteries. In a penlight battery, the center terminal

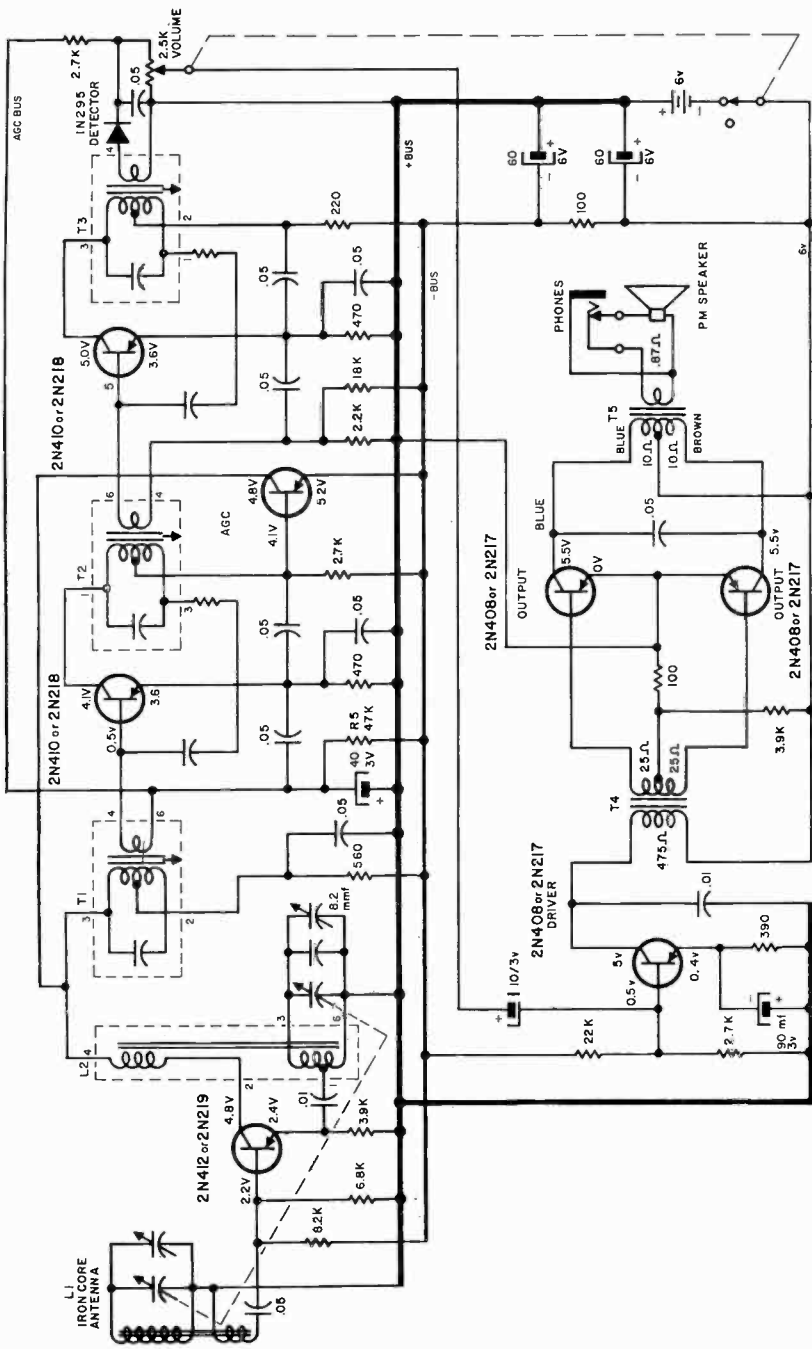


Fig. 304. This set features an agc amplifier. The heavy line is the plus bus. Voltage measurements are made with reference to this line.

on top of the battery is positive or plus. In a mercury battery, however, the center terminal is negative or minus. You can see these differences in Fig. 305.

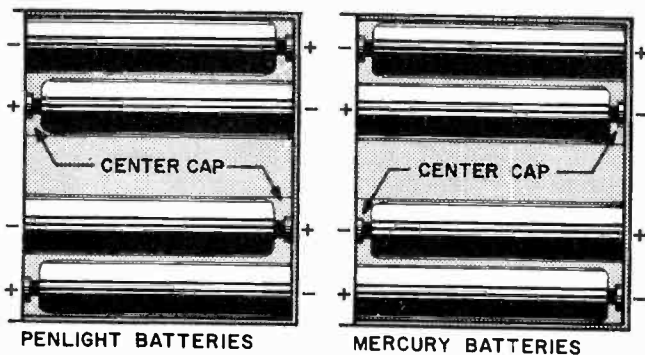


Fig. 305. Mercury batteries and penlight batteries can be interchanged if you watch polarity carefully. The center cap on a penlight battery is plus. The center cap on a mercury battery is minus.

In some receivers you will find a battery pack instead of individual cells. With battery packs the problem of polarity is eliminated since these come equipped with matching male and female connections. Since there is only one way of making the connection, the danger of reversed polarity is avoided. The disadvantage here, though, is that the battery pack must have an exact replacement.

How long should batteries last?

This is a difficult question to answer. It depends on how fresh the battery is when installed and on how much the customer uses the set. Generally, zinc-carbon cells should give about 100 hours of working use. Mercury cells should last about 400 hours.

Stage testing

How can we know if a transistor stage will amplify a signal? There is one way to find out. Feed a signal in, then see if the transistor circuit will do what it is supposed to do.

One way to do this is shown in Fig. 306. Use the 400-cycle modulating voltage of the signal generator. Measure the voltage output of your signal generator with your vacuum-tube voltmeter. (Set the

vtm to read low volts, ac). Then connect your vtm to the output side of the transistor circuit and measure the output voltage.

Knowing the input and output voltages will give you a few choice bits of information. It will tell if the stage is working. It will also give you some idea of how well the stage is working.

Gain per stage

When you compare output signal voltage with the input signal voltage, you are really measuring stage gain. If you feed in 1 volt and get out 5 volts, you have a gain of 5. If you feed in 2 volts and get out 20, you have a gain of 10. Just divide your output voltage by your input voltage and you have the answer.

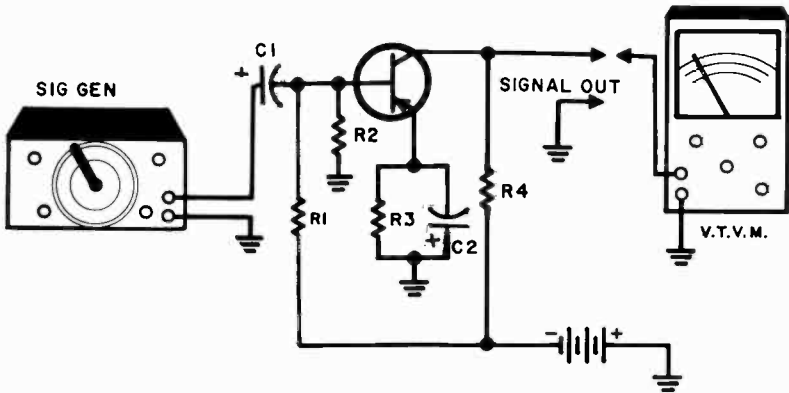


Fig. 306. Method of testing a single resistance-coupled transistor stage.

Some limitations

The audio voltage of the average signal generator may not be a sine wave (Fig. 307). This means that you are not only getting the audio frequency, but quite a few harmonics as well. As a result, what your vtm measures will not be quite correct. We're not going to worry too much about that since we're only making a comparison between input and output anyway.

In Fig. 308 we have a method of checking a transformer-coupled stage. As you can see, the general technique is the same as for the resistance-coupled stage of Fig. 306. While the vtm is connected across the secondary of the second transformer, it could also have been connected in the collector-emitter output of the transistor circuit being checked.

What are the parts?

If we're going to service receivers in a hurry, we should know what each component does in the circuit. There is no time like the present. What have we in Fig. 309? C1 is a coupling capacitor. How about R1 and R2? R1 and R2 are in series. These two resistors are shunted right across the battery. One side of R2 goes to ground. So does the plus side of the battery. And the other end of R1 is connected directly to battery minus. This connection makes R1 and R2 a voltage divider. Since ground is plus, the voltage drop

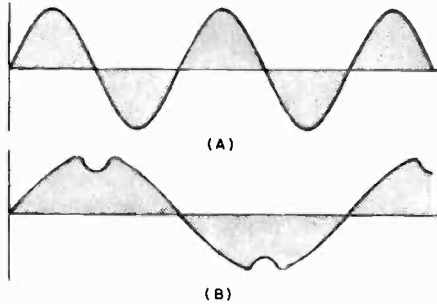


Fig. 307. Most instruments (such as the volt-ohm-milliammeter and the vacuum-tube voltmeter) are designed to measure sine waves, such as the voltage wave shown in A. If the wave is distorted (as shown in B) the information supplied by the instrument will not be accurate.

across R2 makes the base less than plus (or negative). R3 is the emitter resistor, shunted by emitter capacitor C2. Finally, the speaker is our load.

What we have here is a resistance-coupled stage but, if we had transformer coupling, our test would work in the same way, just as shown in Fig. 308.

Stage-by-stage analysis

Now that we have covered general procedures, let's start at the output of the transistor receiver and work our way back through the set, stage by stage. We know that this is like eating a meal backwards, starting with dessert and coffee and working our way toward the beginning of the menu. Many technicians work this way and it's a very easy way to cover quite a lot of troubles.

Before we get started on transistor-stage work, let's become a little more familiar with some of the more common transistor shell

What about controlling the volume? We can't do it with the volume control because that part is in an earlier circuit.

No sound

What if we get no sound at all during this test? Personally, we would think this is lucky. Maybe that sounds strange to you, but let's look at it this way. Here we ran just one test and we've managed to localize the trouble to the output stage.

So now we have a dead set on our hands. Let's check off all the possible things that could keep our output stage from working.

1. Open voice coil.

This doesn't happen often but sometimes the voice-coil lead breaks away from its soldered connection or corrodes at that point.

2. Open output transformer.

This could be in either the primary or the secondary winding. Don't expect the transformer windings to burn out. The currents that flow are too small for that. Corrosion and broken leads are a more probable cause. Pulling on transformer leads can cause them to come out.

3. Shorted bypass capacitor.

Take a look at the bypass capacitor (C3) across the primary. This capacitor opens much more often than it shorts, but it is a possibility to keep in mind.

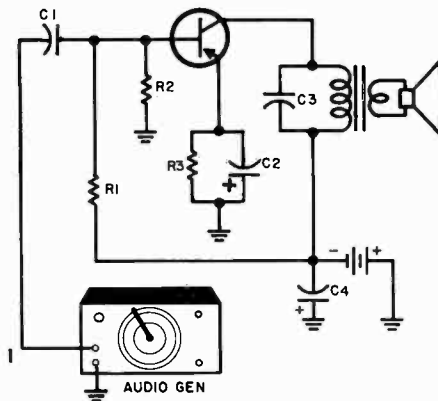


Fig. 309. Testing single-ended transistor stage.

Of course there are always odd troubles that never seem to happen to the other fellow, but inevitably to you and to us. We could have a broken transistor lead or a short between conductors on the printed-circuit board. Look for wires that act like kissin' cousins but which should really be separated. If the set has an output jack

for earphones, take a good look at it. Try operating the set with and without the earphone.

Weak output

The most common cause of trouble is the battery. The clue here is that, not only will the sound be weak, but it will be distorted as well.

Try making the audio generator test shown in Fig. 309 just to make sure that the trouble isn't in some earlier stage. If the output is still weak, check the emitter, base and collector voltages. If volt-

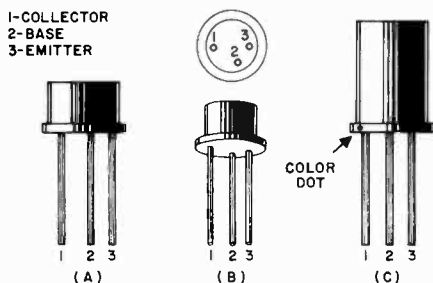


Fig. 310. Method of identifying types of transistors.

age is missing or incorrect, check the resistors. This should be easy to do since there are so few of them.

Once again, weak sound can be caused by troubles that aren't run-of-the-mill. A sticking or rubbing voice coil will discourage any speaker from working the way it should. A leaky audio bypass capacitor across the output transformer primary can cause this trouble. Has someone tried replacing the output transformer? The wrong transformer could produce this trouble. Check the emitter bypass capacitor. If it is open, nothing much will happen; but if it is leaky or shorted, it will produce weak output with distortion.

A typical single-ended stage

Not all single-ended stages are identical but, as you've probably suspected, they are very much alike. There are a few small differences. Note capacitor C2 in Fig. 311. This is a neutralizing capacitor. Its job is to keep the output stage from oscillating.

Here is what we can do to keep the output stage working. (See Fig. 311.)

Troubles in the Output Stage

You are not sure the output stage is working.

And What To Do About Them.

Inject an audio signal at the base of the audio output transistor. If you hear the signal in the earphones or speaker, the stage is working.

No output signal.

Check all the transistor voltages with a vacuum-tube voltmeter. Compare the voltages with those given by the manufacturer. They should be within 10% of those on the schematic.

C1 may be open. This is an electrolytic coupling capacitor. Shunt it with a known good unit. Watch polarity.

If this test starts the set working again, then the original coupling capacitor is probably defective.

No sound or intermittent sound.

Check the jack, the output transformer and the speaker. A shorted jack will kill sound in the speaker and earphones.

Low volume.

Check emitter bypass capacitor C3. Volume can decrease if this capacitor is open. Shunt with a high-capacitance electrolytic (40 μ f or more). If volume is restored, original capacitor is open.

Distortion.

Capacitor C3 is very leaky. Open one capacitor lead (either one). If distortion disappears, replace capacitor. Also check emitter resistor R1. Check C3 and R1 if the voltage at the emitter is not correct.

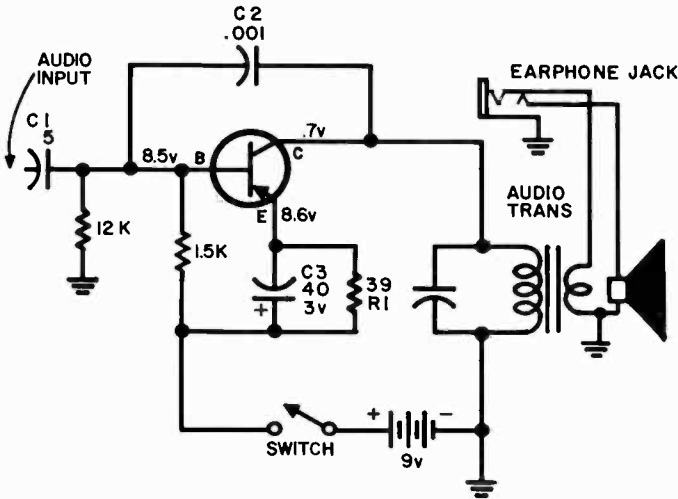


Fig. 311. This single-ended stage is speaker- and earphone-operated.

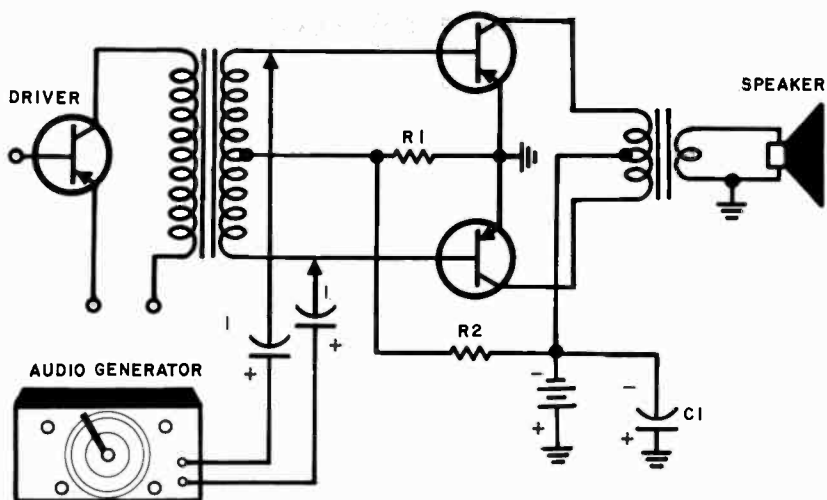


Fig. 312. Testing a push-pull audio output stage. The stage is transformer-coupled at the input and the output.

The push-pull stage

*A designer built a set without enough sound,
At first he suspected a short or ground,
But then he made one transistor push
And he made the other transistor pull,
Now he has more than enough to go around.*

To get a little more volume out of the speaker and a little less distortion, many transistor receivers have a push-pull output stage, just as shown in Fig. 312.

The quick check for the push-pull output stage is a little bit different. Use the connections shown in Fig. 312.

Fig. 312 is a little unusual so follow the explanation carefully. We have two leads connected to the audio generator. Note that a pair of 1- μ f capacitors are in series with each lead. One of these is the ground lead but it really makes no difference which lead is connected to the top transistor and which to the bottom one.

Here is the procedure for checking the push-pull stage quickly with this setup.

1. Turn on the receiver and the audio generator.
2. Connect the generator test leads to the voice coil of the speaker. If you get sound, the speaker is working.
3. Move the leads back to the primary of output transformer. If

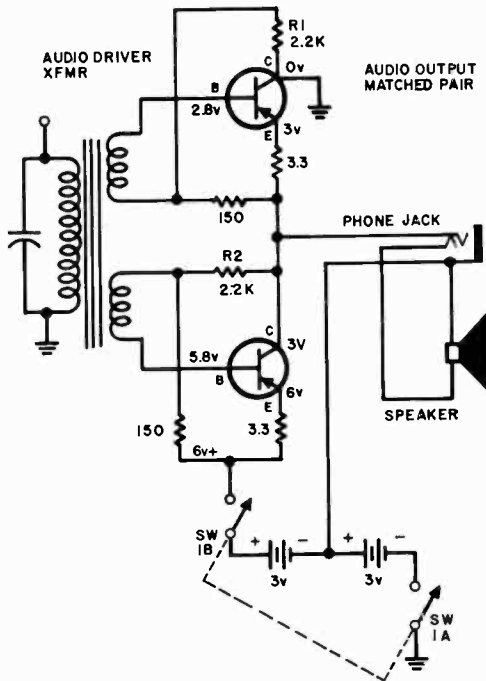


Fig. 313. Push-pull output stage with direct coupling to speaker and phones.

you get sound, both the transformer and speaker are good.

4. Finally, connect the leads as shown in Fig. 312. If the signal comes through, the entire stage is working.

Looking for trouble

What sort of troubles can we expect in the push-pull output stage? Probably the most common is no output signal. Other troubles might be distortion and motorboating. Here are a few troubleshooting ideas.

Troubles in the Push-Pull Stage.

No signal out of the speaker when the audio generator is connected as shown in Fig. 312.

And What To Do About Them.

Look for a possible open circuit. This includes the voice coil, the output transformer, the transistors and bias resistors R1 and R2.

Try a new battery.

Sometimes a bypass capacitor is placed across the primary winding of the output transformer.

Unsolder one end of the capacitor. If the set starts to work, install a new capacitor.

Squealing, motor-boating, oscillation.

Substitute a new capacitor for C1.
Try a new battery.

Sound is distorted. Speech is hard to understand. Music sounds poor.

Make sure the speaker is in good condition. The cone might be torn. The voice coil may be rubbing against its pole piece. It's always a good idea to have a test speaker handy for quick substitution.

Check resistors R1 and R2. If they have changed value, the bias will be incorrect.

Distortion sometimes results if just one transistor of a pair is replaced. Use a matched pair.

A few changes

In one way all push-pull stages are alike—the job they are designed to do is the same. One that is really different is shown in Fig. 313.

When we compare the circuit of Fig. 313 with that of Fig. 312 we see that the output transformer has disappeared. The voice coil of the speaker gets the collector-to-emitter current of each transistor, in turn.

Does this circuit have any new servicing problems? The new

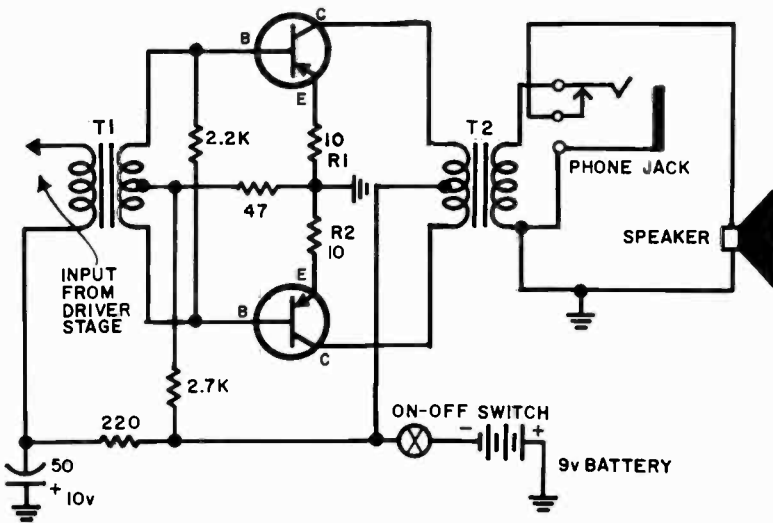
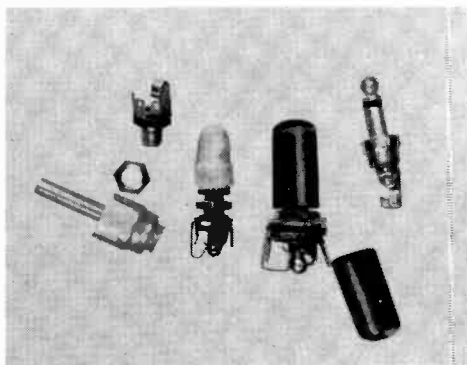


Fig. 314. Typical push-pull output with parts values.

items are the feedback resistors R1 and R2 and the earphone jack. If these feedback resistors change in value or become open, we might get some motorboating or squealing.

There is one other problem. Note how the voice coil of the speaker and the earphone jack are connected. When the earphones are removed, the closed-circuit jack automatically connects the



Components for transistor receivers are small and delicate. Earphone jacks and plugs are compared to the more common phono connector. All are to same scale—approximately actual size.

(Gem Electronics)

voice coil back into the circuit. But what if the jack contacts are dirty? Or what if the contacts don't touch? Several things could happen. The sound out of the speaker could be intermittent (dirty jack contacts) or disappear entirely (contacts not touching).

A typical circuit

In Fig. 314 we have a typical push-pull output circuit with most of the parts values given. Many receivers you will service will have this sort of an arrangement. However, there are differences in push-pull transistor stages, depending on whether the set is intended for car or for portable use.

Checking the transformers

All transformers used in transistor sets are stepdown types. This means that transformer T1 in Fig. 314 has a higher impedance in the primary than in the secondary. Similarly, transformer T2 has a primary with a higher impedance than the secondary.

We aren't going to bother measuring impedances, but with our vom and vtm handy we can certainly measure resistance. Input

transformer T1 (also known as a driver transformer) will have a primary resistance ranging between a few hundred to as much as several thousand ohms. The secondary will be much less, generally below 100 ohms.

To check the transformers, remove the driver and output transistors from their sockets. Make sure the receiver is turned off. Measure the resistances and compare with the manufacturer's values, often given on the schematic.

Output transformer, T2, will have lower resistances than the driver transformer. This will be about a few hundred ohms for the primary and a few ohms for the secondary.

Replace transformers with identical units or equivalent transformers recommended by the manufacturer. Do not interchange driver and output transformers. Transformer leads are color-coded. When replacing, follow the color code given on the schematic.

Distortion

Just as in the case of push-pull tubes, match push-pull transistors

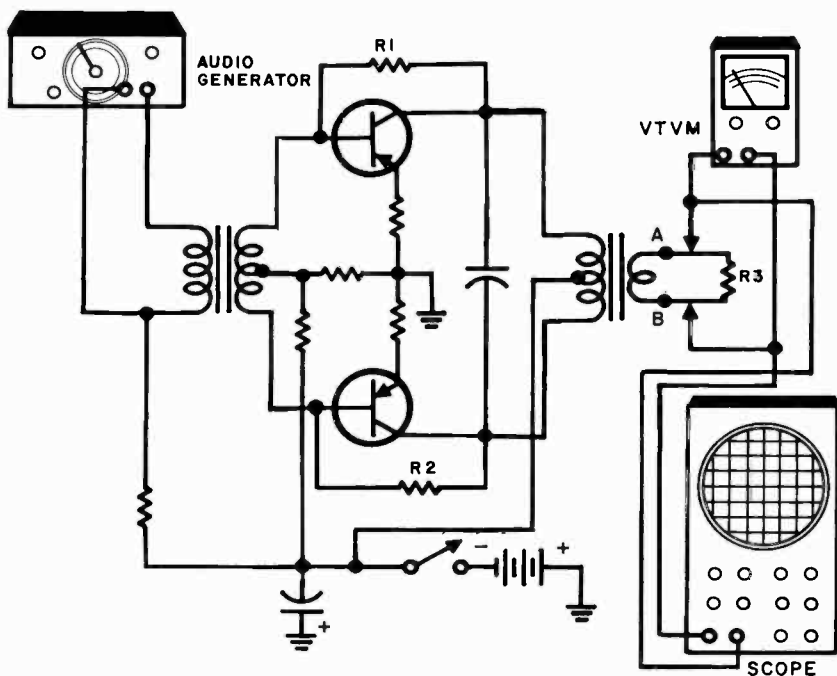


Fig. 315. Circuit arrangements for measuring power output of a transistor receiver.

if you expect a minimum amount of distortion. Test transistors right in the receiver to see if they are balanced.

As an example, let us check the circuit of Fig. 314. Feed a strong audio signal to the primary of the driver transformer. Measure the voltage drop across each emitter resistor (R_1 , R_2) of the push-pull transistors. Do this with a vacuum-tube voltmeter set to read low volts dc (about 3 or 5 volts full scale). Both voltage readings should

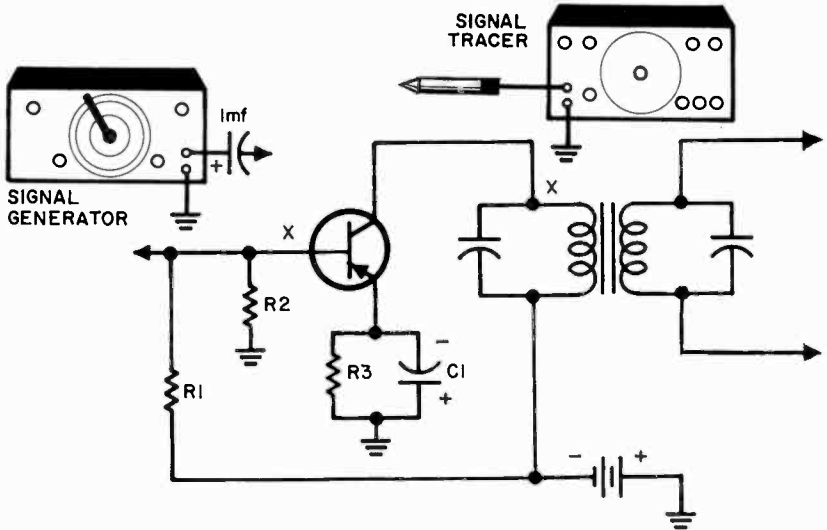


Fig. 316. Check the driver stage quickly with a generator and a signal tracer. (*X's indicate points for injecting signal generator signal.*)

be the same or very close to it. If you get a difference in the readings, the transistors aren't matched.

By using this test, you can match transistors. Incidentally, just because two transistors do not match does not mean they are defective. Keep the transistors for matching in another set.

There is still another way of matching transistors. Connect your oscilloscope across the voice-coil leads of the speaker. Feed an audio signal to the primary of the driver transformer. Now turn the volume control up until you get clipping of the waveform. If there is the same amount of clipping on the top and bottom of the wave, the transistors are balanced. If you get more clipping on one side of the wave, the transistors are not balanced.

Measuring power output

After you get through testing and repairing a receiver, you may be interested in knowing just what its power output is.

But we should explain what these words mean. There are really two types of output power:

1. Maximum power output
and
2. Maximum *undistorted* power output.

Do you see that word we have italicized? That's the word that makes the difference.

We can go about measuring both kinds of power output in the same way. Our first step is to replace the voice coil of the speaker with a resistor, R3 in Fig. 315. The resistor should have the same value as the impedance of the voice coil. If the set uses a 3-ohm speaker, replace it with a 3-ohm resistor. For small receivers, a carbon resistor having a rating of 2 watts will do.

Now connect a scope and a vtvm across the resistor. Set the vtvm to read ac volts. Use the 10-volt scale. Feed an audio signal into the primary of the driver transformer. Watch the waveform on the scope. Keep advancing the gain control on the generator until the waveform on the scope just begins to flatten.

How to calculate maximum undistorted power

1. Note the ac voltage reading on the vtvm. Multiply this reading by itself.
2. Divide the voltage reading by the value of R3. This will give you the answer.

For example, suppose that R3 is 3 ohms. Let us also suppose that our vtvm gives us a reading of 4 volts.

Step 1: We multiply 4×4 and get 16.

Step 2: We divide our answer (16) by the resistance — in this case, 3 ohms.

16 divided by 3 equals 5.3.

Our answer is in watts.

Of course, in making this test, we must use a resistor rated 10 watts or more.

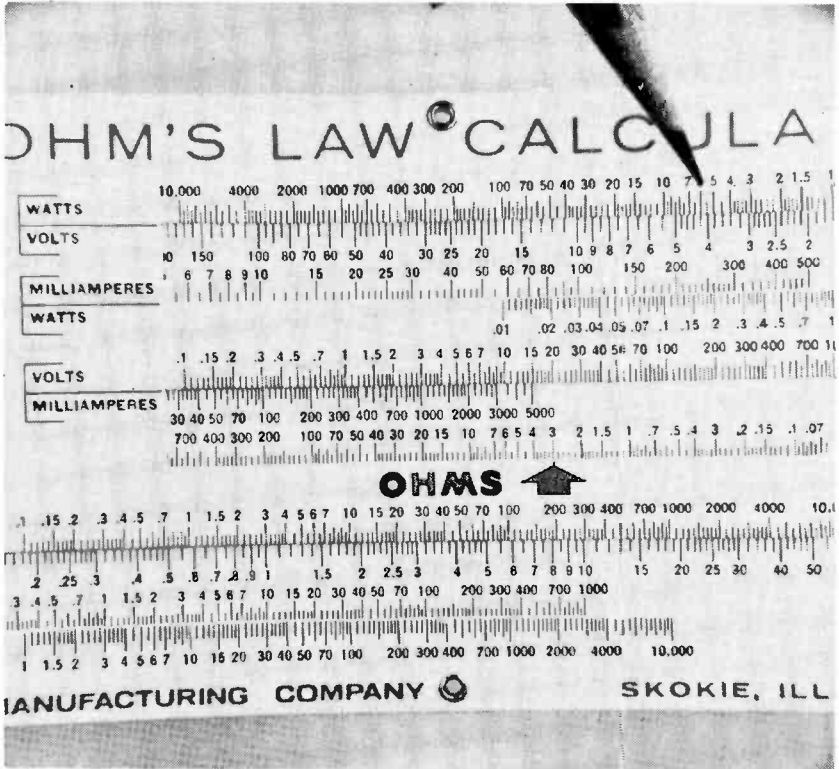
What have we done? In mathematical terms the 4×4 would be called "four squared". It would be written 4^2 . Since the 4 is the voltage it would be represented by the letter E. We divided this by the resistance (R). Written in mathematical language we have:

$$\frac{E^2}{R} = \frac{4 \times 4}{3} = \frac{16}{3} = 5.3 \text{ watts (P or W)}$$

That little bit of arithmetic wasn't so bad after all.

The driver stage

The stage that comes right before the push-pull stage is called the driver. It's just an ordinary transistor audio amplifier.



Special Ohm's Law calculator (slide rule) is as helpful as a servicing tool. The resistance of the speaker (3 ohms) is set above the Ohms arrow. The answer (5.3 watts) is read above the 4 (volts) as indicated by the pencil tip. (Ohmite Manufacturing Co.)

There are several ways of checking the driver. The easiest and the quickest is shown in Fig. 316. Put in (inject) an audio signal at every point marked X. Start at the output, if you like, and work your way back to the input.

What is the output? It is just a transformer. We checked the secondary side of this transformer when we tested the output stage.

To check, touch the generator lead, in turn, to the collector and then to the base of the transistor. That's all there is to it. If you get good sound in both cases, the stage is working.

Using a signal tracer

Some service technicians prefer using a signal tracer. It does have an advantage. You don't have to depend on the output stage. Just connect the test probe of the tracer to the collector of the transistor and the generator to the input.

Driver troubles

We can get the same troubles in the driver that were found in

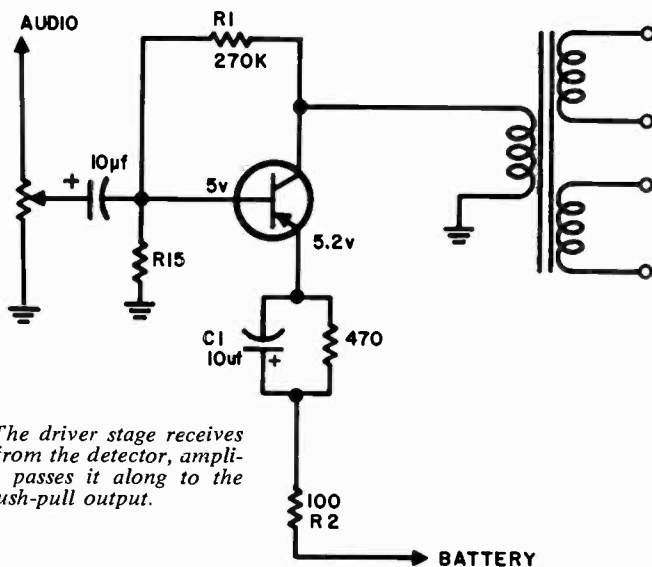


Fig. 317. The driver stage receives the signal from the detector, amplifies it and passes it along to the push-pull output.

the output stage. This isn't too surprising since both are audio amplifier circuits.

However, keep in mind that as you move the generator lead from the output end of the amplifier toward the input, the signal strength of the speaker should get stronger. You should be turning down the output of the generator.

In Fig. 316, R1 and R2 are the base bias resistors. If either of these become disconnected or open, the transistor will stop working. If they change value, the stage might distort the signal.

If emitter resistor R3 opens, the driver won't work.

Look at C1, the emitter bypass capacitor. A typical value for this unit would be 40 µf at 3 volts. If this capacitor is defective, it will reduce the volume. One way of checking is to shunt it with another unit of the same size. Watch the polarity. In the circuit of Fig. 316, the plus side of the electrolytic is grounded.

More about the driver

As you can see from Fig. 317, the driver circuit has very few parts. The signal is picked off from the volume control and fed into the base. In some driver circuits you will find a fairly high value of resistance placed between collector and base. This is resistor R1. This is a feedback resistor and helps stabilize the transistor by supplying a small amount of negative feedback. We could

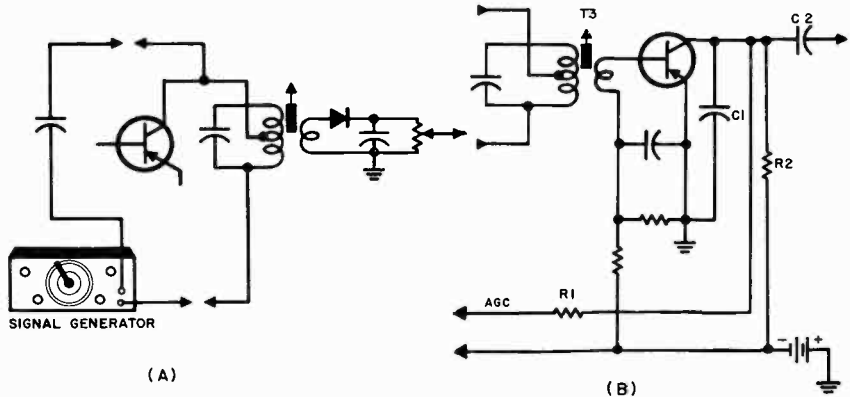


Fig. 318. Signal-generator method of checking a diode detector (A). Signal heard from receiver speaker indicates detector and audio circuits are working. Some receivers use a triode transistor (B) as detector.

accomplish the same thing by omitting capacitor C1 across the emitter resistor.

The detector

*Jumping from base to collector,
Was our hero service technician, Hector.
The set wouldn't squawk,
The speaker wouldn't talk,
The signal hadn't reached the detector.*

And from this little verse we learn a sad, sad story. If the signal doesn't reach the detector, there just isn't much use in looking at the audio driver and output stages for the troubles.

Most transistor sets use a diode detector circuit, as shown in Fig. 318-A, while some have a transistor for a detector.

Before we start to think about detector troubles, let's ask ourselves, "What does the detector do? Why should we use a transistor (Fig. 318-B) in place of the diode?"

Modern detectors have two jobs. They rectify the signal. If they didn't do this, we wouldn't be able to hear the signal. Also, the

rectified detector current (when sent through a resistor) gives us our automatic gain control (we shorten this to agc) voltage. Another name for automatic gain control is automatic volume control (or avc).

Because we know what the detector does, we immediately have an idea of what sort of trouble to expect. No sound — check the detector. Very weak signal — check the detector. Blasting — check the detector.

How do we know the detector is in trouble?

To learn if our detector stage is the troublemaker, feed a signal into the collector of the preceding transistor. Fig. 319 shows how we do this.

Now be careful and don't make a mistake. Up to now we've

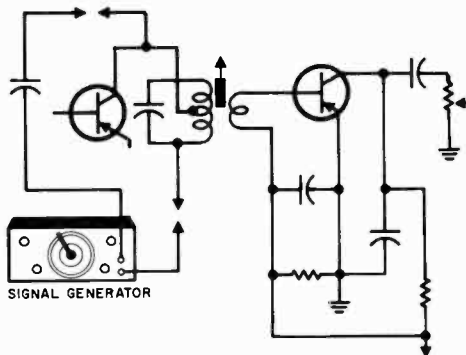


Fig. 319. Signal-generator method of checking a transistor detector. A signal tracer connected across the detector load (usually the volume control) can substitute for receiver's audio stages.

been working with audio stages. For that reason we have been using an audio signal for stage testing. But where are we now? Since we're trying to put a signal in right before the detector, shouldn't we use an if signal? Definitely! The if is 455 kc so we must make sure to set our generator to that frequency.

Anything else we might have forgotten? Yes. An if signal alone is not enough. It must be modulated. You can do this with the *mod on* control on your generator. Finally, put an .01 μf capacitor in series with the "hot" lead of the generator (this will keep collector voltage out of the generator) and we're ready to go.

If, with this test, we get a signal out of the speaker, the detector is working. If you prefer, you can connect your signal tracer across the detector load (the volume control).

What kind of trouble will the detector give us? Use the trouble-shooting chart to help you. We have just one chart for diode and transistor detectors since you'll find the same sort of troubles whether the set has a diode or a transistor as a detector.

Troubles in the detector stage.

And What To Do About Them.

No signal output.

Check for an open circuit, a short circuit, a defective diode or transistor detector. Check C1 and R1 in Fig. 320. Make sure the transistor detector is getting its voltage. The coupling capacitor (C2) may be open. A completely dead battery or one that is very weak might be responsible.

Weak signal.

Check rf bypass capacitor C1. Do not use any larger value capacitor than necessary. The larger the capacitance, the more audio signal we lose.

The if transformer feeding the detector may be misaligned. This is T3 in Fig. 320.

Weak signals sometimes indicate that the diode or transistor need replacement.

Signal sounds good when low, distorts when it is loud.

The agc filter capacitor (C3) may be leaky. Check rf bypass capacitor (C1).

No agc voltage.

Check agc resistor R1. Make sure components in agc line are not open or shorted.

Getting rid of agc voltage

During alignment, it is best to disable the agc. To do this, connect a 100-ohm resistor ($\frac{1}{2}$ or $\frac{1}{4}$ watt will do) between diode cathode and ground as shown in Fig. 320.

How much voltage out of the detector?

This is a hard question to answer since it all depends on the amount of signal we have to begin with, whether or not we have an rf amplifier stage, and on the number of if stages. However, you can usually count on about 0.15 volt at the diode load.

What if we do not have this amount of voltage? Or, what if we have much more? Let's answer these two questions in the order in which you asked them.

A capacitor (rf bypass) is placed right across the output of the

detector. If you don't get enough signal voltage, check this capacitor.

Sometimes one or more of the if stages will start to oscillate. This means, of course, that when they do this they are acting as generators, producing a signal voltage of their own. The diode

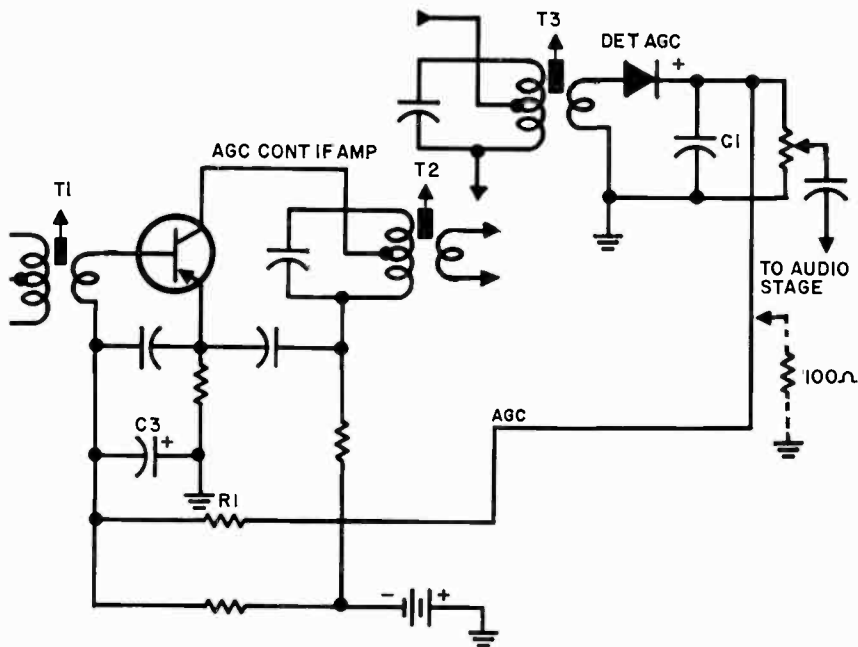


Fig. 320. You can disable the agc line with a 100-ohm resistor.

detector (or the transistor detector) won't know anything about this and will promptly proceed to rectify this artificial signal. Since this problem really belongs with the if stages, we will cover it in a later section.

Checking the detector

If the receiver you are servicing uses a transistor detector and you suspect it, you can check it just as you would any other transistor by the methods we studied earlier.

If the detector is a diode, you can check it by measuring its forward and reverse resistances. Disconnect one side of the diode from the circuit. The reverse resistance should be more than $\frac{1}{2}$ megohm. The forward resistance will range between 40 and 100 ohms.

The agc line

In transistor receivers, automatic gain control is very simple. Fig. 321 shows the circuit. It consists of a resistor, R_1 , and a capacitor, C_3 . The value of R_1 will vary from receiver to receiver, but it will have a range of 1,500 to about 3,300 ohms. The agc filter, C_3 , is

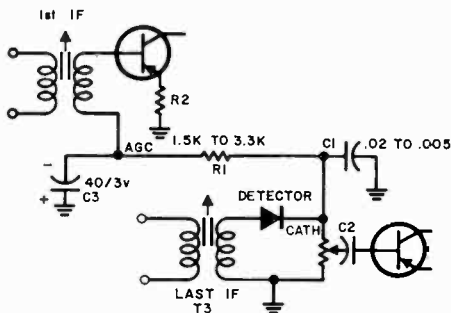


Fig. 321. Agc network for a set using p-n-p transistors. For n-p-n types, the detector and C_3 would be turned around.

usually a 40- μ f unit rated at 3 volts. (Capacitor C_1 in the circuit is an rf bypass.)

Most transistor sets today use p-n-p transistors. However, you may find some that have n-p-n units. In such sets the diode detector will be connected in a manner opposite to that shown in Fig. 320—the cathode of the diode will be connected to the winding of the last if. Capacitor C_3 will also be turned around so that its positive terminal goes to the agc bus and its negative terminal to ground.

Agc operation

In Fig. 321, R_2 is the emitter resistor for the first if stage. In the absence of a signal, the current through this resistor should be about 0.5 ma.

When a signal is received, the current through R_2 will vary, in proportion to the strength of the signal. The stronger the signal, the smaller will be the current through R_2 .

But let us suppose that the current through R_2 increases with the signal instead. The symptoms here would be in the agc line and would be caused by a reversed diode. Remember that the diode not only works to rectify the signal, but helps furnish bias for one or more stages (usually if) in the receiver. When checking controlled

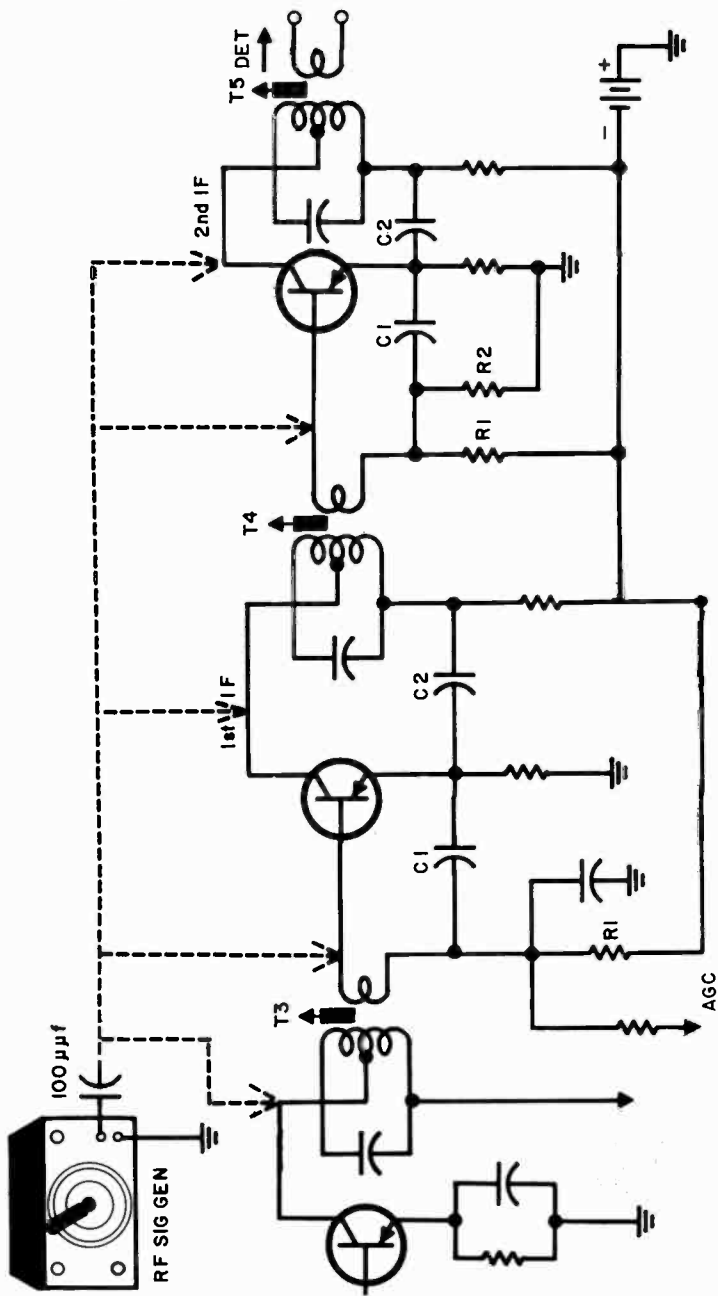


Fig. 322. Method of signal tracing the second and the first if stages.

stages, then, keep in mind that their behavior may be due to something over which they have no control.

*When you've checked the audio,
What else is there to do?
Perhaps the detector,
Could stand a look or two,
But if you're stuck, don't get in a rage,
Just move on back to the if stage.*

The if stages

Perhaps you've been accustomed to working with vacuum-tube ac-dc receivers. If so, you may have become used to the idea of just a single if stage. Transistor radios, especially those used in automobiles, often have two if's although some of the cheaper portables have only one.

Does this mean any extra work? Not actually. If you can fix one you know how to fix two.

Our first problem

Our first question is always the same: "Is the stage working? How can we tell if it is?"

Signal injection is still the answer. Put a signal in. Listen to hear if it comes out.

This method is shown in Fig. 322. To check the second if (the stage nearest the detector) feed a signal into the collector of the first if. If you get sound out of the speaker (or signal tracer), move the hot lead of the generator over to the collector of the converter or mixer. If the sound continues to come through, then both if stages are good.

When you checked the detector the generator was set to the if of the receiver. The generator modulation switch was turned on. Your only precaution now is to keep adjusting the gain control of the generator. As you move toward the front-end (tuner) of the receiver, stage by stage, the gain of the receiver increases the signal strength. This means you don't need as much output from the generator.

How about the if?

An if amplifier is somewhat like an audio amplifier. A big difference is the frequency. As we go higher in frequency it becomes easier for an amplifier stage to oscillate. When this happens, the

amplifier produces signals of its own—and they're certainly not pleasant to hear. They sound like whistling or squealing.

This is just one of the troubles we can expect in the if. Suppose we see what other sort of illness we can expect.

Troubles in the if stages. And What To Do About Them.

No signal output.

Resistance test the if transformers (primary and secondary windings). (Naturally, set must be off.)

Check the base bypass capacitors, C1 (Fig. 322). If this capacitor is shorted, the if stage won't work.

Receiver is noisy.

Check soldered contacts. If the set uses printed-circuit board, examine conductors for cracking or splitting.

Corroded windings in the if transformer produce noise.

Signal is weak.

If one or both if stages are misaligned (even partially), signal strength will be reduced.

Check the base bypass capacitor, C1, and the collector bypass, C2 (Fig. 322). If these are open, signal strength will be lowered.

Distortion.

If stage is agc-controlled, make sure it is receiving agc voltage.

Distortion is produced if transistors are being operated with wrong voltages.

Set will distort if battery voltage is weak.

Make sure the base biasing resistors, R1 and R2 (Fig. 322) haven't changed their value. The resistors should be within their tolerance.

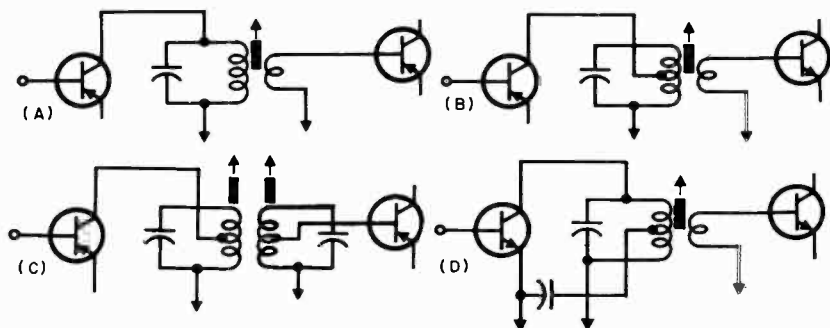


Fig. 323. Four basic transistor if circuits. The dark rectangle and arrow between the transformer coils indicate adjustable slugs for tuning. Generally these are adjusted for maximum signal at 455 kc. Other if frequencies may be used.

If transformers

An if transformer acts as a connecting link, transferring the signal from one stage to the other.

But, like the little boy who carried the pitcher of cream upside down all the way from the grocery store, there are efficient and not-so-efficient means of transporting the signal.

For maximum transfer of signal, we must match impedances. This is why an audio output transformer is a stepdown device. It connects a high impedance (plate of a tube or collector of a transistor) to a much lower impedance (voice coil of the speaker).

If you were to call a transformer an impedance-matching device, you would be absolutely right! And the more closely impedances are matched, the more efficient is the transfer of signal energy.

When we go from the plate of a tube to the grid of the following tube, we are going from a lower to a higher impedance.

If stages in transistor receivers are exactly opposite to this. The impedance at the collector is much higher than that of the following base. Here we need stepdown if transformers.

We have three ways of getting what we want, as shown in Fig. 323. In Fig. 323-A we have a very common type of if transformer. The primary has more turns than the secondary, and that is that.

Some manufacturers try for better selectivity by using the method shown in Fig. 323-B. Here the collector connection isn't made to the top of the if primary winding (point of maximum impedance) but lower down on the winding (point of lower impedance).

Now you might argue that it would have been better to reduce the number of turns of the primary, but to do so would make it more difficult to resonate the primary (to 455 kc). It would also reduce the selectivity.

We can tap down on both primary and secondary, as shown in Fig. 323-C for impedance-matching purposes. Sometimes the emitter is tapped "up" on the primary winding (Fig. 323-D). The result is just the same as though we had tapped the collector "down".

If transformer resistance

The resistance of the primary winding of a transistor if transformer is from about 1.4 to 3.5 ohms. The secondary winding, since it has fewer turns, has a lower resistance. A value of 0.5 ohm is common.

Replacing transformers

In Fig. 323 we show four different transformer circuits. How-

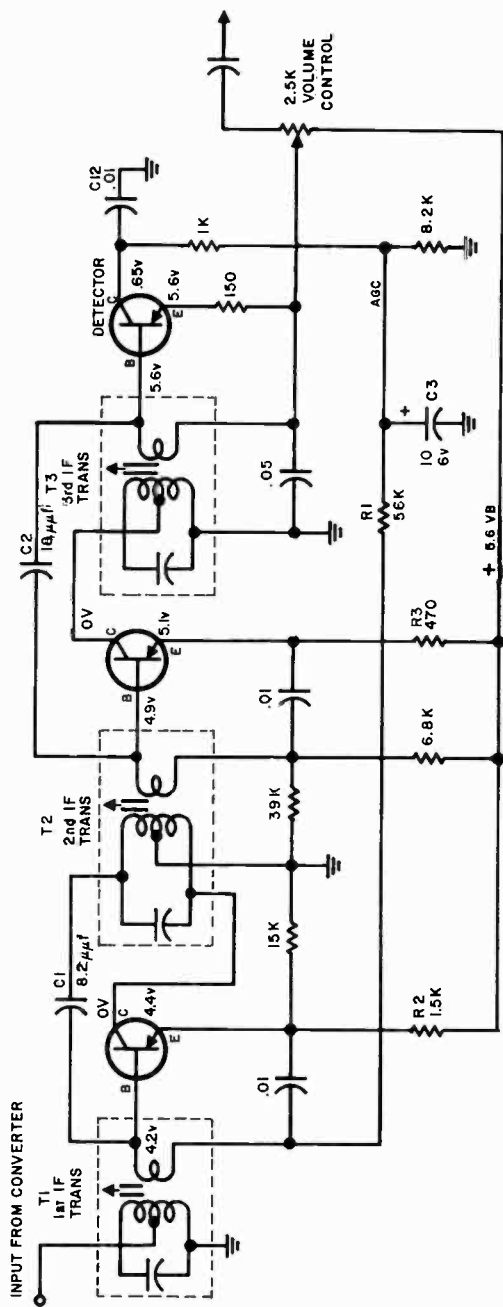


Fig. 324. Two stages of if amplification are quite common in transistor sets.

ever, the impedances of if transformer windings (quite a different thing than the resistance) varies considerably from one receiver to the next. For this reason, you cannot use just any old transformer that may be available. Use an exact replacement or an equivalent unit recommended by the manufacturer.

The if transformers used in transistor sets deserve care and respect. Keep screwdrivers away from them. These tools were never intended for alignment anyway. Use a nonmetallic alignment tool designed for that purpose.

Removing if transformers

Use a low-wattage iron. A unit rated at about 35 watts will do.

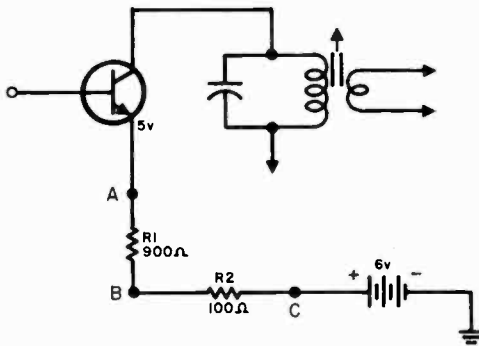


Fig. 325. The emitter resistor supplies convenient check points for the if transistor.

You will need the help of a small brush with stiff bristles. Heat the connection until the solder begins to melt then quickly brush the solder away. Don't keep the soldering iron at the lug any longer than necessary. Move the can from side to side gently until it comes loose.

Examining the if

In Fig. 324 we have a two-stage if system and a transistor detector. This circuit has a few interesting features so let us examine them together.

Note capacitors C1 and C2. These are feedback capacitors (sometimes called neutralizing capacitors). Their purpose is to keep the if stage from oscillating.

The next item is the agc network. This comes from the collector output of the transistor detector and is fed back to the base of the

first if transistor. The agc filter consists of R1, a 56,000-ohm resistor, and C3, a 10- μ f electrolytic.

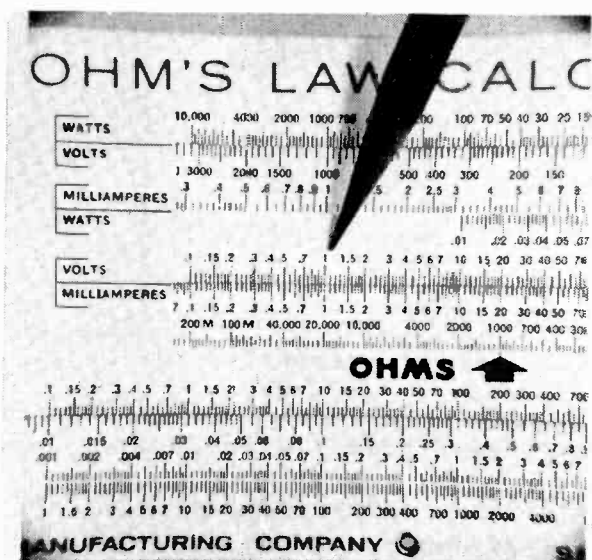
The emitter resistors, R2 and R3, are not bypassed. This supplies a small amount of negative feedback. Thus, R2 and R3 work together with C1 and C2 to keep the if system from oscillating.

A little more arithmetic

You've probably noticed that we have avoided using arithmetic as much as possible. Sometimes, though, a little bit of it can help us in servicing a receiver.

Fig. 325 shows an example. Here we have an if stage. The emitter resistor is 900 ohms. On our way back to the battery, we see a decoupling resistor of 100 ohms. Thus, between the battery and the emitter, we have 900 plus 100 ohms, or a total of 1,000 ohms.

Now let's take a look at the emitter. The manufacturer has very kindly marked the emitter as 5 volts. This means that our resistance of 1,000 ohms has dropped 1 volt.



With the resistance (1,000 ohms) set over the arrow, 1 ma is found under 1 volt, pointed out by the pencil. (Ohmite Mfg. Co.)

With this little bit of information, we can now calculate the emitter current.

$$I = \frac{E}{R} = \frac{1}{1,000} = .001 \text{ ampere, or } 1 \text{ ma}$$

This is all very nice, but suppose the voltage at the emitter doesn't measure 5 volts—what then? Your next step would be to check the resistance values of R1 and R2 (with the receiver turned off, of course).

It is possible, though, that both resistors will be good. Connect a vtvm between points A and B (in Fig. 325) or between points A and C.

Short the emitter to the base. You can do this with a clip lead

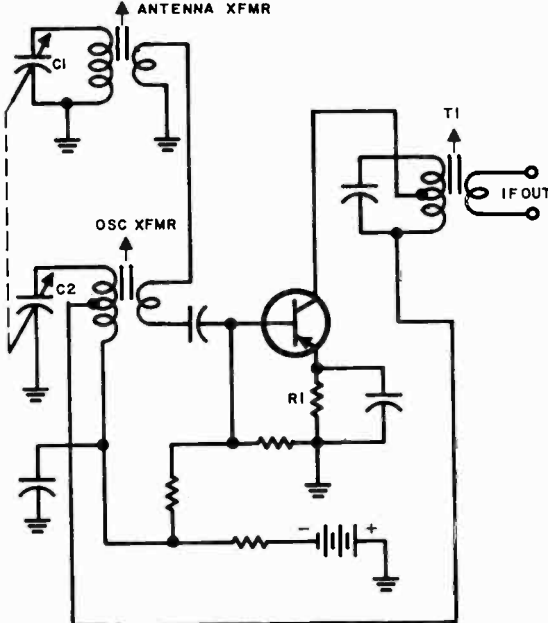


Fig. 326. Converter stage of a transistor receiver.
The converter transistor is a triode.

but be careful not to damage the transistor leads. The voltage you are measuring between A and B or between A and C should drop to zero or very close to it. If it doesn't, the transistor is defective.

Back at the front end

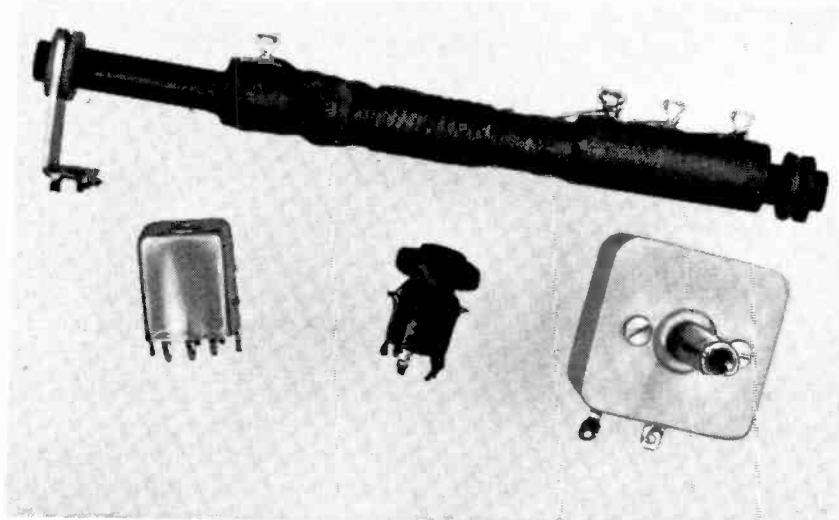
*There was once a converter
(It really needed fixing),
Very anti-social
It didn't enjoy mixing.*

We'll admit that it's taken us some time to reach the converter stage of our transistor receiver. If you had been working on a real

set, you would have found the trouble long ago. What we're trying to do, though, is to learn to fix every section of the receiver.

A quick way to service any set is to divide the set into two parts (in your mind). From the front end (radio frequency or converter) to the detector is one half; from the detector to the speaker is the other half.

Let's see what good this does us. Put an audio signal across the detector diode load. If you get a signal out of the speaker, then you know that the second half of the set is working. Next, inject a signal at the receiver input and put your signal tracer across the



Ferrite loop (top) and (left to right) single-tuned if transformer, oscillator coil and tuning capacitor. Variable capacitor has plastic foil between plates to prevent shorting and increase capacitance value. It is sealed in plastic case to keep out dirt and moisture.

diode load. No signal, weak signal, distorted signal, etc. means that your trouble is in the first half.

Do you see what we're trying to do? We're trying to localize the trouble, pinpointing it to a particular stage. After we do that, we will then search for the particular part (or parts) that are defective.

It's too easy!

Does this sound too easy? If it does, it's because it's a good way to work. We hope you will remember, though, that sometimes we can have troubles in both halves of the set at the same time. You may fix or replace some component in the audio amplifier only to find that the antenna coil is defective. It happens!

The converter

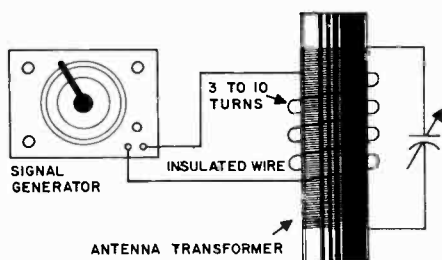
You've probably had a good bit of your experience with vacuum-tube converters of the pentagrid type. Transistor converters are much simpler since they are triodes. Fig. 326 shows a typical transistor converter.

How does it work?

What is a converter, anyway? Isn't it just a combined oscillator and amplifier? The amplifier part consists of the antenna transformer and the transistor. The oscillator is made up of the oscillator transformer and the same transistor.

The signal is fed into the transistor input (base-emitter) circuit

Fig. 327. Method of coupling the signal generator to the antenna transformer of a transistor receiver.



through the antenna transformer. The amplified signal appears in the collector (output).

The oscillator is tuned to a higher frequency than the incoming signal by the amount of the if. In other words, the difference between the incoming signal and the oscillator frequency is equal to the if. Here's an example:

$$\begin{array}{r} \text{oscillator frequency} \quad 1,455 \text{ kc} \\ \text{incoming signal} \quad \quad \quad \underline{1,000 \text{ kc}} \\ \quad \quad \quad \quad \quad \quad \quad 455 \text{ kc} = \text{value of the if} \end{array}$$

Note that C1 and C2 (the tuning capacitors) are ganged (or are rotated at the same time). The dashed line shows that they are ganged or turn together.

Quick check

Before we start to troubleshoot the converter, what do we want to know? As in the case of all the other circuits, we want to know if the converter stage is working. Let's see how we do this.

Take a length of insulated wire and wind a few turns of this wire around the antenna coil, just as shown in Fig. 327. You don't have to fasten the turns. Just keep them loose.

The reason we use an arrangement such as that shown in Fig. 327 is that we don't want to overload the converter transistor. Our generator can supply so much signal that this is easy to do. Also, keep your generator about 12 inches away from the receiver. Your coil can have a pair of connecting wires this long.

Now set the receiver and the signal generator to 600 kc and turn both of them on. Make sure the signal generator modulation switch is turned to the ON position. Keep the gain control of the generator low, since we don't need much signal.

It isn't too likely that the dials of the generator and receiver will match exactly, so turn the receiver tuning knob back and forth slightly. If you hear the modulation tone out of the speaker, the converter is working.

But what if the converter isn't working? What are the troubles we can expect? Use the chart to help you.

Troubles in the Converter Stage.

And What To Do About Them.

No sound.

Look for shorted or open components and leads that have broken away from their joints. The transistor could be defective.

Look for parts, especially resistors, that have changed value.

Check the battery, preferably by substitution. Are the battery clips making good contact? If the set uses two batteries, the fact that one of them is good is of no help. Both must be good.

You can tune in only one station.

If stages aren't aligned. The oscillator section of the converter isn't working.

Receiver cannot tune in stations at the high-frequency or the low-frequency end of the band.

Make sure capacitor plates aren't touching. Work the capacitor back and forth. If you hear a scratching noise, check the capacitor for shorts.

Antenna transformer may be defective.

Make sure emitter bypass capacitor isn't open. An open capacitor will cut down the gain. Weak station may not be picked up.

Poor sensitivity at low- or high-frequency end of the band.

Sometimes the antenna core gets cracked or broken. If it is, replace the core or entire transformer.

Misalignment of the oscillator coil or antenna transformer will cause this trouble.

Receiver is noisy.

Is the set noisy when being tuned, or when the volume control is being adjusted? Then these

components (tuning capacitor or volume control) are probably causing the trouble.

Noise can be caused by a defective converter transistor. Only way to check is by substitution.

Checking the local oscillator

What can we do if all the stages following the converter are good, but we get no sound out of the receiver?

One of the possible causes is that the local oscillator might not be working. Fortunately, we have a number of easy ways to check the oscillator.

The first step is to determine the transistor type. Is it p-n-p or n-p-n? For a p-n-p, connect the negative lead of the vtvm to the

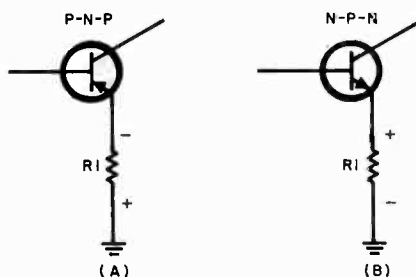


Fig. 328. Methods for determining whether the oscillator section of the converter transistor is working.

emitter, the positive lead to ground. Or, connect the leads across the emitter resistor of the converter, being careful to watch polarity.

Compare the voltage reading you get with that shown on the schematic. If your measurement shows the voltage at the emitter is more negative than normal, the oscillator isn't working.

You can make the same test with n-p-n converter transistors, except that the polarity is reversed, as shown in Fig. 328.

If the voltage at the emitter of the n-p-n transistor is above normal, the oscillator isn't working.

Another way of checking the oscillator is to use another receiver. Of course, the receiver you are going to use as a test unit must be in working order. Turn the receiver on and tune it to about 1500 kc. Turn on the receiver you are checking and adjust the dial until you are at about 1045 kc. Since it may be difficult to locate this frequency exactly on the dial, start at 1000 kc and turn the dial slowly toward 1100 kc. About halfway between these two points, you should hear a whistle out of the receiver you are checking. If you do, the local oscillator is working.

The single-transistor converter

In Fig. 329 we have the circuit for a single-transistor converter. Inductive feedback is used between collector and emitter through oscillator transformer T2.

Bias is supplied by resistors R1 and R2, connected in series across the battery. Additional bias is also furnished by resistor R3, wired between the emitter and the battery.

The amount of feedback can be controlled by adjusting the slug in transformer T2.

Mixer and local oscillator

In some sets you will find separate transistors used as the mixer and local oscillator. In Fig. 330, V1 is used as the mixer while V2 is used as the local oscillator. Note the difference between a converter and a mixer. A converter is a transistor (or a tube) that does a double job—it works both as a mixer and oscillator. A mixer, however, is a transistor (or a tube) that just mixes signals. It requires a separate transistor (or tube) for a local oscillator.

Receiver test points

Did you ever take a trip in a plane? Unless you're very familiar with the area you fly over, you'll not be too sure of just where you are. A good way to check is to use a map and pick out large areas, such as lakes or big cities.

Servicing a radio is like taking this kind of a trip. Until you find the trouble, you really are "up in the air". Examine the typical transistor radio shown in Fig. 331. We've marked various test points with letters A, B, C, etc. For test points at the detector or after it, use an audio signal. For test points before the detector, use a modulated if or rf signal.

More troubleshooting

*Once upon a time,
There was a very ambitious service technician
(A nice young fellow, very fine)
He advertised all his services, now and then
Told all his friends and neighbors how good he was
But while his prices were very fair
He knew very little about radio repair
And so the sets just piled up and up,
Up
Up.*

*Finally, the idea got through to his mind
 That he had to do something about it
 He did!
 He moved!
 And left all the unfixed sets behind.*

Please don't take this very sad poem too much to heart. After all, you are learning more and more about fixing sets.

We've covered the transistor receiver from stem to stern, from

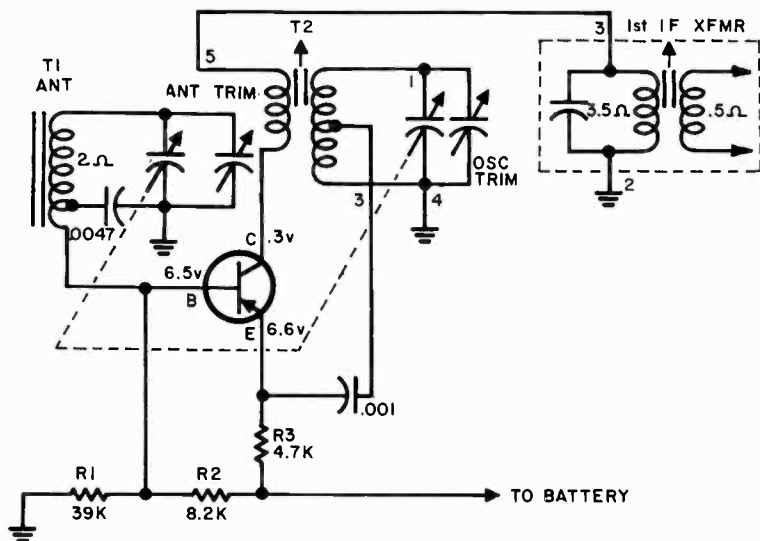


Fig. 329. In this circuit, a single transistor is used as the mixer and local oscillator.

the antenna to the speaker. Most of the transistor receiver troubles have been described but we do have a few more you should know about. We've included them for you in a general troubleshooting chart.

TRANSISTOR RECEIVER SPEED SERVICING CHART

Here are the Troubles.

And What To Do About Them.

The battery needs frequent replacement.

This is most often due to a shorted or a leaky component. Check transistor base-biasing resistors. If they have decreased in value, they will put a heavier current drain on the battery.

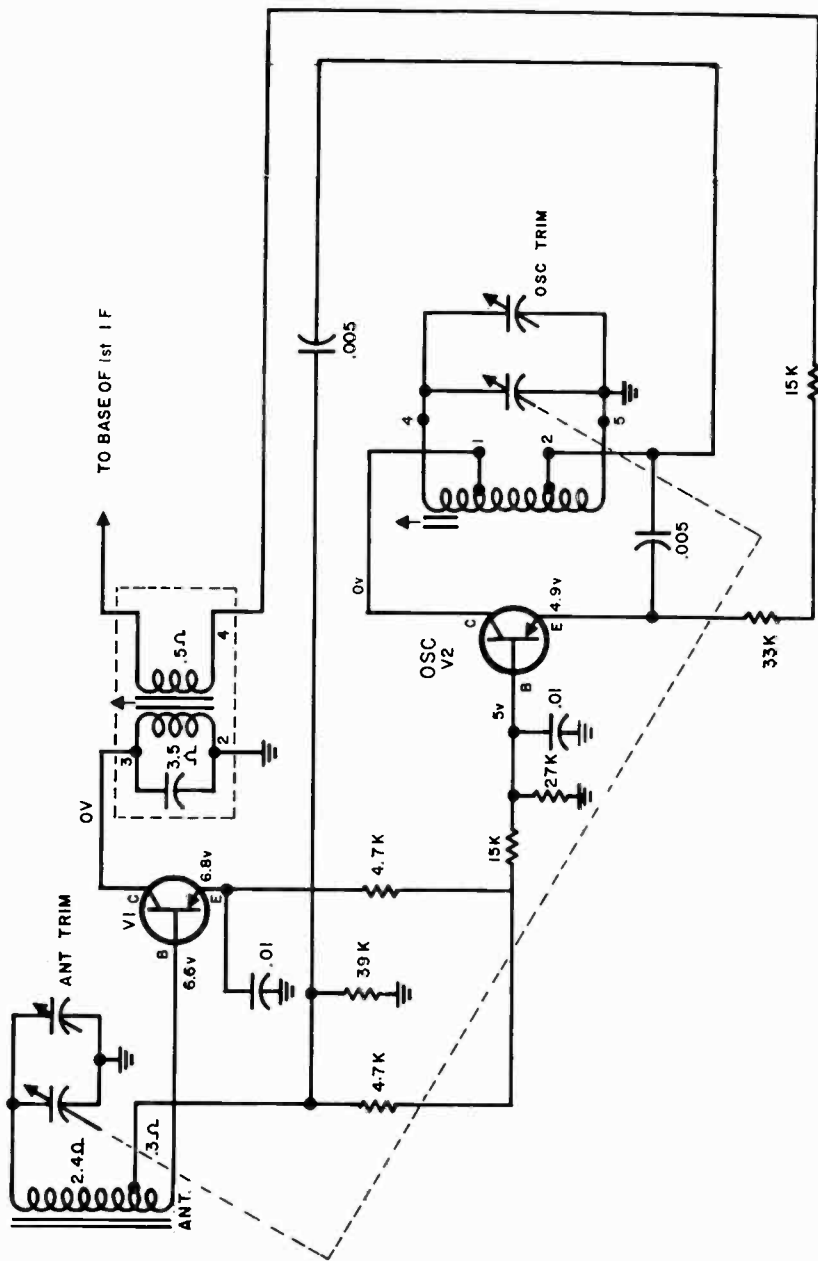


Fig. 330. Front end of a transistor receiver using a mixer and a local oscillator.

Check the ON-OFF switch. It may not switch off. This won't hurt the transistors, but it does put a continuous load on the battery.

You will find a high-value electrolytic shunted across the battery. If this capacitor's leakage increases, battery life will be shortened.

Check the current drain of the audio output transistor or transistors. Use a dc milliammeter for the test. Make sure these transistors do not draw more than normal current. If they do, either the transistors or associated components are at fault.

Sound is low. Setting volume control to maximum doesn't help.

Usually caused by a rundown battery. Symptom is generally accompanied by distortion. Set may be misaligned. If these are not the troubles, check transistor bias voltages throughout.

Sound is distorted.

Try substituting a new battery. If set uses more than one battery, replace both.

Is speaker cone torn? Does speaker voice coil slide back and forth without interference? If set uses earphones, try these to see if distortion disappears. If it does, fault is in speaker.

Leaky or shorted coupling capacitors will cause this trouble.

Unsolder one end of the emitter bypass capacitor (in each stage, one at a time). If distortion is lowered, bypass capacitor is defective. Replace.

In push-pull audio stages, matched transistors are needed. If one transistor of a matched pair becomes defective, distortion will result. Replace both.

Distortion may be natural characteristic of receiver. Some portables cannot have volume increased without increased distortion. This is in the receiver design.

Check agc filter bypass capacitors for short or leakage.

Receiver may be misaligned.

Receiver is intermittent.

Look for dirty or worn contacts on moving components — volume control or switch. Battery fastener spreads sometimes, making poor contact. Make sure battery contacts aren't corroded or dirty.

Is set intermittent when tuning? Check tuning capacitor for short at a particular spot.

Look for a soldered connection that has come loose, making intermittent contact. Check printed-circuit board. Conductor on board may have broken away or may have opened along its length. If possible, hold printed board up to the light for examination.

Set plays for a short while, then fades.

Battery needs replacement. The receiver may play for a time then drift and finally become weak.

Receiver whistles.

Set may be misaligned.

This trouble is often caused by a weak battery. As a battery gets older its impedance increases, thus forming a common impedance for all stages.

Check filter capacitor across battery. Shunt with a known good unit of the same value. If whistling disappears, replace filter capacitor.

This trouble has been caused by defective cores in the antenna transformer or oscillator coil.

Check the neutralizing capacitor. (If more than one, check each in turn.) The capacitor should be replaced with a unit having the same value. Use a zero-temperature-coefficient type.

Receiver volume keeps changing.

Check agc circuit. Agc voltage may be lower than normal or missing entirely.

Receiver does not receive stations at the high-frequency end of the broadcast band. Sometimes the set will not pick up stations at the low-frequency end of the band.

Try replacing the battery. Some stations at the ends of the broadcast band (especially high end) are not as strong as other stations.

Front end of receiver may be misaligned.

Converter transistor may cause this trouble.

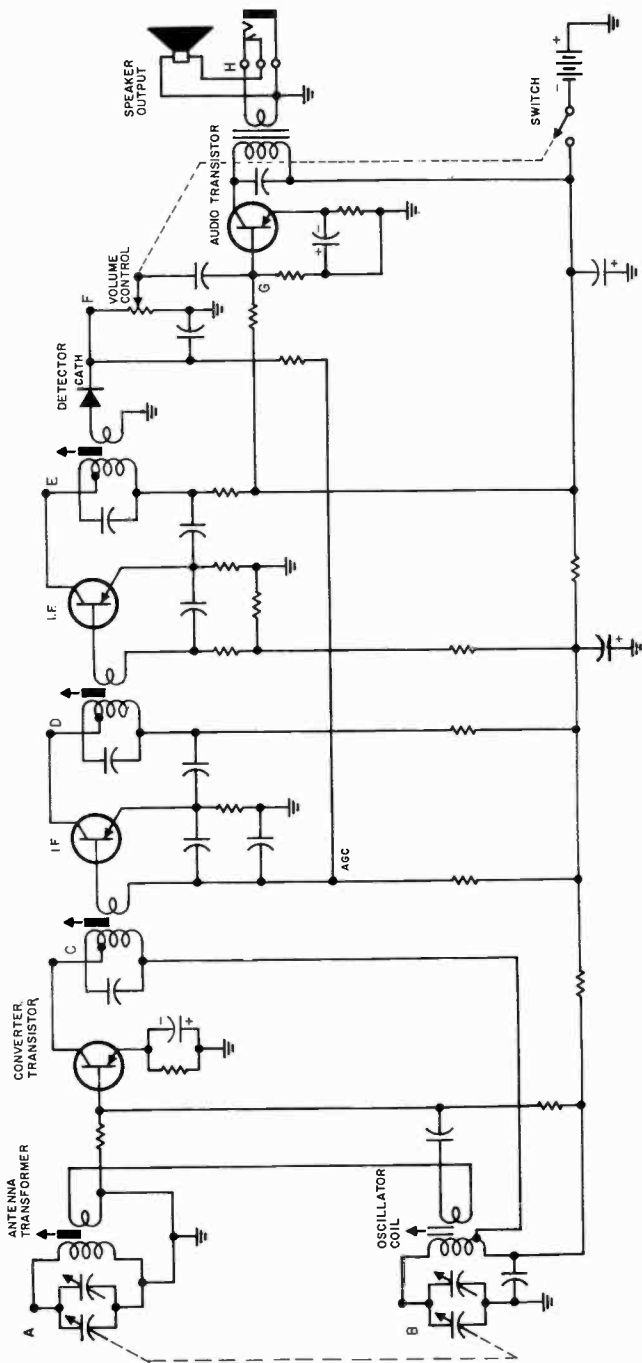


Fig. 331. Test points in a typical transistor receiver.

The most common causes of trouble

Some troubles occur more often than others. In transistor receivers (but not in transistor auto receivers) we can expect servicing problems somewhat as follows:

1. Weak battery.
2. Battery completely dead.
3. Incorrect connections to the battery.
4. Defect in the printed-circuit board.
5. Broken connection.
6. Regeneration in some if or af stage.
7. Defect in some component, often an electrolytic capacitor.
8. Distortion due to unbalanced transistors in push-pull audio output stage.
9. Defective transistor.

QUESTIONS

1. Does an unbypassed emitter produce positive feedback?
2. Can a weak battery cause excessive volume?
3. Will a shorted voice coil produce squealing, motor-boating or other oscillation?
4. Do interstage transformers in a transistor receiver have a 1:1 ratio?
5. What is the normal (approximate) forward resistance of a diode? The reverse resistance?
6. Is an rf bypass capacitor wired across the output of the detector?
7. What is the usual intermediate frequency of a pocket transistor radio?
8. How is the impedance matching of an if transformer accomplished?
9. Is the detector a good place to obtain avc voltage?
10. Will the voltage measured across the detector load be higher or lower than normal if the converter isn't working?

ARE YOU old enough to remember automobiles as they used to be? The most important thing about the old-time auto was that it should run. But what have we today? Autos with air-conditioning and built-in phonographs. We don't have to shift gears and some have powered window openers and seat adjusters.

We like to take our comfort with us. And when we say comfort, we mean pleasure too. That is why automobile radios are so important.

Things have changed

Just as the modern car barely resembles the gas buggy of yesterday, so has the auto radio changed. You might say that a radio is a radio and let it go at that, but it isn't quite so simple. At one time the auto radio was quite ordinary. It used a vibrator type power supply. To help the driver keep his eyes on the road, the set had pushbutton tuning.

But what have we today? We still have some of the old style sets with us. But we also have sets without vibrators—using 12-volt tubes working directly from a 12-volt storage battery. We have hybrid sets using both tubes and transistors. These receivers use tubes for the rf and if stages and transistors for the audio output. And we have *all transistor* receivers.

This isn't all. At one time car radios were for AM reception only. We now have FM receivers as well as converters that can be used with existing AM sets so that FM can be received.

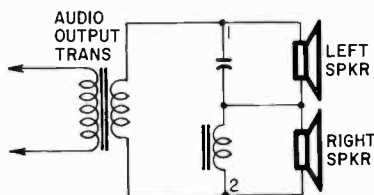
Mechanical variations add to this list. Not all car radios are built into the dash. For sports cars the radio may be mounted right on

the floor. Some radios are designed to be slipped into the glove compartment and then removed for use as a personal portable. Some car radios are now part of the rear-view mirror and do a double job.

Don't go away—we have more

We're not finished yet. Even the auto radio speaker has changed. Instead of having one speaker, we now may have two—one for the front of the car and one for the rear. In some arrangements the speakers can be controlled so that either the front or the rear speaker is on, or both.

This still isn't all. The input to the pair of speakers can be adjusted so that we get a sort of stereo sound in the car. It isn't



Pseudo-stereo system is used in automobiles. One speaker is in front and the other in the rear. Unless specific instructions are followed, or a kit is used, some experimenting may be necessary to separate lows from the highs.

true stereo (we call it pseudo-stereo) but the effect is very impressive.

Mechanical changes

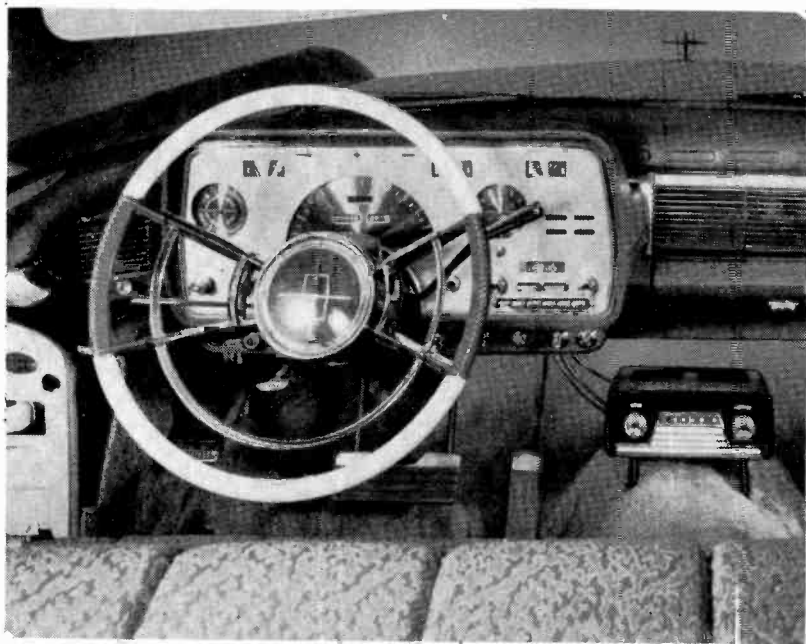
Not only has the electronic design of the car radio been changed but its mechanisms have changed also. Auto radios are equipped with search tuners so the driver no longer needs to bother punching a bunch of pushbuttons. The radio does the job for him.

Where do we fit in?

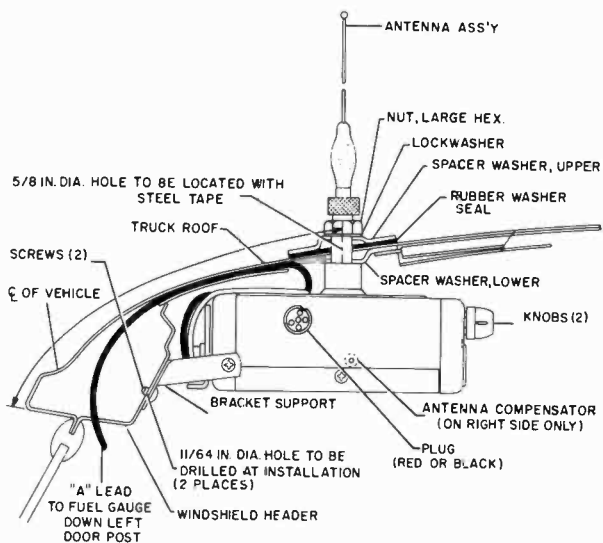
What has all this to do with us? The answer is this—if auto radios have made so many advances, you must stay up-to-date and be able to fix those sets.

A few differences

The five-tube ac-dc home receiver was probably the most popular type ever made and sold. We know you're familiar with it so let's compare it to an auto radio. We can do this in block diagram form, as shown in Fig. 401.



Floor mounted FM tuner is much easier to service.
(The Bendix Corp.)



Radio installation in truck roof is used when dash space is too shallow for other types. Antenna connects directly to receiver without cables. (Philco Corp.)

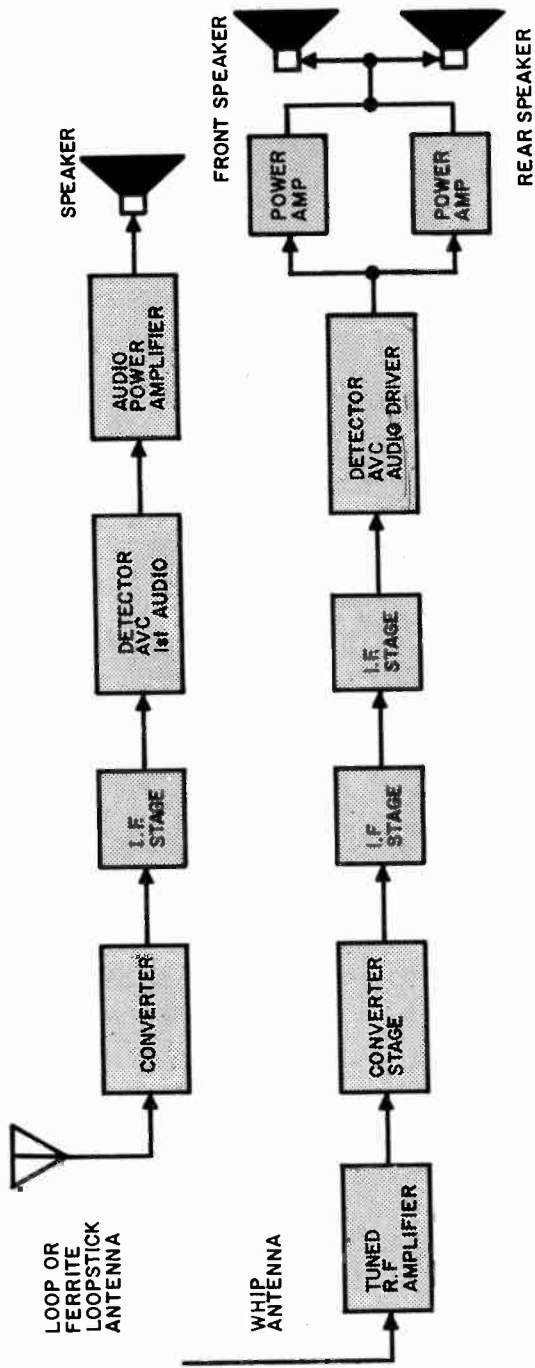
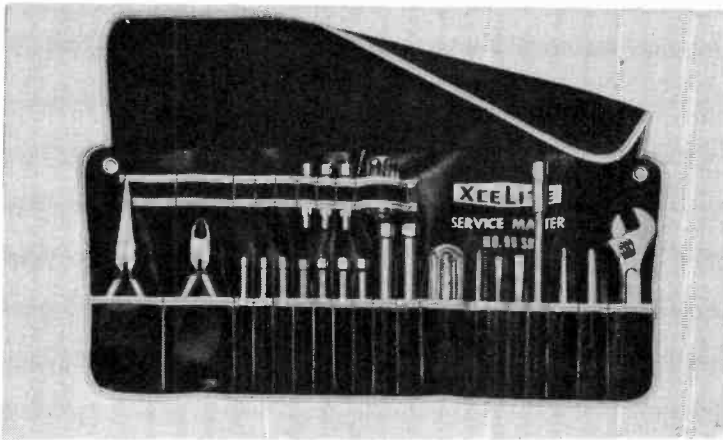


Fig. 401. The auto radio (below) generally has more stages than the home ac-dc receiver (above).

What are some of the differences? Has the auto radio more stages? Does it have more tubes or more transistors?

But what else is there? Take a look at the front end. Many auto radios have a tuned rf amplifier stage. In the home receiver we might not need it, but for auto radios we can't always be sure that we'll have lots of signal strength. Sometimes, when the car is trav-



You will need a tool set when installing or removing auto radios. Also, box-wrenches or automotive socket wrenches will be needed to reach some bracket fastenings. (Xcelite, Inc.)

eling between cities, the signal gets very weak. An rf amplifier improves the receiver's sensitivity and selectivity.

Now let's look at the if section. The auto radio has two if amplifiers while the home set has just one. We have greater gain (supplied by the rf and if stages). We have push-pull output to handle the stronger audio signal.

What do we learn from this? The auto radio has more stages and is a more complicated receiver than the ones in our homes.

Auto radio installation and removal

If a table radio has to be serviced in the shop, we just pick up the radio, tuck it under our arms and take it. The auto radio isn't quite so easy to handle. We must do two things:

1. Disconnect the auto radio from the electrical system of the car.
2. Remove the auto radio mechanically. The auto radio is part of the car and when we remove the radio we are removing a unit that must be securely mounted.

All filaments do not light.

If all the filaments do not light, look for an open fuse, an open filter coil L1 or a defect in the on-off switch or open in wiring. The switch is usually mounted on the volume control.

One filament doesn't light.

Since the filaments are in parallel, one filament not lighting means that the tube or its socket pin connection is defective. The trouble is not in the power supply.

This small instrument is more convenient for testing filament continuity than an ohmmeter.
(Precision Apparatus Co., Inc.)



The line filter

Getting power from a car battery is like living with a large family. You're bound to have noise sooner or later. The battery feeds the ignition system. This creates interference which rides right back along the line to the battery and from there through the filament connections into the receiver.

One way of reducing this interference is by using a filter. This is shown as L1 and C1 in Fig. 403. C1 is a filter capacitor, often called a spark plate (described later in more detail), while L1 is a filter choke. Sometimes the spark plate is made of selenium and acts more like a rectifier than a filter. You will sometimes find C1 drawn as a rectifier (diode symbol) instead of being shown as a capacitor.

The filter system in Fig. 403 is for an AM auto radio. For an FM receiver more filtering is needed. This is shown in Fig. 404. You are probably wondering why we need such a filter for an FM set. There are two reasons:

1. We need the filter to keep interference from coming into the filament line from the battery.
2. Just as important as item 1 above is the fact that we must keep each stage isolated. In an FM set we have high frequencies.

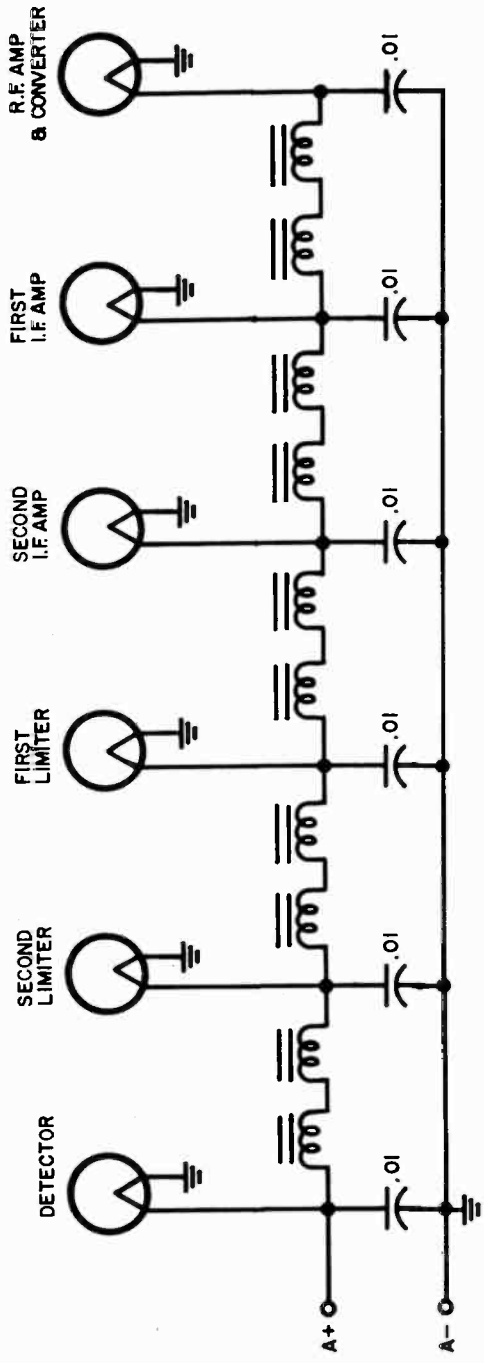


Fig. 404. The filament system of an fm car radio usually has a large number of filter units.

Therefore the filter shown in Fig. 404 works as a decoupling network. The filter keeps signal energy from being fed back from one stage to the other. Without the help of the filter the various amplifier stages might start to oscillate.

Let's look for trouble

*The service technician is a peaceable guy, a good Joe,
Always being asked to fix a set "on the double,"
But he's the only one we know,
Who goes out looking for trouble.*

What sort of trouble can we expect from the filter circuit of Fig. 404? The tubes are all connected in parallel so, if the filament of one tube goes out, the other tubes should remain lighted.

If a particular tube doesn't light, you can be fairly sure the tube



Resistor-capacitor analyzer and capacitor decade boxes are useful in finding and substituting defective filters and bypass networks.

(Cornell-Dubilier Electronics)

is at fault. If not, make sure the filter choke for that filament is in good condition. With the receiver turned off, make a continuity check, using your ohmmeter.

There are a few other troubles we can expect. If the $.01\text{-}\mu\text{f}$ capacitors open, we might get oscillation in the receiver. This could cause a whistle in the receiver, or squealing. If one of these capacitors shorts, the fuse will blow. If a capacitor is leaky, it could

cause oscillation. It could also result in a fuse popping, but the set will play when a new fuse is put in.

12-volt tubes

At one time a 12-volt tube was understood to mean a tube with 12 volts on the filament. Not any more. It can also mean a tube working with 12 volts on the screen and plate, so we should describe such tubes just a little more carefully.

If we want to be very exact about it, none of the elements of these so-called 12-volt tubes work with 12 volts. The filaments may be anywhere between 10.0 and 15.9 volts; the lower voltage from

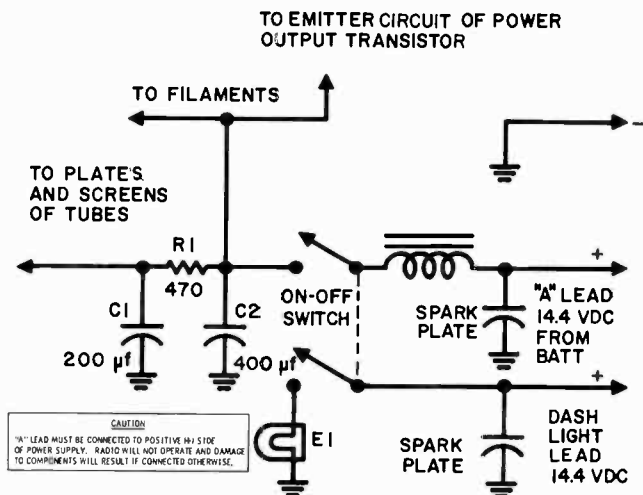


Fig. 405. Only one wire is run to the filaments. One side of the filament of each tube is grounded to the chassis. So is one terminal of the storage battery.

a weak battery and the higher voltage from the charging generator. The plate and screen voltages will generally be lower than the filaments because of the use of decoupling resistors in most circuits.

Power supplies (both filament and plate) for hybrid sets are about as simple as they can be. Actually, there is no power supply since we work almost directly from the battery itself as shown in Fig. 405.

The filter consists of R1, C1 and C2. C2 acts as a filter for the line going to the emitter of the power output transistor, for the

tube filaments, and as the input filter capacitor for the plates and screens. Since this capacitor is common to every circuit in the set, it is a good unit to keep your eyes on.

R1 in Fig. 405 is only a ½-watt resistor. This resistor certainly isn't overrated, so if it starts to burn and char, check C1 for excessive leakage or a short in any circuit except the power output transistor stage.

Spark plates

These are simply line filters and are used to keep out interference picked up by the leads going to the battery. The spark plate is a capacitor, as shown in Fig. 405.

Sometimes a selenium plate is used as the spark-plate capacitor. The symbol for this spark plate is the same as a diode (see Fig. 406). Diode D1 acts as a short for high-voltage interference pulses.

If the receiver works well but gets noisy when the car engine is started, take a look at the spark plates. Shunt with a capacitor rated at about 100 μ f. If the noise gets weaker or disappears, the spark plate is defective.

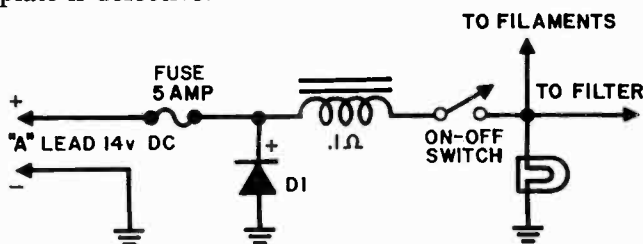


Fig. 406. Sometimes a selenium diode is used as a spark plate.

Power supplies

Now that we have studied the filament circuit, let's move on to the power supply section.

What do we need in the way of B-plus for plate and screen voltage? In a home receiver we have ac which we can step up with a transformer and rectify. But in an auto we start with low-voltage dc. Let's see how we go about solving that problem.

Actually, we have quite a few ways of getting our plate and screen voltages (if we use tubes) and our base, emitter and collector voltages (if we use transistors). Here are the methods:

1. We can use a nonsynchronous vibrator to change smooth dc

(from the storage battery) into pulsating dc (with the help of the vibrator). We can then feed the pulsating dc into a transformer, step up the voltage, rectify and filter it. This will give us the voltage we need for plates and screens.

2. We can use a synchronous vibrator. The operation is about the same as above. With a synchronous vibrator we don't need a rectifier tube.

3. We have the transistor dc-dc converter. This is just a substitute for the synchronous vibrator.

4. Finally, we can eliminate the power supply completely by using 12-volt tubes, or with transistors.

The nonsynchronous vibrator

Using the 12-volt storage battery directly with 12-volt tubes is undoubtedly the best system, so why bother with other methods when the direct-operation method (described as item 4) is so easy. There are definite limitations with 12-volt tubes, particularly in FM



Cutaway of vibrator shows molded foam rubber used to silence vibrator. Leads are kept in place with a rubber band.
(Gem Electronics)

receivers. Also, at that low voltage, power output is low and transistors are used instead in the audio power amplifier. Finally, tremendous quantities of auto radios were made using vibrators and we are going to have them with us for a long time to come. We don't want you turning away jobs from your shop just because something new has been developed.

Fig. 407 shows the circuit of a non-synchronous vibrator supply. As a start, let us ask ourselves one little question. What is a vibrator? It's just a single-pole, double-throw automatic switch, isn't it? All that it does is to let the current from the storage battery

flow in one half of the transformer (T1) primary and then in the other half of the transformer primary. It keeps switching the current back and forth through the primary winding. The transformer steps up the voltage and delivers it to the rectifier tube. The output of the rectifier tube is about 230 volts dc. This is then filtered and sent off to the plates and screens of the tubes.

Here comes trouble!

What sort of trouble can we expect from this power supply? The easiest way to discuss this is with the help of a check list. But let's do more than just talk about it. Use this check list in your work.

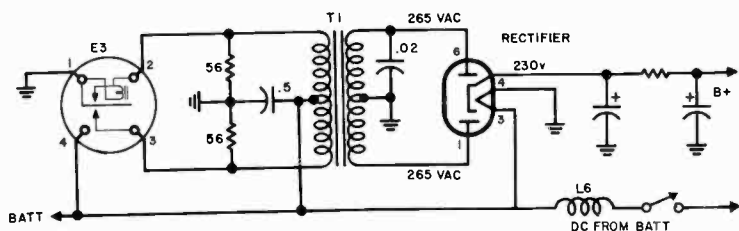


Fig. 407. The vibrator (nonsynchronous type in this case) is just an automatic switch. It keeps interrupting the flow of dc to the transformer (thus permitting the use of a transformer on dc).

Troubles in the Nonsynchronous Power Supply.

And What To Do About Them.

Receiver has a bad hum.

Shunt a 20- μ f capacitor across each of the filter capacitors in turn. If the hum decreases, replace the filter capacitor. Your test capacitor must have a working voltage rating of at least 300 volts. Be sure to discharge the test capacitor when you are finished.

B-plus voltage is low.

Try replacing the rectifier tube. If low B-plus is accompanied by hum, check the filter capacitors. Remove tubes one at a time and note if B-plus voltage goes up. If it rises sharply when removing a particular tube, you may have a short. The storage battery may be run down. This trouble is sometimes due to the vibrator.

No B-plus voltage.

Check to see if voltage is being delivered to rectifier plates. If it is, then trouble exists between output (cathode) of rectifier tube and other tubes in the set.

Replace rectifier tube.

No B-plus voltage.
(Cont.)

Make sure the on-off switch is in good condition. Disconnect the battery lead and check the switch with ohmmeter. Check the vibrator buffer capacitor by substitution. **Important**—use a capacitor having identical capacitance and working voltage rating as original unit.

The power transformer may be defective. Make a continuity check. Also try replacing the vibrator.

If the tube filaments are not lighted, then check fuse.



Battery eliminator has voltmeter and ammeter to monitor output voltage and current.
(Precision Apparatus Co. Inc.)

Fuse keeps opening.

Fuse may be wrong size. Check the service manual to be sure. This trouble is often due to sticking vibrator contact. Don't try to repair vibrators. This requires specialized skill and tools. Also look for heater-to-cathode short in rectifier.

Weak sound, with or without distortion.

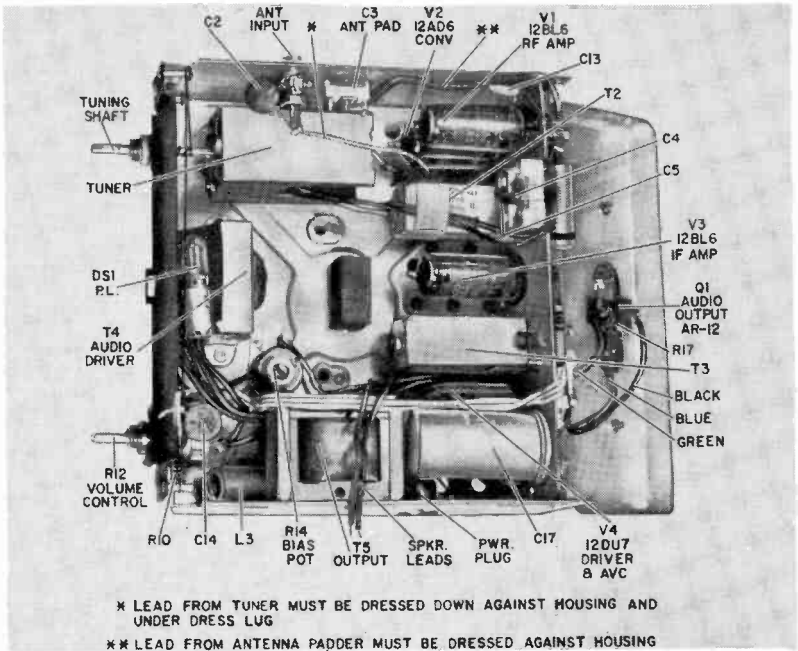
Check B-plus voltage. If low, follow tests as described for the symptom "B-plus voltage is low."

Receiver oscillates.

If you have oscillation together with noise, replace the output filter and then the input filter capacitor. Make sure filter capacitors in the filament line aren't open.

Too much hash.

If set sounds excessively noisy, make sure the vibrator is firmly in position. Try a new vibrator.



This view of auto radio is typical in most service manuals. Callouts correspond with those on schematic and make parts location easier. (Philco Corp.)

(Dirty vibrator contacts will produce this trouble.) Buffer capacitor may be defective. Some sets use a gas rectifier tube instead of a vacuum type. Gas rectifiers produce noise. Try a new tube.

If rectifier tube is metal-type gas rectifier, make sure shell is grounded. Shell is wired to tube pin (which connects to chassis) but sometimes internal tube connection to pin is broken. If rectifier tube is glass-type gas rectifier, make sure external shield is in place. Just having the shield sit on the tube isn't enough. The shield must be grounded.

Vibrator doesn't work.

If the fuse is also open, it's quite possible the vibrator contacts are stuck. Replace the vibrator and the fuse. If the new vibrator doesn't work, check back through the line to the storage battery.

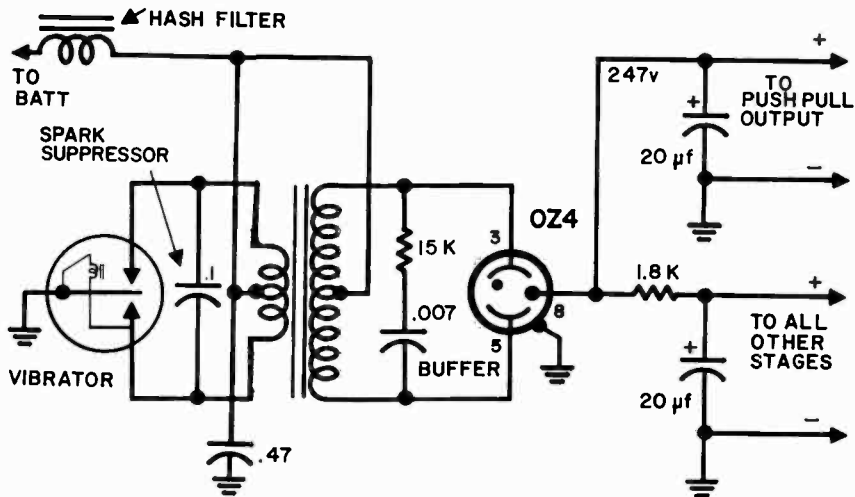


Fig. 408. This auto radio power supply uses a gas rectifier tube.

Rectifier tube plates glow, then fuse opens.

One of the filter capacitors (usually the filter connected to the cathode of the rectifier tube) is shorted.

B-plus voltage keeps changing.

Storage battery defective. Vibrator pins dirty, making poor contact.

Rectifier tube intermittent.

Intermittent short in receiver or power supply.

Vibrator is very noisy.

Rubber is packed into the vibrator. Rubber is a vegetable product and decays. When this happens, the vibrator becomes noisy. Make sure the vibrator can't be touching some other piece of metal which then amplifies the sound.

In the check list we mentioned a gas tube as a rectifier. This is shown in the nonsynchronous vibrator power supply circuit in Fig. 408. Note the 1.8 K filter resistor. If this should open, all stages (except the output stages) would lose their plate and screen voltages.

The synchronous vibrator

The word vibrator is a good one! The word vibrate means to shake and that's exactly what any vibrator does — shake. And so, if you are ever in any doubt as to whether a vibrator is working,

just rest your hand on the vibrator can. If it's working, you'll feel it. Most often, though, you won't be in any doubt. You'll be able to hear the vibrator.

A little earlier we mentioned nonsynchronous and synchronous vibrators. The difference between them is very simple. The nonsynchronous vibrator has one job. The synchronous vibrator has two:

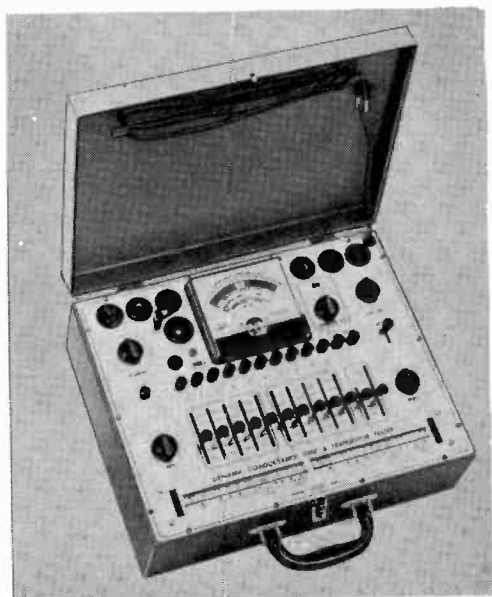
Nonsynchronous vibrator

1. changes straight (unvarying) dc to pulsating dc.

Synchronous vibrator

1. changes straight (unvarying) dc to pulsating dc.
2. acts as a rectifier.

Combination tube and transistor tester is especially useful when servicing hybrid auto radios (EICO)



What's the story?

As you have probably noted by now, we're trying to give you the greatest amount of practical information while keeping theory to a minimum. The synchronous vibrator interrupts the current coming from the storage battery. This changes it from dc to pulsating dc. The transformer steps up these pulses. The increased voltage is then fed back to the vibrator. The vibrator rectifies the voltage, which is then filtered.

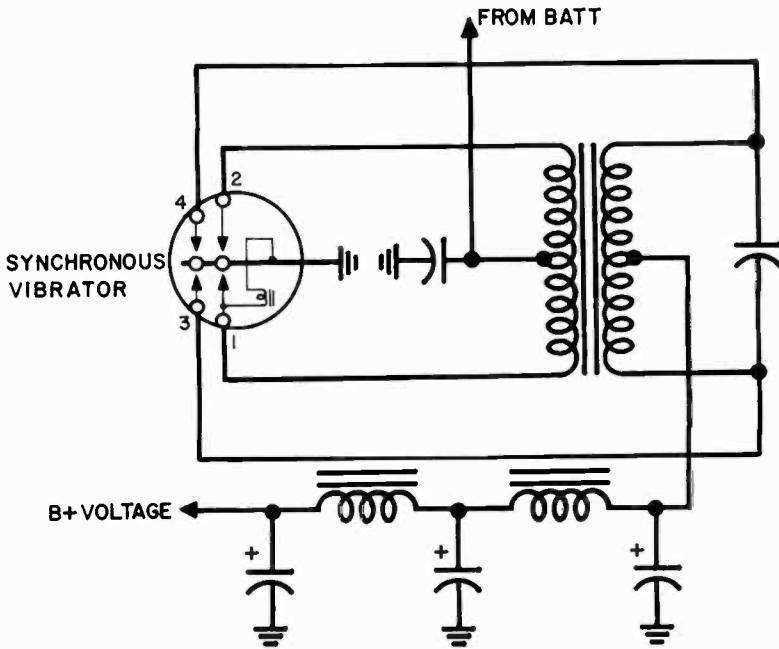


Fig. 409. Circuit diagram of an auto radio power supply using a synchronous vibrator. This circuit does not need a rectifier tube.

We have a synchronous vibrator circuit in Fig. 409. It's almost the same as the circuit shown in Fig. 408.

What is the difference between the two circuits? Our rectifier tube has disappeared. This is the major change.

Bring on those troubles

Now what about troubles in the synchronous vibrator circuit? These are the same as those we covered for the nonsynchronous type so there is no use in repeating the list. Just keep one little fact in mind: A vibrator (of any kind) is a mechanical device. It has moving parts. Moving parts wear out, get dirty and noisy, and have to be replaced. This is especially true in the synchronous vibrator because we now have an extra set of contacts (inside the vibrator) that can become pitted or dirty.

The transistor dc-to-dc converter

Suppose you had a very noisy neighbor. What could you do about it? You might move, get the neighbor to move or try living

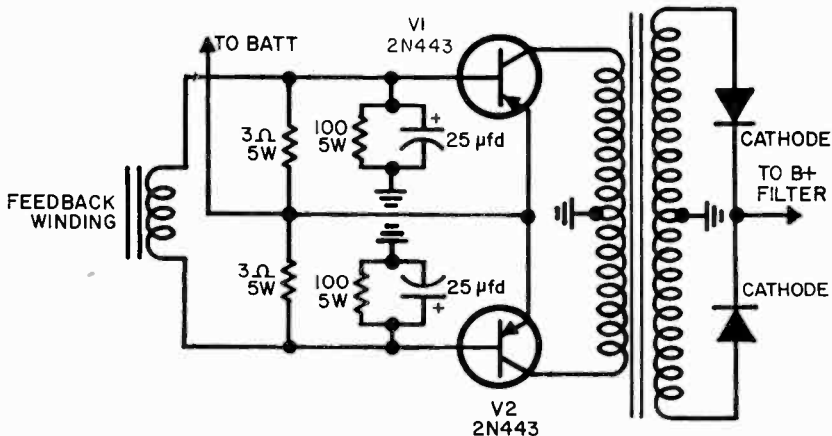


Fig. 410. *Transistor dc-to-dc converter. This is a multivibrator type.*

with all the windows closed. You would do whatever you could to get rid of the noise.

A vibrator is just like a noisy neighbor, so we aren't too surprised to learn that we have two ways for doing without this nuisance. One way is to use tubes that work with 12 volts on plates and screens. This is just about the easiest way.

A transistor dc-to-dc converter is a quiet substitute for the vibrator. In some receivers you can actually use a transistor dc-to-dc converter as a replacement for the vibrator.

This sounds like a good forward step, so let's investigate it a bit further.

A typical transistor dc-to-dc converter power supply is shown in Fig. 410. By working on it together we will be able to see how it works, quickly!

Whenever you get a circuit, such as this one, that seems a little strange, look around for a part that seems familiar. What can we recognize? Wouldn't you say that the step-up power transformer and full-wave rectifier (using semiconductor diodes) are old friends?

The filament circuit wiring and its filter are also old-timers, so what have we left? Just the transistors. The two transistors form a multivibrator.

What's that?

We've had the synchronous vibrator, nonsynchronous vibrator and now we have another member of the family — a multivibrator. But do you remember what we said about vibrators? Give them

any kind of a first name you like, but all they can possibly ever be is just a switch.

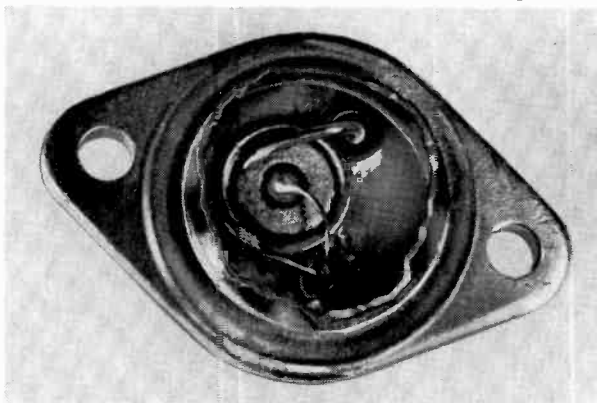
And so a multivibrator is a switch. But we have a pair of them. This is perfectly all right. All that it means is that we have two single-pole single-throw switches instead of one double-throw switch. When transistor V1 is turned on (it does so automatically, like any vibrator), transistor V2 is off. And when V2 is off, V1 is on.

Each transistor controls current through one half of the transformer primary. This is exactly the same as our nonsynchronous vibrator?

Learn one—learn them all

One of the nicest things about electronics is that if you learn something about a circuit, you can use the same information over and over again.

To show what we mean, let's ask ourselves this question: "What

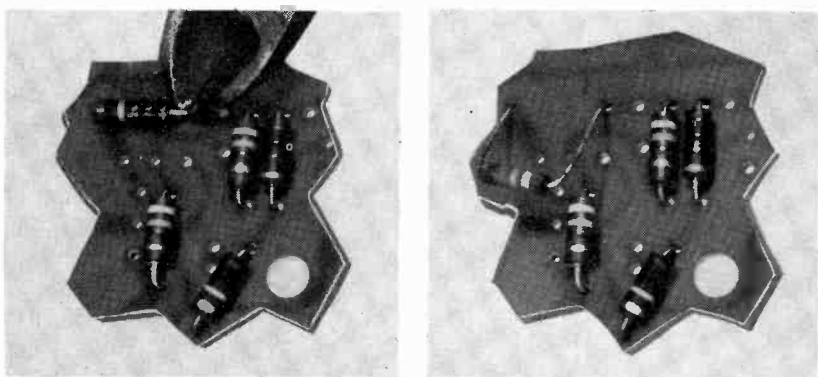


Type of transistor used in dc-to-dc converter. With the top of the case cut away the semiconductor wafer and its connections are exposed. About twice actual size. (Clevite Transistor).

have we changed in all of the auto radio power supplies?" The filter remains the same. The power transformer remains the same. All we do is use different vibrator circuits. Can you see the advantage now? Learn the troubles for one circuit and you've learned them for a whole group.

Transistor dc-to-dc converter troubles

Although the power supply in Fig. 410 has no moving parts, we can still have trouble. By now you've realized that electronic circuits and servicing go hand in hand, so telling you that this cir-



Don't be afraid to destroy defective components to remove them from P-C power-supply board (left). When lead-holes have been cleaned it is easy to insert a new component (right).

cuit will need servicing surely doesn't come as a great big surprise.

What could go wrong? A common symptom is no B-plus output. This is easy to check quickly.

Set your vtvm to read dc voltage (select a suitable range) and

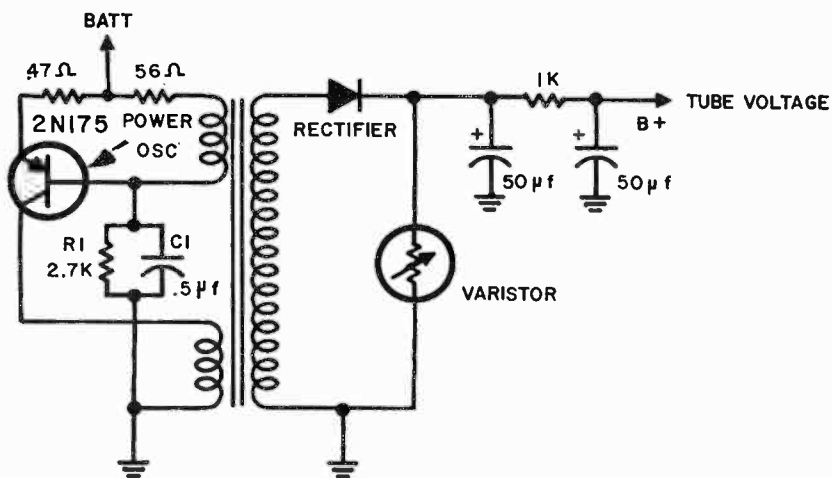


Fig. 411. Transistor dc-to-dc converter. This is a blocking oscillator type.

check for B-plus voltage starting at the output of the filter. If you have no B-plus, move the test prod over to the cathodes of the selenium rectifiers (either cathode). B-plus here means that your filter resistor is open.

We are sure that you are beginning to get the general idea of

how this is done, but just to make it easy for everybody, let's set this up in the form of a progress chart:

Here is how we check

1. Check for B-plus at filter output.
2. Check for B-plus at either cathode of selenium rectifier.
3. Measure voltage from ground to anode of both semiconductor rectifiers.
4. Measure emitter voltages. These voltages should be on manufacturer's circuit diagram. Measure other transistor voltages as indicated on the circuit.

Step by step

Voltage here indicates supply is working. If no voltage, move on to next step.

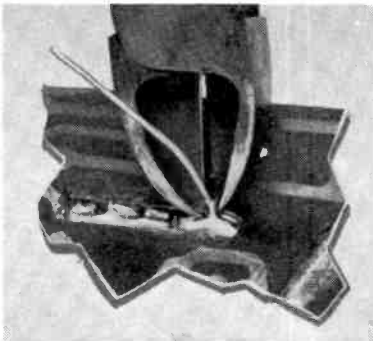
B-plus here shows filter resistor is open. If no B-plus, take next step.

Be careful. We're measuring ac here, so change the function selector switch on your vtvm. If you get voltage here, but you had no B-plus, the rectifiers are defective. If you get no voltage, move on to the next step.

If transistor voltages are absent, test back to the storage battery. Is battery delivering voltage? If not, fuse may be open. Lead to battery may be disconnected.

If transistors have abnormal voltages, shut receiver off and check all resistors, substitute base bypass capacitors with known good units. Do this for each transistor, one at a time. After making substitution, check for B-plus output.

If you still have no voltage, try switching the transistors. If this doesn't start the unit working, try new transistors.



After soldering leads to circuit side of board trim them off close to the solder.

Other troubles

This is a fairly long chart, but it covers only one trouble — absence of output voltage. We could have other problems, but these

are the same as those in any type of power supply. For example, insufficient output could be due to a defective diode unit or to excessively leaky filter capacitors.

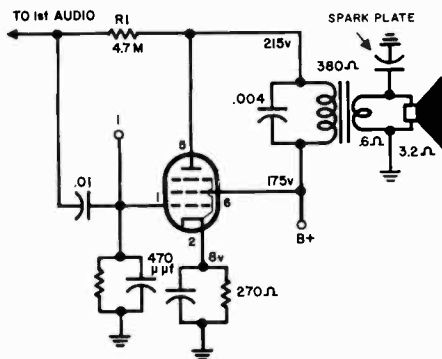
In Fig. 411 we have another type of transistor dc-to-dc converter. This one looks a little simpler than that of Fig. 410. It uses just one transistor in a blocking oscillator circuit. All that this means is that we have just one switch — the transistor — that goes on and off. The rectifier is also simpler. It is a half-wave unit instead of the full-wave rectifier shown in Fig. 410.

Why make it complicated?

Are you wondering why manufacturers don't use the circuit of Fig. 411 all the time? It's easier than that of Fig. 410, so why should they go to extra trouble and expense?

It is true that the circuit of Fig. 411 is simpler, but it has more

Fig. 412. Single-ended vacuum-tube power amplifier stage for an auto radio.



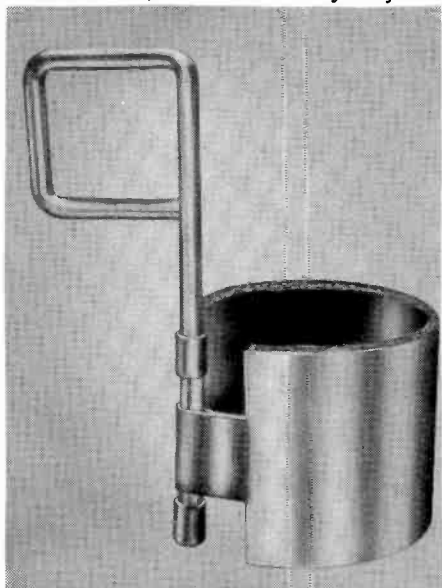
problems. The output voltage depends on how often the transistor switches on and off. This is controlled by resistor R1 and capacitor C1. If these change in value, the switching action of the transistor will get either faster or slower.

Is this any cause for alarm? It could very well be. An increase in voltage might damage the rectifier or the filter capacitors. To prevent such damage we put in a device known as a *varistor*. This is just a resistor with a fancy name. A varistor is a voltage sensitive resistor. If the voltage goes up, the varistor draws more current, and down goes the voltage.

Sometimes we use a diode (known as a Zener diode) for the same job. When the voltage becomes too high, the diode breaks down, conducts heavily and the voltage drops.

Audio power amplifier output stage

One of the things to know is to be on a sharp lookout for differences among radio receivers. There is a good reason for this. If the circuit for an auto radio stage is exactly the same as that of a home receiver, we need study it just once. But if we come across



The vibrator puller locks around the body of the vibrator with a twist of the squared-loop handle making removal from compact chassis much easier. (Gem Electronics)

circuits that aren't alike, then we must know something about them to be able to fix them.

In auto radios you will find interesting differences in the audio amplifier power output stages. Here are the four basic types:

1. Single-ended vacuum-tube amplifier.
2. Push-pull vacuum tube amplifier.
3. Single-ended transistor amplifier.
4. Push-pull transistor amplifier.

As a start, let us examine the single-ended vacuum-tube amplifier shown in Fig. 412.

As usual, we have two questions. How can we tell if the circuit is working? What sort of troubles can we expect?

Checking the single-ended stage

To test the circuit shown in Fig. 412, connect an audio generator to the control grid and listen for the signal out of the speaker. No signal means the stage is dead. A weak, noisy or distorted signal also means trouble.

The fast test

If you're in a hurry (and what service technician isn't?), you can test the stage without a generator. "Click-test" the stage by pulling the tube almost completely out of its socket and then adjust the tube until its pins just about make contact. A loud click out of the speaker will assure you the stage is working.

Another way is to touch the control grid with your finger. A loud hum or growl will answer your question as to whether the stage is operating. Another way is to short the grid to ground, quickly and intermittently, and listen for a loud click to come out of the speaker.

Here comes trouble

Now let's see what sort of troubles we can expect from the single-ended audio amplifier.

Troubles in the Single-Ended Vacuum-Tube Stage. And What to Do About Them.

No sound out of speaker when signal is put in at the control grid.

Tube is defective.

No plate or screen voltage.

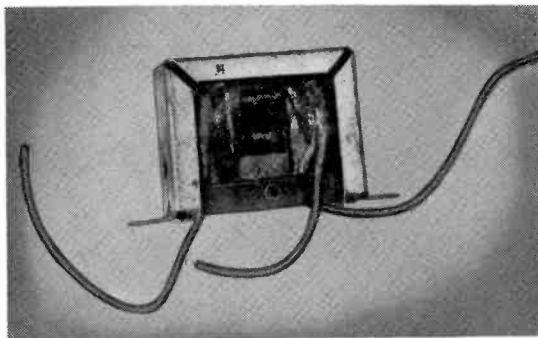
Open cathode resistor.

Capacitor across primary or secondary of output transformer is shorted.

Defective output transformer.

Defective speaker (voice coil open or leads not making contact).

Shorted grid resistor.

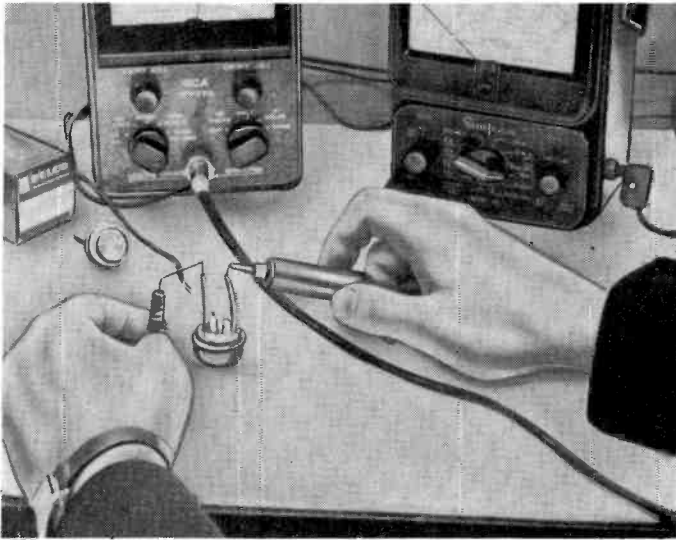


Cutaway of output transformer. Inner layer of heavy wire is the secondary. (Gem Electronics)

Weak sound.

Tube may be weak.

Lower than normal B-plus voltage. Try replacing the rectifier tube.



Most vtm's use 3-volts or less for resistance tests of semiconductors. Batteries of 15 volts and higher are often used in vom's.

Weak sound (Cont.)

Open dropping resistor to screen grid.

Trouble may be in driver stage; not enough signal being delivered to grid of output tube.

Wrong bias on tube can produce weak, distorted sound. Check cathode resistor and bypass capacitor.

Oscillation.

Check R1 in Fig. 412. This is a feedback resistor and minimizes the possibility of oscillation (and improves the quality of the sound).

Check lead dress. Make sure plate and grid leads are separated.

Check grid resistor.

Check screen grid bypass capacitor.

Distorted sound.

Make sure plate and screen have correct voltages.

Check bias.

Signal input to grid may be distorted.

Substitute new tube. Low emission of weak tube can cause distortion.

Plate bypass capacitor leaky.

Defective speaker (torn cone, rubbing voice coil).

The push-pull stage

The push-pull stage is capable of handling a greater amount of signal drive and provides less distortion than the single-ended stage. You can test the stage (Fig. 413) to see if it is working by using the same methods we used for the single-ended stage.

We can expect all of the troubles of the single-ended stage plus a few extras. Here they are:

Troubles in the Push-Pull Vacuum-Tube Stage.

And What To Do About Them.

Distortion.

Check cathode resistor. Bias may be incorrect.

Push-pull tubes should be matched. Substitute matched pair.

Part of output transformer primary may be open. B-plus on one tube only.

Incorrect drive. One tube may be getting more signal than the other. Fault is in phase inverter (driver) stage.

Unbalanced plate voltages. Voltages on both plates should be the same.

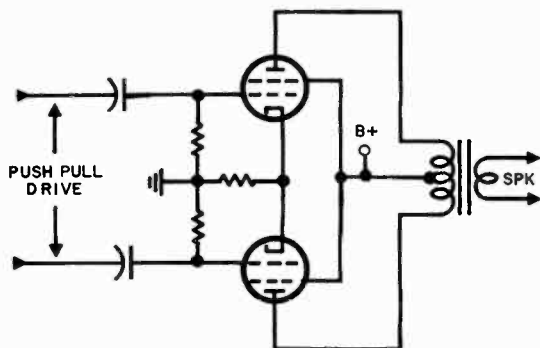


Fig. 413. The push pull stage can have all the troubles of the single-ended stage plus a few of its own.

No Sound.

No input signal.

No B-plus at center tap of primary of output transformer.

Defective speaker. Leads broken.

Open in secondary of output transformer.

Sound gets distorted after auto radio is in operation for short time.

Replace tubes. Can be caused by heater-to-cathode short or by grid emission.

Weak sound.

Try new tubes.

Check plate and screen voltages.

Signal from driver stage may be weak.

Bias on tubes too high. Check cathode resistor.

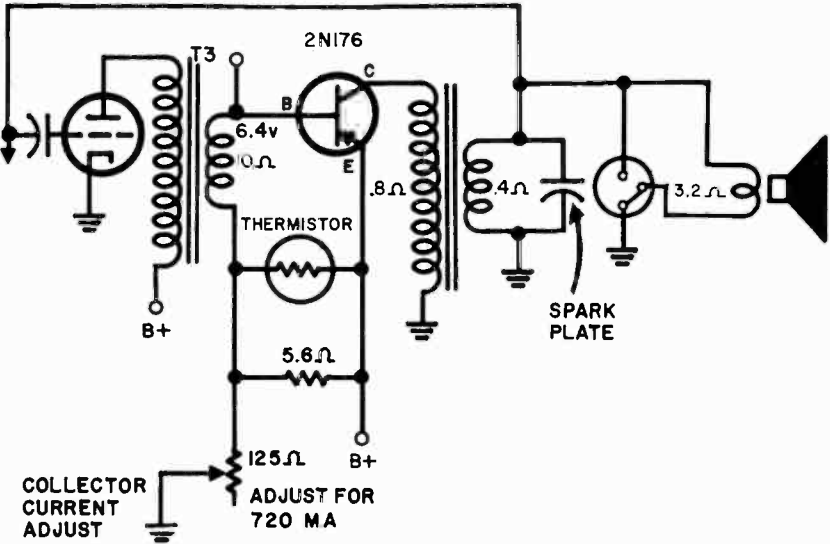


Fig. 414. This single-ended transistor stage has a variable resistor for adjusting the collector current.

Intermittent sound.

Can be caused by the tubes.

Poorly soldered connection.

Broken wire.

Check components by pulling gently on leads. Lead may be making intermittent connection with component.

The single-ended transistor stage

The circuit is shown in Fig. 414. We studied this circuit in Chapter 3 but there are some differences between transistor audio output circuits used in auto radios and those in small, personal receivers. Basically, the circuits are the same, but let's examine the changes made for automobile operation.

1. Auto radios must be capable of supplying a much greater amount of volume than a portable. The auto receiver works under conditions of greater electrical noise pickup and ordinary sound noise. Fortunately, auto batteries can supply large amounts of current — far greater than that of small penlight batteries or mercury batteries. Special output transistors are used, designed to work with large amounts of current. Transistors of this type are shown in Fig. 415.
2. Some audio stages come equipped with a variable resistor so the collector current of the output transistor can be adjusted.
3. You may find a thermistor connected in the output stage. A thermistor is a temperature-sensitive device. The thermistor is mounted close to the transistor. If the temperature of the transistor goes up, the resistance of the thermistor goes down. In Fig. 414, the thermistor is connected between base and emitter. If the thermistor resistance decreases, so does the base bias. When this happens, collector current decreases.

When the temperature of a transistor rises, so does its collector current. But an increase in collector current increases temperature. This gets to be a sort of run-away merry-go-round. In the transistor this condition is known as thermal runaway. The thermistor prevents this from happening.

Heat sink

The power output transistor (or transistors, in the case of push-pull output stages) gets hot. To get rid of the heat, the power transistor is mounted on a metal chassis. In the auto radio you will find a bit of metal having a wavy shape being used as a radiator. This has a large surface area, enabling the heat to escape into the air.

In some cases it might seem as though the transistor is mounted directly on the chassis when actually there will be some insulation between the two. The insulator is usually a very thin washer having a thickness of little more than 1/1,000 inch. To make good contact and better conduction of heat the washer is coated with silicone grease. If the transistor you are replacing has such a washer, make sure you use it for the new transistor.

The washer is not needed if the circuit calls for a grounded collector.

The push-pull transistor stage

The push-pull stage is like the man who went up to the bar and

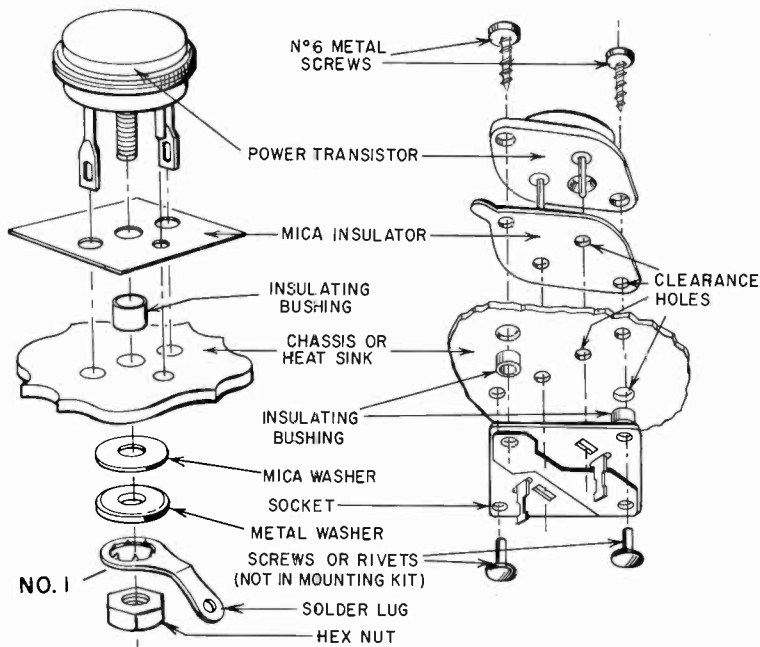


Fig. 415. Two types of power transistors. Power-transistor mounting must insulate for electricity but conduct heat away from the case.
(Motorola Semiconductor Prod. Inc.)

ordered an extra "one" just for the road. He probably felt twice as good. The extra transistor is also "one for the road."

The push-pull stage shown in Fig. 416 doesn't have any new servicing problems for us, but there are a few points we should study.

The push-pull stage has a variable resistor, R1. The output transformer winding has a special tap where you can connect a milliammeter. The amount of current to be taken by the transistors will be specified by the manufacturer and will be supplied on the schematic. If you get a set for servicing, don't take for granted that the adjustment is correct. You can use a vom to read dc milliamperes and make the adjustment very quickly.

Speaker control

The modern trend in auto radios is to use two speakers, one front and the other rear. Switches or variable resistors are supplied to control the speakers.

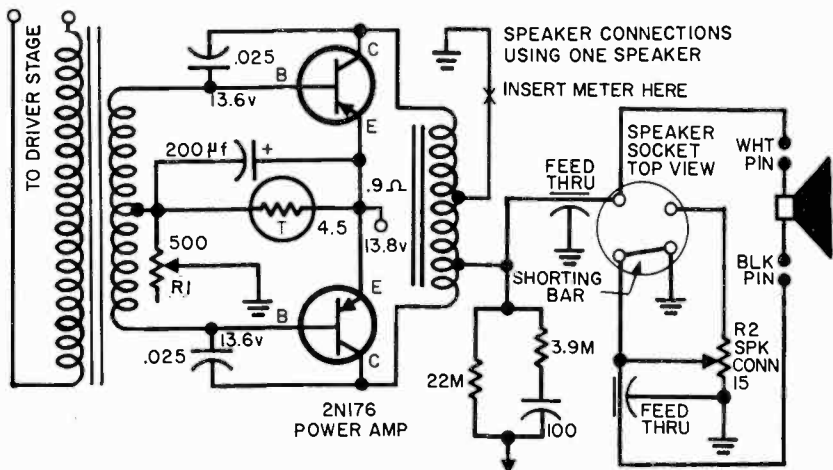


Fig. 416. Push-pull transistor output circuit for an auto radio.

You will also find a number of different switching arrangements. In Fig. 417 the auto radio operates two speakers, but with only one speaker working at any one time. When servicing a set with this arrangement, check the switch if neither speaker works.

In Fig. 418, the front speaker works all the time. A switch per-

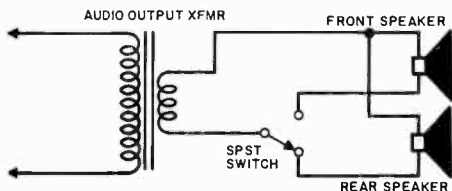


Fig. 417. With this arrangement, only one speaker (either front or rear) works at a time.

mits the rear speaker to be put in operation. Check the switch if the front speaker works but the rear speaker does not.

Sometimes a variable resistor is used in place of the speaker switches, as in Fig. 419. The resistor is known as a fader control. With the fader control, either speaker, or both, can be on. We can also adjust the amount of volume from each speaker.

Adding a speaker

When you install a radio, or repair one, look to see if it has a special connection for a rear speaker. Generally you will find this on the side or the back of the receiver. Known as a rear-speaker jack, it comes equipped with a shorting plug or bar. Sometimes

the customer will tamper with this bar and remove it. When this happens, the speaker stops working because the connection to the speaker is open. The circuit for the rear-speaker jack is shown in Fig. 420.

Multiple speakers

If you want to add another speaker to the auto radio, you can use the speaker jack (shown in Fig. 420) in two different ways.

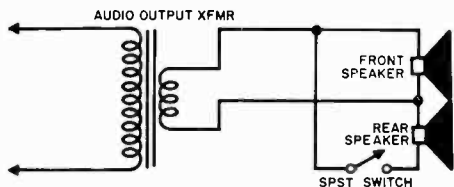


Fig. 418. The front speaker is permanently connected. The rear speaker can be switched in or out.

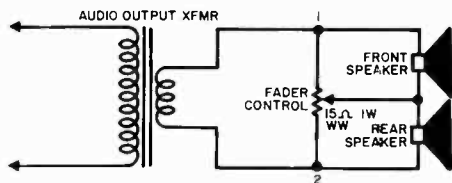
Connect the extra speaker to terminals 1 and 3 of the jack, and you will have the two speakers in parallel. The shorting plug must remain in position for this.

If you want the two speakers in series, remove the shorting plug. Run one lead from the rear speaker to pin 3 on the jack, and the other lead to pin 2.

Four terminal jack

The jack shown in Fig. 420 is a three-terminal jack. Sometimes

Fig. 419. The variable resistor controls the volume out of the front and rear speakers. When the arm is in the center, the same volume comes out of both speakers. As the arm moves up toward 1, the front speaker is gradually cut out. As the arm moves toward 2, the rear speaker is gradually cut out.



a four-terminal jack is used, as shown in Fig. 421. With the four-terminal jack, the shorting plug is always used, but it is moved into different positions, depending on whether we want to use one or two speakers.

The mysterious case of the output transformer

We are so accustomed to the idea of having a two-winding output transformer between the amplifier and the speaker that the circuit shown in Fig. 422 (and Fig. 416) may come as a surprise.

Although it has only three leads, T1 is still a transformer, except that it is called an autotransformer. The entire primary extends from point 1 to point 3. The secondary is from the tap (point 2) to point 3 (Fig. 422).

In a circuit of this type, the collector current flows through the transformer and also through the voice coil of the speaker. A polarized plug is used to connect the speaker.

You can check a transformer of this type by making a resistance

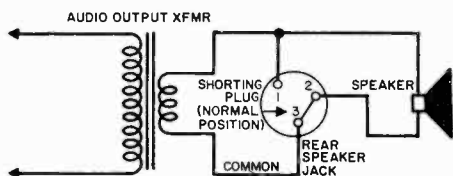


Fig. 420. A three-pin jack is used on some sets. The jack is to be used when you want to install a rear speaker. If a rear speaker is not used, the shorting plug must be in position. If not, the front speaker will not work.

check. Test across the entire winding since the resistance between the tap and ground is so small you may not be able to read the measurement on the meter.

You can replace the autotransformer with the ordinary four-

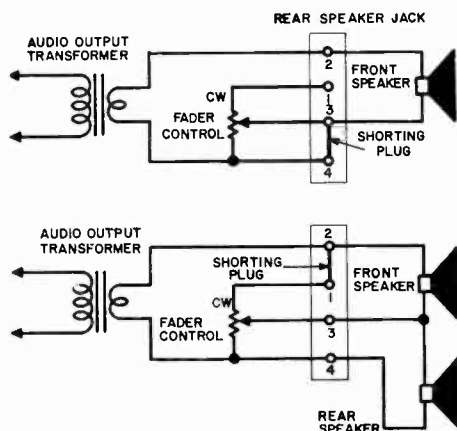


Fig. 421. Circuit arrangement for a four-pin rear-speaker jack.

terminal type, provided it matches the impedance of the transistor and the voice coil of the speaker.

Negative feedback

Negative feedback is used to keep the output stage stable. This can be done with the help of a resistor R1 (Fig. 423). This set uses

an autotransformer with R1 connected from the "hot" side of the voice coil to the grid of the driver tube.

If the set oscillates or whistles, check to make sure R1 is connected. Also make certain that R1 is attached to the correct voice coil lead.

In some auto receivers, a special winding is used to supply the feedback. Fig. 424 shows how this is done. The output transformer

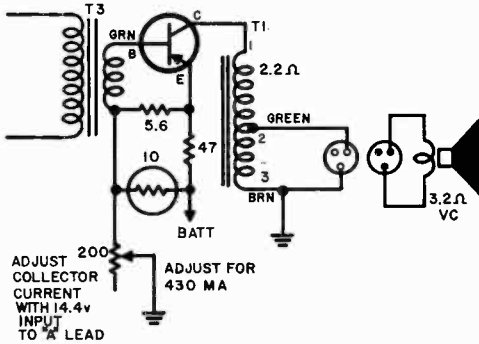


Fig. 422. This auto radio uses an autotransformer to connect the output transistor to the speaker.

is the autotransformer type. It has an additional winding which is part of the cathode circuit of the first audio amplifier.

The signal current flows through the autotransformer to the collector of the output transistor. The magnetic field of this current induces a voltage across feedback winding A. This current is out of phase with the current normally flowing through the first triode audio amplifier.

This is feedback over several stages, instead of between two adjoining stages as in Fig. 423.

The receiver will oscillate if connections to primaries or secondaries of either transformer T1 or T2 are reversed. If the output transformer becomes defective, it will need an *exact* replacement.

Thermistor and varistor

A little earlier we told you about the use of a thermistor and how it works to keep the temperature rise of the output transistor from running away. Sometimes an additional unit, known as a *varistor*, is used. (The varistor was also discussed earlier in connection with Fig. 411.) This is shown in Fig. 425.

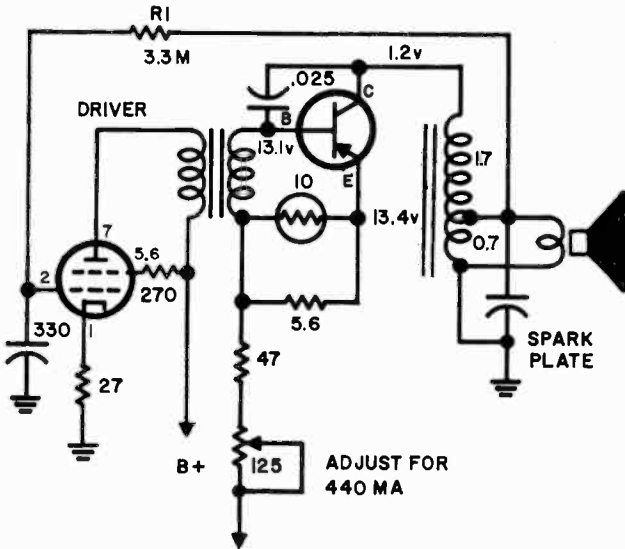


Fig. 423. Single-ended transistor stage in hybrid auto receiver.

A varistor is a voltage-sensitive device. (The thermistor is temperature-sensitive.) The resistance of the varistor varies inversely with the voltage. All that this means is that its resistance goes down when the voltage tries to rise.

If the voltage at the collector in Fig. 425 should go up, the resistance of the varistor would decrease. As a result, it would

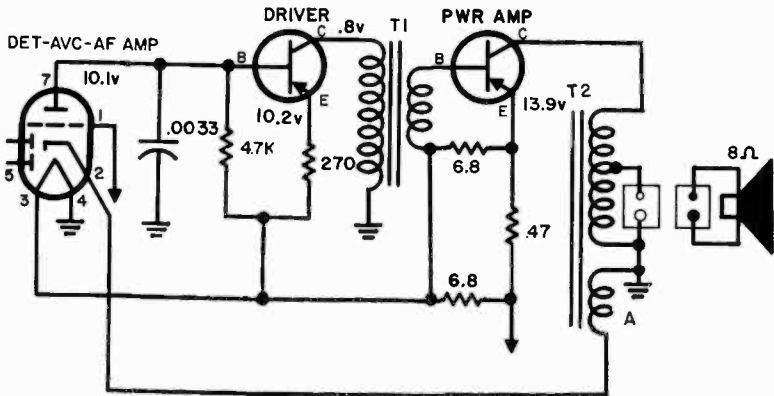


Fig. 424. Some auto radios have a feedback winding as part of the output transformer.

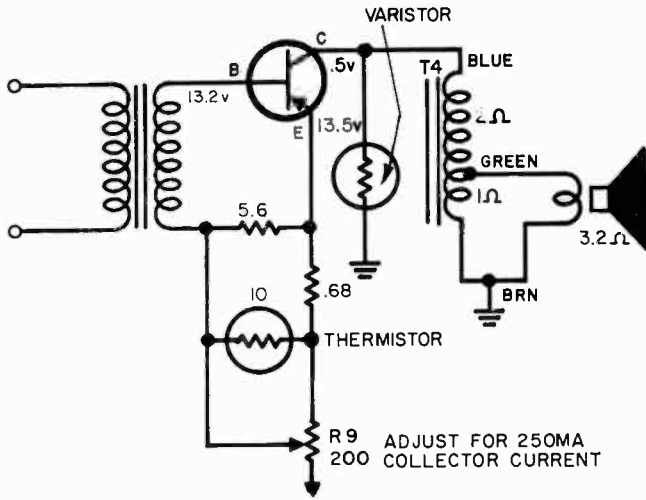


Fig. 425. The thermistor and the varistor are both used to prevent excessive collector current.

draw more current, loading the voltage supply. This would decrease the voltage and keep it within safe limits.

If the set you are working on has a history of burned-out power transistors, make sure that the thermistor (and also the varistor, if used) has not been removed from the circuit.

QUESTIONS

1. What is a thermistor? A varistor? What is the difference between them?
2. What could cause oscillation in a transistor amplifier? How is it prevented?
3. What is a spark plate? What does it do? What two symbols are used to represent spark plates?
4. What is the difference between a synchronous and a nonsynchronous vibrator?
5. Why does a power transistor require a heat sink?
6. What is the purpose of a line filter in an auto radio?
7. What could cause a vibrator to become noisy? What quick check can you make to determine if the vibrator is working? What component should you check if the vibrator doesn't operate?
8. What is a dc-to-dc converter? Where is it used? What are its advantages? Name two circuits used by these converters.
9. What is a fader control? In what circuit is it used? What is the advantage of such a control?
10. Name two types of output transformers used in auto radios.
11. What is negative feedback? Why is it used?
12. In checking a receiver having a nonsynchronous power supply you note a bad hum. What should you do? What should you do if such a set has low low B-plus voltage? What might be the trouble if the fuse keeps opening?

CHAPTER 5

servicing auto radios (part II)

REMEMBER some of the told-time automobiles? Perhaps you've seen pictures of them. All that any owner ever asked (or prayed for) was to be able to keep going once he managed to get the car started—and getting it started was a job in itself.

Once the mechanical bugs were licked, however, we soon wanted more than just a made-over buggy seat mounted on a horse-and-carriage spring. And, as we told you at the beginning of Chapter 4, we wanted comfort and style to be part of the car.

The auto radio is part of that comfort. And just as you can have your choice of many different makes, styles and costs when you buy a car, so too is there a big choice of auto radios. You might, somewhere, find a home without a radio, but it's less likely that you would find a car without one. That is why servicing auto radios is such good business.

The driver stage

In Chapter 4 we talked about power supplies and different types of audio power amplifiers. But a power amplifier is like a car. It needs someone or something to drive it.

In any radio set, the tube or transistor that amplifies the audio signal and feeds it into the power amplifier is known as the driver. In Fig. 501 we have a transistor driver. This driver requires an input signal of 0.15 volt. In turn this will allow the power amplifier to produce 1 watt of audio output from the speaker.

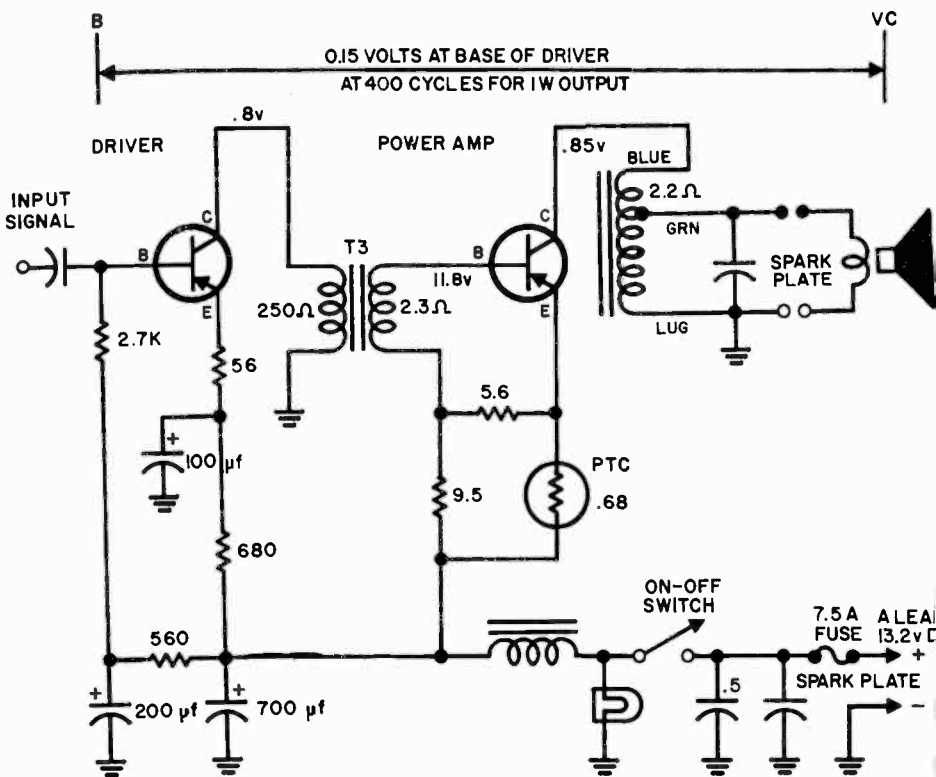


Fig. 501. Driver stage in an auto radio. The driver is transformer-coupled to the audio power amplifier.

The driver stage of Fig. 501 has just a few parts. But these few parts can be troublesome.

*Some people look back to the good old days,
Keep thinking about them, singing their praise,
But what about troubles in the old-time car?
Couldn't get started, couldn't go far,
But while they may have been a bag of tricks,
None of them had an auto set to fix.*

In an earlier chapter we learned how to service driver stages in portable receivers. We can repair driver stages in auto sets in the same way.

Put your finger on the base of the driver transistor for your first

quick check. A growl or squawk out of the speaker tells you that the driver and the power amplifier are both on the job.

If this doesn't produce results, touch the base of the power amplifier transistor. If you get a squawk now, then you can be sure the driver is not working. Check the transistor's voltages for a clue as to the trouble. Check the emitter resistor and its bypass capacitor, and also the transformer between the two stages.

Driver for push-pull output

The driver for a push-pull stage (Fig. 502), is almost the same as the circuit shown in Fig. 501. Actually, though, it is a little

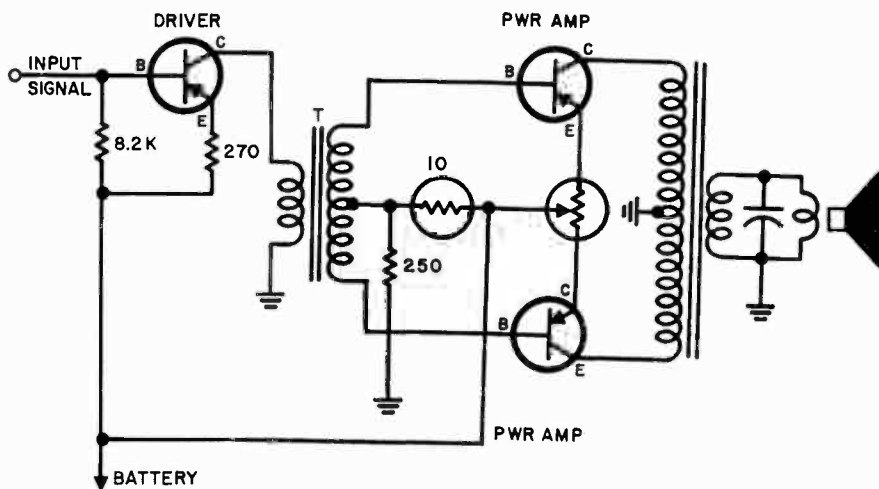


Fig. 502. The driver for a push-pull stage has just a few parts.

simpler. We have no emitter bypass capacitor. The main difference is in the interstage transformer (T). The secondary of this transformer is designed for push-pull output.

Servicing of this driver is the same as for all transistor drivers. First check to see if the driver is working, then check the components. Since there are so few, this is easy to do.

Vacuum-tube driver

Do you remember reading about hybrid sets in an earlier chapter? At that time we told you that a hybrid set was one that used both tubes and transistors. The tubes are 12-volt types. This is the approximate voltage, not only on the filaments, but on screen and plate as well.

Fig. 503 shows one of these tubes used as a driver. The input is resistance coupled from the first audio amplifier. The output is transformer-coupled (we call it an interstage transformer) to the power amplifier.

What can go wrong with this circuit? One of the probable trouble spots is the tube. If it's dead, the stage won't operate. A weak tube (low emission) means weak or distorted sound output.

Check the tube first, by substitution if possible. Then make voltage checks at the tube socket. If you get voltage at the screen, but not at the plate, the primary winding is open.

A good check for proper tube operation is to measure the bias

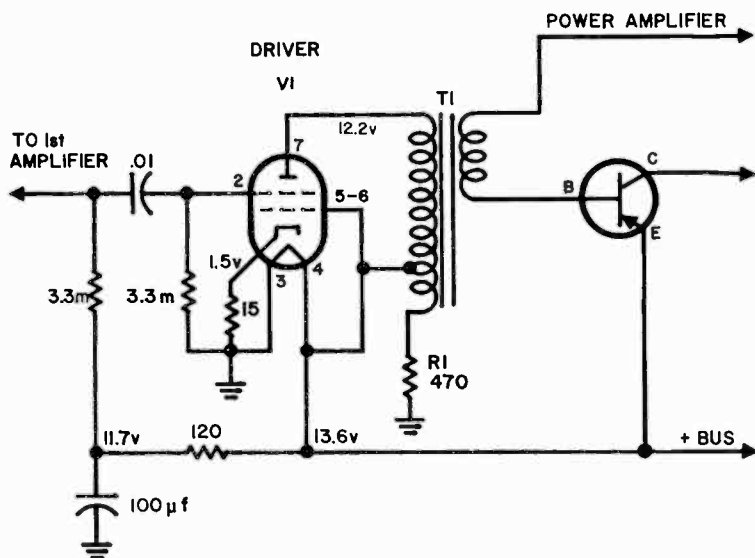


Fig. 503. Not all interstage transformers (T1) are alike. This one has a tapped primary. If the transformer is defective, it will need an exact replacement.

voltage. Set the vtvm to read low volts dc. Connect the plus probe to the cathode of the tube and the common probe to ground. In the circuit in Fig. 503 the bias should be 1.5 volts.

If the bias is incorrect, try a new tube. If this doesn't help, check the cathode resistor.

What if you just want to know if the stage is good? Put an audio signal in at the control grid. If you're in a hurry, touch the grid with your finger. A loud squawk out of the speaker is your answer if the driver is working.

amperes) produces the bias. The amount is dependent on signal strength, but 2 volts is typical. In the absence of signal, the bias developed (contact bias) is about 0.5 volt.

Now from your experience with ac-dc sets you might think this is just fine. However, the auto radio works under worse conditions than a home radio.

Does this make it more difficult for us to service this stage? Not at all! As far as we are concerned, it is just another driver stage and we can service it in the same way.

As our first quick check, put an audio signal into the control grid of the tube, V1. The center arm of the volume control is a convenient spot. You can use the finger test if you like without worrying about a shock. All the voltages are small.

If you get no signal output, move directly to the control grid of the tube. Signal output here means that coupling capacitor C1 is open. If you get no sound output, try a new tube.

It's about time that we collected our facts so that they are handy for servicing. Here's our check list for vacuum-tube drivers.

Troubles in the Driver Stage.

And What To Do About Them.

No sound output.

Defective tube.

Open cathode resistor (when one is used).
Cathode lead disconnected from ground (when cathode resistor is not used).

Open in winding of interstage transformer.
No B-plus voltage.

No signal input from earlier stage.

Intermittent.

Tube can cause this trouble. Tap tube gently. If set stops playing after it has been on for a while, substitute a new tube.

Can be caused by defective component, such as coupling capacitor. Check volume control. It may have a worn spot.

Motorboating.

Check decoupling filter, such as R1 and C2 in Figure 504.

Check lead dress. Keep plate and control grid leads separated.

Battery may be run down.

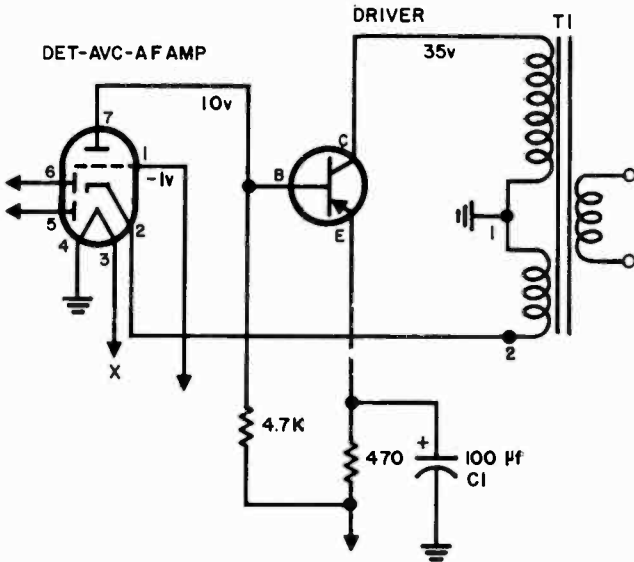


Fig. 505. The interstage transformer in this driver circuit has a feedback winding.

Weak sound.

- Try a new tube.
- Check plate and screen voltages.
- Storage battery may need recharging.
- Input signal may be weak. Try different station.
- Check bias.
- Check coupling capacitor for leakage.

Driver-stage feedback

When they are very young, some girls (and boys, too) go through a stage known as the giggles. Just looking at them is enough to get them started.

Triode tubes and transistors (and most transistors we're working with are triodes) belong to the giggle class. Give them half a chance and they'll oscillate. We keep a strict check on that sort of thing by using negative feedback.

One way of doing this is shown in Fig. 505. Part of the winding of interstage transformer T1 feeds an out-of-phase signal back to the cathode of the first audio amplifier.

What does this mean to us? First, we cannot use just any old

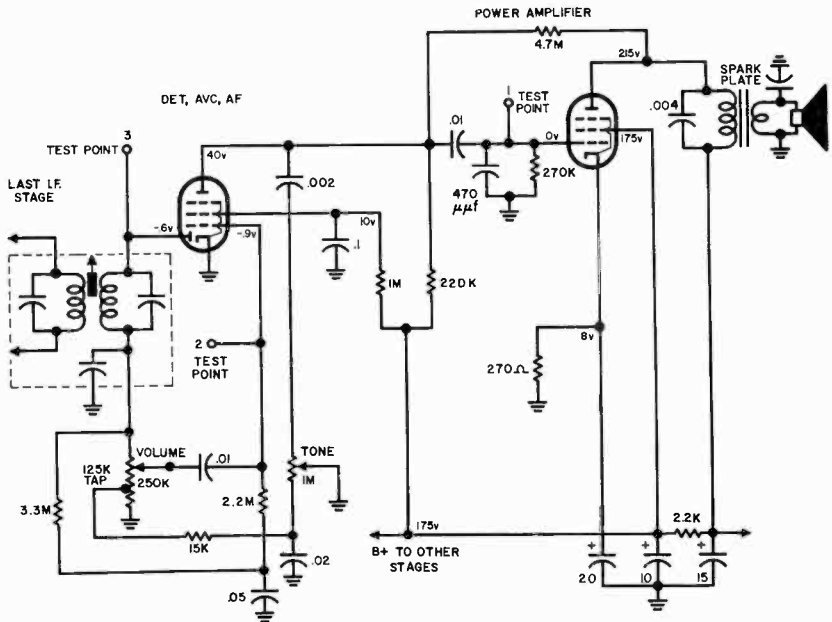


Fig. 506. Driver and output stage of older type receivers.

interstage transformer when making a replacement. And second, even if we do use an exact replacement, we must be careful of our connections. If we should accidentally transpose leads 1 and 2 on transformer T1, the receiver would oscillate strongly.

If you're sure that you've made your connections properly, but the receiver wants to oscillate, especially on strong signals, try disconnecting C1. The price we pay for this cure is reduced volume.

The old-timers

Tremendous numbers of auto radio receivers were made using a vibrator supply and high-voltage (100 to 300 volts) tubes. These are going out of style but you will still come across them on your service bench. They will gradually disappear since the hybrids and all-transistor sets are so much quieter, use less power and, in the case of all-transistor sets, instant starting.

You can service these sets in the same way as any hybrid or vacuum-tube receiver. The troubles are the same. The tube voltages are higher, so using your finger for a squawk test may not be such a good idea. It's too easy to touch the wrong tube pin. For a

quick check, click the control grid of the driver or the power amplifier to ground. If you prefer, use an audio signal generator.

In most cases the troubles are caused by the tubes. If the tubes are good, check at the tube pins for proper voltages. If any voltage is low, or missing at any tube pin, work back along the connection to that pin until you find the defective component. A typical driver and power amplifier are shown in Fig. 506.

The odd-ball

When servicing auto radios, you can run across some strange circuit combinations. One of these is shown in Fig. 507. The set is a hybrid but, unlike most such sets, uses ordinary tubes (instead of special low-voltage tubes). The set has two power supplies. One is the battery supply and filter for the output transistor. The other is a dc-to-dc converter that furnishes about 66 volts for the tubes.

Servicing a set of this type is exactly the same as for any hybrid. The double power supply will be confusing unless you've been warned about it and you know enough to look for it.

Loss of B-plus for the driver (and earlier tubes) is usually due to failure in the transistor power supply. This is the blocking oscillator type that we studied earlier.

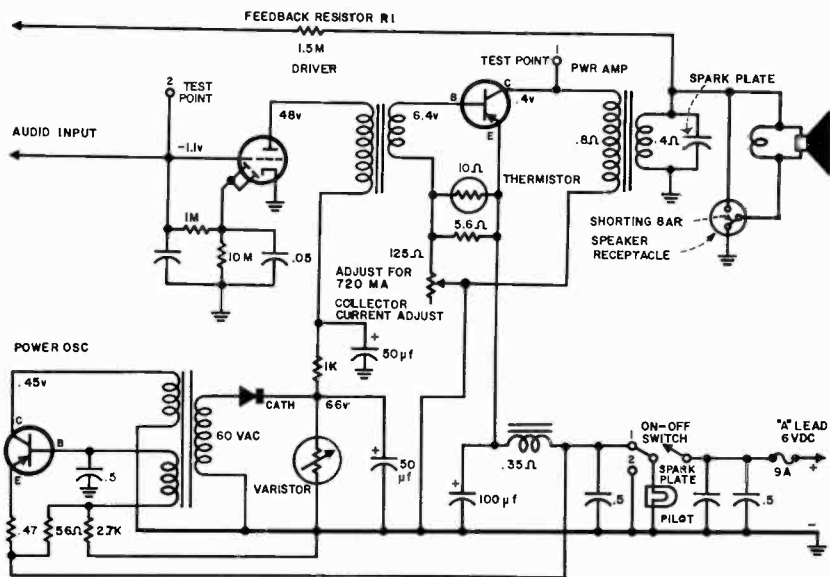


Fig. 507. This type of hybrid auto radio uses a double power supply.

The on-off switch (mounted on the volume control) turns on both power supplies at the same time. No heating time is required for the power supplies.

Servicing this type of set will be a little easier for you if you consider the power amplifier and its power supply as separate and independent units.

The circuit in Fig. 507 has a few points of interest that will help us in servicing. Note test point 1. This could be a closed-circuit jack for insertion of an ammeter to check collector current. Set your meter to read 1-ampere full-scale deflection and adjust the 125-ohm potentiometer until the meter reads 720 milliamperes. This check is made in the absence of signal. A good method is to ground the grid of the driver since this will eliminate both noise and signal voltages.

Note the low voltage on the plate of the driver. If you get no voltage here, check the primary of the interstage transformer and the 1,000-ohm resistor for continuity. If you get plate voltage but it is too low, check the decoupling network (1,000-ohm resistor and the 50- μ f capacitor) connected to the primary of the interstage transformer. The voltage drop across the 1,000-ohm resistor should be less than 18 volts (allowing for a small voltage drop across the primary). If it is more than 18 volts, disconnect the 50- μ f capacitor. If this brings the voltage back to normal, the 50- μ f capacitor is excessively leaky.

The driver in Fig. 507 uses contact bias. A 10-megohm resistor is part of the bias network. Check to make sure the resistor is within its tolerance rating if the complaint is distortion. A quick check on driver bias is to make a voltage measurement at test point 2 with your vtvm.

Servicing if and detector stages

Ever take a long bus ride? The people who run the bus lines are smart enough to know that it's a good idea to have a rest point about halfway along the route.

It's also a good idea in servicing radio receivers to have a half-way point—and what better circuit could we have for this than the detector.

Two things happen at the detector. The detector demodulates or slices the signal in half. Either the top or the bottom half of the signal is rejected. What is left is half the carrier and the audio signal. With the help of a bypass capacitor, the remaining carrier is junked while the audio signal is sent into the driver stage.

What sort of troubles can the detector give us? The usual kind —no signal, weak signal, distorted signal, etc.

Before we settle down to examining these troubles, our first question, as always, is: Before we point the finger of suspicion at the detector, how do we know the detector is working?

Fig. 508 shows a typical if and detector arrangement in a hybrid receiver. To make a quick check, set your generator to the if of the receiver. Make sure the modulation is turned on. Connect

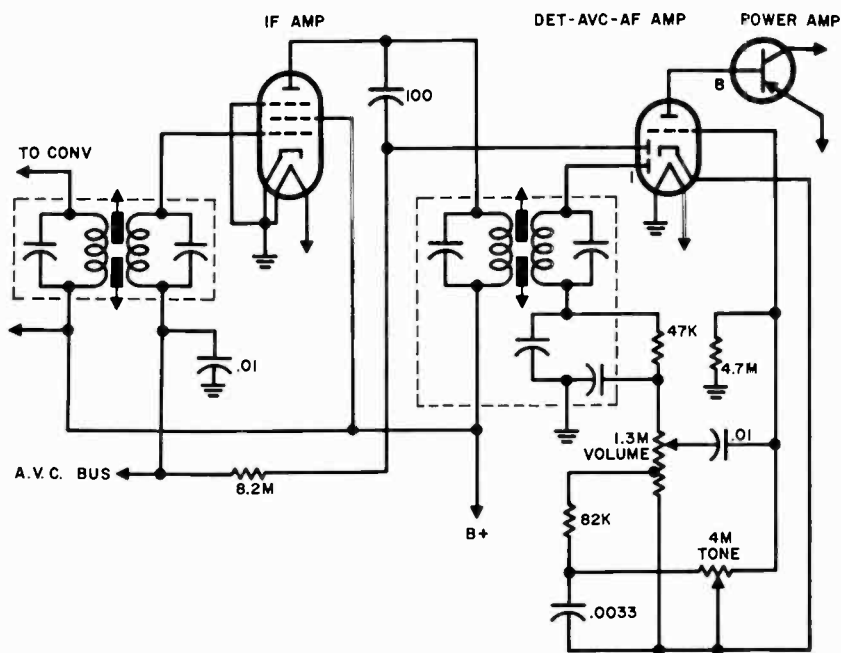


Fig. 508. The if and detector stages in a hybrid set using low-voltage tubes.

the test lead to point 1 of the detector diode and listen for the tone out of the speaker.

If you don't hear the tone, don't assume the detector is bad. You may have the wrong if. Some are 455 kc; other sets use 262.5 kc. Try both. The one that works is the right one.

If neither of these frequencies produces results, set the dial of your signal generator to 200 kc, with modulation on, gain control at or near maximum. Turn the generator dial slowly toward the higher frequency range. The secondary of the last if transformer

may be very badly misaligned. You can be sure of this if the signal wants to come through somewhat near 262.5 or 455 kc.

Now if you hear the signal, you know the detector is operating. If you don't, put an audio signal across the volume control. If the signal comes through, you've narrowed the trouble down to the detector.

If the detector passes the signal, move your signal generator test lead to the control grid of the first if amplifier tube. Don't change the controls on the generator. If the signal out of the speaker comes through loud and strong, then you know the if is working and any trouble you may have is in the converter.

Detector types

Vacuum-tube detector diodes are used in hybrid receivers. For the most part these diodes will be in multi-element tubes, such as diode triodes, duo-diode triodes and diode-pentodes.

In the all-transistor auto radio there would be no point in having a vacuum-tube diode. In such sets, semiconductor detectors are used, as shown in Fig. 509.

Servicing the if and detector stages in a transistor auto radio is the same as the servicing procedure we learned earlier. In Fig. 509 there is one difference to note. This is the use of a separate diode for automatic gain control.

But how different is this? Isn't it really the same idea that we have in vacuum-tube circuits when a double diode is used—one diode for detection and the other for automatic volume control?

Detector and avc troubles

Since we have already had a troubleshooting chart for transistor if, detector and avc circuits, let's set one up for vacuum tubes. Although the chart refers to auto radios, you should be able to use it for any AM receiver using vacuum tubes.

Troubles in the Detector and Avc Stages.	And What To Do About Them.
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Receiver is noisy.

Ground the grid of the last if. If noise continues, the trouble is after this point.

Check the volume control. This component is usually the diode load. A worn spot on the control can produce noise.

Look for corroded connections.

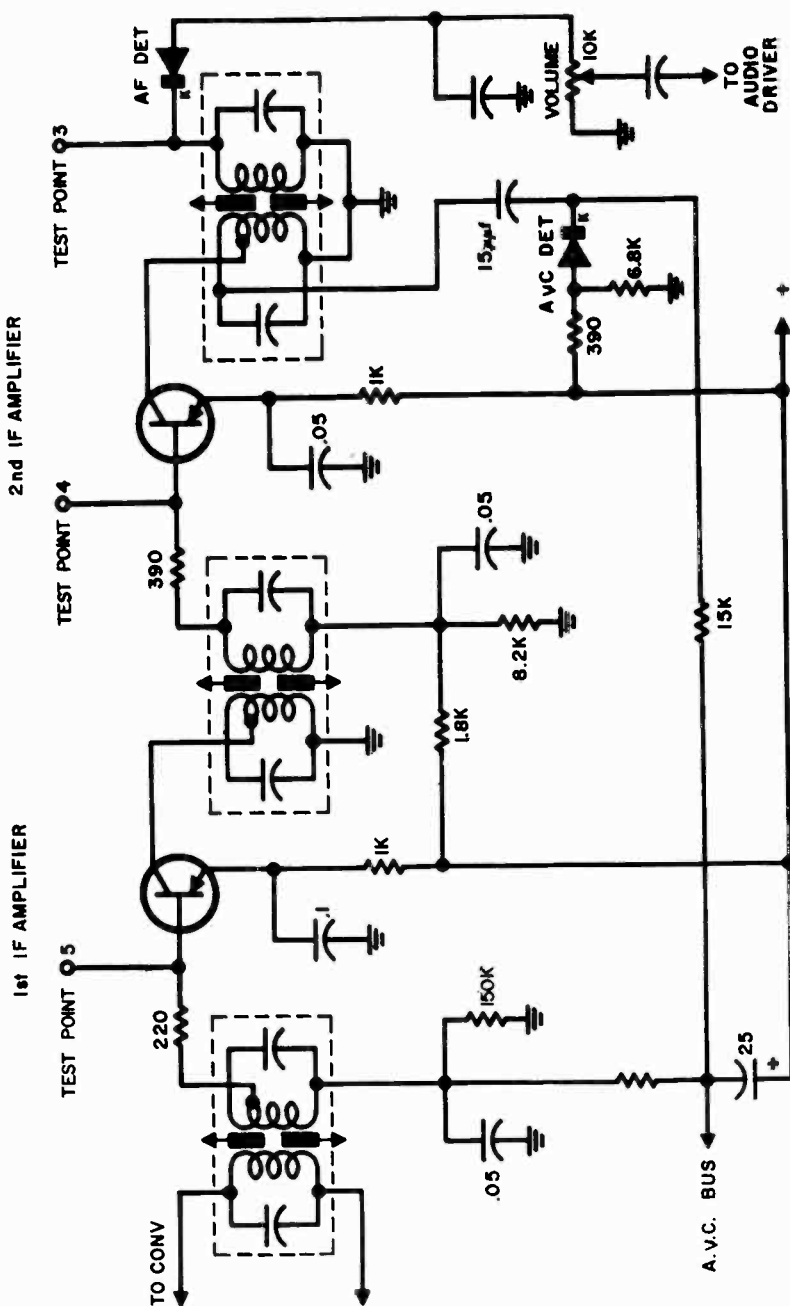


Fig. 509. All-transistor auto radios use a semiconductor diode as the detector. A separate semiconductor diode is used for automatic gain control.

Signals are weak on all stations.

Secondary of last if may be badly misaligned. Can be caused by detector tube having weak emission.

Some more troubles

Transistor auto radios usually have more if stages than home receivers. Two or more stages are very common. Once again, the reason for this can be found in the conditions under which we expect the auto radio to work. The auto radio is jammed in against an engine that radiates interference. It is in a car, often moving in weak signal areas. These are just a few of the reasons why you'll find more circuits, more tubes or transistors in auto radios.

However, you will find that while transistor auto radios have two if stages, vacuum tube auto sets usually have only one. You can see this quite easily by comparing Figs. 508 and 509.



Fig. 511. Signal tracer is extremely useful in servicing receivers.
(Allied Radio Corp.)

What are the troubles we can expect to find in the if stages of a vacuum tube auto radio? You will find it easier to anticipate the kind of troubles if you will remember that an if amplifier and an audio amplifier are very closely related. The big difference between them is the frequencies at which they work.

Here is our check list for vacuum tube if stages. Before you use the chart, though, make sure the stage is working. Feed a modulated if signal into the grid of the first if amplifier tube. (Make sure the generator is set on the correct frequency.) You should get a strong tone.

Troubles in the if Stages. And What to Do About Them.

No sound.

Inject modulated if signal at grids and plates of each if to learn where signal disappears.

Try substituting new if tube (or tubes).

Check B-plus voltages on plate and screen of if tubes. If missing, trace circuit.

Open in primary or secondary of if transformer.

If transformer is misaligned.

Slug in if transformer may be shorting windings.

If winding may be shorting against metal can.

Plate and screen may be connected to decoupling circuit. Check for open.

Make sure tube hasn't pushed out of the socket.

Weak sound.

Defective tube.

Low B-plus on plate or screen. Check series dropping resistors, if any.

If transformer is misaligned.

Open capacitor in the avc line.

Signal from converter is weak.

Oscillation.

If tube is shielded, make sure shield is on and that it is grounded.

Decoupling capacitor open.

Check screen bypass capacitor.

Intermittent operation of set.

Make sure each tube is seated firmly in socket. Tube pins may be bent.

Connect vtvm to each screen grid. Grid voltage should be steady. If not, check screen bypass capacitors and screen dropping resistors, if any.

Back at the front end

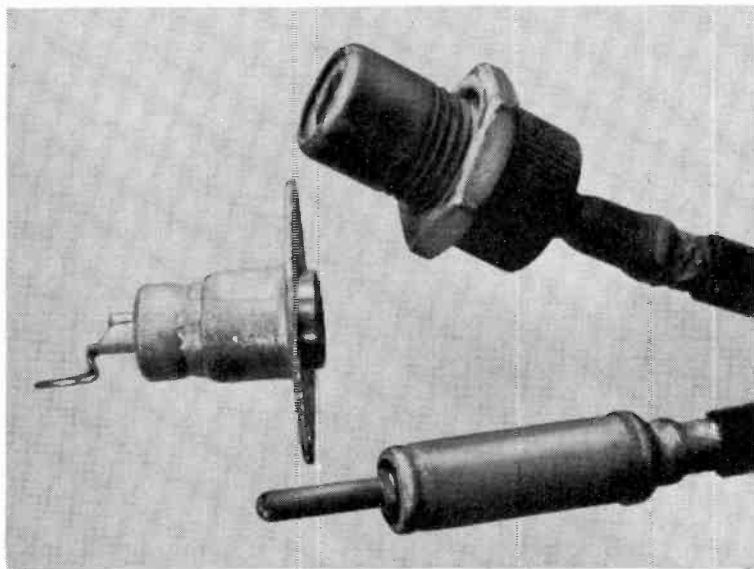
Did you ever try to buy a 5¢ newspaper with a \$10 bill? This is a basic problem in conversion. It may not happen very often to you or to us, but we have a similar problem every time we tune in a radio station.

The mixer or converter takes the high frequency of the radio station and (with the help of the local oscillator) “changes” it into a much lower frequency—the intermediate frequency.

Sometimes, though, the converter runs into trouble and, when that happens, our signal can disappear. But before we get into that, let’s examine a circuit and see what it looks like.

Start with Fig. 510. This shows a pentagrid converter. Slug tuning is used for the rf and local oscillator. Mixing action takes place in the tube and the output is fed into the first if.

A quick check of this stage can be made by tapping the signal grid of the converter with your finger while listening to the speaker. A better method is to feed in a modulated signal (somewhere in the broadcast-band range). You can check at the output of the converter with a signal tracer. A test unit of this type is shown in Fig. 511. With the signal fed in at the antenna, touch the demodulator probe (shown in the photo) to the plate of the converter tube. If the converter is working properly, you should be able to



Antenna connector (top), chassis-mount jack (center) and lead-in plug (bottom) are all possible sources of intermittent reception and noise.

hear the signal in the speaker of the signal tracer. But what if you don't hear the signal? Or what if the signal is weak or distorted? Let's consult our check list to see what we can do about servicing the converter stage.

Troubles in the Converter Stage.

And What To Do About Them.

No sound.

Check the tube by substitution.

No B-plus voltage on one or more elements of the tube.

B-plus voltage may be too low. Check components from tube pins to the power supply or battery.

No station on the air or set not tuned to a station.

Local oscillator not working. Check oscillator coil, oscillator tuning slug, grid leak and grid capacitor. Oscillator slug may be broken or not moving in or out of the coil.

Primary of first if transformer may be open.

Set works over part of broadcast band only.

Check oscillator tuning coil and slug. Slug may be shorting the coil.

Check B-plus voltage on oscillator anode grid.

Whistling; birdies.

Try aligning rf and local oscillator sections. If misaligned, whistles can be caused by image interference.

Noise; weak signals.

Try a new converter tube.

Front end may be misaligned.

Look for broken connections, corroded soldered joints.

Examine rf and local oscillator coils for broken strands of wire.

The rf amplifier

Did you ever see a mirror that magnifies? Look in one of these mirrors and suddenly everything is giant size. When you shave, you get the feeling that you're covering a lot of territory.

An rf amplifier in an auto radio is like this mirror. It makes the signal bigger. But it does a little more than that. The antenna of the car radio is very close to a big source of electrical noise. When this electrical noise is sent into the converter, the poor con-



Excessive electrode gap in the spark-plug (left) or corroded top connector can help generate excessive noise just as wear and burning of the rotor tip or a dirty or poor contact will at the center contact of the rotor. These normal-wear points can create noise before hard-starting or engine performance is affected.

verter has no choice but to send it along to the if section where it is amplified. Finally, we hear the noise as annoying crackles and scratches coming out of the speaker.

An rf amplifier gives the radio signal a fighting chance to overcome the noise.

In Fig. 512 we have the rf amplifier used in the front end of an auto radio. Our rf amplifier also has a sensitivity control so that we can adjust the set for best operation.

The sensitivity control is a variable resistor in the cathode circuit of the rf amplifier and controls its gain. Sometimes all that is needed in servicing a set of this type is to adjust the control properly. As the rf amplifier tube gets older, its gain becomes less, so some adjustment is needed.

For a quick check of the rf amplifier, touch the control grid. Listen for sound out of the speaker. Better yet, feed in a modulated signal and then put the probe of your signal tracer on the plate of the rf amplifier tube.

Just because the rf amplifier is a simple circuit doesn't mean that it can't have its share of troubles for you to work on. Here's our check list.

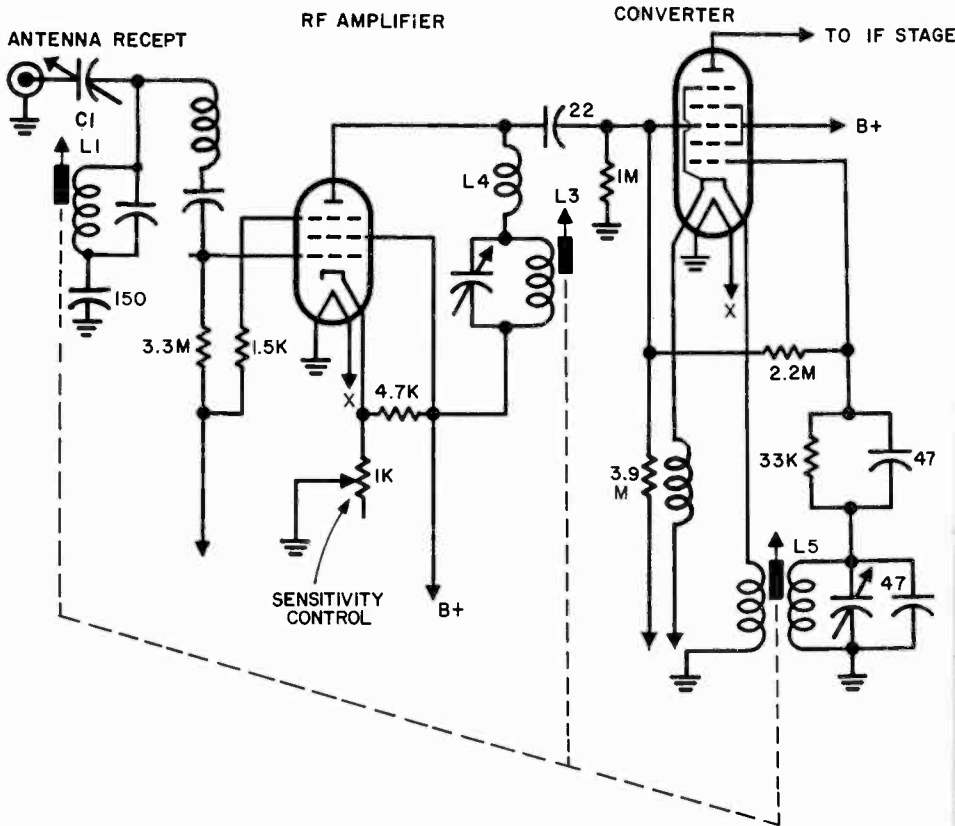


Fig. 512. For best operation, the auto radio should have an rf amplifier ahead of the converter.

Troubles in the Rf Amplifier Stage.

No signal.

And What To Do About Them.

Tube is dead. Try a new one.

Check voltages on screen and plate. If voltage is missing, trace back along B-plus lead.

No signal input. Antenna may be shorted to body of car. Antenna cable may be disconnected. Hot lead of antenna cable may be shorting to braid of cable.

Filter circuit between antenna connector and control grid may be open.

Cathode resistor (or sensitivity control) may be open.

Weak signal.

Low emission in tube.

Low plate or screen voltage. Check all components connected to plate and screen.

Slug may not be moving in and out of rf coil. Slug may be broken or severely chipped.

Input circuit trimmer (C1 in Fig. 512) may not be properly adjusted.

Intermittent signal. Signal fades in and out.

Tube may be intermittent.

Antenna connection may be loose or corroded.

If rf tube is avc-controlled, check avc filter capacitors.

The transistor rf amplifier

Every time we see a transistor rf amplifier stage we are reminded of that old song

*Anything you can do,
I can do better.*

Perhaps a transistor rf stage is better than a vacuum-tube type. At the present time, it's a bit difficult to say. But since both types are being manufactured, we need to work with both.

To test the rf stage, feed a weak signal into the antenna circuit using the method described earlier with transistors.

Unlike the tube rf amplifier, the transistor is the last item to suspect. Make sure the battery is fully charged. Check the voltages at the transistor elements. If any of these do not agree with the information given on the manufacturer's schematic, check back along the lines going to the transistor elements.

A good test of the rf transistor is to measure the voltage drop across the emitter resistor. If the voltage is too high, the transistor may be excessively leaky. If too low, bias voltage between emitter and base needs looking into.

Some of the same troubles that we have with vacuum-tube rf amplifiers will show up with the transistor rf stage. You can expect weak sound if the stage is misaligned. You can expect noisy, intermittent reception if the antenna lead is corroded or shorting. Examine the slugs to make sure they move in and out of the rf and oscillator coils. See Fig. 513.

Some final servicing notes

Ever watch a bunch of women in action on "bargain" day in

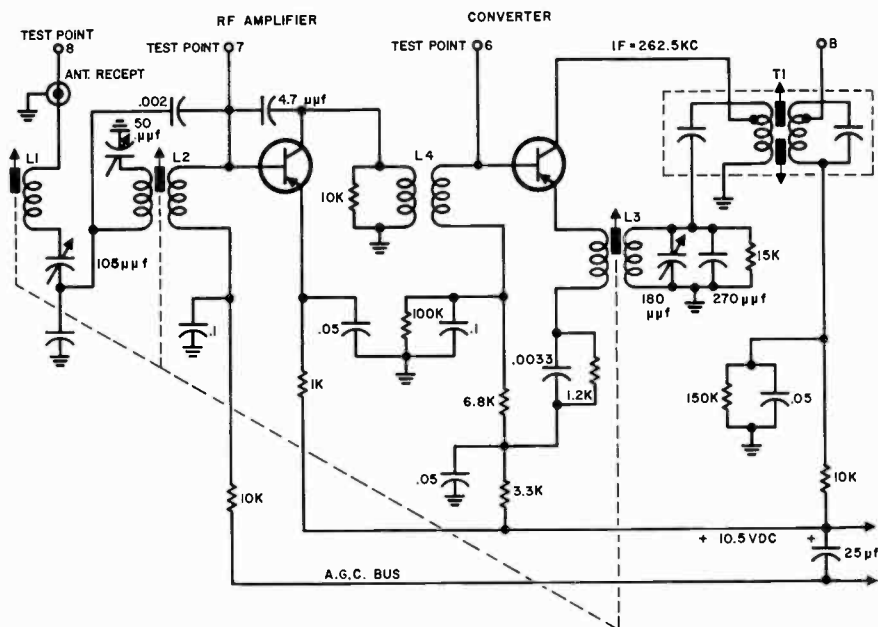


Fig. 513. Transistor rf amplifier in an all-transistor auto radio.

some department store basement? They tear through from one rack to the next in a matter of seconds. Reminds us of the way some service technicians work on radio sets. They jump like wild-fire from stage to stage. Sometimes they even get sets fixed.

Although we prefer a more orderly method of servicing, working back from stage to stage, this doesn't mean that this is always the best way. Also, while we have given definite information about servicing each stage, there are still a few precautions to follow in servicing auto radios.

Screwdriver servicing

Screwdriver testing—that is, probing from tube or transistor elements to the chassis with a screwdriver—can be risky. The energy in a storage battery can lift a ton of metal a mile into the sky. And while you can put both hands across a battery without getting hurt, a bit of metal (such as a screwdriver) across a battery can be very dangerous.

Now you are probably going to tell us that you would never do such a thing, you would never put a screwdriver across a bat-



Fig. 514. Battery eliminator and eliminator with extra filter. (EICO)

tery. But when you spark-test at different points in an auto radio, you are practically doing just that.

Storage batteries are designed to deliver current in amperes—many amperes—and this kind of current can burn wires and components quicker than a hamburger on a grille at a picnic.

Shorting the base of a transistor to ground is a good way to increase the sales of new transistors. When the transistor base is shorted, its bias is removed. When the bias is removed, the amount of current flowing through the transistor will fuse it.

Testing the receiver

If you remove a radio from a car, you need a source of power to test it. Whether it is all-transistor or hybrid the best source is another storage battery.

Capacitors are made with special mounting brackets for use in cars. In Fig. 516 we have a $0.5\text{-}\mu\text{f}$ capacitor mounted right on the generator. You will find a ground screw in the generator metal frame. This is a tapped screw and can be easily removed. Use this screw for holding the mounting bracket of the capacitor.

On the generator you will find two terminals. One of these will be marked ARM (for armature) while the other will be marked FIELD. Do not touch the field terminal.

Disconnect the wire going to the terminal marked ARM. Connect this wire to one side of the capacitor. Connect the other side of the

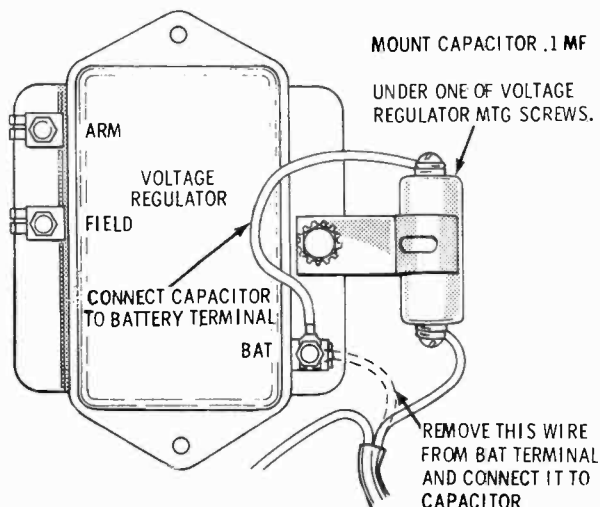


Fig. 517. This drawing shows how the capacitor is mounted on the voltage regulator. (Motorola Consumer Products, Inc.)

capacitor to the ARM terminal and the job is done. Make sure all the screws are tight.

Installing a voltage-regulator capacitor

To install an interference-elimination capacitor on the voltage regulator (as shown in Fig. 517) remove one of the screws that holds the regulator in place and use it to hold the capacitor bracket.

On the regulator you will find three terminals marked ARM (for armature), FIELD and BAT (for battery). The BAT terminal is the one we are going to use. Disconnect the wire going to it and connect it to one side of the capacitor. Connect a wire between the other side of the capacitor and the BAT terminal and the job is done.

After you have installed the voltage regulator and the generator capacitors, turn the motor on and tune in a station. Note whether you have made an improvement. Tune the set from one end of the band to the other since the interference may concentrate at one end.

Installing a capacitor on the ignition coil

On the ignition coil you will find two wires. One runs to the distributor and the other to the battery terminal. Mount the capacitor as shown in Fig. 518. Disconnect the wire going to the battery terminal and connect it to one side of the capacitor. Now connect the other side of the capacitor to the battery terminal and the job is finished.

More noise suppression

The steps we have described so far should help eliminate most of the interference. But you can always expect to run into stubborn cases. This doesn't mean that you should recommend that your customer turn his car in for a bicycle. There are still a few more cures you can try.

One of the things you can do is to install more suppression capacitors on the voltage regulator. Fig. 519 shows just how we do this. Get a pair of capacitors and mount them near the voltage regulator. Remove the wire from the terminal marked ARM and connect

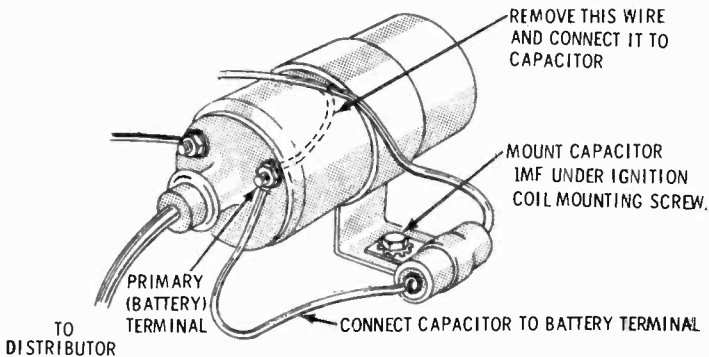


Fig. 518. Method of mounting the capacitor on the ignition coil. (Motorola Consumer Products, Inc.)

it to one of the capacitors. Connect the other side of this capacitor to the ARM terminal.

The other capacitor is a common type which has one connection automatically made to the "ground" or frame of your car when you

mount the capacitor. This capacitor has just one lead. Connect this lead to the FIELD terminal on the voltage regulator.

Other steps you can take to reduce interference

It is possible that you might still have some trouble with interference. Some makes of cars have special resistance ignition wiring

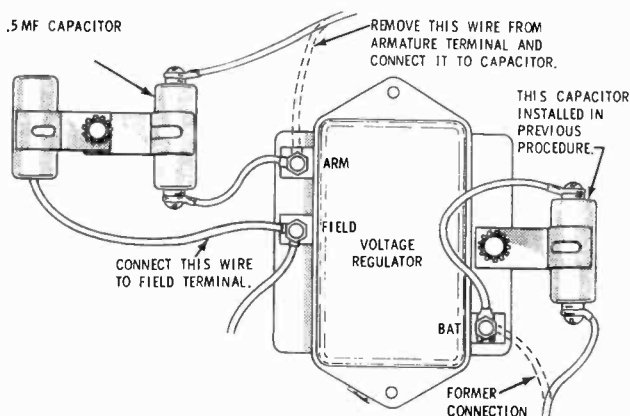


Fig. 519. Additional capacitors can be used in cases where the interference is still annoying. (Motorola Consumer Products, Inc.)

to eliminate interference. If the car you are working on doesn't have such wiring, you can replace the original wiring with resistance wiring.

Resistance wiring is obtainable from automotive parts dealers.

Importance of grounds

The frame of the car is ground but it's a little less solid than the earth we walk on. Since the frame of the car isn't one piece, some rubbing action takes place and, since ground is part of the antenna system, it's just as though we had a poor connection to the antenna.

What are the things we can do to overcome this problem? Run a woven metal strap from the engine block to the firewall. In some cars you will find a support for the dash bolted to the firewall. Try connecting the ground strap to the firewall at this point.

Run a ground strap from one of the mounting screws on the voltage regulator to the grounded terminal of the car battery.

There are other methods you can try. Use spark plugs with built-in suppressor resistors. Install a suppressor resistor at the distributor. Use shielded ignition wiring. Make sure that the receiver is mounted

securely. One way of doing this is to use star lockwashers on both sides of all metal contacts. The connections should be tight enough so that the washers bite into the metal.

Some radios are powered through the ignition switch. The contact resistance of the switch or the connections can help introduce ignition noise into the radio. If tightening the connections doesn't



This do-it-yourself ignition noise suppression kit can be used to advantage with any internal combustion engine where it interferes with the reception on broadcast, marine or Citizens bands. It includes suppressors, capacitors, an R-C network and shielded generator wiring. (Raytheon Company)

help, try running a wire directly to the battery's *hot* terminal. This will eliminate one more possibility.

Noise can be generated by such unlikely things as the wheels. Static electricity (a mild form of lightning) is created by friction. This is stored up (usually by the front wheels) until the voltage is high enough to arc over. This can be reduced by using special springs in the bearing covers or adding graphite to the wheel bearing lubricant to give a low resistance electrical path.

Search tuners

The best way to drive an automobile is with two hands. But if a driver must tune a radio while trying to operate a car, the

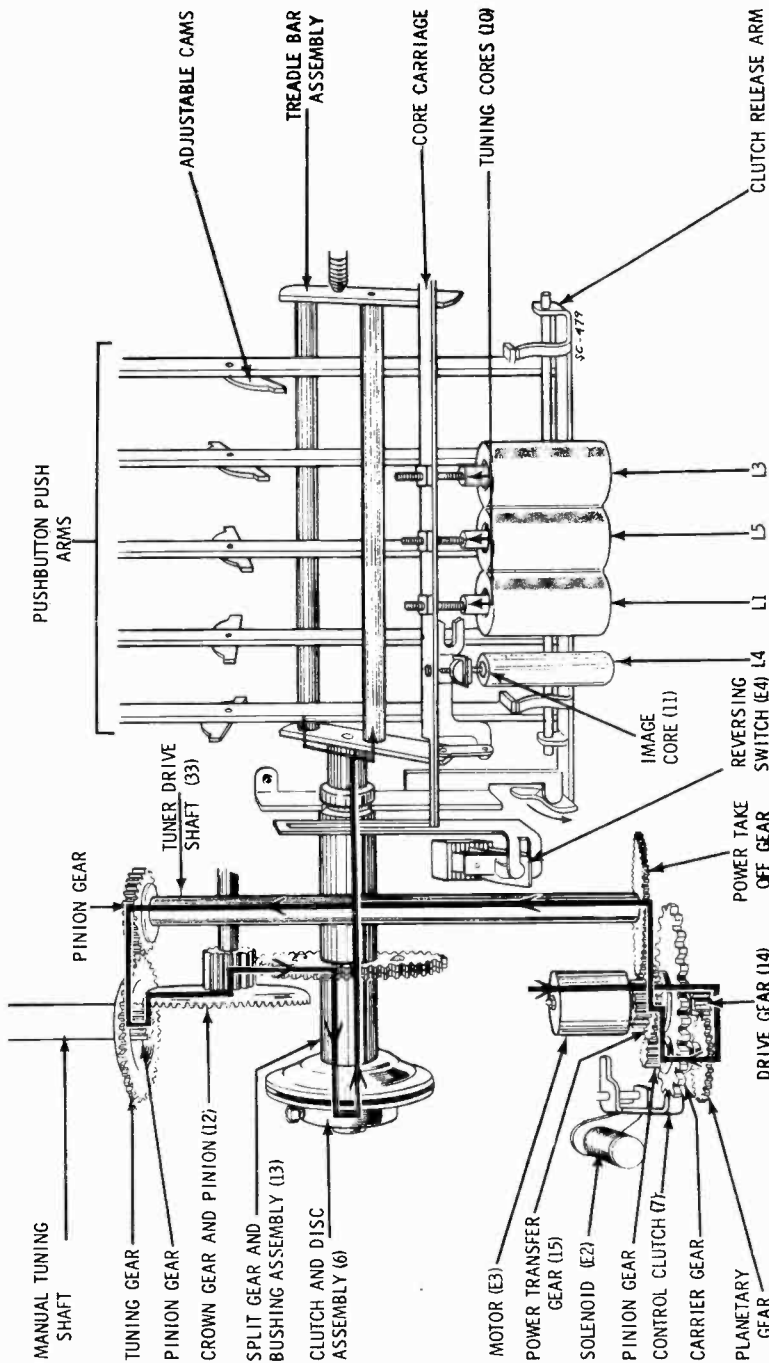


Fig. 520. The tuning slugs in this search tuner are operated by gears which are driven by a motor. (Motorola Consumer Products, Inc.)

chances for an accident becomes a little greater. That is why some auto radios come equipped with search tuners.

The search tuner may be operated by a foot pedal or by pushing a bar on the front of the set to start the search tuner into operation.

The search tuner has a small motor which operates the tuning slugs instead of the knobs or pushbuttons. The effect of this is to cover the broadcast band from the low-frequency to the high frequency end.

In some search tuners, a spring returns the tuning device to the low-frequency end (somewhat like a typewriter return spring) and then the search motor goes into operation once again.

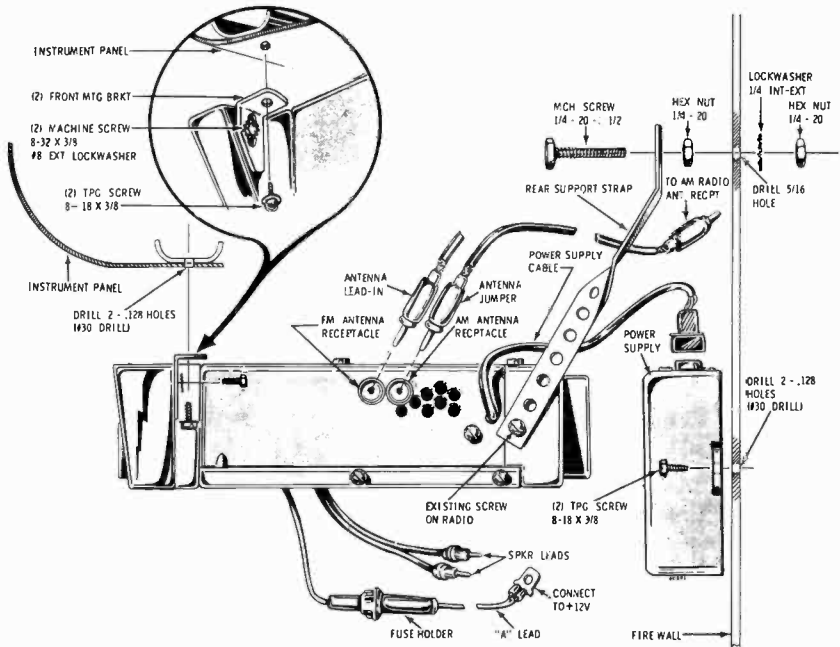


Fig. 521. Mechanical and electrical connections for an auto radio. (Motorola Consumer Products, Inc.)

In other search tuners, the motor is a reversing type so that the tuner sweeps in two directions—from low frequency to high and from high frequency to low.

The search tuner in action

When the search pushbutton or bar is depressed, the search tuner goes into action. Between stations the speaker is muted so

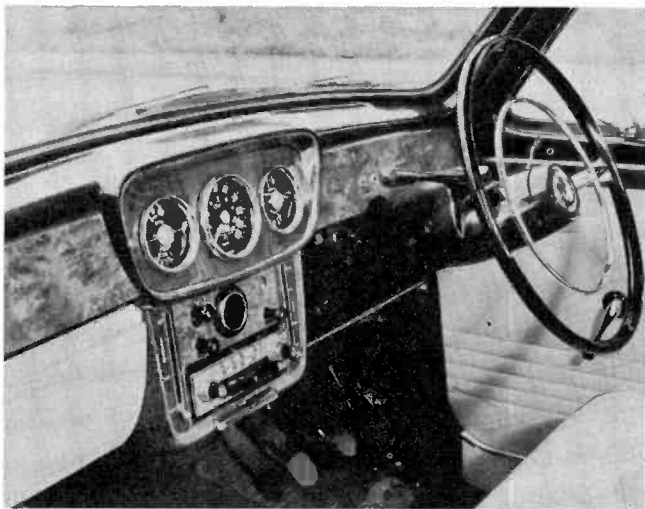


Fig. 522. There are many ways of installing car radios. This shows an installation in a foreign car. (Pye Corporation of America)

that the set is quiet. When a station is found, the search action stops and the speaker is permitted to operate. If the customer doesn't like the program all he needs to do is to touch the search pushbutton or bar once again.

Servicing search tuners

Only the more expensive auto radios come equipped with search tuners. The search tuners are fairly complicated mechanisms and they vary somewhat from one model to the next.

If you have a receiver to service and the search tuner does not work, your best source of information is the service manual supplied by the manufacturer. These come equipped with detailed drawings of the mechanism plus full instructions on how to service that particular model.

A drawing of a search tuner is shown in Fig. 520. The drive motor operates a gear train which moves the slugs (tuning cores) in and out of their coils.

Installation and removal of auto radios

You've probably heard that old saying, "The first million dollars are hard to make. After that, it's easy."

The same thinking could be applied to many auto radios. Once you have them out of the car, servicing isn't too difficult.

When you remove an auto radio, you are taking out part of a car, and the way some of them are installed, you could easily believe that they were never intended to come out.

Types of installation

You will find auto radios installed practically everywhere in the car. You will find some in the glove compartment. In some cars the radio is mounted right on the floor. In many cases, it is installed behind the dash. And a recent transistor type acts as a combined radio and a rear-view mirror.

A complete book could be written just on installing and removing auto radios. For this reason many service technicians are not too anxious to get started in this particular branch of radio

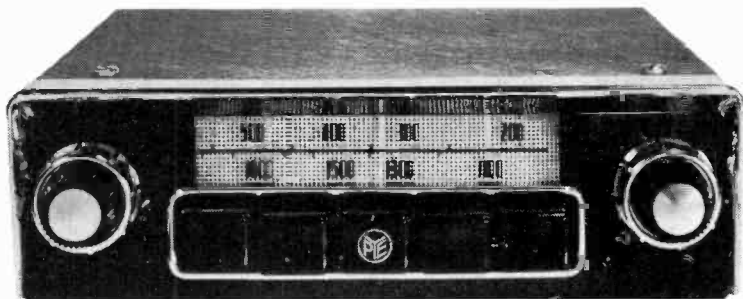


Fig. 523. This auto radio is designed to slide in and out of special compartment. (Pye Corporation of America)

repair. And yet servicing the electronic section of an auto radio requires far more thinking ability.

Installing and removing radios can be learned by doing. If you remove a set, make a mental note of the hardware and where each piece belongs. Note how the set is mounted before you remove it. Use the right tools. A socket wrench is much easier for removing nuts, and much more practical, even though a pair of gas pliers could be used.

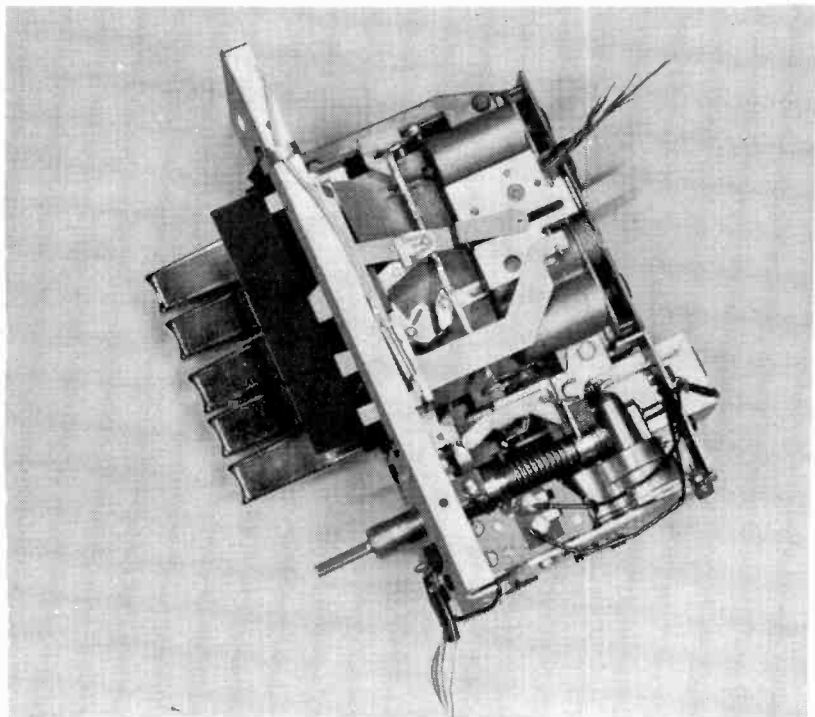
Note how the washers are mounted on machine screws. Watch for screws that are cross-threaded or corroded and replace them.

Fig. 521 shows the installation details for an AM-FM auto radio. This radio is supported by the instrument panel and by a pair of rear support straps holding the receiver to the fire wall.

Not only must you remove hardware, but electrical connections as well. Make your electrical disconnections before you remove

the brackets and other supports, otherwise you will have the receiver hanging by its wires—and that won't do either the receiver or the wires any good.

If you want to be absolutely sure about which wire goes where and you aren't too certain about your ability to remember the electrical connections, tag each one as you remove it. You can

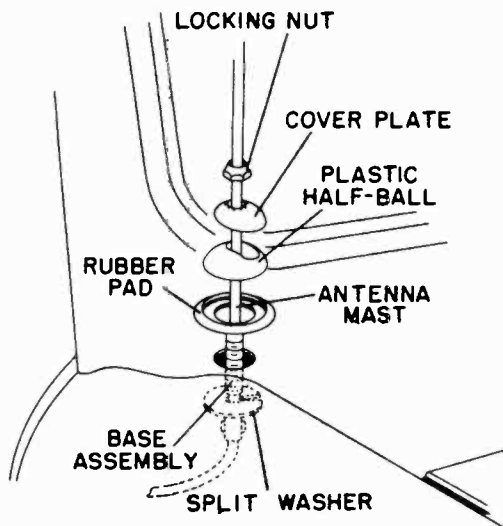


Search tuner troubles can be mechanical, electrical or electronic. A control amplifier (electronic) activates the motor-drive circuits (electrical) that move the tuning slugs (mechanical) that tune in the station. (Delco Radio, Div. General Motors Corp.)

get small tags with strings attached in most stationery stores.

The first wire to disconnect is the lead to the battery. This will avoid the possibility of accidentally shorting the hot battery lead to ground.

After disconnecting the set electrically, examine the way in which the set is mounted mechanically. As you loosen the machine



For antenna installation select the desired cowl mounting location, then center-punch and cut a hole. Feed the lead-in down through the hole. Insert one edge of the split washer into the hole, and twist the base assembly until the washer slips through the hole. Place the rubber pad on the mast, followed by the plastic half-ball, cover plate, and locking nut. Pull up on the mast, and tighten the locking nut while holding the mast in the desired position. (Philco Corp.)

screws, support the receiver so that it will not drop accidentally.

In some foreign cars, such as the one shown in Fig. 522, there is an arrangement for supporting the car radio in a small enclosure below the instrument panel. Here again, examination of the way the receiver is installed will give you the clue as to how it should be removed.

The same receiver is shown out of its compartment in Fig. 523.

Antennas

Auto antennas have many enemies, few friends. It is exposed to vandalism, corrosion, vibration. Some antennas are of fixed length; most are of the telescoping variety. Moving the sliding parts in and out wears away the tight fit the antenna elements must make with each other. Unless the trouble is a minor one, it hardly pays to repair the antenna. A new one can be installed easily, quickly. A typical installation is described at the top of this page.

QUESTIONS

1. What is a sensitivity control? Where would you expect to find it? What does it do?
2. What are some intermediate frequencies used in auto radios?
3. You have whistling and birdies due to trouble in the converter? What can you do to eliminate them?
4. After replacing an output transformer, the receiver whistles and howls? What is wrong?
5. The voltage drop across a decoupling resistor is excessive? What associated component might cause this?
6. A driver stage uses a cathode resistor. What is the effect if this resistor opens?
7. Name one possible cause of trouble in an intermittent vacuum-tube driver stage. What troubles could cause motorboating? Weak sound?
8. An interstage transformer has a primary and secondary winding, but sometimes a third winding is included. What is the purpose of this winding?
9. A receiver has a control marked "collector current adjust." How would you set this control properly?
10. What is a hybrid receiver?
11. What might be the effect of shorting the base of a transistor to ground?
12. What might be the effect if the avc filter capacitor [or capacitors] is leaky?

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