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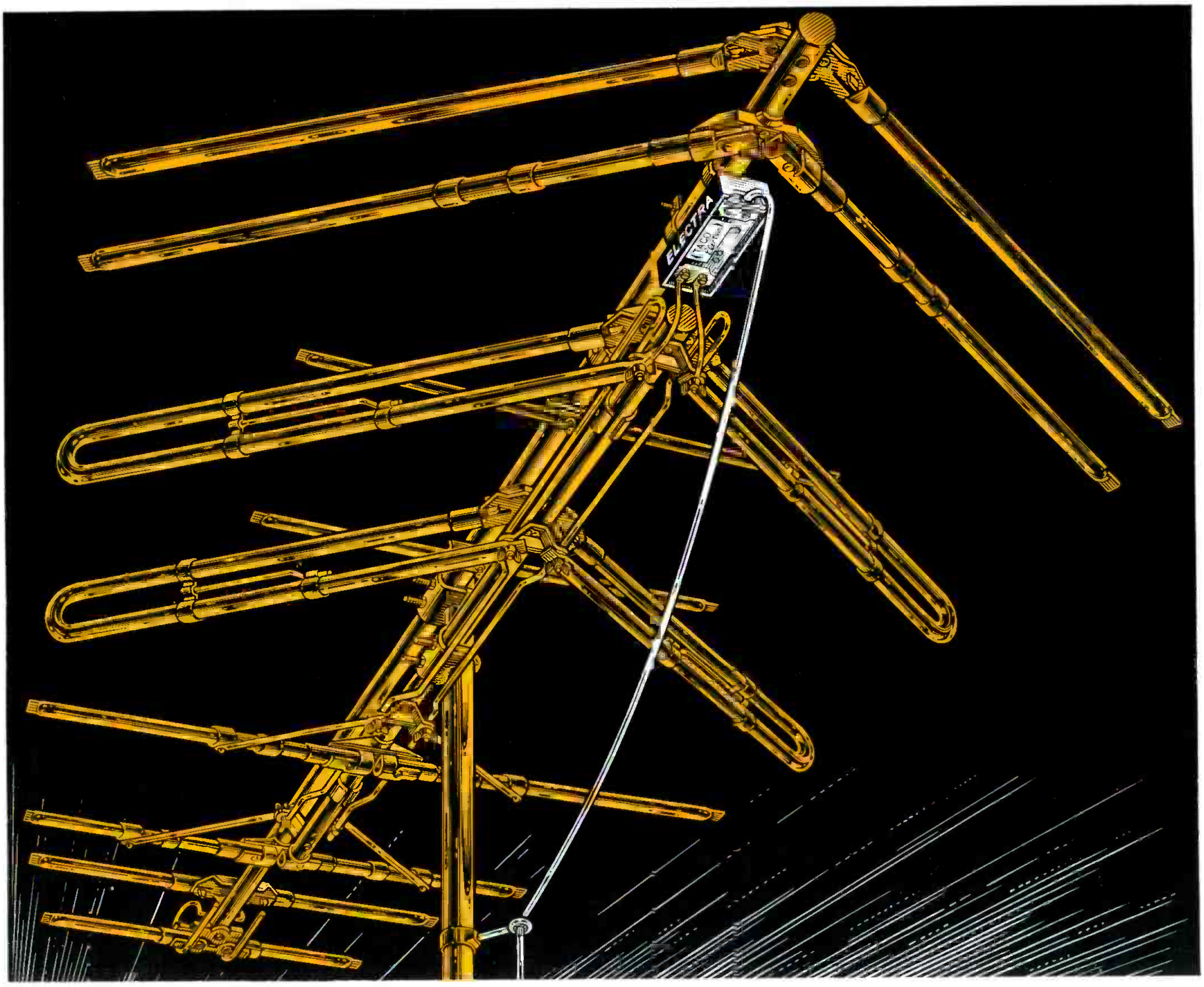


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# KNOW YOUR TRANSISTOR CIRCUITS

***You can learn to figure out how a transistorized stage works, just by looking at the schematic.***

Are you confused by transistor theories which abound with such terms as *holes, donor* and *acceptor* impurities, and *valence bonds?* Perhaps you are worrying needlessly about these concepts. If you are interested in transistors strictly from a servicing standpoint, it is much simpler to think in terms of electrons, since you are already familiar with these concepts from vacuum-tube circuit theory. It is not necessary, when you service transistor equipment, to know all about design theory of transistors, just as you can troubleshoot tube circuits without a knowledge of tube design. So let's take a look at transistors without trying to become design engineers for either semiconductors or the circuits in which they operate.

### Transistor Elements

Transistor elements are formed from two basic materials — P (positive) material and N (negative) material. The P elements take their name from the fact that they contain very few free electrons and as a result have a positive charge. The N elements have an excess of free electrons, and take on a negative characteristic.

In its simplest concept, a semiconductor is formed by joining N and P sections. The result of this union is called a semiconductor diode (two elements), and is most commonly used as a rectifier. If a diode is connected as in Fig. 1A, with P to the positive and N to the negative terminal of a voltage source, electrons will flow across the junction and in the circuit. The junction is then said to be *forward biased*. If the polarity of the bias voltage is reversed (Fig. 1B), the junction will display a blocking characteristic, and there will be no electron flow. Thus, a semiconductor diode conducts readily in only one direction.

### NPN Transistors

Now that you understand the operation of an NP junction, you are ready to consider what happens when a third element is added. In Fig. 2, another N section has been added to the NP combination, forming what we call a transistor. However, the P section of the new unit is much thinner than either N section. This is important to the operation of the transistor. Each section, or element, has a name—the *emitter, base*, and *collector*, as labeled in Fig. 2.

You will notice that two junctions have been formed in this transistor. This gives the transistor certain characteristics of a diode; in fact, it is sometimes considered as two diodes connected "back to back." This concept will simplify the explanation of transistor biasing depicted in Fig. 3. The base-emitter junction of the NPN transistor in Fig. 3A is said to be *forward biased* since it is connected so current flows across the junction. In Fig. 3B, the base-collector junction is *reverse biased,* and blocks current flow. As you will soon see, these bias arrangements are the key to transistor operation.

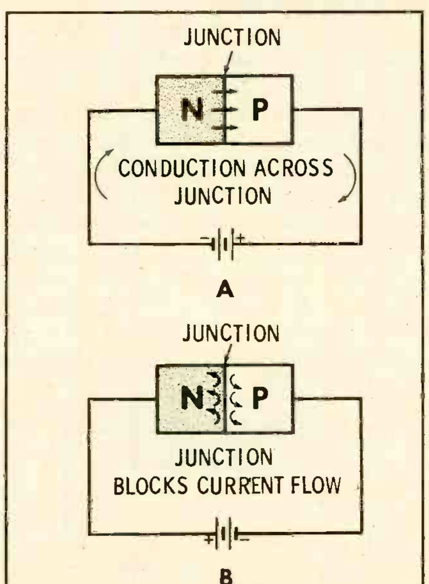


**Fig. 1. Forward bias and reverse bias of a simple NP diode semiconductor.**

A different base-collector bias configuration is shown in Fig. 3C. Here the reverse bias is applied between the emitter and collector, but notice the collector (N material) is still connected to the positive voltage source. Since the negative end of the voltage source is connected to an N material (the emitter), and since the base (P material) is nearer than the emitter to the positive end of the source, the *base-emitter* junction can be considered as forward biased. Therefore, the effect of the negative voltage is transferred across this junction and applies reverse bias to the *base-collector* junction, the same as in Fig. 3B.

Fig. 4 shows two NPN transistors with their bias arrangements. The first (Fig. 4A) is connected in an arrangement known as common-base, and the circuit in Fig. 4B represents a common-emitter connection. In both instances, the collector is biased at a high positive potential. This positive collector bias is essential to the operation of an NPN transistor. The base-emitter junction is forward biased. In order to understand the effects of these bias voltages, let's study the resulting current flow in each circuit.

In the common-base circuit of Fig. 4A, voltage A forward biases the base-emitter junction, and the resultant current flow produces an unusual effect in the *base-collector* junction. As current flows across the base-emitter junction, it causes the base-collector junction to become conductive. The high positive voltage B on the collector attracts the current-carrying elements (supplied by the emitter) within the transistor, and a large collector current flows. In this manner, a very small base-emitter current causes a large emitter-collector current. When the forward bias is removed, the base-collector junction again becomes a very high resistance in the circuit, and collector current ceases to flow.

In the common-emitter circuit of Fig. 4B, the same actions take place. Base-

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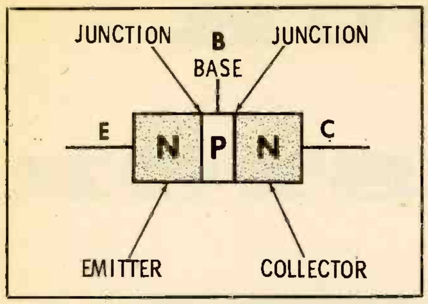



**Fig. 2. Construction of an NPN transistor showing elements and junctions.**

emitter bias current causes the base-collector junction to conduct, and a large collector current flows from the negative to the positive terminal of voltage B.

### PNP Transistors

The elements of PNP transistors differ from NPN types only in the polarity of the diodes (see Fig. 5). A thin layer of N material is sandwiched between two sections of P material. Thus, correct biasing requires voltages which are opposite in polarity from those used with an NPN transistor.

The common-base bias arrangement of a PNP transistor is shown in Fig. 5A. The operation of PNP transistors is the same as NPN types; a very small forward bias current across the base-emitter junction causes a large collector current across the base-collector junction. Of course, the opposite bias voltages cause the direction of flow also to be opposite. However, in either case, when electrons flow, it is from the negative terminal to the positive terminal of the bias-voltage source.

In the common-emitter circuit of Fig. 5B, current flow takes place in the same manner as described for an NPN common-emitter circuit. Of course, the opposite bias polarities cause the flow to be in the opposite direction.

It is important that you remember this characteristic of NPN and PNP transistors. If you are to determine the cause of an abnormal voltage in a transistor circuit, you must consider the normal direction of electron flow in the circuit and be able to analyze whether a voltage change is caused by an increase or a decrease in normal current. This reasoning must be adapted to whichever type of transistor is used in the circuit.

### Amplification

In order to amplify, a transistor must somehow use a small change in voltage, current, or signal to cause a large change in the output-circuit voltage, current, or signal. The schematic diagram of Fig. 6 will help you to understand how this is possible. Let's consider the common-emitter circuit first, since this is the most commonly used configuration.

As mentioned before, if the base-emitter bias (called simply base bias in a common-emitter circuit) is removed, conduction in the collector circuit ceases. If the forward bias is merely increased or decreased, the collector current follows suit, with a small base change causing a large collector variation.

To make use of this current change, some form of load ($R_L$) is inserted in the collector circuit, and the current through it develops an IR voltage drop. If some form of signal voltage (represented in Fig. 6 by generator $S_1$) is introduced into the input circuit—in this case the base-emitter circuit—it adds to and subtracts from the normal base voltage A. The varying voltage results in a varying junction current, and a corresponding large variation of the current through and voltage across collector load $R_L$. By making $R_L$ sufficiently large, a sizable voltage gain can be realized from the current-amplifying characteristics of the transistor, since the output circuit impedance will be much greater than the input circuit impedance.

We can analyze the instantaneous actions and learn exactly what happens in circuits such as those of Fig. 6. In the NPN circuit of Fig. 6A, a positive swing of input signal $S_1$ adds to voltage A and increases the base current. Collector current increases by a much larger amount, and develops a large negative voltage swing across $R_L$, as shown. A negative swing of the input signal would have an opposite effect. Thus, two things are happening to the signal: First, it is being reproduced in the output circuit with a large voltage increase; second, it is being inverted, or receiving a 180° phase change.

Fig. 6B shows a PNP transistor connected in a common-emitter circuit. (An NPN transistor symbol has the emitter arrow pointing *outward;* the PNP emitter arrow points *inward.)* The actions are similar to the NPN circuit, except that certain polarities are different. A positive swing of signal $S_1$ in the PNP circuit subtracts from base voltage A. The current in load resistor $R_L$ decreases, and the normal positive drop across $R_L$ decreases or becomes more negative. This causes the voltage *swing* to have the polarity shown in Fig. 6B.

It is very important to recognize that the negative-going output voltage in Fig. 6B is caused by a *decrease* in the *positive* drop; otherwise, it will be difficult to understand circuit operation. Once you realize the significance of this fact, troubleshooting the cause of DC voltage shifts in transistor circuits will become very simple.

A negative swing of the input signal again causes an opposite effect in the circuit. Thus, you see the primary difference between the NPN and the PNP circuit is in the DC bias voltages; as far as signal voltages are concerned, both types amplify and both types invert the signal from input to output.

### Common-Base Amplifiers

You can understand transistor amplification even better by analyzing the common-base circuits in Fig. 7. A composite waveform signal is used for $S_1$, and demonstrates that no signal inversion takes place in a common-base circuit. When the signal voltage in Fig. 7A is positive at E (with respect to B), it subtracts from bias voltage A. This causes a decrease in collector current, and a corresponding decrease in the voltage across $R_L$. Since the normal drop across $R_L$ is negative, a decrease appears as a positive-going change (less negative), the same as the input voltage. On the next half-cycle, the input voltage adds to the forward base bias, and the collector current increase causes a negative-going change in the $R_L$ voltage drop. Fig. 7B shows a PNP common-base amplifier, whose circuit action is essentially the same; amplification is produced, but with no signal inversion.

Another aspect of amplification can be more readily analyzed in these circuits —that of input impedance vs. output impedance. The secret of the transistor's ability to amplify is that the amount of

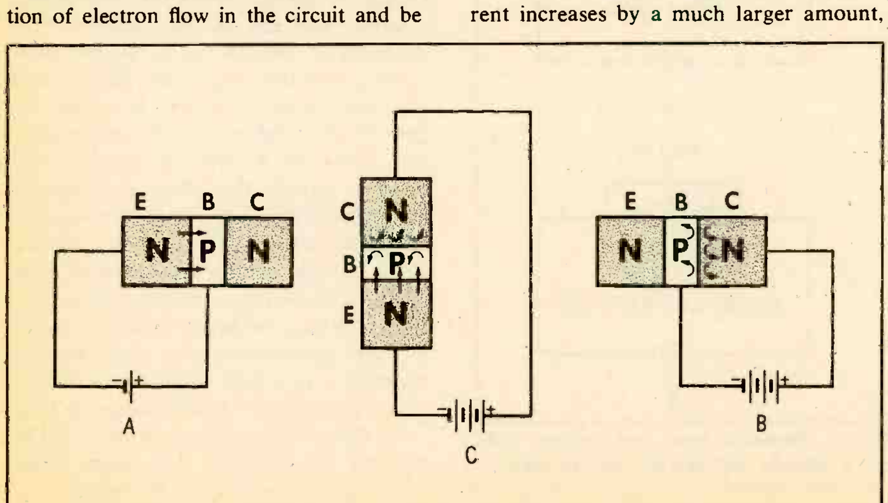



**Fig. 3. Transistor bias arrangements show how junctions conduct or block.**

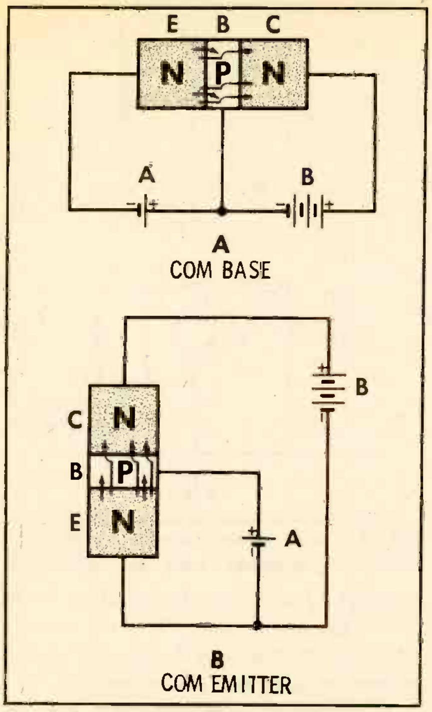



Fig. 4. Common-base and -emitter bias configuration of NPN transistor.

collector current is almost entirely dependent on the base-emitter bias instead of on the base-collector voltage. For this reason, the value of $R_L$ can be made quite large (within limits) without seriously altering the collector current. As $R_L$ is increased, the voltage developed across it also increases. If the collector circuit has a greater impedance than the emitter circuit, more voltage appears across the collector load. This is amplification, and while the transistor is primarily a current-amplifying device, the impedance difference between input and output circuits makes it a practical voltage amplifier. Common-base and common-emitter circuits are both capable of appreciable voltage gain.

### Common-Collector Amplifiers

Common-collector amplifiers are used primarily for impedance matching, since they produce a voltage gain of less than one (unity). However, their circuit characteristics are such that they can be used to demonstrate how one power supply can be used to provide both bias voltages, and make it easier to understand practical circuits.

Fig. 8A shows how bias voltages are applied to an NPN transistor in a common-collector circuit. At first glance, this circuit appears similar to the common-emitter configuration, since the A and B voltages are tied together near the emitter. However, note that load resistor $R_L$ is in the emitter circuit, and the emitter voltage is thus at some level other than the tie point of the two bias-supply voltages. Still, it doesn't look much like the collector is common; we shall resolve this, but first let's briefly analyze the operation of the circuit.

The normal DC voltage drop across $R_L$ has the polarity shown in Fig. 8A. A positive swing of $S_1$ adds to the forward base bias (voltage A) and increases collector current. Since the collector current also flows in the emitter, the voltage drop across $R_L$ shows a corresponding increase, and the emitter end of the resistor becomes more positive. A negative swing of the input signal causes a less-positive voltage across $R_L$ or a negative swing. Since $R_L$ is the output circuit for this arrangement, you can see the output is in phase with the input signal.

Why is there no amplification in this circuit? Load resistor $R_L$ is in the emitter-collector circuit, but it is also between the base and emitter. Thus, any increase in the value of $R_L$ will decrease the forward base-bias current and lower the collector current. For this reason, $R_L$ cannot be made very large; in fact, the output impedance of this circuit is always less than the input impedance, and therefore no voltage amplification takes place. As mentioned before, however, the circuit is used quite often to match a higher impedance to a lower impedance.

Fig. 8B shows a practical common-collector amplifier that uses a PNP transistor. Now you can see why this circuit is called a common-collector arrangement. In the first place, the base is above ground potential because the input signal is developed across R2. Secondly, the emitter is above ground potential because $R_L$ is the load for the output signal. Thirdly, and the main reason for calling the amplifier a common-collector circuit, capacitor C2 keeps the collector at ground potential for the signal. Note the similarity of this circuit to the cathode follower in vacuum-tube circuits; in fact, this transistor circuit is often called an *emitter follower*.

It is interesting to analyze the DC biasing arrangement in Fig. 8B. Instead of using two separate bias supplies, only one power source is used. The B voltage is applied to the collector, as usual. In this case, however, resistors R1 and R2 form a voltage divider across the B voltage. The base is connected to the junction, and the small voltage drop across R2 forward biases the base-emitter junction. R2 is large enough that the bias voltage is greater than the DC voltage developed across $R_L$ at the emitter, For this reason, the input impedance will be larger than the emitter (or output) impedance.

The operation of the circuit in Fig. 8B is the same as that in Fig. 8A, except a PNP transistor is used. A positive-going signal reduces the forward bias, decreases the emitter-collector current and causes a less negative voltage across $R_L$. A negative-going signal adds to the base bias furnished by R2, increases the collector current, and produces a more negative voltage across $R_L$. The signal output is obtained across $R_L$, and is of the same phase as the input signal.

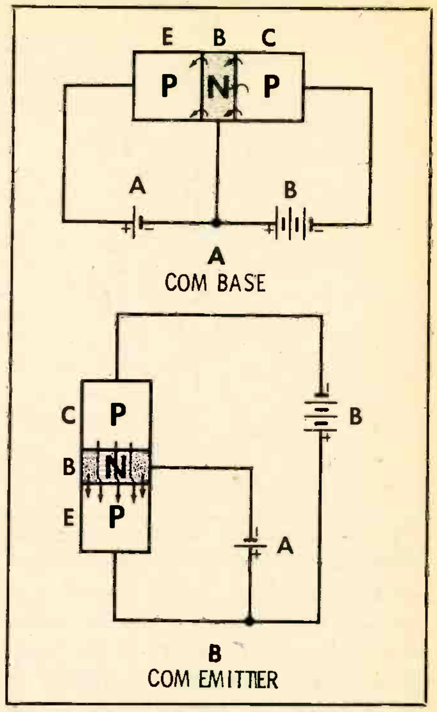



Fig. 5. Bias voltages for PNP transistor are opposite to those of an NPN.

### Practical Transistor Circuits

You have seen and analyzed the three basic transistor circuit configurations, and you recognize the differences between NPN and PNP circuits. Now, let's examine the operation of some circuits found in electronic equipment, particularly those in the most common of transistorized devices, the portable radio.

We shall analyze each circuit from three basic viewpoints. First, we shall identify the type of circuit configuration. Second, we will trace the DC biasing arrangement and learn the various means of obtaining these voltages. Third, we will analyze the signal operation of each circuit. In this way, you will learn to identify and analyze almost any circuit you may encounter in transistorized equipment.

### Audio Amplifiers

Transistor audio amplifiers can be subdivided into three classes, according to their function in the set. Audio amplifiers which drive a speaker must furnish power, so we have transistor *power amplifiers*. The output stage needs a certain amount of driving-signal power, and a low-power amplifier (called a *driver*) does this job. A *voltage amplifier* stage is used to build up the tiny audio-signal voltages from the detector to the level needed to operate the driver stage.

Fig. 9 shows the audio amplifier used in a typical transistor receiver. This circuit uses a PNP transistor in a common-emitter circuit. Don't be confused by

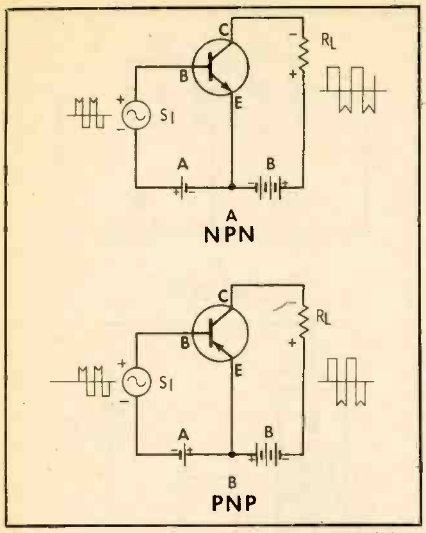



**Fig. 6. Common emitter amplifier causes signal inversion in output load.**

resistor R4 in the emitter circuit; it is bypassed by C2, which places the emitter at ground potential as far as the signal is concerned. The signal is applied to the base, and the output is taken from the collector, offering further identification for the common-emitter configuration.

The high negative collector bias is applied by R5, the collector load. Since X1 is a PNP transistor, the base also must be more negative than the emitter. Voltage divider R2-R3 is connected to furnish minus 1 volt at the base, and emitter current creates a minus 0.8 volt bias at the emitter. The resultant base-emitter forward bias is 0.2 volt, with the base more negative than the emitter.

In operation, the detected audio signal is applied to volume control R1, and a portion is coupled to the base of X1 by capacitor C1. R3 serves as the input-circuit load resistor, between base and ground. The signal variations in the base circuit create large current variations in the collector circuit, and load resistor R5 develops a large signal voltage. C3 couples the amplified signal from R5

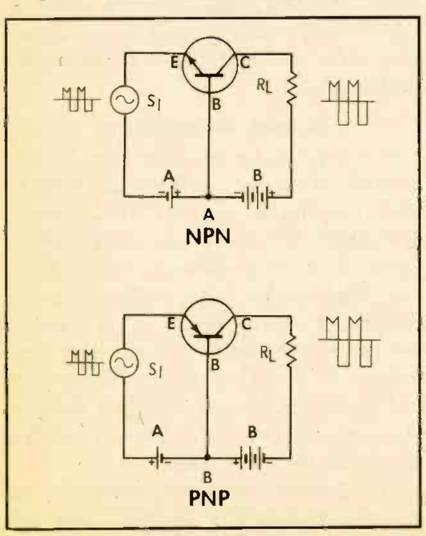



**Fig. 7. Common-base circuits amplify without reversing phase of the signal.**

to the next stage. C4 serves to place the "bottom" end of R5 at RF ground potential and prevent signal voltages from entering the DC supply. C2 holds the emitter at RF ground, while permitting R5 to perform its function of DC biasing the emitter.

This last statement brings up another point. We have talked of base bias and collector bias, but not of emitter bias. To avoid confusion, it is necessary to consider *all* the bias voltages in a circuit. For example, the emitter in Fig. 9 appears to be negatively biased, but the theory of transistor operation tells us it should be positive for a PNP transistor. However, you will notice that it is less negative than either of the other elements; this means, in effect, that it is more positive than the other elements, and this is the condition we need. So it is necessary that each bias voltage be computed as that existing *between* the elements, and not necessarily the voltage from the elements to ground. Thus, the term *emitter bias* means the bias between the emitter and ground, and does not necessarily indicate the base-emitter bias.

This is important to remember, because emitter bias *does* play an important part in some transistor circuits. An emitter-bias network such as C2-R4 is often used for temperature stabilization. If the junction temperature in a transistor becomes unusually high due to either internal or external heat, more current will flow through the transistor. To overcome this effect, C2 and R4 develop a small voltage which opposes the forward bias. If a junction heats and current increases, the voltage across R4 increases and reduces the forward bias, automatically decreasing the current through the transistor.

A typical driver stage is shown in Fig. 10. The signal is applied to the base, the output is taken from the collector, and the emitter is bypassed to ground, all of which stamp the circuit as a common-emitter amplifier. The transistor is a PNP type; therefore, the base and collector should be more negative than the emitter. Let's see if they are.

Voltage divider R1-R2 sets the base voltage at 4 volts with respect to ground. The current flow through the transistor and R3 causes the voltage at the emitter to be 4.2 volts; thus, the emitter is more positive than the base, and a 0.2-volt forward bias exists. The collector circuit is returned to ground through the relatively low DC resistance of transformer T1 (the voltage drop across the winding is only 0.3 volt.) The collector is much less positive (more negative) than the emitter voltage, and satisfies the bias conditions for this transistor.

Capacitor C1 couples the signal voltage from the preceding stage to the base of X1, across input resistor R1. The large collector-current signal in the

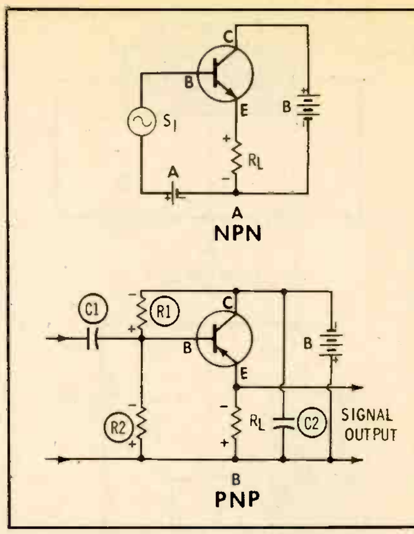



**Fig. 8. There is no gain in a common-collector amplifier and no inversion.**

windings of interstage transformer T1 is fed to the output stage. C2 and R3 stabilize the transistor; C3 bypasses signal voltages around the power source.

The driver stage is very much like the audio amplifier, but its operating characteristics are chosen to cause high signal currents in the load (usually a transformer). The purpose of the driver is to furnish signal power for the output stage and, since power is proportional to the square of the current ($P = I^2R$), a reasonable signal current in T1 will provide a good signal-power input to the output stage. In less-expensive receivers, a circuit such as Fig. 10 is often used as an output stage, and T1 is connected directly to the speaker.

A push-pull Class-B output stage is diagrammed in Fig. 11. Once again we have a common-emitter circuit, since R3 is very small and places the emitters almost at ground potential. Also, the bases and collectors are used as input and output elements, respectively. The transistors are NPN types, as indicated by the arrows pointing outward on the emitter symbols.

If we didn't have a schematic, you could still identify transistor types by the voltages you find on their elements. For NPN transistors, you will recall, the collector and base must be positive with respect to the emitter. Therefore, if you

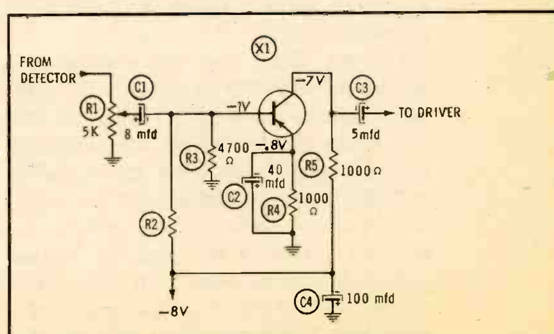



**Fig. 9. This voltage-type amplifier is found very often in transistor radios.**

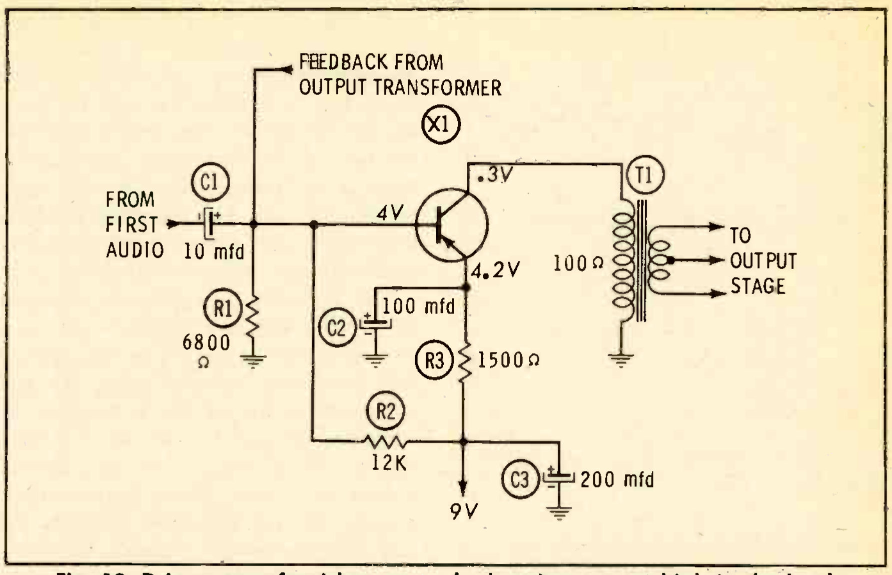



**Fig. 10. Driver stage furnishes power by keeping current high in the load.**

find a transistor circuit in which the collector and base are positive with respect to the emitter, you can safely assume the transistor is an NPN type.

In the circuit of Fig. 11, R1, R2 and R5 set the base voltage for the transistors at 0.2 volt. The DC winding resistance of T1 has little effect on this voltage, since the base currents are almost insignificant. The emitter currents cause a small drop across R3, setting emitter bias at 0.1 volt. Therefore, the forward bias for X1 and X2 is 0.1 volt. The very small winding resistance of T2 causes almost no DC voltage drop in the collector circuit, and the full source voltage appears at the collector.

You'll see something slightly different in the R1-R2-R5 bias network of Fig. 11. R5 is a thermistor, which maintains a constant forward bias on the transistors regardless of temperature variations. This is important since the trasistors are biased just above cutoff and slight bias variations could cause undue distortion. With this bias, the transistors operate as Class-B amplifiers; if the base bias decreased too much, they would approach Class C, and distortion would occur. If the bias became too high, they would approach Class-A operation, and the driver stage would overdrive them, again causing distortion.

The signal applied to transformer T1 from the driver stage is fed push-pull style, to the bases of X1 and X2. The amplified output is developed (push-pull) in output transformer T2 and fed to speaker SP1. C1 is a damping capacitor which prevents inductive transients in the winding of T2 from damaging the transistors. C3 is the power-supply bypass filter.

Feedback network C2-R4 supplies a signal from the secondary of T2 back to the driver stage. Since the feedback is out of phase, it cancels some of the noises and distortions introduced by the audio system. Temperature-compensating resistor R3 also contributes to stage linearity, because it is unbypassed and introduces a small amount of signal degeneration.

## Detector-AVC Systems

Transistor receivers normally use a diode detector such as shown in Fig. 12A. Practically all modern detector circuits include some form of AVC, which is fed to the IF or RF stages to prevent strong signals from overloading the receiver.

The detector-AVC system in Fig. 12A takes the IF signal from T3, and M1 rectifies it, producing both an audio signal and a DC component. Filter C1-R1-C2 removes the IF component from the detector output, and the audio and DC components are developed across volume control R2. Capacitor C3 couples the audio signal to the audio amplifier, and blocks the DC voltage.

The DC voltage, which is proportional to the amount of signal being received, is fed through R3 to the AVC line and to the base of the first IF stage. AVC filter network R3-C4 removes the audio signal from the AVC voltage. R4 is connected to a negative voltage source, which furnishes the normal forward bias for the IF amplifier transistor. When a strong signal reaches M1, the detector DC output (which is positive) "bucks" the bias voltage, lowering the forward bias on the IF transistor. Stage gain is thus reduced and overloading is prevented.

## Transistor Detectors

A transistor detector is shown in Fig. 12B, but its operation is very much the same as that of a diode. The reason is because the base and collector are tied together, and in this configuration, the transistor takes on the characteristics of a diode. Let's analyze the action to see why.

The transistor is a PNP type, as you will recognize by the inward-pointing arrow. You also remember that both the base and collector of a PNP transistor must be more negative than the emitter if the transistor is to conduct. If the base is tied directly to the collector, its forward bias is the full negative collector bias, and the base-collector junction is highly conductive.

Notice that R1, R2, and R3 form a voltage divider for the positive 5.2-volt source, and a slight positive voltage is applied to the emitter. Since the other elements are tied to ground (negative), a very small collector current flows, de-

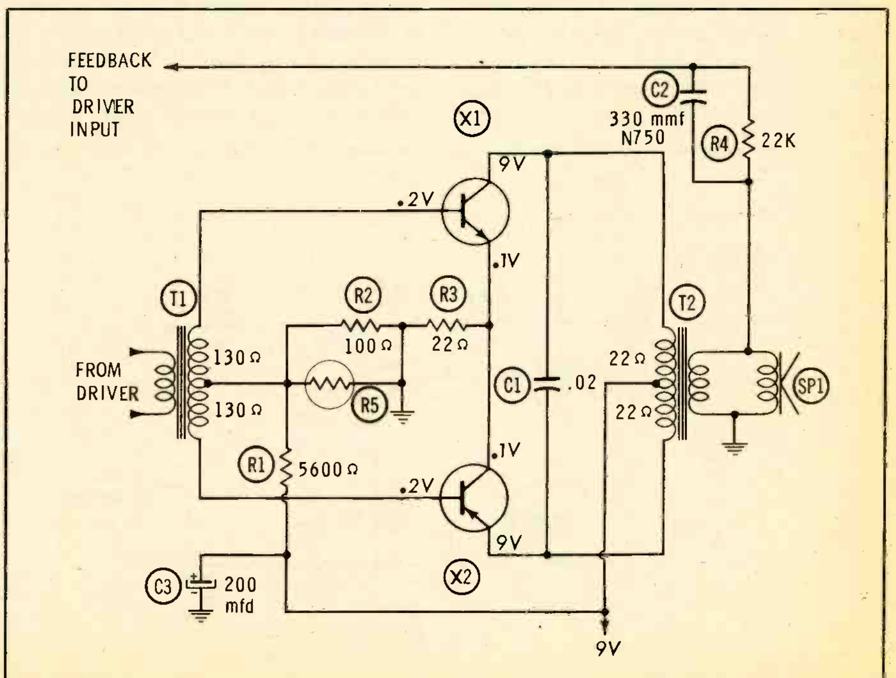
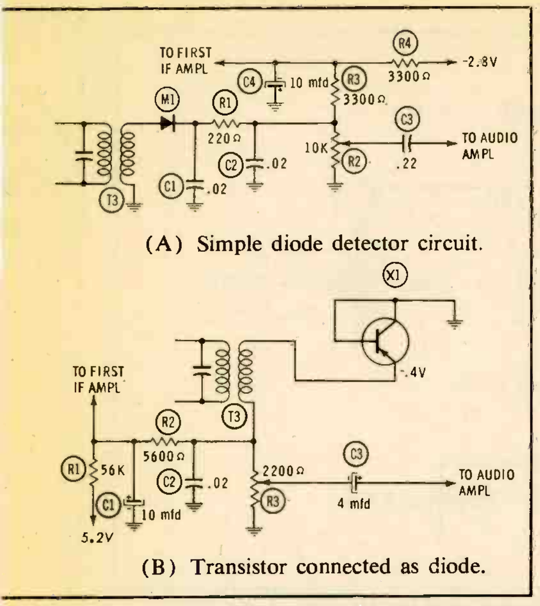



**Fig. 11. Matched transistors add to balance in push-pull output stages.**




(A) Simple diode detector circuit.

(B) Transistor connected as diode.

**Fig. 12. Detectors in transistor radios.**

veloping the slight negative voltage which is measurable at the emitter.

If a signal is applied to T3, the secondary winding develops a varying voltage in the emitter circuit. A positive-going input signal swings the emitter more positive and the transistor conducts heavily. A negative-going alternation biases the emitter more negative than the base and the transistor ceases to conduct. Thus, the transistor acts just like a diode. C2 serves as an IF bypass for detector load R3, which is also the volume control. C3 feeds the signal to the audio amplifier.

When the transistor conducts, a DC voltage develops across R3, opposing the slight positive voltage from divider R1-R2. During no-signal operation, the noise energy reaching the detector causes slight conduction; this AVC voltage barely overrides the bias voltage. When a strong signal is received, the negative AVC voltage opposes the normal IF stage bias at the junction of R1 and R2, reducing the IF gain. R2 and C1 filter audio signals from the AVC line.

In Fig. 13, a PNP transistor, biased as a Class-B amplifier, is used in a common-collector circuit. Negative collector bias is obtained through R5 from the −8 volt source. The emitter and base are held at the same zero potential, so there is no forward bias on the base-emitter junction. The transistor conducts only when the input signal applies a negative-going voltage to the base.

The IF signal is applied to the base of X1. The transistor conducts on negative swings of the signal just like a detector, developing voltage across R3 and whatever portion of R4 is between its slider and ground. C1, R3, and C2 filter the IF components from the output, leaving only audio signal across volume control R4. C3 effectively grounds the collector for signal currents. R2 temperature-compensates the transistor and, in conjunction with R1, maintains the Class-B bias.

Fig. 13 also includes an unusual AVC system. The IF and RF amplifiers receive forward bias from the —8 volt source through R5, R6 and divider networks R7-R8 and R9-R10. When transistor X1 conducts (only while receiving signal), it draws more DC current through R5 and causes a greater voltage drop. Because of this, less forward bias is applied to the RF and IF amplifiers, and their gain is reduced. R6 and C4 remove any audio voltages which exist on the AVC line.

A Class-B transistor detector can easily amplify its audio output. If a common-emitter circuit is used, a voltage gain will be realized in addition to the detector action. In the circuit of Fig. 14, the PNP transistor is Class-B biased to give detector (rectifying) action. The output, which is taken from the collector, is IF-filtered by C1, R3 and C2, and the amplified audio signal is fed directly to the output stage. X1 furnishes sufficient voltage gain and enough power to drive the output circuit with no additional amplification.

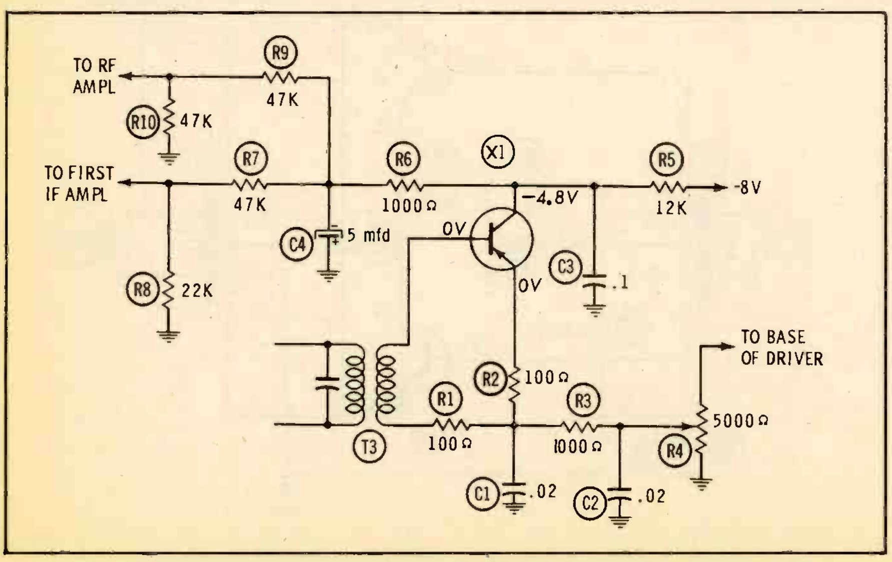



**Fig. 13. Transistor detector includes an unusual AVC-circuit arrangement.**

## IF and RF Amplifiers

IF and RF transistor amplifiers are very similar to each other. In common usage, about the only difference is that RF amplifiers must be tunable, while IF stages are fixed-tuned. Otherwise, they both amplify signals which are practically alike. We will examine several types of IF amplifiers and remember that RF stages operate in pretty much the same way.

Fig. 15 includes several different circuit arrangements for IF amplifiers. For example, the first and second stages use NPN transistors, while the third uses a PNP type. The coupling between the second and third stages is not only untuned, but is direct as well. L3 represents an autoformer type of IF coupling, a different approach than the usual transformer coupling. The first stage is AVC-controlled, while the other two are examples of uncontrolled IF amplifiers.

First, let's analyze the power supply arrangements in these circuits, and see how each transistor receives its bias voltages. The power source for the entire group is a positive 5.6 volts. X1 receives its 0.4-volt base bias from the junction of R1 and R10. Emitter bias is developed across R2, and amounts to 0.2 volt. The difference between these two voltages is the base-emitter bias for X1, and since 0.4 volt is more positive than 0.2 volt, the junction is forward biased. R3 applies positive bias to the collector through the winding of L2.

In the second stage, R4 and R5 divide the source voltage to furnish 1 volt of base bias for X2. R6 develops 0.75 volt of emitter bias, creating a forward bias of 0.25 volt for NPN transistor X2. Collector bias for X2 is a bit more complicated to analyze, since X3 has some effect. Essentially, however, R7 and its parallel path (R8 and the forward junction resistance of X3) carry the supply voltage to the collector of X2. 4.6 volts develops at the collector and at the direct-coupled base of X3.

The emitter resistor of X3 drops the supply voltage to 4.8 volts at the emitter. Since the voltage at the base of X3 is 4.6 volts, it is more negative than at the emitter, and X3 is forward biased. (X3 is a PNP transistor, remember?) The collector is returned to ground through the winding of L3, placing it at a much less positive (high negative) potential.

The operation of these IF amplifiers is very uncomplicated. The IF signal from the mixer or converter is coupled to the base of X1 by L1. C2 keeps the low end of L1 secondary at the same signal potential as the emitter, so temperature-compensating resistor R2 will not cause degeneration. C3 performs the

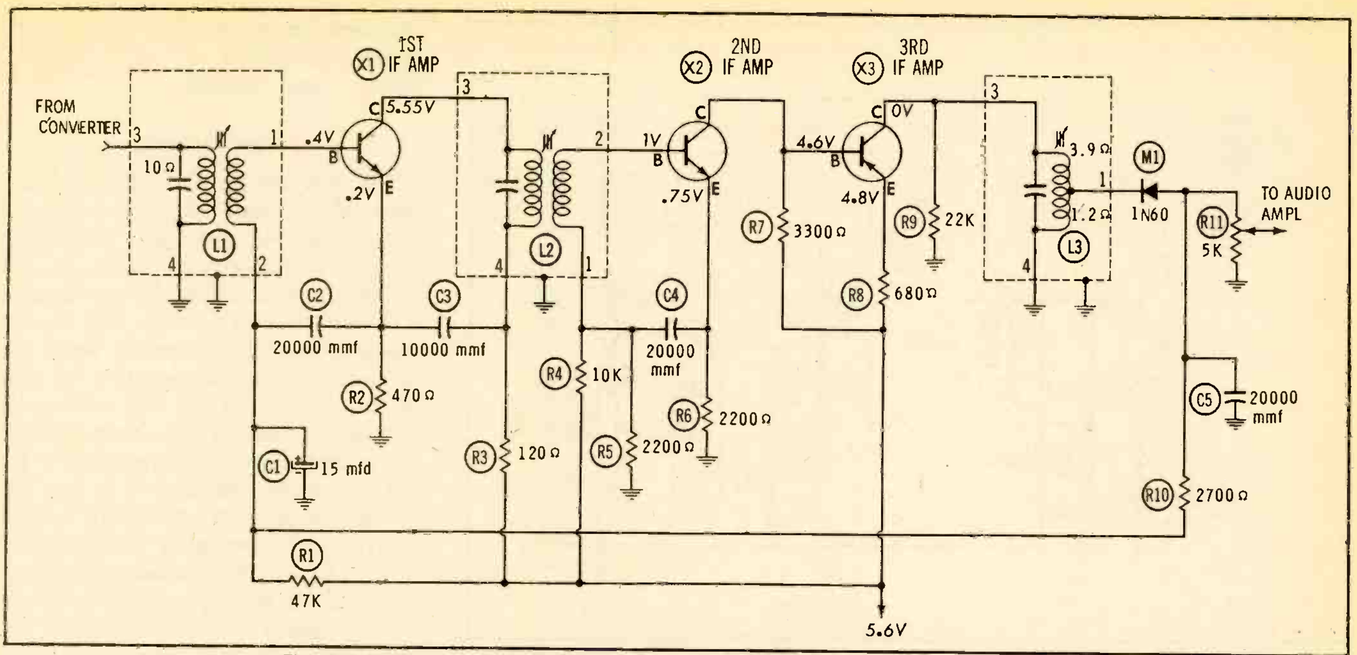



**Fig. 15. IF system uses a wide variety of IF amplifier circuit configurations.**

same bypass duty for the tuned primary of L2, which is the collector load for X1.

In the second IF amplifier, signal voltages are treated the same as in the first stage. L2 couples the signal to X2 and C4 prevents R5 and R6 from causing any signal degeneration. The amplified output is developed across collector load R7 and connected directly to the base of X3, without benefit of a tuned circuit.

R8 in the emitter of X3 is unbypassed, and does add a little degeneration. This improves the noise and distortion characteristics of the stage, as does the direct coupling from the preceding stage. The collector load for X2 is tuned autoformer L3, shunted by resistor R9. R9 slightly loads L3, providing a broader bandpass for the high-Q tuned circuit.

The detector circuit is included merely to show how the first IF amplifier is AVC-controlled. The forward bias for X1 is determined mostly by the divider consisting of R1, R10, and R11. When a strong signal reaches detector M1, a positive DC voltage appears at the junction of R10 and R11, and is proportional to the strength of the incoming signal. This opposes the normal base bias on X1, lowers its forward bias and reduces the stage gain. C5 is the IF filter for the detector circuit, and R10 and C1 are the AVC filter components.

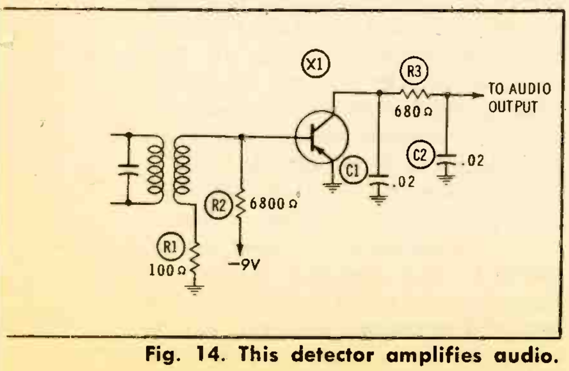



**Fig. 14. This detector amplifies audio.**

## Oscillators and Mixers

Transistor oscillators are very much like tube-type oscillators in their manner of operation. To sustain oscillation, a transistor circuit must provide: amplification, an in-phase feedback arrangement, and a tuned circuit to set the frequency of oscillation. The transistor circuits in Figs. 16 and 17 meet all these requirements.

Fig. 16 shows a PNP transistor in a common-base oscillator circuit. The common-base configuration is recognizable because the load is in the collector, the feedback is to the emitter, and C1 holds the base of X1 at signal ground.

Close examination of the biasing arrangement will reveal that the base-emitter junction is reverse biased. This Class-C bias is common in transistor oscillators, and causes the transistor to operate more efficiently. R1 and R2 set the base bias at –0.4 volt, while emitter current causes a voltage drop of –0.7 volt across R3 and R4. Thus, the net base-emitter bias is –0.3 volt, and since the emitter is more negative than the base, the PNP transistor is reverse-biased. Collector voltage is supplied through R5 and part of L1.

Circuit action starts with the initial rise of collector current before emitter voltage builds up to cutoff. The current through L1 excites the tuned circuit consisting of L1, C5, and M1 (the tuning capacitor). C4 completes the signal circuit for L1. The oscillatory action in the tank circuit is coupled into the feedback winding of L1, and applied to the emitter of X1 across R3-R4. C1 and C3 complete the signal circuit between base and emitter, and the applied signal reduces the emitter voltage to a point below the –0.4 volt base voltage. The resulting forward bias causes a rise in collector current through L1, and the action continues.

The downward excursion of the signal cycle begins when the forward bias reaches a point (saturation) at which collector current ceases to rise, the field in L1, collapses, the emitter bias increases toward the reverse-bias region, and the collector current drops off. This causes the emitter bias to become even more negative, and the action builds up until cutoff is reached. Feedback from the oscillatory action in the tuned tank circuit keeps the rise and fall continuing as long as power is applied to sustain circuit losses.

C2 takes a portion of the signal developed across unbypassed resistor R4 and feeds it to the mixer circuit where it combines with the incoming station signal to develop the intermediate frequency. The collector is connected to a tap on L1 so the high-Q tuned circuit is properly matched to the lower impedance of the transistor.

Fig. 17 shows a common-emitter PNP oscillator which uses inductive oscillator feedback along with inductive coupling to the PNP mixer. Oscillator transistor

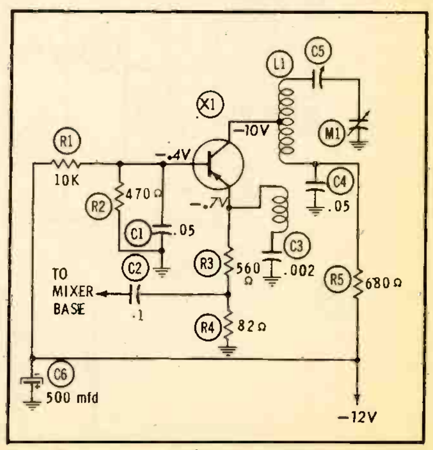



**Fig. 16. Common-base oscillator uses a tickler coil for feedback to emitter.**

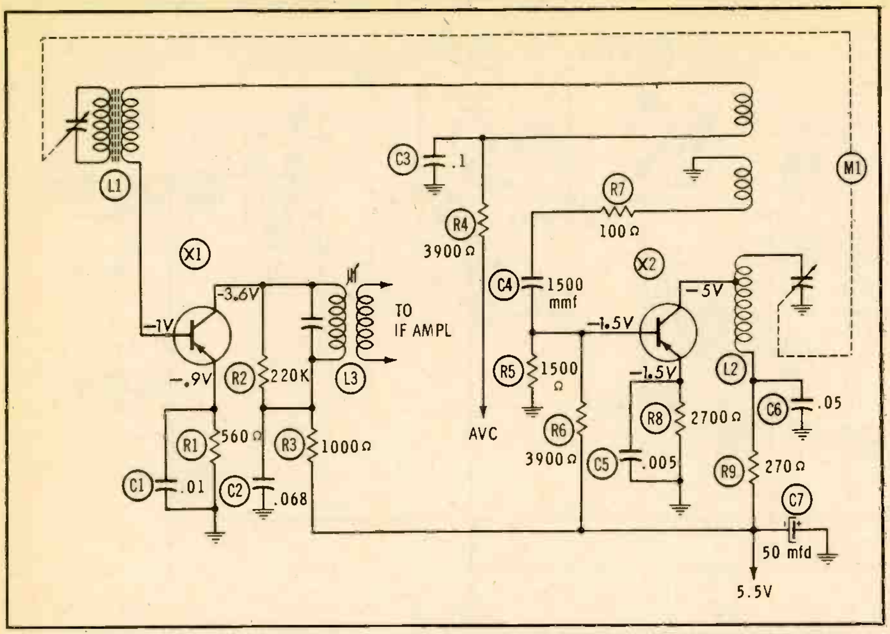



Fig. 17. Oscillator-mixer-RF stage uses coil for feedback and mixer injection.

X2 is Class-B biased, with the base and emitter at the same bias voltage. R6 and R5 set the –1.5-volt base bias, and R8 utilizes emitter current to hold the emitter at –1.5 volts. R9 and the tank winding of L2 feed the reverse bias to the collector.

Mixer transistor X1 receives –1 volt of base bias from the AVC line through R4. (Remember, most AVC networks include a voltage divider which sets the no-signal bias on the AVC line.) The –0.9 volt emitter bias is developed by R1. R3 and the primary of L3 carry the high collector bias to the transistor. You will notice the base-emitter junction of X1 is forward biased.

Oscillator operation is the same as for the circuit in Fig. 16, except base instead of emitter feedback is used. The oscillator signal is coupled by the output winding of L2 to the mixer circuit; C3 keeps the low end of this winding at RF ground. To reach the base of mixer transistor X1, the oscillator signal must go through the secondary of antenna coil L1. The station signal, tuned by M1 in the resonant primary of L1, is also fed to the base of X1. Both signals combine within the transistor, producing the usual mixer products. Tuned IF coil L3 chooses only the IF component in the output and couples it to the first IF amplifier. C2 keeps the bottom of the IF-coil primary at signal ground and, with R3, prevents signals from being coupled into the power-supply lines. C1 in the emitter circuit prevents temperature-compensating resistor R1 from causing signal degeneration. C7 is the power-supply bypass capacitor.

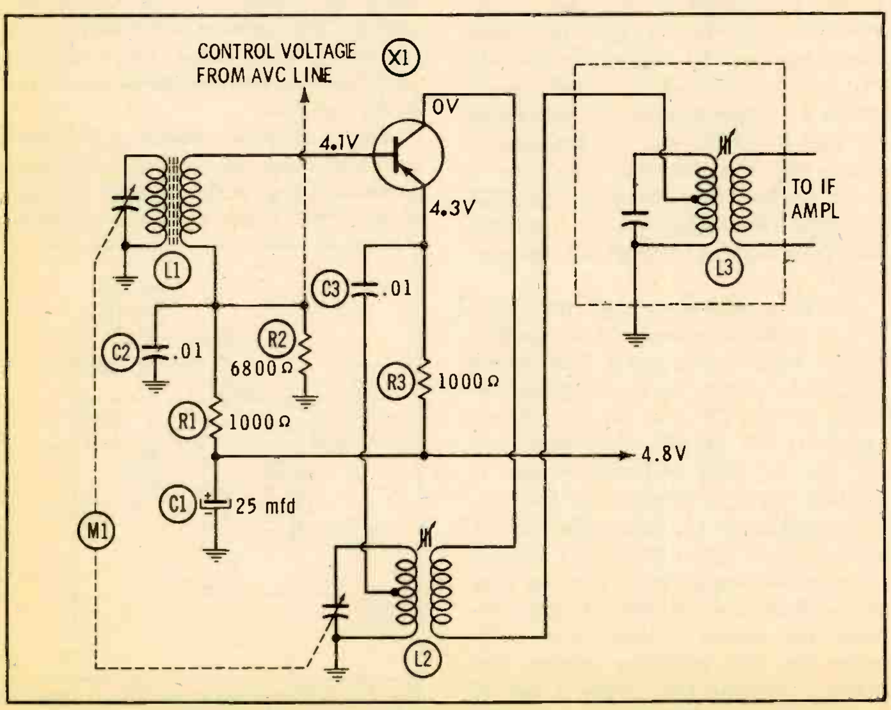



Fig. 18. One transistor serves as an oscillator, mixer and RF amplifier.

## Converters

The converter circuit of Fig. 18 combines the oscillator and mixer into one circuit. The PNP transistor is a high-gain RF type which oscillates readily. R1 and R2 set the bias voltage for the base at 4.1 volts, and R3 drops the 4.8-volt supply to the 4.3-volt level at which the emitter operates. This provides 0.2 volt of forward bias for X1. The collector is returned to ground (negative) through the secondary (feedback) winding of L2 and the primary winding of IF coil L3.

The operation of the circuit is best analyzed by considering the oscillator action first, and then examining the mixer function. The first surge of collector current through L2 excites the tuned primary circuit. A bit of this signal is fed to the emitter by capacitor C3. This develops a signal voltage across R3 which varies the normal forward bias, creating an amplified signal current in the collector circuit. The feedback winding of L2 couples some of this energy back to the tuned primary and sustains the action. The tuned primary of L2 determines the signal frequency generated in the circuit, and a section of tuning capacitor M1 tunes the primary winding.

Meanwhile, the station signal is tuned in by M1 and L1 (a loopstick antenna) and is applied to the base of X1. C2 holds the other end of L1 secondary at signal ground, to eliminate degeneration across R1 or R2. The RF signal at the base and the oscillator signal at the emittter both affect the collector current; the result is a mixing action in the output. Remember, a mixer produces four outputs — the RF and oscillator signals, plus their sum and difference frequencies. The secondary of L2 and the primary of L3 are in series with the collector, so all these signal currents flow in both coils. The tuned circuit of L2 chooses the oscillator signal for feedback purposes, and L3 separates the difference frequency for the IF amplifiers. Thus, one transistor performs the functions of both oscillator and mixer.

If it were desired to control the RF gain of the converter transistor to prevent overload on strong signals, AVC could be applied as shown in Fig. 18. This would control the gain for RF signals, while having little effect on the oscillator. This is explained by the fact that, as an oscillator, the circuit operates with a common base, but as a mixer-RF amplifier it is a common-emitter circuit.

If you understand the biasing and operation of these transistor circuits, you should have very little problem analyzing and troubleshooting any circuit you encounter in the ordinary run of servicing.

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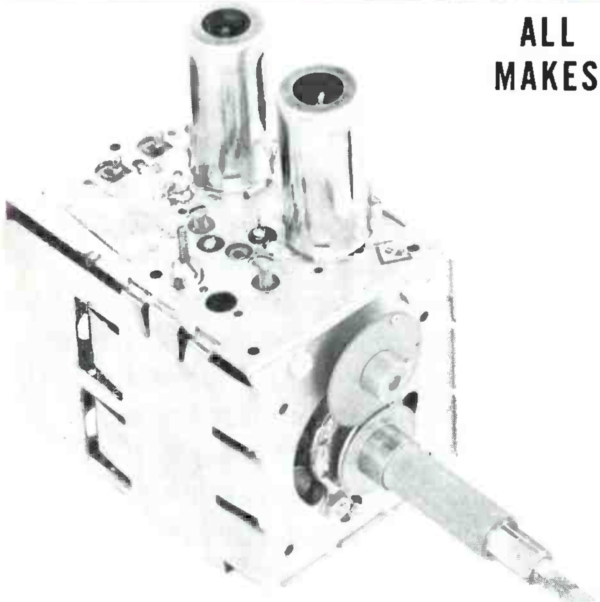

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# PF REPORTER
## including Electronic Servicing

*VOLUME 12, No. 3* — *MARCH, 1962*

## CONTENTS



### ABOUT THE COVER

The transistor's star is rising. Uses for this component are multiplying and spreading into all areas of electronics. To underscore the importance of this development to servicemen, we are dedicating this entire issue to transistors and the equipment in which they are used.

# LETTERS TO THE EDITOR

*Dear Editor:*

On page 25 of your January issue, you show a listing of various brand names for transistor radios, with the name of the importer or manufacturer of each.

Under the brand name *Coronado,* you have shown our address to be 15 North Third Street, Minneapolis. This was evidently a typographical error. Our correct address is 15 North Eighth Street, Minneapolis 3, Minnesota.

GERHARDT LANGE

Gamble-Skogmo, Inc.
Minneapolis, Minn.

*Glad we don't have to crawl those five blocks on our knees to apologize! We also located the General Electric Radio Receiver Dept. at 869 instead of 1001 Broad St., but they moved when we weren't looking!—Ed.*

*Dear Editor:*

For some time, I have considered starting a small antenna-installation business. Therefore, I would like to know if any of the ads in your "Service Dealer Advertising Program" apply to this specialty.

CHARLES N. FALLETTA

Buffalo, N. Y.

*The illustration for Ad Group 5 on page 67 of our January issue showed an ad that should be just fine for your purposes. For additional ideas, check "There's Big Money in the Antenna Business" (December issue). The check list on page 45 of that issue could serve as a basis for your own advertisements or handbills.*

*In addition to advertising, check with other TV shops in your area who would be willing to refer all their antenna work to you.—Ed.*

*Dear Editor:*

I fail to agree that your PF REPORTER is the best in its field. Please cancel my order immediately.

GEORGE W. PRATT

Newberg, Ore.

*Dear Editor:*

PF REPORTER has been one of my favorite magazines for a long time. I have also completed the color-TV course presented in PHOTOFACTS, and would like to congratulate you on it. It is the most complete and up-to-date course I have seen yet. I'm now looking forward to the second-class radiotelephone course and others to follow.

JOHN KAPSAR

Glassport, Pa.

*Dear Editor:*

I just got through reading my January issue, and I think PF REPORTER is the greatest electronics servicing magazine I've ever read. I'm enclosing $3.50 for seven back issues I'd like to have.

J. B. HENRY

Santa Rita, N. M.

*Dear Editor:*

I have been a subscriber for over a year now, and can say that PF REPORTER is the best magazine in its field yet. I have found it useful and would not want to be without it.

STEPHEN DOLYNIUK

Steve's Radio & TV
Belfield, N. Dak.

*Sorry, George, but a show of hands indicates the "ayes" have it by an overwhelming majority.—Ed.*

*Dear Editor:*

I am a new subscriber, and truly have made good use of PF REPORTER. If at all possible, could you do an article on tape recorders and their common problems?

ANDREW W. DRUGA

Andy's Radio & Television Shop
Pittsburgh, Pa.

*We've done it before, and we can do it again! While our next article is in the works, we'd like to call your attention to several past coverages on the subject—"Servicing Tape Recorders (March, 1961), "Regular Recorder-Repair Routines" (July, 1960), and "Care of Tape-Transport Mechanisms" (May, 1960).—Ed.*

*Dear Editor:*

This is in answer to Mr. Stanley Caldwell's request for information regarding TVI from CB units in his area (January *Letters*). Since we have been in CB service almost from the beginning of 27-mc operation, we feel qualified to point out a few possible reasons for his troubles.

Mr. Caldwell failed to state what TV channel or channels were bothered, and whether it was picture or sound interference. In no case have we ever ex-

## Have You Seen This Man?

**Ronald Willis Terrentine** is being sought by the FBI for Unlawful Flight to Avoid Confinement for the crime of armed robbery. He may be employed as a radio or TV technician, since he took courses in electronics while an inmate of the Ohio State Penitentiary.

A Negro American, born at Cleveland in 1921 or 1923, he is 5′ 6½″ tall, approximately 170 lb., has black kinky hair, brown eyes, a medium build, and may wear eyeglasses. Scars are on his right thigh, left side of upper lip, center of back, and back of right shoulder; he also has a bump on his right shoulder and two dog-bite scars on his right leg. Aliases include George Collins or Melvin Collins.

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| M. A. Dill, Jr., 20 Cherry St., Gardiner, Maine | 1st | 12 |
| Bernhard G. Fokken, Route 2, Canby, Minn. | 1st | 12 |
| Kenneth F. Foltz, Broad St., Middletown, Md. | 1st | 12 |
| James C. Greer, Mound City, Kansas | 1st | 12 |
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| Clyde C. Morse, 7505 Sharronlee Dr., Mentor, Ohio | 1st | 12 |
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I am interested in: ☐ Home Study, ☐ Resident Classes 29-C perienced picture TVI from properly designed and adjusted CB units, except at extremely close range (a block or less). Even a correctly-operated CB transmitter can cause sound interference if the TV receiver picks up a sufficiently strong CB signal. This effect is due to rectification in the high-impedance grid circuits of the TV set: it could even occur in AC-DC radio receivers or in some hi-fi sets. Generally, this condition can be eliminated by adding a small bypass capacitor and/or choke in the affected grid circuit. This remedy has been covered many times in various ham journals and technical publications.

Sometimes the TVI is the fault of the CB unit and not that of the TV set. We have, on occasions, encountered CB units that were loaded beyond their ability—not to mention the legal limitations set by the FCC. The output of these transmitters was extremely rich in harmonics, as well as FM components, that might fall anywhere in the frequency spectrum. In addition, certain brands and models of CB equipment without a low-pass filter in the antenna feed line will radiate a strong second harmonic of approximately 54 mc, which is very close to channel 2. It might be possible for a 27-mc signal to get into the IF strip of an older 21-mc TV set, but to date we have not experienced this problem.

ED WALTER

Ed's Radio Shop
Beloit, Kansas

*Dear Editor:*

In reply to Mr. Caldwell's letter on CB interference, the first thing to try is a good high-pass filter, installed as close to the TV tuner as possible. If this does not cure the interference problem, the first audio tube of the TV set may be rectifying the CB signal: in such cases, I have found a 47K-ohm resistor in series with the grid lead to be most helpful. If the disturbance is video, rather than audio, and the filter does not clean it up, the video IF's may have to be shifted in frequency.

It may also help to replace the TV antenna or to move it as far as possible from the CB antenna.

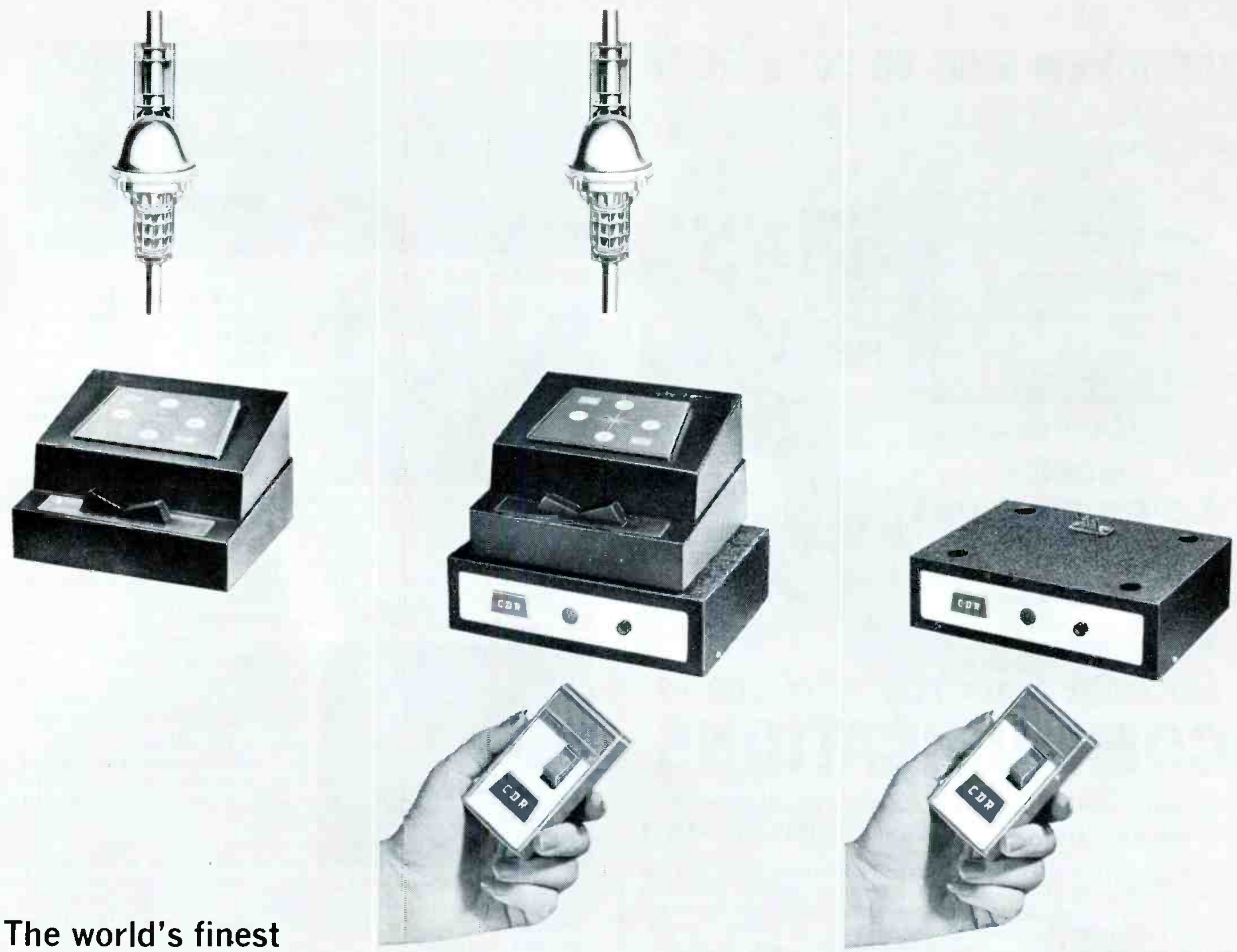
Since the CB transmitter is limited to 5 watts input, it is unlikely that it is capable of much fundamental overloading. Also, the second harmonic falls no higher than 54.510 mc (barely at the lower edge of TV channel 2), although the third harmonic does fall very close to the video-carrier frequency on channel 6.

The above comments presuppose that the CB transmitter is properly filtered and is using a good matched line and antenna. If the CB'er's own TV set has no interference, his transmitter is usually accepted as satisfactory by the FCC inspectors, and the complainant's TV set is regarded as defective or improperly installed.

LON TONIK, W3DVB

Philadelphia, Pa.

*Many thanks to both of you. Your suggestions will help CB'ers and TV men to cooperate in clearing up interference problems.—Ed.*

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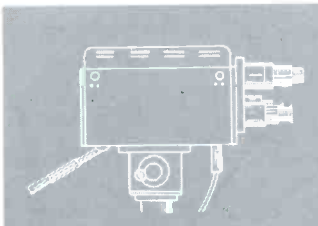


# The Electronic Scanner

### *Jerrold Acquires Pilot Radio*

Mrs. Isidor Goldberg, widow of the late founder and owner of **Pilot Radio Corp.**, is shown signing a contract by which **Jerrold** purchased the firm. Also shown are Sidney Harman, Jerrold president, and Leon A. Munchin, Mrs. Goldberg's counsel. Pilot will be operated as an autonomous company.

### *Expansion of Color-Tube Facilities Planned*

An anticipated 250% increase in industry demand during 1962 is the reason given for a $1.5 million expansion planned by **RCA** for its color TV picture tube manufacturing facilities located at Lancaster Pa. The additional facilities should be in full operation during the second half of 1962.

### *Sams Co. Receives NATESA Award for 1961*

For the ninth consecutive year, **Howard W. Sams & Co. Inc.** has received the "Friends of Service Management Award" from NATESA (National Alliance of TV and Electronic Service Associations. The award was personally presented to Mr. Sams (second from right) by Ralph Woertendyke, NATESA president. Also on hand for the presentation were Frank Moch, Executive Director of NATESA (far right), and John Stefanski, Secretary General. The plaque reads, "Presented to Howard W. Sams & Co., Inc. for outstanding service in creating better customer relations."

### *Stromberg-Carlson Auto Radio Sold*

The purchase of the **Stromberg-Carlson** auto radio operation from **General Dynamics Corp.** was recently announced by the **Tenna Mfg. Corp.** Production facilities in Rochester, N. Y. will be continued with most administrative and production personnel being retained. Auto-radio distribution will be maintained through the numerous established franchised distributors, both domestic and foreign.

### *Cartridge and Needle Sales Aids Offered*

"Window blind" wall charts, cartridge dispensers, and storage bins are among the sales aids offered by **Electro-Voice** in a new cartridge and needle promotion program. Also included are counter-top displays, wall banners, and plastic tray merchandisers. Most of the aids will be provided without charge with qualifying needle and cartridge orders.

### *Transistor-Radio Replacement-Parts Program*

Such diverse and minute components as capacitors, dial needles, oscillator coils, transformers, and battery clips, are catalogued in detail on a spare parts list published by **Channel Master Corp.** The list cross-indexes all of the company's radios and indicates the types and quantities of components used in each set.

### *New Microwave Catalog Announced*

A complete new catalog (Bulletin 620) has been issued by **Mark Products** describing their line of microwave antennas and accessories. Among the items shown are parabolas designed for use at frequencies from 400 to 12,700 mc. In addition, the brochure shows pictures of the company's design and manufacturing facilities in Illinois.


Tung-Sol "ET" transistor packages are marked to eliminate guesswork in selecting the correct replacement for every job. Type numbers, class of service and junction polarity is stamped on each end flap. This is a time saving feature as well as a safeguard against service slip-ups. Tells you at a quick glance where your inventory stands.

The compact "ET" line was engineered by Tung-Sol specifically to eliminate confusion in entertainment service resulting from almost endless similarity and duplication of types. Eleven PNP and NPN units replace hundreds of older transistors. "ET" transistors measure up fully to Tung-Sol's one high standard of excellence and reliability. The most advanced quality evaluation techniques assure product uniformity, lot after lot.

When you order transistors, specify "ET." High turnover with low inventory and customer satisfaction will show that it's the profitable way to buy transistors. Tung-Sol Electric Inc., Newark 4, New Jersey.

**TUNG-SOL®**

**A TYPE FOR EVERY JOB**

**PNP TYPES**

**Low power**
- ET1 Mixer/oscillator/converter
- ET2 IF amplifier
- ET3 AF amplifier 6v.
- ET4 AF amplifier 12v.
- ET5 AF amplifier 9v.

**Medium power**
- ET6 AF power amplifier

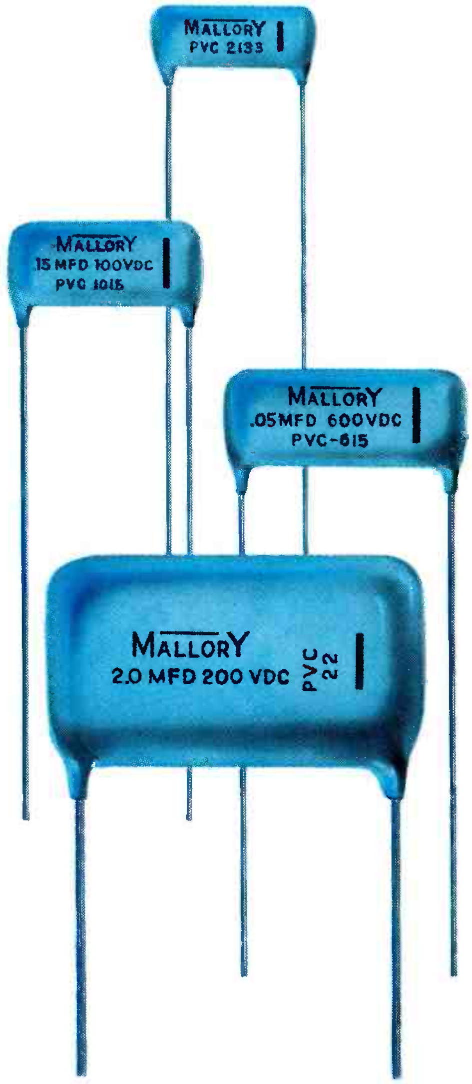
**High power**
- ET7 AF high power amplifier

**NPN TYPES**

**Low power**
- ET8 Mixer/oscillator/converter
- ET9 IF amplifier
- ET10 AF amplifier 9v.
- ET11 AF amplifier 12v.

**Ask your Distributor for the Tung-Sol Transistor Interchangeability Guide**

# PVC




# PV

**TC TUBULAR ELECTROLYTICS**

Economical filter capacitors. Also special TCX type for —55°C. Twin-pack keeps leads free from kinks.


**FP ELECTROLYTICS**

Original 85°C capacitor, now better than ever. Etched cathode gives hum-free performance. Chassis or printed circuit mounting.

**STA-LOC® CONTROLS**

End searching and waiting. Your distributor can custom-build, in just 30 seconds, any of over 38,000,000 single or dual controls.

**GOLD LABEL® VIBRATORS**

Quietest ever made . . . for the best in auto radio servicing. Buttonless contact design gives longest trouble-free service.

# STOP CALL-BACKS WITH MALLORY PVC MYLAR* CAPACITORS

Best thing about Mallory PVC coupling and by-pass capacitors is that you can install 'em and forget 'em. They won't drift, won't pop out. Not even when you put them in a hot spot, load 'em up to full voltage (or even higher). Not even when the weather stays hot and wet for months. Here's why.

**All Mylar dielectric.** Not a combination of paper and Mylar that invites moisture absorption and causes voltage failure and capacitance drift. There's nothing but Mylar between capacitor foils. And you *know* that's the most moisture-impervious dielectric used today.

**Performance-plus.** Use PVC's at any ambient from —40 to +105°C . . . no need for derating. Push them up to full rated voltage. They've been tested at *twice* the voltage marked on 'em. They won't drift . . . no danger of a call-back to fix a sweep circuit that won't hold sync.

**Foolproof leads.** Flexible PVC case lets you bend leadwires at sharp angles without breaking the moisture seal.

**Small and handy.** Rating for rating, Mallory PVC Mylar capacitors are almost one-third smaller than other capacitors. And they're furnished in a handy, zip-close reusable package.

There's a wide range of ratings, priced lower than you'd think possible for so much quality. Get Mallory PVC Mylar capacitors—and all other Mallory quality components—from your Mallory distributor.

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**MALLORY RMC DISCAPS®**
Ceramic capacitor replacements . . . tops for customer satisfaction. Long the quality standard in original equipment.


**MALLORY MERCURY BATTERIES**
Tops for transistor radios. Steady power, up to 3 times longer service . . . they live for years when idle. Guaranteed leakproof.


**GEMS**
Rugged, moistureproof tubular capacitors. Handy five-pack keeps stock clean, leads kink-free.

# Wise servicemen earn $2.85 to $16.00 more profit on every 21" Admiral Ensign

## ...and even higher margins on other tube sizes!

★ **NEW PRICE**—more profit than you can make on any other name brand replacement tube...the biggest profit margin in the industry for a completely rebuilt tube.

★ **ACCEPTANCE**—just tell them it's an ADMIRAL ENSIGN replacement tube. The famous-name brand helps you sell. They know it and OK it.

★ **TOP QUALITY MATERIALS, WORKMANSHIP**—ENSIGN tubes are all new except for the glass envelope...each tube is completely washed and a new aluminum and phosphor screen and lacquer barrier automatically installed. Only the highest quality electron-guns with the latest electronic advances are used.

★ **WIDE SELECTION**—Admiral Ensigns are available in all tube sizes: 10", 12", 14", 17", 19", 21", 23", 24" and 27".

★ **AVAILABILITY**—ADMIRAL'S national distribution gets the ENSIGN into your hands *fast*, when you need it and can sell it.


**NEW**
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Remarkable, new package is lighter, stronger...has built-in carrying grips...takes 40% less space! Another Admiral Ensign "Extra."

**NOTICE!** All materials and parts used in the manufacture of ADMIRAL ENSIGN tubes are new, except for the glass envelope; which, prior to re-use, was carefully inspected to meet the standards of the original envelope.

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# REVOLUTION in Auto Radio – Transistors Are Taking Over

**Tips on servicing new all-transistorized designs and recent-model hybrid units . . . by *Jack Beasley***

Completely transistorized auto radios are coming into their own. Increasing numbers of them are being supplied for use in 1962 cars, marking a new phase of the development which began in 1956-57 with the introduction of "hybrid" tube-transistor models. Auto-radio servicemen, already accustomed to repairing transistorized output stages, are now called upon to develop efficient troubleshooting techniques for other circuits using transistors.

There appears to be a feeling among many servicemen that all-transistor car radios will be "tough dogs," and that many of the easy, high-paying jobs of the old days are gone with the vibrators and rectifier tubes. Another group of servicemen maintain that all-transistor radios will be generally easier to service. The more optimistic group are placing their confidence in a service approach based on a systematic, logical thought pattern or way of reasoning. This does not mean they have worked out a "cut-and-dried" formula for finding troubles, but it does indicate that certain lines of thinking can be extremely helpful.

### Getting Down to the Stage

Transistorized auto radios are no different from other electronic equipment when it comes to troubleshooting — the first step is to localize the trouble to one particular stage. This is most easily done by injecting a signal into the various stages, one by one, and judging whether the resulting output from the speaker is okay or whether it indicates some trouble. Simple, rough tests are adequate for analyzing dead sets or those with very weak output; but finding the cause of slightly weak, distorted, or intermittent output requires more accurate and careful testing.

Conventional signal generators and radio signal tracers can be employed, but most shops prefer to use battery-powered noise generators for working on transistorized radios. Since their output contains many harmonic frequencies, these units can drive a signal through any stage in a radio without being specifically tuned to its operating frequency. Pencil-type noise injectors are the handiest to use, but they usually have a fixed output. On occasion, this can cause misleading test results by overdriving some stage, or by temporarily shocking a defective transistor into normal operation. Larger types of noise injectors generally provide a variable output to overcome this disadvantage.

A crude test using a screwdriver is sometimes adequate for troubleshooting a completely dead set. Grasping the metal shank of the screwdriver, simply tap the base terminal of each transistor and listen for a click in the speaker.

More important than the choice of noise-injection equipment is the user's skill in interpreting the test results. You can make effective use of any injection device if you know what output to expect when you apply signals to certain points in a radio circuit. Gain familiarity with a particular signal injector by practicing on radios which are operating normally.

Isolation tests can either find a stage the signal will not pass through, or locate a stage with insufficient gain. When a signal is injected first at the collector and then at the base of a transistor, an increase in output from the speaker will usually be noted. Watch out, though, because there are a few cases in which a normal stage will appear to provide no gain—or even a loss in output. This effect can result from a bad mismatch between the output impedance of the noise- or signal-injection equipment and the input impedance of the transistor. Here again, learn what to expect from your own test instruments.

#### *Signal-Injection Sequence*

The output stage of an all-transistor auto radio is very similar to the equivalent stage of a hybrid radio. Reasonably normal operation of this stage can usually be assumed if a thump is heard from the speaker when the set is turned on. Unless you have good reason to suspect poor gain in the output stage, you can then proceed with signal injection as outlined in Fig. 1.

A good place to start is at the col-

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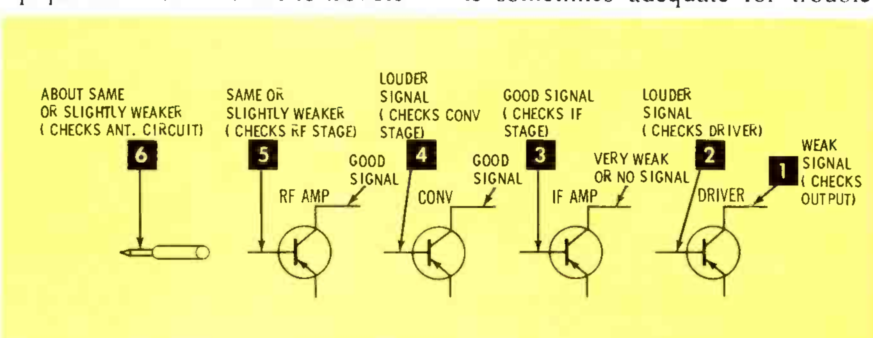


**Fig. 1. Results expected in progressive steps of signal-tracing procedure.**

# TEST EQUIPMENT for TROUBLESHOOTING TRANSISTOR RADIOS

**Instruments that simplify testing of transistors and circuits. by Jim Galloway**

Just like any other new, specialized branch of electronics servicing, transistor-radio repair has created a demand for new types of test equipment which are exactly suited to the job at hand. The most obvious need is for instruments to use in testing the transistors themselves. In addition to transistor testers, different types of auxiliary equipment have been developed to satisfy the special requirements of transistor-radio servicing. In some cases, these units perform most of the same basic functions as already-existing instruments, but their designs are especially modified to provide greater speed and convenience in transistor-radio troubleshooting. Other auxiliary instruments offer special tests which are not commonly made in servicing vacuum-tube circuits, but which are of great value in checking transistor-circuit operation.

### Transistor Testers

Although transistors have no filaments to burn out, they sometimes develop open elements or leakage between sections. Commercial transistor testers provide tests for these conditions, and also afford some means of checking the amplifying ability of a transistor. The gain characteristic usually measured is *beta* (the current amplification in a common-emitter circuit), which gives the truest indication of transistor performance in actual radio circuits. In most inexpensive equipment, the

| MFR. | MODEL | Iceo | Icbo | SHORTS | GAIN TEST | OTHER TESTS | PNP/NPN | MISC. NOTES |
|---|---|---|---|---|---|---|---|---|
| B & K | 960 | ✓ | ✓ | ✓ | actual DC beta | in-circuit tests | | metered pwr. sup., sig gen., VTVM |
| EICO | 680 | ✓ | ✓ | | actual DC beta | indirect AC beta | switch | VOM included |
| EMC | 210 & 210A | | | ✓ | actual DC beta | checks diodes | switch | |
| | 212 | ✓ | ✓ | | actual DC beta | oscillator in-circuit tests | | |
| G-C | 36-560 | ✓ | | ✓ | actual DC beta | checks opens | switch | |
| | 36-568 | ✓ | ✓ | | actual DC beta | checks diodes | switch | pwr. sup., sig. gen. |
| HEATH | IT-10 | ✓ | ✓ | ✓ | indirect gain | checks diodes | switch | |
| | IM-30 | ✓ | ✓ | ✓ | actual DC beta | checks diodes & DC alpha | | pwr. sup. |
| HICKOK | 810 | ✓ | ✓ | | good—bad scale | | 2 sockets | |
| | 850P | ✓ | ✓ | ✓ | actual DC beta | | switch | |
| | 870 | ✓ | ✓ | ✓ | actual AC beta | | switch | |
| | 890 | ✓ | ✓ | ✓ | actual AC beta | input and circuit Z | | |
| MERCURY | 700 | ✓ | ✓ | ✓ | actual DC beta | | switch | |
| MOTOROLA | 67T65 | | (1) | ✓ | oscillator (2) | checks opens | switch | |
| PACO | T-65 | ✓ | ✓ | ✓ | actual DC beta | checks diodes | switch | |
| PRECISION APPARATUS | 960 | ✓ | ✓ | ✓ | actual DC beta | checks diodes | switch | |
| | 660 | ✓ | ✓ | ✓ | actual DC beta | checks diodes | switch | Iebo Icbs tests |
| | 10-60 | ✓ | ✓ | ✓ | actual DC beta | checks diodes | switch | Iebo Icbs tests |
| SECO | 100 | | | ✓ | oscillator go—no-go | in-circuit tests | switch | |
| SENCORE | TR110 | ✓ | (3) | ✓ | actual DC beta | checks diodes and tetrodes | | voltmeter & milliameter included |
| SIMPSON | 650 | | | | incremental DC beta | Ico test | switch | add-on for Model 260 |
| WINSTON | 620 | ✓ | ✓ | ✓ | actual DC beta | breadboard setup | switch | chart lists ave. beta, Ico |

**(1) Leakage results in excessive reading** **(2) Relative gain indicated by frequency of audio output tone** **(3) Indirectly**

actual value of beta is not measured; instead, a ratio between beta and leakage is used to indicate a good transistor.

Transistor testers perform their tests in different ways, depending upon manufacturer preference and instrument cost. For instance, some have meter scales divided into colored areas, one of which is labeled BAD. Others have simple calibration marks to use as a standard in determining the beta-leakage ratio.

Fig. 1 shows one method used to measure leakage and gain. A voltage is applied between the emitter and collector, and the leakage current is read on the meter. When the GAIN switch is depressed, a 200K-ohm resistor is connected to the base and to the power supply. A current of 30 ua flows in the base, and (if the transistor is good) produces an increase in the current through the emitter-collector circuit. The resulting change in the meter reading is proportional to current gain. The actual circuit of the tester is somewhat more complicated, having provisions for both PNP and NPN types.

Typical of testers that allow the actual value of beta to be read directly, the circuit shown in Fig. 2 gives a more exact indication of transistor performance under actual operating conditions. The meter is first calibrated by adjusting the potentiometer until the meter reads a specified value marked CAL. The selector switch is then placed in the BETA position, which replaces the meter movement with an equivalent resistance in the collector circuit. The meter is switched into the base circuit and measures the current required to cause the specified amount to flow in the collector circuit. Because of the previous calibration, the value of beta can be read directly on the meter.

The advantage of this type of tester over the less expensive units is that the circuit is actually set up for each individual transistor and, therefore, does not apply universal operating conditions to all types.

Many other methods are used in different equipment, but basically the theory is to cause a change in collector current by changing the current in the base circuit. Since this is the basic principle on which

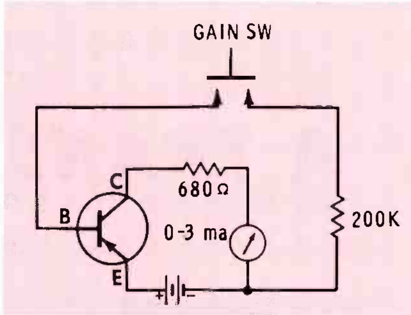


**Fig. 1. A method for obtaining leakage and transistor relative-gain checks.**

all transistors operate, such a test gives a good indication of transistor operation.

## Auxiliary Equipment

Helpful as they are in spotting transistor defects, the testers just described are not ordinarily used to check all transistors as a matter of routine. Instead, other instruments are used first to isolate the stage causing trouble.

### *Signal Injectors*

An ordinary signal generator can be used to signal-trace a transistor radio in the same manner as in a tube-type set. One word of caution—transistors are more easily overdriven than tubes, so the generator should be operated at a very low level, and the signal always injected through a .1-mfd capacitor. Otherwise, a transistor stage may become blocked, and will give an indication that it is not amplifying.

Many technicians prefer to use what is called a noise or harmonic generator. Usually transistorized and simple, these units do not require much adjustment and, therefore, are quick and convenient to use.

These generators operate on the harmonic principle; the fundamental is a square wave in the audio range, but there are harmonics present that extend the output to frequencies beyond the broadcast band—allowing all three sections of a receiver to be checked with the single instrument. The sound heard in the speaker sounds something like a doorbell.

Two types of noise generators are available. There are small, metal-cased units which usually have a control to vary the output-signal level, as well as pen-size injector probes which do not have a variable output.

The secret to using such devices lies in knowing what sounds should be heard from the speaker of a normal radio when signals are injected at various points. If the technician knows what to expect from each stage, he can tell when a stage is not operating properly.

### *Battery Eliminators*

A frequent cause of transistor-radio failure is worn-out batteries. In order to check on this possibility, some servicemen like to use bench power supplies. These "battery eliminators" are available in a wide price range. The cost of the unit depends on such characteristics as regulation, ripple content, and accessory features. Due to the small current drain of a transistor radio, good regulation and low ripple are not difficult to achieve; therefore, almost all of the supplies available are entirely adequate in this respect.

Much can be learned about the operation of a particular transistor radio by metering the power-supply current while performing certain operations. Many technicians do a large portion of their troubleshooting in just this manner. For this reason, many of the battery-eliminator supplies have a built-in milliammeter which monitors the current

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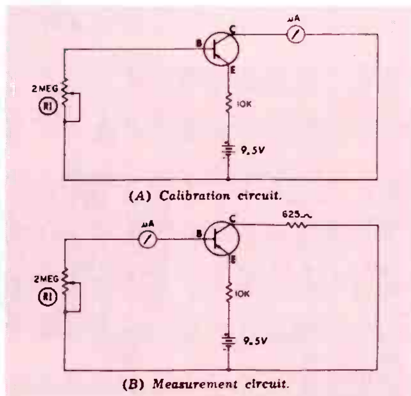



**Fig. 2. A typical circuit for obtaining an actual reading of transistor beta.**

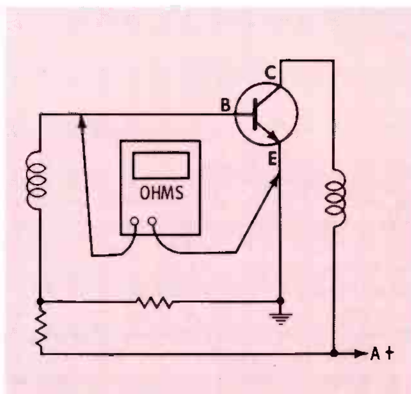


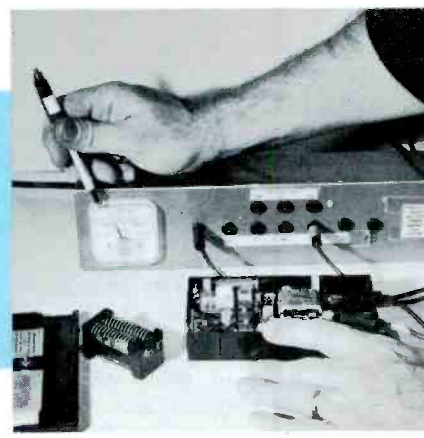

**Fig. 3. An ohmmeter is connected between base and emitter in open-lead-test.**

# MEET A TRANSISTOR RADIO

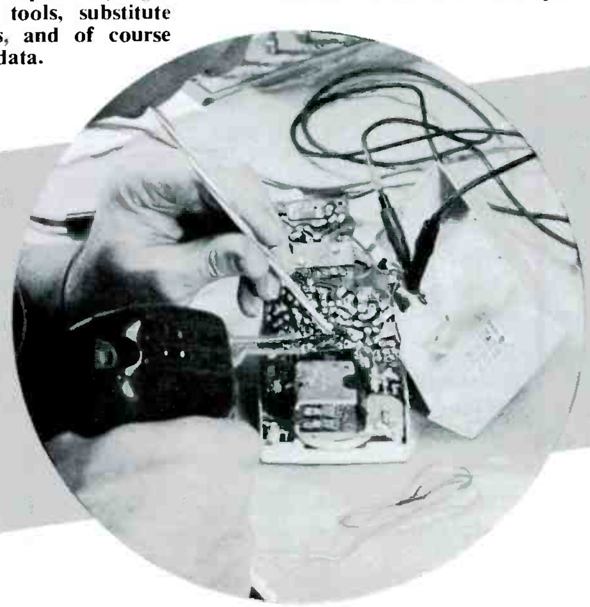
In talking with hundreds of servicemen, we find no subject more controversial than transistor radios. Some technicians refuse to service them; many do repair them, but at no profit; and a few really go in for this business in a big way — and make good money doing it! Since the controversy seems to boil down to the matter of profitability, we decided to find someone who had made transistor-radio servicing pay off, in an effort to find out how such a venture could be profitable.

Here's Wayne Lemons of Buffalo, Missouri, at his workbench. His transistor-radio business is profitable, even though his modest, flat-rate charge for run-of-the-mill troubles even includes parts. His secret? Learn how to diagnose and repair the average radio in 30 minutes, have all the tools and test equipment you need to do an efficient job, and line up enough business to keep you busy for several hours at a time.

Just what does it take to put yourself in business? According to Wayne, "If you already service tube radios, you probably have most of the necessary equipment. The rest can be purchased for $100 or less." Included in this array photographed at his shop are a power supply, VOM, signal-tracer, grid-dip meter, regular- and miniature-size tools, substitute transistors and batteries, and of course all the pertinent service data.



"I still have the home-made battery-operated power supply I started with," reports Wayne, "although I have since purchased two commercially-available units which are even better. One of the first tests I make, regardless of the trouble, is to measure total battery drain. Even if the radio seems to operate normally, excessive drain from a leaky transistor or capacitor may be running down the batteries too quickly."

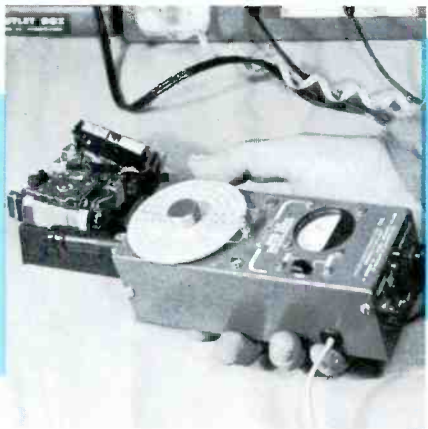


Removing multiple-terminal parts from a printed board is one of the trickier jobs. Here, we see Wayne using the "soda-straw" technique. "A medium-sized gun should be used;" he says, "35 watts won't do the job. Always blow the solder away from points where it might lodge and cause trouble. This method works well for cleaning solder out of holes in the board, too.

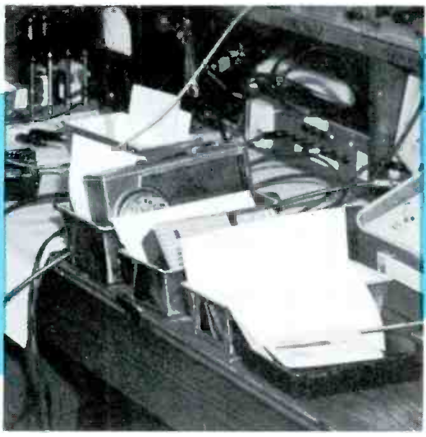
"You can use a razor blade or pocket knife to sever a printed-circuit conductor for making tests. The cut can be repaired with a blob of solder. Cutting two conductors to a transistor and 'spotting in' a substitute is often more desirable than removing the suspected transistor."

# SERVICE SPECIALIST!

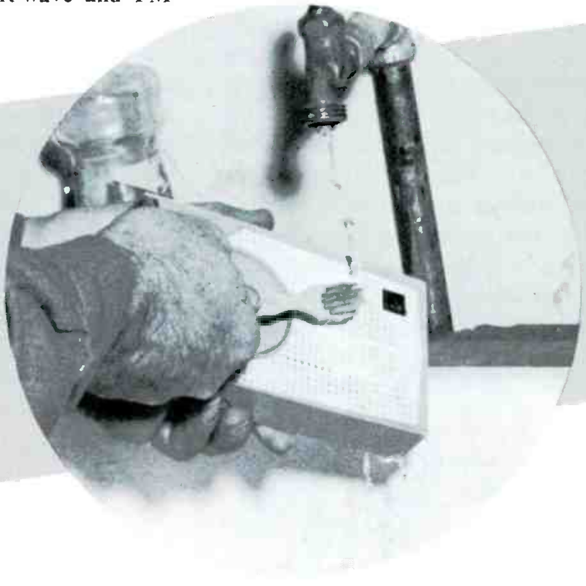
Wayne is constantly on the alert for tools and other devices especially designed for working with miniature portables. We found him already using two special drivers that hadn't been on the market more than a week or so. "Removing and replacing earphone nuts and jacks used to be tricky. I even went to the trouble of grinding down a screwdriver. These subminiature drivers are just what I needed."



Asked if there were any other tools or instruments he found useful in minimizing trouble-diagnosis time, Wayne replied, "Sure is—a low-frequency grid-dip meter. I use mine to inject alignment signals, to substitute for the local oscillator, and to check the resonance of loopstick and oscillator coils. Since it also supplies higher frequencies, I find it useful for checking short-wave and FM bands, too."



Here are a few more jobs waiting to be "operated on." Metal trays are used to hold the cabinet, screws, battery holders, and similar parts while the set is being repaired—or as is the case here, to hold an entire disassembled set until new components required for completion of the repair are obtained. The card has the owner's name, a list of parts needed, date ordered, and estimates of service time and price.



"Perhaps nothing pleases customers (especially women) more than having the radio returned with all the little dirt-catching crevices cleaned. A denture brush, or a toothbrush that doesn't have plastic bristles, will get into these crevices and do a good cleaning job. All it takes is a little cold water, liquid detergent, and some elbow grease.

"Sink cleanser should not be used unless the plastic case of the radio is very dirty—perhaps pitted—and has lost all its original gloss anyway. Of course, be sure to remove the chassis and speaker before performing the scrub-down. Also, do not reinstall the speaker until the grille cloth is absolutely dry."

Watching an expert like Wayne Lemons makes the job of servicing transistor radios seem easy. But, having repaired dozens of them ourselves, we knew there was more to this business than meets the eye. "Let no one deceive you," Wayne advises, "transistor-radio repair can't be learned overnight, but it can be learned. And it can be profitable, too, more so than tube radios or small appliances. It can be exasperating, of course, but what kind of service isn't?"

# Mobile Radio . . . Transistor Style!

New two-way transceivers using semiconductors are compact and consume minimum power . . . *by Edward M. Noll*

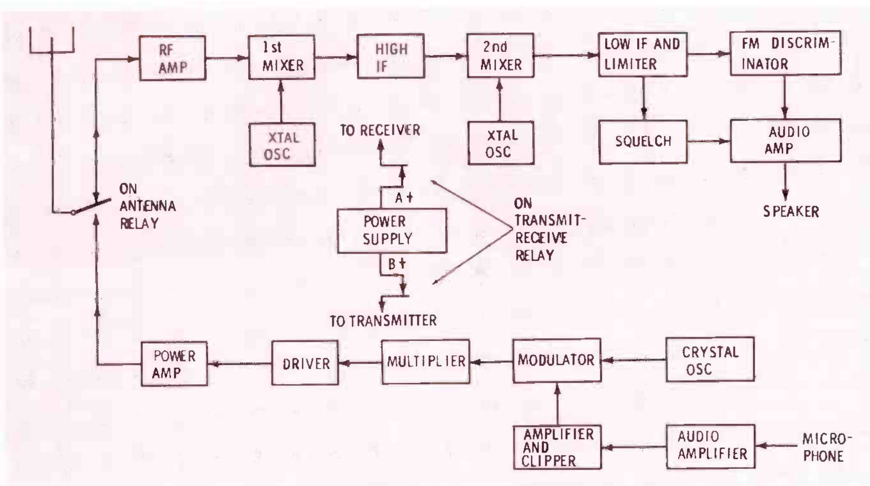



**Fig. 1. Block diagram of two-way set with double superheterodyne receiver.**

Modern two-way radio equipment is more compact and lightweight than its earlier-day counterpart. The main reason for this is the miniaturization of circuits made possible by the transistor and its associated components. The transistor stages used in today's equipment are highly reliable and provide a great degree of circuit stability despite rough treatment and even extreme temperature changes. Because of their excellent operating characteristics, transistors are rapidly becoming the sole amplifying devices in two-way radio. Many two-way radio receivers are fully transistorized, while others are about half tubes and half transistors. Also, more often than not, transmitter speech-amplifier circuits are completely transistorized.

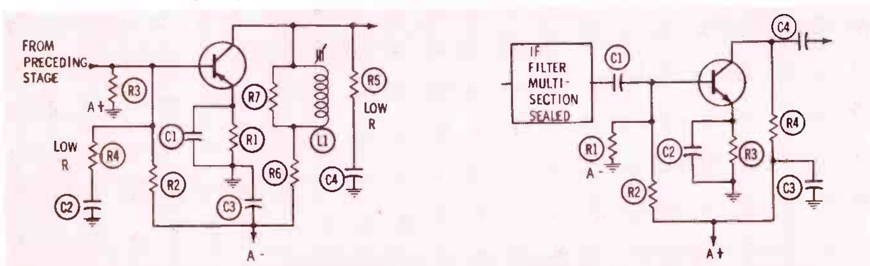
Although the principle of the transistor differs considerably from that of the vacuum tube, the actual circuit operation of the two is quite similar. Therefore, the servicing techniques that apply to the transistor (such as alignment and troubleshooting) are pretty much the same as those for the vacuum tube.

The functional block diagram in Fig. 1 shows a typical transistorized commercial two-way radio. Notice that the antenna and power supply are common to both the transmitter and receiver. In the receive condition, the transmit-receive and antenna relays are both de-energized. The transmit-receive relay controls the power to the transmitter and receiver, and also energizes the antenna relay. In the de-energized condition, one set of transmit-receive relay contacts keeps the antenna-relay circuit open, a second set keeps the A+ path to the receiver closed, and a third set keeps the transmitter B+ circuit open. In this mode, then, the transmitter is off and the receiver is on.

When the "push-to-talk" switch on the microphone is depressed, the transmit-receive relay is energized, and two things happen. First, the A+ power is removed from the receiver and B+ is applied to the transmitter. Second, the antenna relay is closed, thus disconnecting the antenna from the receiver and connecting it to the transmitter.

### The FM Receiver

All FM receivers used in the commercial two-way services are of the double-superheterodyne type. The combination of the RF amplifier and high-frequency IF system insures good selectivity and image rejection. The high-gain low-IF amplifier has very sharp selectivity, and therefore provides effective rejection of noise




(A) Tunable, with PNP transistor.

(B) Fixed-tuned; NPN transistor.

**Fig. 2. Typical low-IF amplifier.**

and adjacent-channel interference. Inasmuch as frequency modulation is used, the low-IF amplifier system also includes limiter stages which clip excessive noise components from the incoming signal.

***RF and IF Amplifiers***

Because of their excellent operating characteristics, transistors are used in both the RF and IF sections of many two-way radio receivers. The circuitry of RF and IF amplifiers is practically identical, except that the bandpass requirements of the IF amplifier are more stringent than those of the RF amplifier.

The selectivity of a transistorized RF or IF amplifier is determined not only by the characteristics of the transistor and other components, but also by the use of resonant circuits, either tunable or untunable. A tunable low-IF amplifier using a PNP transistor is shown in Fig. 2A. In this circuit, temperature stabilization is provided by the combination of R1 and C1 in the emitter circuit, and emitter-base bias is provided by voltage-divider resistors R2 and R3 in the base circuit. Since R3 has a much smaller value than R2, the voltage at the junction of these two resistors is only slightly negative with respect to A+ (ground). Thus, the forward bias between base and emitter is small—about 0.3 volt. The difference between emitter and collector voltages is equal to the full A– supply voltage minus the IR drops across R1, L1-R7, and R6—or approximately 4 to 5 volts. (The collector is negative with respect to the emitter.)

The incoming signal is developed across the RC combination of R4 and C2. As the signal swings positive at the base, it reduces the forward bias, and the transistor conducts less. Conversely, as the signal swings negative, the transistor conducts more heavily. The output is taken off across the RC combination of R5 and C4. The tunable combination of L1 and R7 is resonant to the operating frequency, and thus helps develop the output signal.

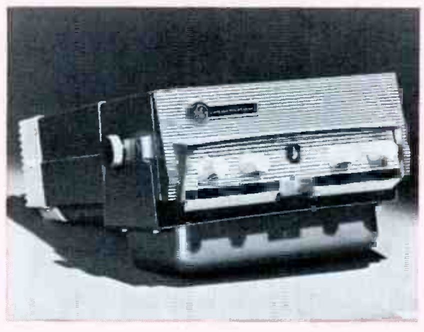
Fig. 2B shows another commonly-used IF amplifier. Notice the lack of a tunable component. In this NPN-transistor circuit, the emitter-base forward bias is developed

• *Please turn to page 90*

*Separate, hand-held transmitter and receiver units are included in fully-transistorized Motorola set for operation on 25-54 mc band.*

*General Electric two-way unit for 152-174 mc VHF operation contains both receiver and 1-watt transmitter in single hand-held case.*

*Portable FM "Handie-Talkie" by Motorola uses tubes only in RF section of transmitter. Switch on top of case selects one of two channels.*



*RF exciter section of transmitter in G-E mobile radio uses transistors; two-frequency listening is provided through common receiver.*

*"Extender" circuit, controlled by switch on front panel of this Motorola mobile set, is used to increase effectiveness of noise rejection.*

# SERVICING TRANSISTORIZED TV CIRCUITS

by Thomas A. Lesh

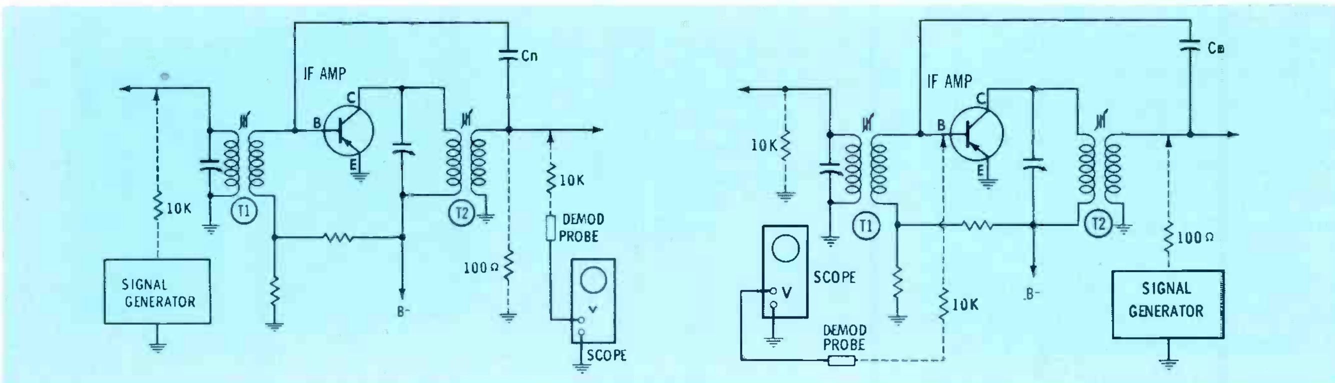



Fig. 1. Two-step setup to check the neutralization of a video IF stage.

For years, a "portable TV set" was one which could be hand-carried from one AC outlet to another. The high power requirements of vacuum tubes made a self-contained power supply impractical, and thus were a major obstacle to the development of truly portable receivers. Transistors have changed this situation, since they can be operated from low-voltage battery supplies. By making it possible to design completely portable sets, they have found a means of entering the TV market. You might receive a call today to service a transistorized set, and you can expect to see many more of them in the future.

Although working on this equipment will be a new experience, you will be able to draw heavily on your past knowledge of TV servicing, as well as on any previous acquaintance with other types of transistorized equipment. Let's take inventory of the assets that will give you a head start in transistor-TV servicing, and then consider some of the new problems to be faced.

### Familiar Ground

You can isolate trouble to a specific section of a transistor TV set by using the same basic techniques that apply to ordinary receivers. The stage line-up is practically the same, no matter whether transistors or tubes are used, and the same general type of cathode-ray tube and speaker are used in both cases. Therefore, you can make use of past experience in localizing trouble by observation of symptoms —for instance, you'll know that a set which is having difficulty staying in horizontal sync is probably suffering from trouble somewhere between the last sync stage and the horizontal oscillator.

As for test equipment, you'll find that most of the instruments you now own can be used on transistorized sets. VOM's, VTVM's, scopes, and signal or sweep generators are just as effective as they are on sets with tubes, or even more so. Since impedances are lower in most transistor circuits, an oscilloscope can be used with less concern for waveform distortion due to circuit loading. For the same reason, a 20K-ohms-per-volt multimeter is often usable when it would not be satisfactory for a similar measurement in an all-tube set. This inexpensive and handy instrument does not excessively load down many transistor circuits, even when used on the low

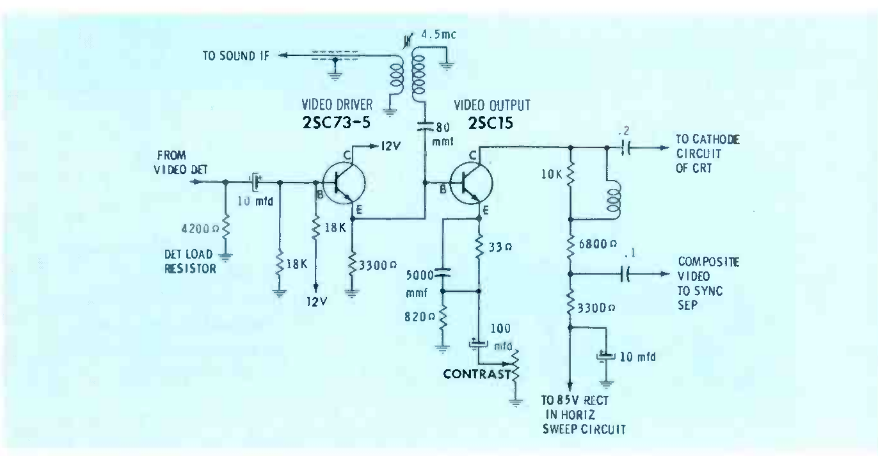



Fig. 2. Driver couples video signal to the output stage without amplification.

ranges necessary for checking DC voltage in transistor circuits.

Measurements are of prime importance, and the more you can develop your ability to analyze base, emitter, and collector voltages, the more quickly you will be able to pinpoint defects.

Previous experience in physically handling transistor circuits will likewise be an asset. While transistorized TV chassis do not have such a cramped layout as pocket radios, they use many of the same small, delicate components. The largest transistors (those in the sweep output stages) are in many ways similar to the types used in the output circuits of auto radios. At the other extreme, the high-frequency transistors used in RF, IF, and sync circuits have even lower electrical ratings than ordinary small-radio types, It's not necessary to work on these units as if you were performing an eye operation, since several years of field experience have indicated that transistors can put up with excessive heat and voltage much better than originally supposed. Nevertheless, reasonably careful treatment will insure that transistor damage will be held to a minimum. If you are troubled with a rash of transistor failures, double-check your soldering and testing techniques. Perhaps one of your test instruments, designed for use with tube circuits, is injecting a DC, hum, or pulse voltage which is more than the transistors can tolerate.

### Differences in Transistor TV

In preparing to service transistorized TV, the main problem is to learn how the individual stages operate and what special tests need to be made. Here is a summary of pertinent facts about various sections of present transistorized receivers:

#### *RF Tuner*

Both turret and incremental-switch types are now in use. They are physically similar to the compact units which are now popular in all-tube TV receivers, and should present no new problems in correcting mechanical defects. Tuning adjustments are also very similar to those in tube-equipped models. Many transistorized tuners have the conventional type of individual-channel oscillator slugs; the RF amplifier usually includes a variable neutralizing capacitor; the tuner-IF coupling network is adjusted by means of a tunable mixer-collector coil; and the antenna-input circuit generally includes one or more tunable traps to reject FM radio signals or to prevent IF signals from being radiated.

The only circuit feature likely to cause much confusion is the AGC system. Sometimes it controls the gain of the RF amplifier in basically the same way as a tube stage, by using the AGC bias to decrease the conduction of the transistor. (Remember, output current is reduced by *decreasing* the difference between base and emitter voltages.) However, many systems follow a different procedure, with the AGC voltage reducing stage gain by decreasing the voltage between emitter and collector. In some cases, this is accomplished by increasing the base-to-emitter voltage so that transistor conduction is increased. A greater voltage drop is then produced across a series resistor in the emitter circuit, and the emitter-collector voltage is lowered.

To find out which type of AGC system is being used, you can check the voltage on the AGC line under different signal conditions, or analyze the action of the area switch if one is employed. In either case, you can expect much smaller bias-voltage changes than in a tube system.

#### *Video IF*

Transistorized sets generally have three or four IF amplifiers, the first one or two being controlled by AGC. The most common trouble symptoms are the same as in tube sets—weak video, signal distortion due to misalignment, and overloading.

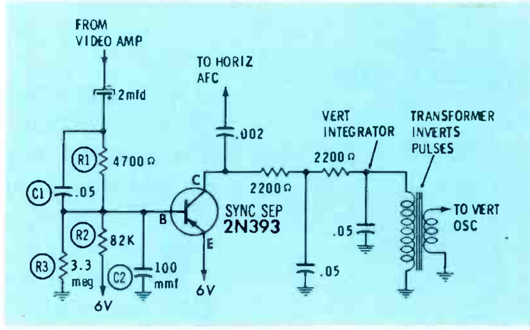



**Fig. 3. Simple sync-separator circuit produces positive pulses at collector.**

To find out if this last symptom is due to AGC trouble, you can clamp the AGC line with a substitute DC bias voltage. Follow the instructions given in service data for applying a fixed bias during IF alignment; then vary the clamping voltage *slightly* above and below this specified value, watching for an improvement in the picture.

Alignment procedures will, on the whole, seem familiar. Different models use either stagger-tuned or overcoupled (broadly-tuned) IF-coupling circuits, or combinations of both types. Since the low impedance of transistor stages causes them to have a relatively broad bandpass, stagger-tuned coils will not peak as sharply as those in tube sets.

When a transistor is replaced in the IF strip, an over-all alignment check is a good way to see if the replacement is working properly. Touching up the adjustments in the repaired stage may improve performance considerably. Inability to restore normal alignment is a sign that further servicing is needed.

A transistor, being a type of triode, requires neutralization in order

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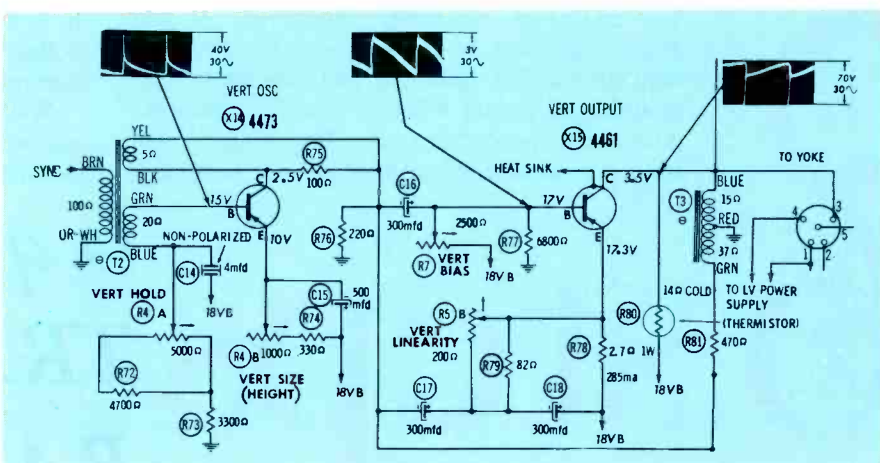



**Fig. 4. Most transistorized vertical sweep systems use blocking oscillators.**

QUICKER SERVICING

by

*Forest H. Belt*

# 6 steps *to quicker TRANSISTOR-RADIO repairs*

Servicing a transistor radio need be no more complicated than servicing a tube-type receiver. The primary differences lie in the size of the set and its components, and in the power supply. Therefore, service procedures must be adapted to these factors.

How should you approach a transistor radio? How can you simplify the service procedure and make it a sure-fire thing instead of a hit-or-miss affair? Dividing the transistor radio into sections (as in Fig. 1) facilitates the development of a logical step-by-step approach to servicing the entire receiver. The steps can be itemized as follows:

1. Test the power supply and its associated circuits.
2. Make a visual inspection of the circuit board and components.
3. Check the audio section and speaker.
4. Check and align the IF stages.
5. Check operation of the oscillator and mixer circuits.
6. Check over-all receiver operation and align it for maximum sensitivity.

Whether the service complaint be a dead set, distortion, noise, or some intermittent problem, the *logical* procedure we have outlined will uncover any fault in the quickest possible time. Such a step-by-step procedure permits you to approach *all* receivers in the same manner, gives you a starting point for *any* set, and assures the same standard of quality for each finished job. You are not so likely to forget any important tests or performance checks. Once you adopt such a procedure, servicing transistor radios becomes an automatic, routine operation; therefore, it becomes a business in which you can make money.

As you proceed through each step, you will likely discover short cuts. For example, if the complaint is a dead set, and you find that a dead battery is the only problem, you would likely proceed immediately to the final step, testing the performance and aligning the set for maximum sensitivity. However, if you begin with step 1, and proceed step by step through the list, you will certainly locate the trouble, no matter what or where it may be. The entire procedure takes less time, in the long run, than a hit-or-miss type of servicing.

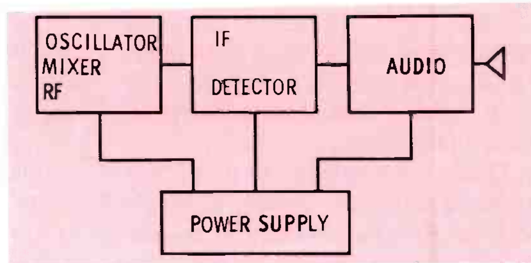



**Fig. 1. Dividing the radio into blocks aids in following service procedures.**

The serviceman who wants to do an efficient, thorough job with a minimum of inconvenience will find certain small-sized tools helpful (see Fig. 2). A small pair of diagonal cutters and needle-point pliers, a set of small screwdrivers, a couple sizes of tweezers and a magnifying glass will be valuable aids when you start working on these miniature receivers. Now that you have armed yourself with the needed implements, let's proceed to examine the receiver in logical sequence.

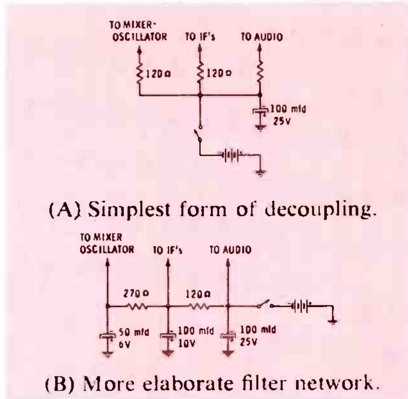
### The Power Supply

The power supply is probably the greatest source of trouble in the transistor radio, as well as being the easiest section to test. Three test methods are commonly used, and you can choose whichever is most convenient for you. The first and simplest test involves merely changing the battery. Of course, this requires that you carry a stock of the most popular types. If the receiver plays properly with the new battery, you would normally assume the trouble is cured. This is not always true, however, and in the interest of a thorough job it is best to make additional tests such as those described in the second method.

The second method takes a little more time, but it gives a more complete analysis of conditions in the power-supply circuits. Since a transistor radio requires very little power compared with a tube radio, it is very important for voltages and currents to be close to those for which the circuits are designed. Therefore, it is a good practice to measure the battery voltage (both no-load and full-load) and the current drain of the set.

Some servicemen consider battery-voltage measurement a waste of time, but this is not so. A battery which has been in use, or on the

Fig. 2. Small tools assist in troubleshooting miniature portable receivers.




(A) Simplest form of decoupling.

(B) More elaborate filter network.

Fig. 3. Decoupling networks keep signals from entering improper circuits.

shelf for awhile, may develop a high internal resistance, in which case it probably will work for only a very short time. To determine if a battery has developed this condition, measure its voltage out of the set; then reconnect it and measure its voltage with the set on and the volume control at maximum. The *difference* between these two readings in a good battery should be less than 5%. Any battery which displays a voltage variation greater than 5%, or which has a no-load voltage less than 80% of its rated voltage, definitely should be replaced.

The current drain of the set can indicate troubles which may occur in the power-supply circuits. A shorted transistor or a leaky bypass capacitor will usually result in an abnormally high input current to the radio. This could reduce battery life, even though the set might still play. So this is an important measurement.

The third method for testing power supplies is to substitute a bench DC voltage source for the battery. Bench supplies usually include a meter which measures the radio's input current. Since the meter connection is made automatically when the radio is connected to the supply, this is usually much handier than connecting a meter in the battery leads. The correct voltage is applied to the radio, and the performance is checked to see if there is any need for further servicing. Of course, this eliminates the battery as a possible trouble during these tests.

Certain capacitors in the transistor radio should be considered a part of the power supply, since their function is to prevent the power supply from coupling signals between stages. They may be called bypass capacitors, decoupling capacitors, or even filter capacitors, but their location and purpose are the same in any case. Less expensive sets often have only one such capacitor, as in Fig. 3A, while more elaborate receivers may use several capacitors and resistors to do a more complete job of decoupling, such as in Fig. 3B.

Many cases of motorboating and/or short battery life can be traced to decoupling capacitors which have become defective. If you suspect that motorboating is caused by one of these components, disconnect one end and bridge a known good part into the circuit; if the oscillation clears up, you have found the defective part. If you suspect that a bypass capacitor is guilty of shortening battery life, disconnect one end from the circuit, and use an ohmmeter to check for leakage (watching polarity, of course). In sets using more than one decoupling capacitor, each may be tested in this way.

### The Visual Inspection

You can sometimes save valuable service time by this next step in the procedure. Circuit boards have an annoying habit of developing cracks which cause open circuits. Loose connections may develop in poorly-soldered component joints. The results appear as noisy reception, popping and cracking, a dead receiver, or some sort of intermittent condition.

A visual inspection with a magnifying glass will often reveal the source of these complaints. A tiny crack, which can completely disable the set, may be visible only under the glass. Sometimes a lamp placed on the opposite side of the component board will help locate such faults.

You may try a bit of probing with an insulated tool, applying pressure to various components and points on the printed-circuit board. This will often cause a critical connection to make or break, indicating trouble in a definite area of the circuit board. Sometimes, slightly twisting the board will produce the same result, but be very careful you don't twist it enough to create additional troubles.

If a quick examination does not disclose the trouble, don't waste time just looking around, for as you progress with the remaining steps, any printed-board troubles will be isolated as if they were component failures.

### Audio is Next

The third step toward a complete transistor-radio service job is a thorough check of the audio stages. When you get this section working normally (or if it already is), it acts as a signal tracer which indi-

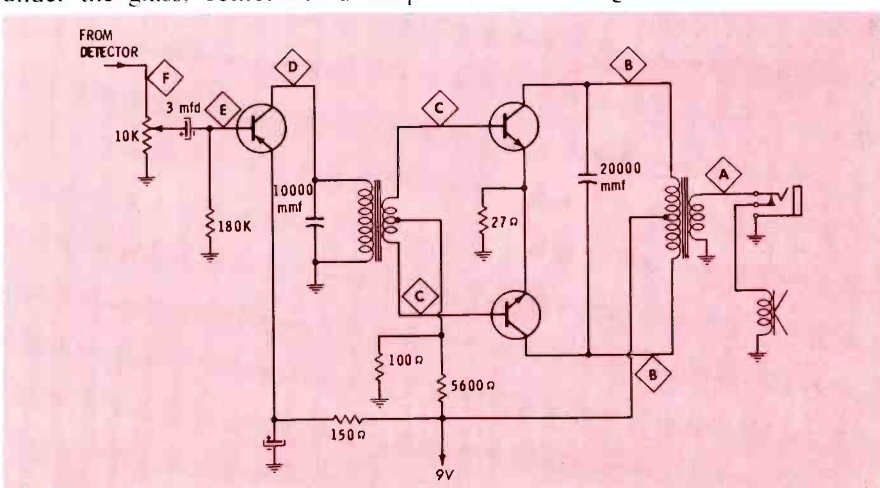



Fig. 4. Key test points form basis of step-by-step troubleshooting procedure.

cates whether or not the remainder of the set is operating properly.

The quickest check of the audio sections is the tried-and-true "finger test," applied at the top of the volume control. A loud hum from the speaker of the set will tell you the audio amplifiers are operating, even though they may be operating poorly. If you are a technician who frowns on such "grass-roots" techniques, an audio generator will do a more thorough job. Apply the audio signal to the receiver output—point A in Fig. 4. This should cause sound in the loudspeaker. A signal applied to point D will tell you if the output stage is amplifying, and whether it is distorting the signal.

By moving the test signal from point to point, you can test each audio stage, and note the gain and distortion. If a point is found where the signal is lost, blocked, or distorted, voltage checks will usually enable you to identify the guilty component. Remember, the amplitude of the signal source must be reduced as the signal is injected at points farther from the speaker. Otherwise, overload distortion may be introduced which is no fault of the receiver.

### The IF Stages

With the audio stages functioning, the next step in the logical service procedure is the examination and testing of the IF amplifiers. The detector stage is a part of this section, since the crystal diode is usually connected directly to the last IF transformer.

You can best analyze the IF amplifier stages by injecting a modulated signal from a generator. This signal can be injected at the detector-diode input to see if the detector is functioning. By progressively moving the injection point back toward the mixer output, you can test the IF amplifiers much the same as you did the audio amplifiers.

Each IF coil must be tuned to the correct frequency. It can be checked at this point in the service procedure, or postponed till the final step, but there are good reasons for doing it now. The act of tuning the coil will give some indication of how well the tuned circuits are functioning, as you will see presently. A DC VTVM connected to the output of the detector diode will serve as an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GENERAL DYNAMICS | ELECTRONICS—ROCHESTER indicator of resonance as each transformer is adjusted. An accurate IF signal should be injected at the base of the mixer transistor.

Transistor IF transformers, in some cases, tune a bit more broadly than those used in tube radios. The slightly broader tuning results from the fact that transistor IF coils have a lower Q because they are designed to match low-impedance circuits. If one is found which does not tune, or whose peak is at one end of the slug's travel, the transformer should be replaced.

Erratic IF tuning may also be caused by defective bypass capacitors in the IF stages. In Fig. 5, for example, if C8 or C9 were to open or lose value, the tuning of L3 or L4 would become uncertain, causing oscillation in the stage or a poor alignment indication on the VTVM. A quick test (bridging each capacitor with a good one) would definitely establish whether these components were at fault.

### Mixers and Oscillators

The mixer combines the local-oscillator and station signals to produce the IF signals; this is its only function. One good test of mixer-stage operation is to inject the IF signal at both its input and output. If the stage is normal, it will pass the IF signal with no attenuation.

The oscillator, on the other hand, must furnish a signal (unmodulated) to mix with the incoming station signal (see Fig. 6). It must be tunable so the same difference in frequency will always exist between it and the station signal. In tube-type receivers, the usual method of checking the oscillator is to meas-

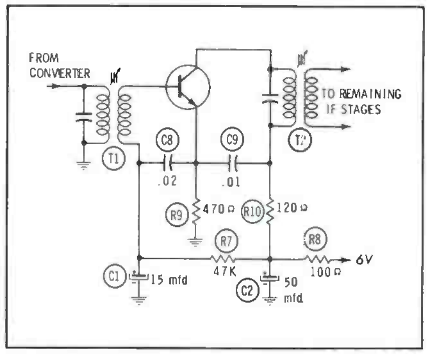



**Fig. 5. Failure in IF decoupling network may make tuning IF stage difficult.**

ure the voltage at the oscillator-tube grid, since the circuit depends on the bias developed by its own action. This method must be altered somewhat for use with transistor oscillators. The bias voltage in the transistor oscillator also is indicative of whether or not the circuit is oscillating, but it drops only a small amount when the circuit quits oscillating. Thus, you would have to know the *exact* voltage which should exist in each circuit—and this is well-nigh impossible, for this voltage varies from one radio to another.

The transistor oscillator is very sensitive to changes in frequency; as a result, the bias in the circuit varies as the frequency is changed. Therefore, you can measure the voltage at point A (Fig. 6) while you rotate the tuning capacitor through its range; if the circuit is oscillating, the voltage will vary with the frequency. If the circuit is dead, the bias voltage will remain constant.

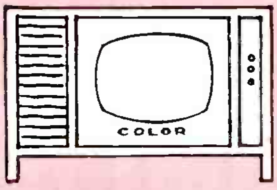
Oscillator-circuit trouble can be caused by the same faults which affect other circuits. A resistor can change value, a capacitor might de-

### Quicker Servicing?

According to an AP item datelined January 22, and published in the New York Daily News, John Fleming of Hunstanton, England, has "a legitimate kick" about his TV set's performance.

At regular intervals, the picture goes haywire, whereupon Mr. Fleming clouts the street light outside his door with a crowbar. Discovery of this cure was strictly accidental; after failing in repeated attempts to find out what the trouble was, Fleming walked out of the house one day and kicked the post just to relieve his feelings.

"It brought the picture back perfectly for awhile," he said. Now, whenever the picture acts up, one good whack usually corrects the trouble for half an hour or so. Noting that some of his neighbors report the same trouble, we wonder if John has thought of collecting a service fee for knowing how to place a well-delivered clout?

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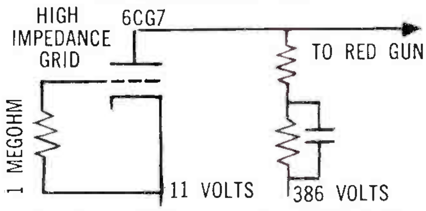
***Typical high impedance circuits like these, need the Mighty Mite for accurate checks***

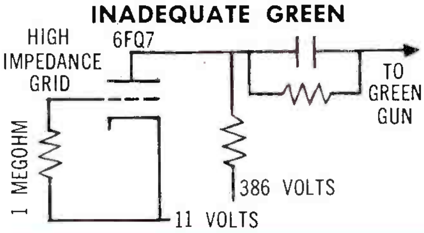
### INADEQUATE RED




### RCA & ADMIRAL R-Y AMPLIFIER

If this tube draws as little as 2 microamps of grid current, the bias is upset 2 volts causing reduced red signal. To correct this, you may go to all the trouble of readjusting the red gun when the Mighty Mite, with its high sensitivity grid check, would have indicated the tube bad, saving you this trouble.

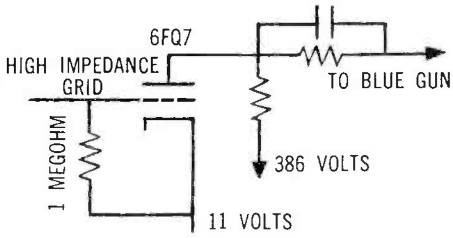
### INADEQUATE GREEN




### RCA & ADMIRAL G-Y AMPLIFIER

If this 6FQ7 tube starts to draw only 2 microamps of grid current, the tube bias will be upset 2 volts because of the high impedance one megohm grid resistor. An old fashioned tube tester, or drug store type that requires 25 microamps of current to indicate the tube as bad, would pass the troublesome tube as good.

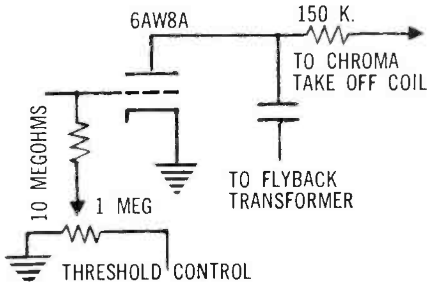
### INADEQUATE BLUE




### RCA & ADMIRAL G-Y AMPLIFIER

Conventional tube testers will not show this tube bad until it develops a change of 25 volts positive bias in circuit. The Mighty Mite will find it as soon as it starts to cause poor color mixing.

### COLOR INTERFERENCE




### RCA & ADMIRAL COLOR KILLER

If the tube draws only 1 microamp of current through this 10 megohm grid resistor the bias will be upset 10 volts restricting operation of the color killer. Color signal will interfere with black and white programs. The Mighty Mite will locate this faulty tube in a hurry while old fashioned testers will pass it as good.

Checks them all, including the New RCA Novars, Nuvistors, Sylvania 10 Pin, GE Compactrons, and picture tubes too. A real money maker for servicing color, black and white, radio, Hi-Fi.

***Available at Electronic Parts Distributors • Manufactured by Sencore, Inc., Addison, Ill.***

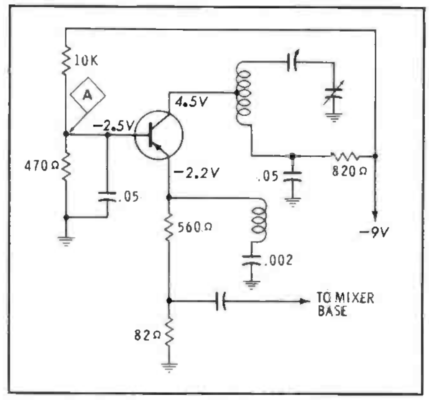



**Fig. 6. Typical oscillator circuit is normal if tuning varies bias voltage.**

velop some operating fault, or a defective transistor may just refuse to sustain oscillation. Voltage measurements and component tests will lead you to the trouble in short order.

Fig. 7 shows the converter circuit used in most transistor portables. You can consider the oscillator portion without regard for the antenna coil, provided continuity exists for all supply voltages. The voltage between the transistor base and emitter (point A) changes with frequency, as in other oscillators, and is a dependable indication that the oscillator is working.

The RF section of most transistor receivers consists solely of the antenna coil, its tuning capacitor, and the associated trimmer (Fig. 7). In those sets which have an RF amplifier stage, your modulated signal generator will provide a signal for testing. First, of course, you must be sure the oscillator is functioning.

### Finishing the Job

By this time it should be obvious why a complete procedure is outlined, even though you may have found the *main* trouble at any point in the process. When you use this method, you get a complete picture of set operation, and can quickly eliminate any small additional troubles.

At this point, you should give the set a quick over-all operational check. Try tuning in a few local stations. Are they clear and free of distortion? If not, the RF, IF, or AVC circuits may need more attention. How about distant stations; does the set have normal sensitivity and selectivity? If not, perhaps alignment will help when you reach the final step in your service pro-

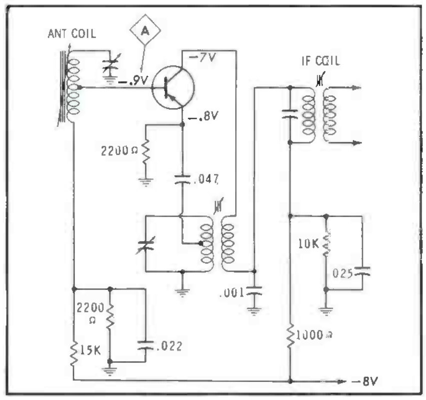



**Fig. 7. Converter circuit combines the functions of the oscillator and mixer.**

cedure. How good is the volume control; does it need cleaning, or perhaps replacing? Are there any tone controls, speaker jacks, earphone plugs? Each should be examined, because a defect in any of these will bring the set back to the shop just as surely as if you had not fixed it at all.

A complete alignment check will wrap up the job and stamp it as a thorough one. The sensitivity of many of these sets is low at best, so many a customer will be sent home happy with a set that has been carefully and completely aligned. This is not a time-consuming chore; it usually can be done in five minutes or less, if the generator is warmed up beforehand.

First of all, recheck the alignment of each IF coil, being sure it is precisely peaked. Most transistor IF coils have only one adjustment, but be sure this is the case before leaving the IF stages. An easily-found injection point for the IF signal is the oscillator trimmer connection. The DC VTVM can be connected to the detector or the AVC line and used as an indicator throughout the alignment procedure.

Next, set the radio dial at a frequency near the high end of its tuning range, say 1500 kc. Set the generator to the same frequency, and loosely couple it to the loop antenna. Adjust the oscillator trimmer for maximum indication on the VTVM. At the same time, adjust the RF trimmer for maximum indication.

Now set the tuning dial at a frequency near the low end of its range, for example at 600 kc. Adjust the slug in the oscillator coil for maximum indication. If the RF stage (where one is used) has such a slug, adjust it at this frequency also. Repeat the high-end and low-end adjustments until you can obtain no further improvement. The receiver is now at maximum sensitivity, and the dial tracking should be at its best. The set is ready to be returned to the customer.


**Line Monitor**

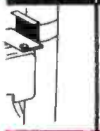
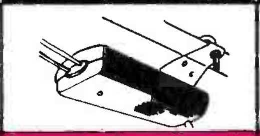
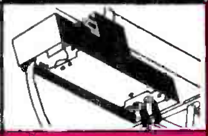
Certain troubles often show up on the service bench which can waste valuable time for the serviceman. After troubleshooting a particular set for a while, he finds that part of the trouble is due to abnormally low or abnormally high line voltage at the bench.

The RCA Model WV-120A *Power Line Monitor* furnishes the serviceman with a means of continually monitoring his bench power line, or the line voltage at any point in the shop. The unit, which plugs into an AC outlet, incorporates a large-size expanded-scale meter to indicate line voltages from 100 to 140 volts AC.

Priced at $14.95, the unit is designed to meet the need for an easily-read monitor which responds readily to instantaneous line-voltage fluctuations. The meter uses a fast-acting moving-vane type of movement, and indicates rms voltage values regardless of their waveshape.

Mounted on the wall of the shop, the WV-120A can furnish the serviceman with a continuous, accurate indication of any unusual line-voltage conditions. This may prevent damage to equipment which might be otherwise subjected to high line voltages, or supply the reason for short-lived light bulbs. In addition, it relieves the technician from worrying over varying line voltages, and enables him to take such variations into account when making final adjustments to sets. ▲

# ...PLIFIER COMPARISON CHART ...WITH THE JFD SPECIFICATIONS THAT COMPETITION FORGOT(?)

| OR A lus Batt. | COMPETITOR B List $44.95 | COMPETITOR C List $39.95 | JFD TRANSIS-TENNA $36.95-AC and $34.95-DC List |
|---|---|---|---|
|  |  |  |  |
| | | | |
| b | 4 db | 17.2 db | 18 db |
| ) | 9.5 db | 13.5 db | 15 db |
| | 1:2.5 | 1:2 | 1:1.4 |
| | 1:3 | 1:2.5 | 1:1.4 |
| )NLY) | NO (INPUT ONLY) | YES | NO |
| | NO | NO | YES |
| 3, 4 | Ch. 2, 3 | CH. 2, 6 | NONE |
| | NO | NO | NO |
| | NO | YES | YES |
| | YES | NO | NO |
| R | POOR | GOOD | EXCELLENT |
| | | | |
| | NO | NO | NO |
| | NO | NO | NO |
| ) | YES (NOT EASILY INSTALLED WHEN AMPLIFIER IS RE-REMOTED FROM ANTENNA) | YES | NO |
| Y TYPE UPPLY | YES | NO | YES |
| ) | YES | YES | YES |
| ; | OUTPUT OF AMPLIFIER ONLY | YES | NO |
| | 4 | 2 | 4 |
| | | | |
| BATT. | 44.95 | 39.95 | $36.95-AC and $34.95-DC List |
| BATT. | 28.77 | 26.63 | As low as $22.70 for AC. As low as $21.47 for DC. |
| ) | NO | NO | YES |
| ) | NO | NO | YES |
| $2.00 LACEM. | 27¢ | 27¢ | 27¢ |

*...art are available on request. JFD will be ... its Transis-tenna brochure which shows ... many consumer benefits into profits.*

# JFD transis-tenna AMPLIFIER

REGISTERED TRADE MARK

Ferrite transformer is used in JFD amplifier input only. Not needed in output because the output circuit has been designed for 300 ohm balanced operation.

MADT denotes "micro-alloy diffusion transistor" production technique. JFD uses PADT denoting "post-alloy diffusion transistor" production technique. Both types are 4-lead VHF transistors with high gain, low noise figures.

JFD power supply is designed to provide more than adequate filtering under standard load. Why use two filters when one better filter will do as well? With the bonus of fewer parts that minimize servicing needs.

Why add something not really needed? Almost all AC outlets are duplex types nowadays. Besides, power supply and amplifier will always remain "on" if TV set is plugged into built-in AC receptacle. JFD "sensible" engineering provides you with "on-off" switch so amplifier can be turned off when TV is not being used.

No gain control is needed in JFD amplifier since it is designed and tuned for maximum gain on all channels at all times. Moreover, if a local signal is strong enough to require attenuation, why penalize all the other channels by turning down the gain control? Instead, JFD engineers recommend that the serviceman pad the offending channel only, leaving all the others to come in with maximum gain.

Neither is a polarity switch needed. Polarity is set at time of installation. Why offer the TV viewer a useless polarity switch? If he or one of the family should accidentally reset the switch, it means a needless call-back at the serviceman's time and expense.

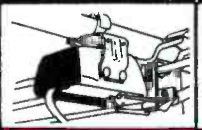
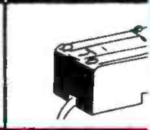
It's common sense to provide a minimum of necessary operating controls for the use of the consumer. The fewer the controls the smaller is the possibility of trouble with consumer handling of unit. This is part of JFD engineering philosophy.

Because the best place for the amplifier is at the antenna terminals. Why defeat the very purpose of an amplifier by attaching it any place but the right place? — at the point of highest signal-to-noise ratio — the antenna's take-off points. Be it single-driven, twin-driven, stacked-conical, Yagi or any other antenna design, that's where the JFD amplifier goes.

No-strip terminals are used only on output of JFD amplifier and JFD power supply. The input to JFD amplifier is effected through indestructible heavy gauge solid aluminum busbars which attach directly to antenna terminals. (One less potentially troublesome twin lead connection.)

# HERE IS THE ANTENNA AN

## ANTENNA AMPLIFIER COMPARISON CHART

| | THIS IS THE ANTENNA AMPLIFIER MANUFACTURER WHO MADE THIS TEST | COMPETIT List $29.95 p |
|---|---|---|
| |  |  |
| **PERFORMANCE FEATURES** | | |
| 1. Average gain, low band | 18 db | 13 d |
| 2. Average gain, high band | 14 db | 7 dt |
| 3. Average VSWR, input | 1:1.5 | 1:2 |
| 4. Average VSWR, output | 1:1.5 | 1:2 |
| 5. Balanced input & output ferrite transformer | YES | NO (INPUT ( |
| 6. High pass input filter | YES | NO |
| 7. Channels where amplifier phase shift hurts picture quality | NONE | CH. 2, |
| 8. Uses MADT 4-lead (VHF) transistor with high gain, low noise figure | YES | NO |
| 9. Designed with enough power to drive up to 6 TV or FM sets | YES | NO |
| 10. Two section power supply filter | YES | NO |
| 11. Circuit stability (won't oscillate) | EXCELLENT | FAII |
| **CONVENIENCE & SERVICE FEATURES** | | |
| 1. AC receptacle on Power Supply for plugging in TV | YES | NO |
| 2. Polarity and Gain Control switch | YES | NO |
| 3. 3-way amplifier mounting bracket that is easily mounted anyplace from antenna boom to TV set | YES | NC |
| 4. Rectifier, filter condenser and power transformer in power unit instead of up on antenna amplifier | YES | BATTERY POWER S |
| 5. Electric Power Supply with AC isolation transformer | YES | NC |
| 6. No-strip terminals on both input and output of amplifier and power supply | YES | YES |
| 7. Number of set outputs on power supply | 2 | 4 |
| **SELLING FEATURES** | | |
| 1. List price | 34.95 | 29.95 + |
| 2. Dealer net price | 20.97 | 19.00 + |
| 3. Compact, set-up display carton | YES | NC |
| 4. Nationally advertised to your customers | YES | NC |
| 5. Cost per year to operate | 27¢ | AT LEAST BATT. REP |

*Reprints of the above c*
*pleased to send you als*
*you how to convert t*

# LET'S GET THE RECORD STRAIGHT

A JFD competitor is currently circulating the "unbiased" antenna amplifier comparison chart shown on the right. This enlightening analysis (not surprisingly) claims the competitor's amplifier superior in every respect.

However, my competitor overlooked (?) one important detail.

**HE CONVENIENTLY OMITTED THE JFD TRANSIS-TENNA AMPLIFIER.**

I am not surprised, but I am disappointed at my competitor's oversight.

Just for the record, only the JFD transistorized amplifier has the unique and desirable feature of mounting directly on the dipole terminals at the point of lowest noise level. It is available as a built-in part of 16 JFD Transis-tenna antennas. It is also used as an "add-on" amplifier that is universally adaptable to any other antenna be it inline Yagi, conical or otherwise. In my opinion, this versatility makes the Transis-tenna the best of the "add-on" amplifiers.

I had believed that the members of the antenna industry had outgrown the need for such so-called "authentic" comparison charts. At this point, however, I feel that every distributor and dealer is entitled to know the complete story. So with apologies to our competitors, we are reproducing the data from his chart with the JFD features added.

I invite your review of the now complete analysis. Judge for yourself which is truly the best "add-on" antenna amplifier in value and performance.

JFD ELECTRONICS CORPORATION

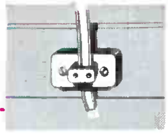
Edward Finkel

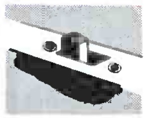
Edward Finkel,
Vice President — Sales

Open this flap for the *complete* "add-on" amplifier story...

# ...AND HERE ARE SOME MORE EXCLUSIVE transis-tenna AMPLIFIER FEATURES OUR COMPETITION NEGLECTED TO MENTION!

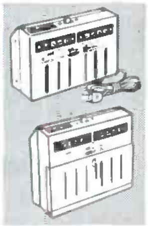
REGISTERED TRADE MARK

1 
JFD supplies 300 ohm male and female twin lead connectors for 4-set operation or to provide four different locations where set(s) can be used.

2 
JFD power supply employs on-off switch for viewer's convenience and use when set is shut off. (Also used by competitor A.)

3 
JFD multi-set distribution system uses low-loss ferrite core transformer circuit... not lossy resistor design such as that of our competitor's.

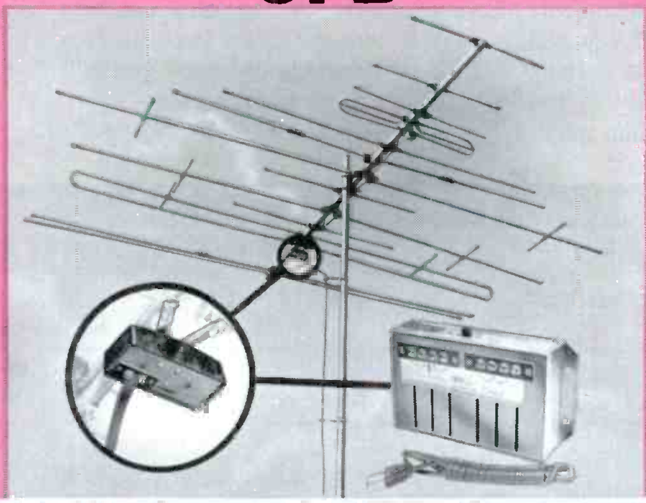
4 
JFD amplifier is corrosion-resistant. It is constructed of aluminum busbars, butyrate housing and an iridited steel terminal plate.

5 
Only JFD offers choice of AC or DC operated amplifier (excellent for accessible attic installations).

6 
Only JFD provides you with the widest selection of electronic Transis-tenna antenna-amplifier-distribution systems that helps you make every antenna sale a profitable Transis-tenna sale.

## Only the JFD transis-tenna amplifier *integrates* itself into your antenna system

REGISTERED TRADE MARK



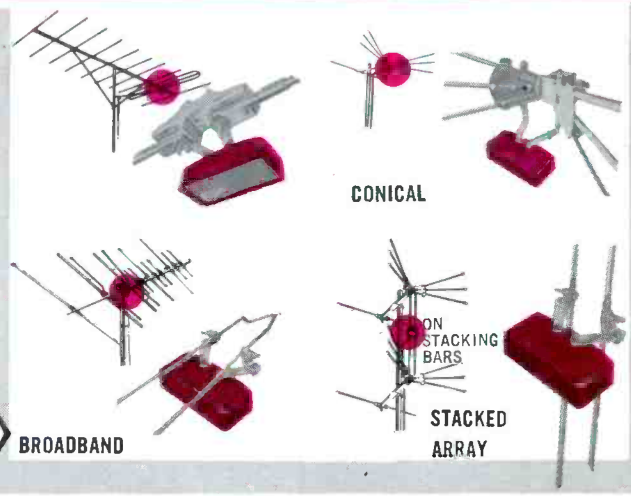
The Transis-tenna is the only amplifier designed to be an electrical and mechanical built-in part of the antenna.

JFD mounts its amplifier at the point of highest signal-to-noise ratio. You do not attach it to the mast, or the crossarm, or at the set—but at only one place, the right place—directly to the antenna take-off points. That is why you get no makeshift straps, clamps or brackets with the Transis-tenna. And for all-new antenna installations, JFD offers you the choice of 16 different Transis-tenna systems complete with integrated amplifier, antenna, power supply and set-coupling units. You pick the right electronic antenna package, perfectly matched to the location.

## Only the transis-tenna amplifier converts *any* antenna type into a truly *electronic* antenna system!

REGISTERED TRADE MARK

The Transis-tenna amplifier mounts directly to the take-off points of any antenna in 30 seconds.




## NOW... PROVE THE TRANSIS-TENNA'S SUPERIOR PERFORMANCE TO YOURSELF!

JFD invites your on-the-job comparison of the design and performance advantages of the Transis-tenna. See for yourself why more quality-conscious, performance-conscious, profit-conscious service-dealers are switching to the JFD Transis-tenna amplifier.

*Call* YOUR JFD DISTRIBUTOR TODAY FOR transis-tenna

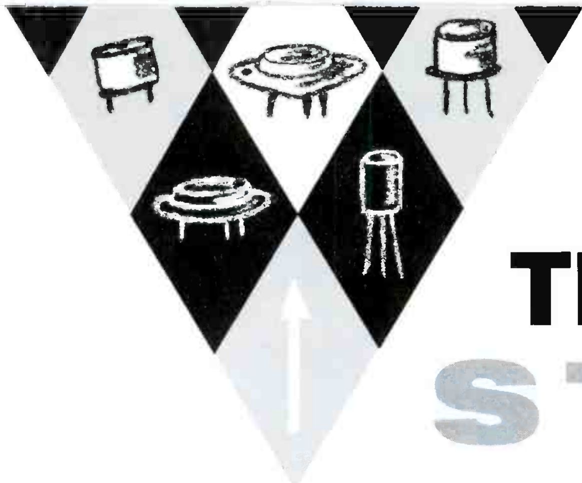
REGISTERED TRADE MARK

**JFD**

THE BRAND THAT PUTS YOU IN COMMAND OF THE MARKET

**JFD ELECTRONICS CORPORATION**

6101 Sixteenth Avenue, Brooklyn 4, N.Y.
JFD Electronics-Southern, Inc., Oxford, North Carolina
JFD International, 15 Moore Street, New York, N.Y.
JFD Canada, Ltd., 51 McCormack Street, Toronto, Ontario, Canada



# Update your Basic TRANSISTOR STOCK

**Types to keep on hand for substitution-testing and replacement**

Rather than attempt to stock exact replacements for the hundreds of different transistors found in various transistor radios, a serviceman can choose a basic substitution stock from the selection given below, that will work 90% of the time.

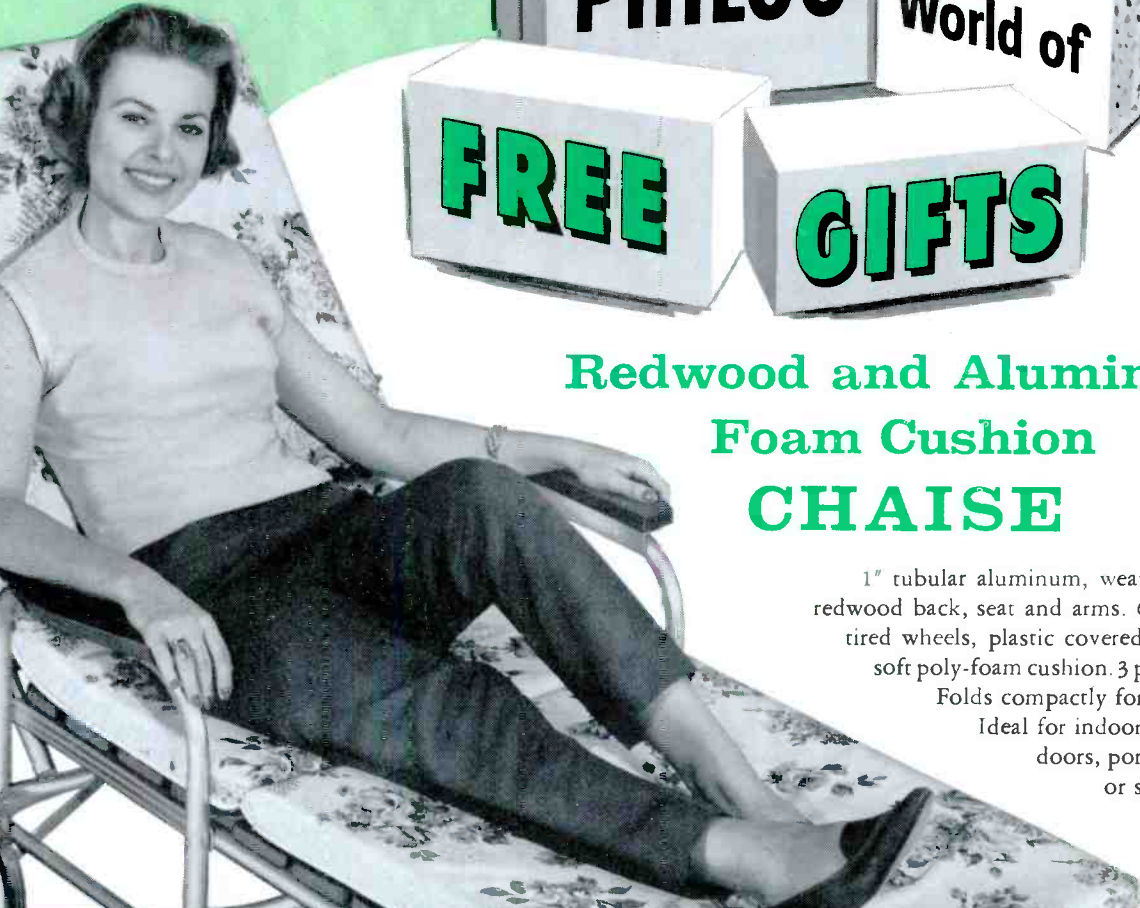
Several manufacturers have changed their recommended types since we published the substitution stock guide in the August, 1961 issue. Don't be surprised if you find that the types you have been using are no longed listed. Chances are they are still available, but might be put on a limited production schedule sometime in the future. In many cases, the new types are very similar to the old, differing only in that they have been made a little more nearly universal and will work better in more circuits.

| MANUFACTURER | RF | | MIX-OSC-CONV | | IF | | DRIVER | | OUTPUT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PNP | NPN | PNP | NPN | PNP | NPN | PNP | NPN | PNP | NPN |
| AMPEREX | 2N2092 | | 2N2092 | | 2N2092 | | 2N280 | | 2N284 | |
| CHANNEL MASTER | | | 2SA52 | | 2SA53 | | 2SB54 | | 2SB56 | |
| DELCO | DS25 | | DS25 | | DS25 | | DS26 | | DS26 | |
| GENERAL ELECTRIC | GE-1 | GE-5 | GE-1 | GE-5 | GE-1 | GE-7 | GE-2 | GE-8 | GE-2 | GE-8 |
| MOTOROLA | 2SA73 | 2N1086 | 2SA52 | 2N1086 | 2SA49 | 2N169 | 2SB54 | | 2SB56 | |
| PHILCO | 2N344 | | T1306 | | T1233 | | T1001 | | T1005 | |
| RCA | 2N1632 | | 2N1526 + | | 2N410 + | | 2N406 + | 2N649 | 2N408 + | 2N649 |
| RAYTHEON | 2N416 | | 2N486 | | 2N483 | 2N1367 | 2N362 | | 2N632 | |
| SEMITRONICS | HF20 | NR10 + | HF12 + | NR10 + | HF6 + | NR5 + | AT20 + | NA20 + | AT30 + | NA30 + |
| SPRAGUE | 2N344 | | 2N344 | | 2N344 | | | | | |
| SYLVANIA | 2N544 | 2N94A | SYL105 + | SYL101 + | SYL106 + | SYL102 + | SYL107 + | SYL103 + | SYL108 + | SYL104 + |
| TEXAS INSTRUMENTS | 2N1107 | 2N172 | 2N1108 | 2N172 | 2N1110 | 2N253 | 2N238 | | 2N185 | |
| TUNG-SOL | ET-1 | ET-8 | ET-1 | ET-8 | ET-2 | ET-9 | ET-5 | ET-10 | ET-4 | ET-11 |
| WORKMAN | BA6A | SA7 | BE6A | SA7 | BA6A | SK7 | AT6A | SQ7 | B5A | L6 |

NOTE: Several manufacturers supply kits of replacement transistors. Types included in these kits are marked.

# Spring Comes Early...

## in the wonderful


AD 3993

## Redwood and Aluminum Foam Cushion CHAISE

1″ tubular aluminum, weatherproof redwood back, seat and arms. 6″ rubber tired wheels, plastic covered 2″ thick soft poly-foam cushion. 3 positions. Folds compactly for storage. Ideal for indoors or outdoors, porch, patio or sunroom.

**FREE WITH $415 WORTH OF PURCHASES . . . $25 LESS WITH BONUS CHECK**

AD 3989

### Folding Arm Chair

Redwood and aluminum, 1″ tubular frame. Folds flat to 6″ for storage. Weatherproof.

**FREE with $130 worth of purchases**

AD 3967

### Fitted Travel Case

For the ladies. Scuff resistant vinyl covering, fitted with Jewelite Nylon brush, comb and mirror set.

**FREE with $125 worth of purchases**

## MANY OTHER OFFERS NOT SHOWN!

AD 3965

### Nylon Bag, Gloves

Clutch style purse with gold finished chain. Nylon palm stretch gloves to match. Black only.

**FREE with $60 worth of purchases**


AD 3982

### Ronson CFL Shaver

1962 Mark II Electric Shaver. $23.50 value. Multi-blade miracle cutter gives quickest shaves.

**FREE with $250 worth of purchases**

AD 3983

### Men's Ban-Lon Sox

First quality, 100% Ban-Lon yarn, reinforced top and heel. Stretch type, fits sizes 10 to 13.

**FREE with $12 worth of purchases**

AD 3986

### 3/8″ Electric Drill

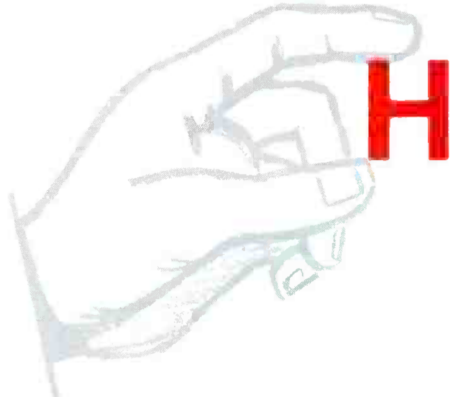
3/8″ electric drill with new "Speedsight" for easier drilling at any angle. "Speedway" brand.

**FREE with $225 worth of purchases**

**SEE YOUR PHILCO DISTRIBUTOR TODAY . . . SELECT YOUR FREE GIFTS NOW . . . PROGRAM ENDS APRIL 30th**

DOLLAR & SENSE *Servicing*

**by Wayne Lemons**



# How to HANDLE TRANSISTOR RADIO CUSTOMERS

Fred Ellis is one of the most prosperous technicians I know. He lives in a small town (pop. 2986), and has made all his money in the service business. Fred owns his own business, has a new service truck, a two-year-old car, wife and three kids, and is buying a new home. Obviously, he's a man who knows something about pleasing customers. Since I knew he did a good business in transistor radio servicing, I picked a night when he wasn't busy in community activities, and drove up to see him.

After exchanging amenities, I got right down to business. "I'm here to find out your secret for pleasing customers," I said, "especially transistor radio customers."

"That's a big order," Fred said. "I don't know any secret that works in every case."

"Then your method isn't infallible?" I asked.

"I don't know anything that is, do you? But it works most of the time, and I'd be willing to say that it works every time on customers you really want to keep. After all, what has the customer got to lose? I offer to check the set free, and I'm not going to bill him until I pre-prepare him."

"What's that again?" I asked. "Pre-prepare him?"

"That's what I said," Fred laughed. "It's no doubt an atrocious word — something like calling early morning before-before noon — but it sort of explains my philosophy about preventing customer complaints."

"Could you give me an example?" I asked.

"Well, let's suppose Mrs. Jones comes in with an off-brand transistor radio. I try new batteries and find this doesn't cure the trouble. I realize the job is going to take some time to analyze, and more time to find parts if it needs something special, and all this is going to cost more money than she is probably expecting to pay. I can't very well say, 'Where'd you pick up this piece of junk?' or 'Why didn't you buy a good radio if you were going to get one?' — even though I may have an overpowering urge to do just that. But I know this sort of answer is an inexcusable diplomatic error, since it belittles her judgment, or the judgment of a dear friend or relative if the set happens to be a gift. It's here that I have to start the job of 'pre-preparing'."

"And how do you do that?"

"I explain to her that the parts for this model are not available locally, and the only way we can get them is from the manufacturer. This, I point out, takes time. I also tell her that the repair will probably cost her around $15.00, or whatever my judgment tells me would be a *high* estimate. If I can conveniently delay making a quotation, I don't try to 'guesstimate' until I've had a chance to check the set further."

"Do you always make the estimate high?" I asked.

"No," he grinned, "I don't always, but I sure *try* to. It's a heck of a lot easier to come down on an estimate than to go up, as you know. In fact, you can actually build good will when the final charge is less than the quoted price, but unless you want to risk losing a customer, you'd better not try to charge more than the estimate."

"But won't the customer be tempted to take his radio somewhere else if the estimate is too high?"

"He might be tempted, but you'd be surprised how seldom I lose a job because the estimate is high — especially if I explain that the estimate might possibly be a little bit high, since I can't be sure just what is wrong nor what the parts will cost. But to get to the heart of the matter, I'd rather lose a job than to lose *money* on the job, and this is easy to do on transistor radios."

"But," I protested, "will people pay almost what the radio cost originally just to have it repaired?"

"Yes, they will, and that was surprising to me too, at first. But the owner often becomes strongly attached to one of these midget marvels, either because they are gifts or have some other personal appeal. The value of the radio to the owner often isn't measured in just money. Reminds me of a man I once knew. He was broke and hungry, yet he wouldn't part with his whittlin' knife for a good price. Intrinsic value, I think the books call it, and you find it applies pretty well to transistor radios."

"This leaves just one approach open for getting a fair price to fix these radios, and that is what I called pre-preparing. Tell the customer in advance that the bill will be $15.00, and she'll let you fix it and be pleasantly suprised if it doesn't run that much. Hit her with even a $12.50 bill without advance warning and she's apt to go right through the ceiling, yelping like a stepped-on dog."

"Do most transistor radio repair bills run $12.50 to $15.00?"

"No, actually they run quite a bit less as a general rule, especially if the radio hasn't been tampered with and it's a standard brand. On this kind I usually have a top estimate of eight or nine dollars — often the final charge isn't more than five or six dollars."

"Can you make money at these prices?"

"I didn't on the first few I tackled, but then I couldn't very well charge the customer for my ignorance. Since I've worked on several, I can probably turn out eight or ten a day if necessary and not work too hard either."

"I take it, though, that you don't please everybody?" I asked.

"Oh, no," he smiled, "I can't always please *myself!* I remember a fellow we had speak at Rotary one time. He said he didn't know the secret of success, but he knew how you could be a failure: 'Try to please everybody.' I'm not just sure how he meant it, whether you'd be a failure in the sense that it's impossible to please everybody, or whether he meant that trying to please everybody, without exception, doesn't leave you enough time for getting anything else done."

"Then you don't believe in trying to

---

*Editor's Note: The name of the main character in this story is fictional, made up by the author from the first names of two business associates. The facts, however, are truthful, based on the experience Mr. Lemons has gained in successfully dealing with customers over a period of several years.*

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please everybody?" I asked.

"I didn't say that," he laughed. "I try, but I don't consider my efforts are in vain just because I can't please everybody without exception — and I keep on trying. Actually, I get a big kick out of making an irate customer 'eat out of my hand', so to speak — especially when all my natural instincts say, 'Punch him in the nose!' I've developed it into a sort of game I play, where I try to win the argument without the customer realizing it."

"And do you always win the game?" I asked.

"No, I must admit I don't always win," he said, "though I fortunately haven't lost to the point where I've punched somebody in the nose, much as I've felt like it. I try to remember the admonition in the book of Proverbs, 'A soft answer turneth away wrath.' And you know, it works! I think if I were advising someone on how to handle customers, or people in general for that matter, I'd say, 'Read the book of Proverbs.' Such passages as, 'If a man would have friends, he must show himself friendly,' or 'Seest thou a man that is hasty in words? There is more hope of a fool than of him.' You just can't improve on counsel like that."

"Then you believe the customer is always right?" I asked.

"To quote an old saw, 'They may not always be right, but they're always the customer.' And after all, it's the customers who pay my grocery bills!"

"Then you always let the customer have his way?"

"No, not always," he smiled. "What I really like to do is to let the customer have *my* way — but I like for him to think it's *his* way."

"Could you give me a 'for instance'?"

"Sure," he said. "Let's suppose Mr. Smith comes raging in with a transistor radio I repaired last week. 'This thing's no better'n it was before you fixed it,' he screams. Well, I could simply ignore him and hope he'd go away, or I could say, 'What'd you expect outa that hunk o' junk?' But neither would make him jump for joy, and if a customer isn't satisfied, it's me that suffers in the long run."

"So how do you handle the situation?" I asked.

"I just try to remember the 'soft answer' and 'hasty word' advice, and though it sometimes hurts my pride a little, I usually say something like, 'Say, I'm sorry, Mr. Smith. Just what isn't right about it?' And I really try to be genuinely sorry — if not for the customer, at least for myself. But can you see what an answer like this does?"

"I don't know if I know what you're driving at."

"Well, what I mean is, it gives the customer a chance to explain — whatever's eating him, he gets it off his chest. And you know, it's just like a magic potion—when a customer gets a chance to talk about his complaint to someone who'll listen, his anger melts like snowballs in July."

"But what then?" I asked. "Do you fix

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the set free?"

"That all depends on what the complaint is. If it *is* the same complaint, or even if it *appears* to be, I usually feel it's better to repair the set free than to risk *trying* to explain and *still* have to fix it free. I just charge it up to my advertising or *good will* fund."

"But what if it *is* a different complaint?"

"This is where listening and a good file system pay off," he smiled, "and I try to make it work to my advantage. After Mr. Smith explains the nature of his complaint, I get out the original bill and see what the earlier complaint really was. Sometimes there is no resemblance! If the complaint *is* different, I try to bite my lip and refrain from saying, 'This sure as heck ain't what you said was wrong with it the first time!' which is just a shade under calling him a liar. Instead, I try to say something like, 'Mr. Smith, the complaint I have listed on the original bill indicates the set was weak. Now, you seem to have some static-like noise. I suspect some *other* part must have gone bad.' There are probably better answers, but I think this pretty well gets the point across."

"I'm not sure I quite understand," I said, urging him to go into more detail.

"Well, my basic point is that I want to give the customer a chance to save face. First, I describe the complaint *I had listed* originally. Next, I describe the present complaint so that the customer can make a comparison. He can hardly help figuring out that his two complaints are *not* the same — but you see I haven't told him this in so many words. Finally, I plant the suggestion that because the complaint *is* different, the trouble must be in some *other* part. This is the conclusion I want him to arrive at on his own. By this time the customer is usually calmed down (if I have remembered to speak softly) and more often than not I get a question from him something like, 'How much will it cost?' "

"And then . . ." I encouraged further.

"I say something like, 'Mr. Smith, since you just had your set in here for repair, I'll check it over free. After I find out what's wrong, I'll call you and tell you how much it will cost to have it fixed, and I'll make it as easy as possible.' "

"But don't you have customers who insist that the trouble is the same, even thought you point out that it isn't?"

"Oh yes," he admitted. "There are a few people who will refuse to admit the trouble is any different — in spite of all evidence to the contrary."

"What do you do about this kind?"

"I try to give the radio a quick check while they are here. This shows them I'm interested in their problem, and willing to see if they *could* be right. I also try to point out the part was installed before, and if I can make an educated guess as to the part now giving trouble, I do so. I also explain that if the part we replaced is defective, there will be no charge for the repair, but that if another part has gone bad I will have to charge. I usually give them some simple example, such as, 'If you purchased a new front tire for your car, you wouldn't expect any consideration for something that happened to a rear tire.' This usually gets the point across, and if I keep a friendly tone, I'll get the job and most likely keep the customer, too."

"But if they still insist you should fix it free, what do you do?" I asked.

"Then I conclude that this customer doesn't intend to be pleased or else he's a born chiseler. I firmly, but politely, inform him that my policy is to guarantee my work and the parts I put in. However, I can't guarantee all the other parts in the set, which are just as old as the part that originally failed. If it goes farther than this, I start to thinking that I'm right and that the customer is wrong. I have had to tell a few — not many — that if they didn't trust me to be fair, I would advise them to take their business elsewhere. This is a drastic move, and I don't like to do it. But sometimes this shock treatment is the only way to handle such a customer. Sometimes they respond favorably — often they don't. But like I said, I'd rather not get the job if it means losing money."

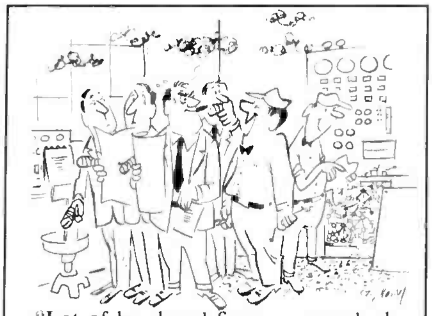
"Have you ever had to throw a customer out?"

"No," he laughed, "but I did show a customer the front door once. He told me he'd never trade with me again — and he hasn't. And I told him I didn't want to see him again — and I don't. He questioned my honesty in abusive language — that's my breaking point. Like the man said, 'You're sure to fail if you try to please everybody.' "

I got up and put away my note pad. "It's been an interesting visit," I said. "I wonder, though, if you could sum up your philosophy on pleasing customers in a few words?"

"That's still a big order," he laughed, "but if I have any advice that might be worthwhile, it would be: 'Listen carefully, keep a genuinely friendly attitude, speak softly — and only after you get all the facts — and pre-prepare the customer by giving an estimate of the possible cost involved!' I might add: 'Try to convince the customer that price is only what she pays, value is what she receives.' "

"I'd say that's pretty good advice from a man who ought to know, Fred. Thanks a lot." ▲



"Lot of bandaged fingers—everybody smoking cigars down to the NUB?"

# TUNNEL DIODES

## Semiconductors With Negative Resistance

by C.A.Tuthill

Blasting its way into the headlines, the tunnel diode—first reported in 1958 by Japanese scientist Leo Esaki—has met and exceeded the challenge of diligent research. This microminiature device operates a hundred times faster than a transistor, consumes about 1/100 as much power, and is more stable. Amplifiers, oscillators, electronic switches, and control circuits are possible within one tiny diode package. Consequently, uses for these diodes in industrial, TV, and kindred equipment are being actively investigated.

### Crystal-Diode Principles

Technicians can obtain a working knowledge of ordinary transistors and diodes without studying about "holes," "energy levels," and other concepts that explain what goes on inside the semiconductor material. However, such concepts *are* needed for an understanding of tunnel diodes, since the operation of these units is dependent on an internal phenomenon in which electrons *tunnel* through an extremely thin potential barrier within a semiconductor crystal. Before tunneling can be further defined, the basic theory of conventional diodes must be explained in some detail.

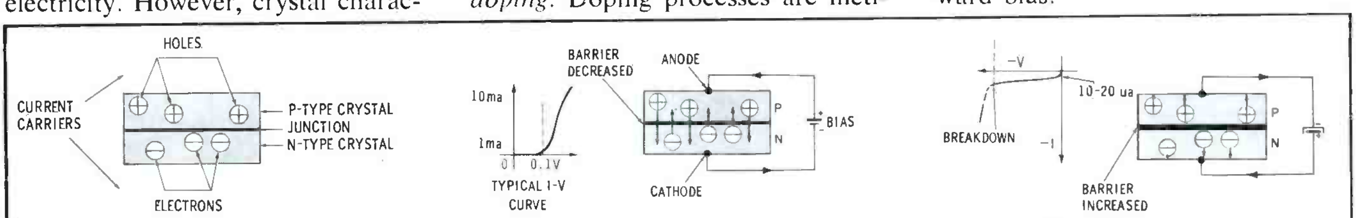
Individual crystals of germanium and silicon in a highly purified state are extremely poor conductors of electricity. However, crystal characteristics are changed, and conductivity is improved, when certain impurities are injected into the atomic *lattice structure* of the crystal. Some of these impurity elements, including arsenic and antimony, are called *donors* because they create a surplus of free electrons. Although the latter are inside the crystal, the additional electrons are not bound into the crystal lattice, and are therefore free to move. As a result, they are readily available to function as *current carriers*. A crystal that contains a donor impurity is known as an *N-type*.

Other impurity elements like indium and gallium, called *acceptors,* cause a deficiency of electrons in the atomic structure of the crystal, and thus create positive charges termed *holes*. These do not have fixed locations in the crystal lattice, but can be caused to migrate or move through the crystal; in so doing, they act as current carriers, just as electrons carry current through ordinary conductors. The addition of an acceptor impurity creates a *P-type* crystal.

Holes in the P-type crystals, and excess electrons in the N-type, are called *majority carriers*. Both types of crystals also have some *minority carriers*—holes in the N-type, or electrons in the P-type.

The process of modifying crystals by injection of impurities is called *doping*. Doping processes are meticulously controlled during fabrication of a diode, since they determine its final characteristics. A single crystal that has been doped so that both a P-type and an N-type region are formed in its crystal structure is called a diode or rectifier. The newly-formed boundary within the crystal, separating the P and N regions, is termed the diode *junction* (see Fig. 1); it presents a *potential barrier* which restricts current between the regions.

Fig. 1B illustrates the internal diode activity that occurs when a small forward bias voltage causes the anode to be positive with respect to the cathode. The negative voltage of the bias battery repels free electrons in the N-region across the junction barrier, where they combine with holes attracted toward them by that same negative bias voltage. Similarly, holes in the P-region cross the junction and combine with electrons in the N-region. Electrons from the negative battery terminal continue to enter the N-region to replenish the deficiency created when electrons and holes combine. Thus, a current flow is maintained through the diode. When the external bias voltage is increased, the junction barrier is reduced in magnitude, and current flow increases. The curve in Fig. 1B illustrates the sharp rise of current that results from an increase of forward bias.




(A) With no bias applied. (B) With forward bias. (C) With reverse bias.

**Fig. 1. Inside a PN junction diode.**

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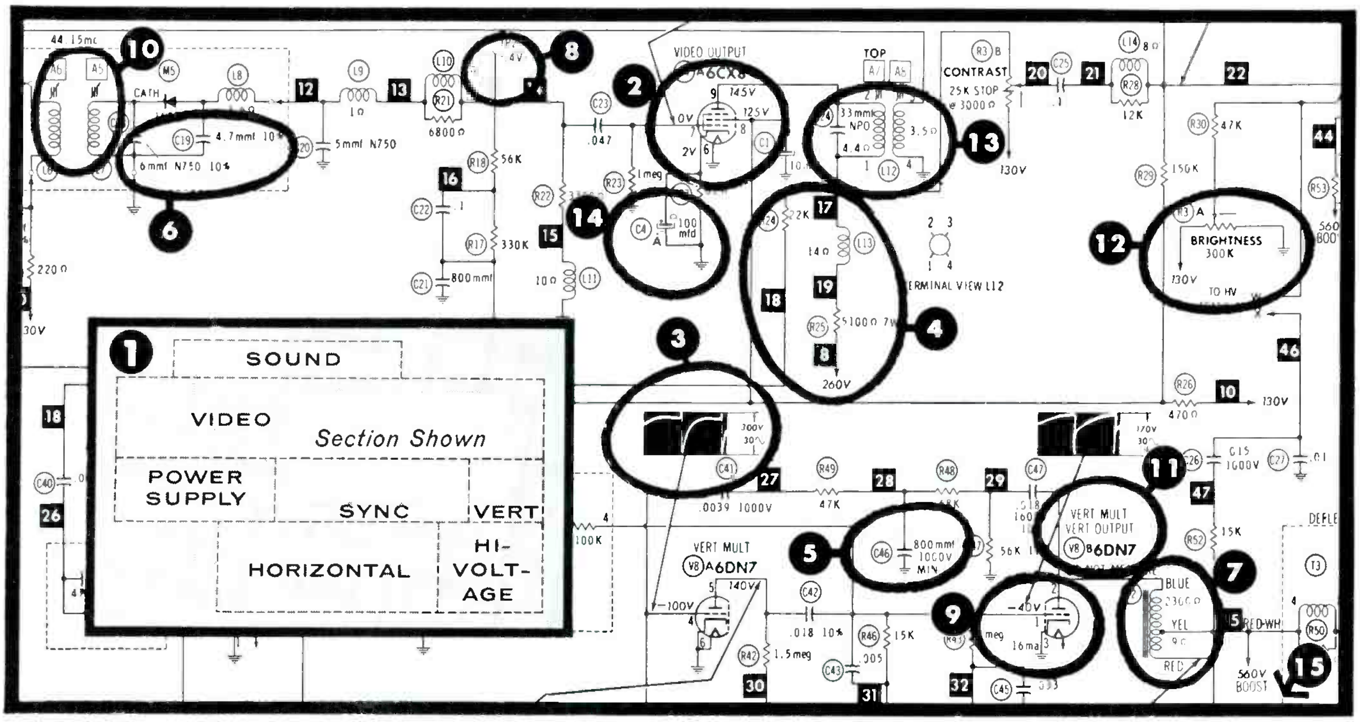


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When the applied bias is reversed, as in Fig. 1C, the holes are attracted toward the negative terminal of the battery and away from the junction. Similarly, the electrons are attracted away from the junction and toward the positive terminal. This combined action adds to the current-blocking effect of the junction barrier. Even so, with small amounts of reverse bias, a small reverse current flows—consisting of thermally-generated minority carriers. In a germanium crystal, this current increases only slightly when larger values of reverse bias are applied, until some high value of reverse bias finally causes junction breakdown (Fig. 1C). The result at this point is a sudden increase of reverse current flow, called *avalanche* current. Certain diode junctions may become permanently damaged if sustained and excessive reverse current is permitted to flow. However, most diodes are self-healing and recover completely from temporary breakdown. In fact, some diodes are expressly designed for operation in the breakdown or *avalanche* mode. Fig. 2 shows a current-vs-bias-voltage curve for a germanium diode. Notice the steep slope obtained when the diode is operating in the *avalanche* region.

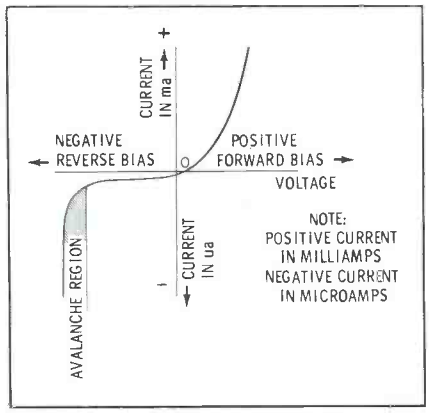


**Fig. 2. Voltage-vs-current curve for conventional germanium crystal diode.**

### *Energy Bands*

Electrical charges in a semiconductor crystal exist at various *energy levels,* and energy must be either added or subtracted to change them from one level to another. In studying current flow, we are mainly concerned with free electrons and with holes in the crystal lattice. Their energy levels fall into two distinct bands, separated by an intervening *band gap* consisting of energy levels that cannot be occupied by either holes or electrons (according to the laws of semiconductor physics). The electrons bound into the crystal structure, and also the holes created by missing electrons in P-type regions, are in the *valence band* (see Fig. 3). The holes can travel through the crystal as current carriers, but not as readily as the free electrons, which are at higher energy levels in the *conduction band.* The number of holes in the valence band, and of electrons in the conduction band, can be critically established through controlled crystal doping. Incidentally, applying heat energy to the crystal raises some of the valence-band electrons to the conduction band, thus enabling them to break loose from their lattice bonds and create additional free electrons and holes. This explains why current in semiconductors generally increases at high temperatures.

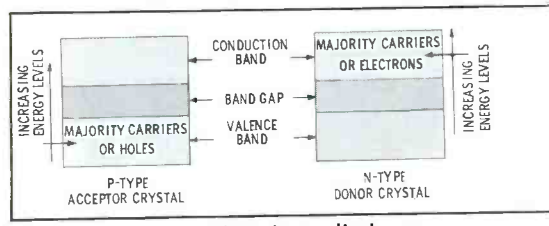


**Fig. 3. Current carriers in a diode occupy two different energy levels.**

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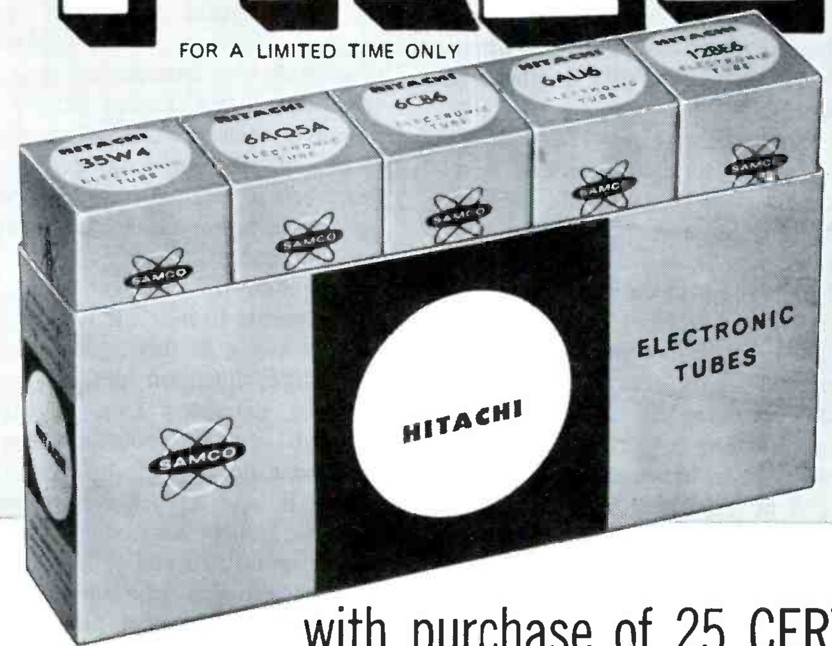


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### Tunneling Process

As we have seen, a PN junction presents a potential barrier that can prevent electrons from crossing over, even though they are at a high energy level; however, the barrier can be decreased or increased by appropriate forward or reverse bias, as shown in Figs. 1B and 1C. The greater the forward bias, the greater the number of electrons and holes that can surmount the barrier and produce current through the diode.

In tunnel diodes, the PN junction barrier exists, but is made extremely thin, usually less than one millionth of an inch in width. Thus, barrier penetration by means of the *tunneling effect* is possible. In this process, an electron lacking adequate energy to surmount the barrier can "tunnel" underneath or through it and appear almost instantaneously on the other side.

When a low value of forward bias is applied, tunneling occurs, developing a large current peak (point B, Fig. 4). Beyond the peak at point B, an increase of bias voltage results in a decrease in current through the diode (region from B to C on the curve). This dynamic *negative resistance region* contrasts with *positive* resistance, as in a wire or resistor, where an increase in voltage results in an increase of current. Instead of absorbing an input signal, as a resistor would, the tunnel diode increases, or amplifies, the signal. The usefulness of the negative resistance region can probably be best explained by comparison with vac-

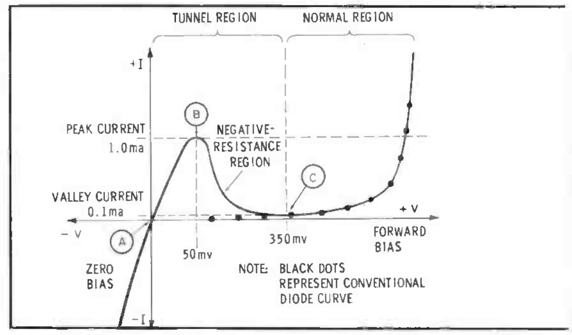


**Fig. 4. High peak at B characterizes voltage-current curve of tunnel diode.**

uum-tube characteristics. The effectiveness of a vacuum tube as an amplifier is determined chiefly by its transconductance, which embraces both the amplification factor and plate reactance, and thus establishes a figure of merit. For tunnel diodes, the amplification factor and figure of merit depend directly upon the magnitude and linearity of *negative conductance,* as determined by the negative-resistance characteristics.

In general, tunnel diodes may be described as high-current, low-voltage devices having large negative conductance.

Although the voltage swing between points B and C is limited, the current swing in this region can be very large; thus, considerable power may be extracted from a tunnel diode. Biasing to a point midway on the linear portion of the curve between B and C achieves greatest dynamic range; consequently, bias control is critical and must be highly stabilized. The behavior of a typical germanium tunnel diode under different bias conditions is shown by

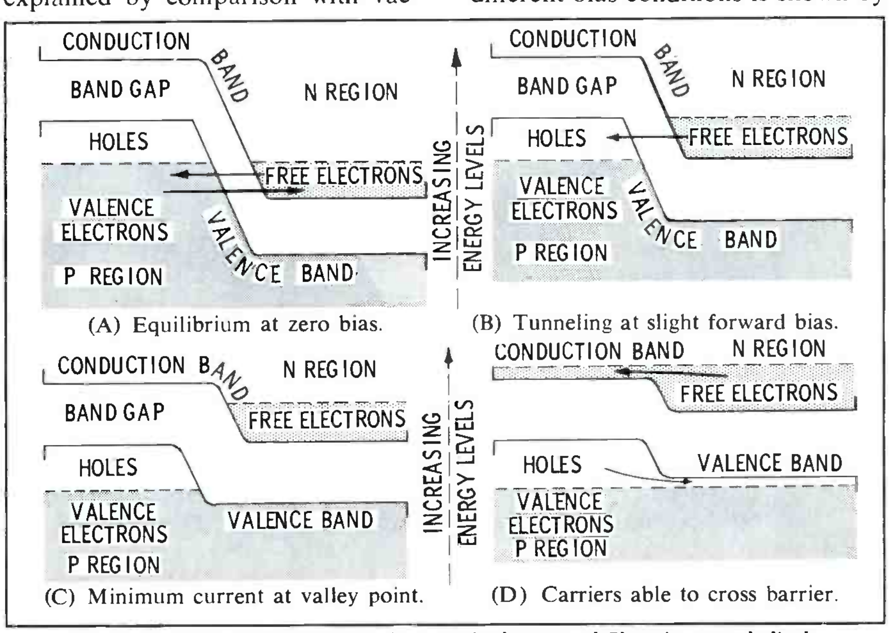


**Fig. 5. Current across junction in a typical General Electric tunnel diode.**

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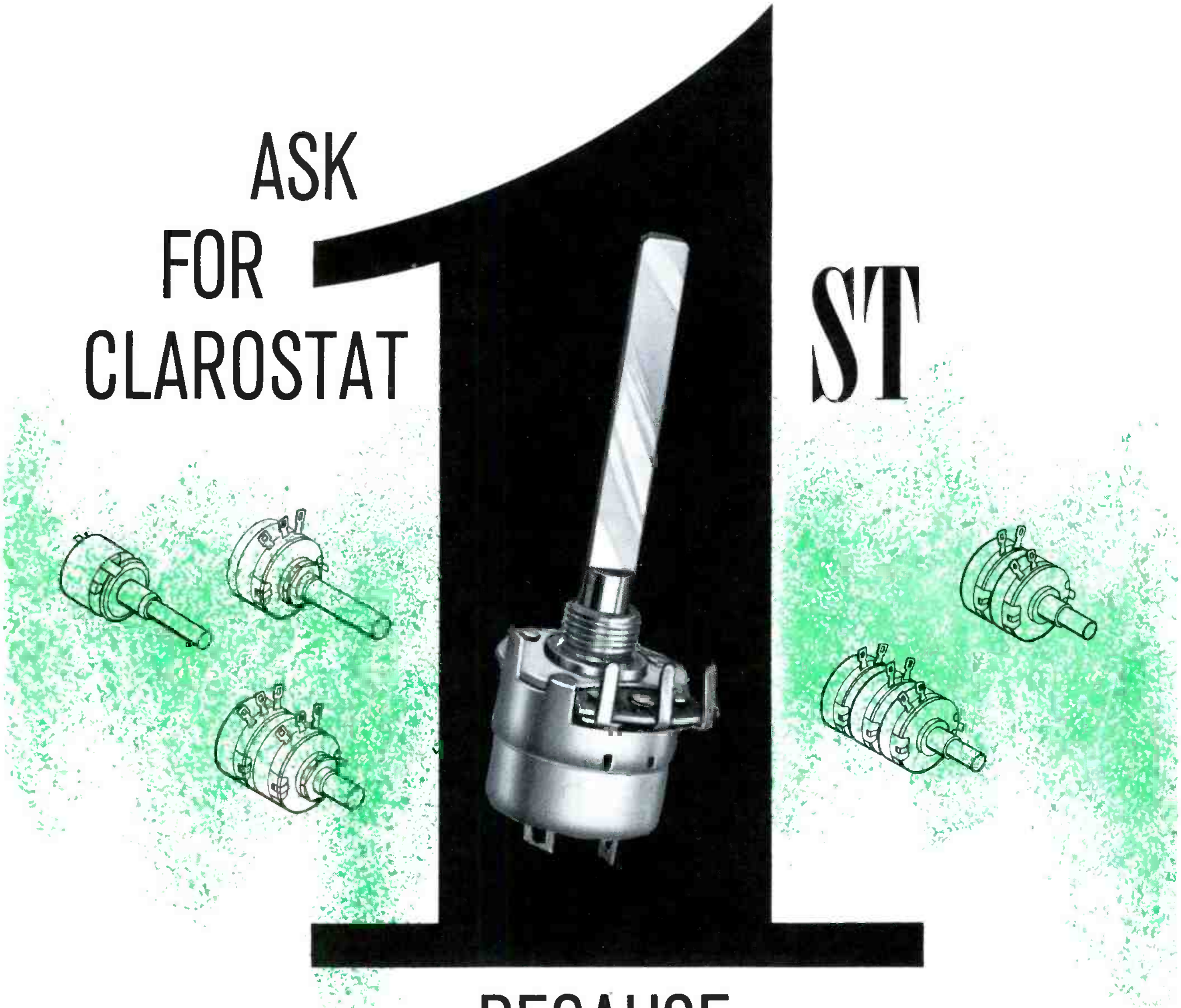

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# CLAROSTAT

CLAROSTAT MFG. CO., INC. DOVER, NEW HAMPSHIRE the series of illustrations in Fig. 5. In these graphical representations of energy levels, the junction barrier is represented by a "zigzag" in the energy bands. Note that the electrons and holes are concentrated in certain energy levels within each band. In a condition of static equilibrium, or zero bias (Fig. 5A), the free and valence electrons on opposite sides of the junction are effectively at the same energy level. Electrons can cross the junction with equal ease in either direction, and the net current flow is negligible.

The ideal operating condition for tunnel diodes is obtained when a *small* forward bias voltage is applied—50 mv in the example of Fig. 5B. The valence and conduction bands are shifted so that the free electrons in the N-region have the same energy level as the holes in the P-region. Strong tunneling current can then flow freely from N to P, with a peak of approximately 1 ma occurring at point B in Fig. 4.

As the forward bias is further increased the energy levels on the N side continue to rise, so that more and more of the electrons are opposite the band gap in the P-region. The current therefore diminishes, because the product of holes and electrons at equal levels on opposite sides of the junction is less.

When the forward bias reaches 350 mv (Fig. 5C), all electrons and holes are opposite the band gap, and only minute current flow is possible. This condition corresponds to point C in Fig. 4, called the *valley point*. With still greater increases in forward bias, free electrons in the N region can spill over the barrier as illustrated in Fig. 5D. Current then rises, first gradually and then sharply—just as in a normal PN junction diode.

### Tunnel-Diode Applications

Tunnel diodes have found application in many common circuits. The primary advantage of these units, a consequence of their very thin junction barrier, is their almost instantaneous transit time — a characteristic which allows them to be used at exceptionally high frequencies. Another advantage of tunnel diodes in many industrial applications is their ability to operate at temperatures far above the usable range of other semiconductor devices—up to 200° C for germanium types, or 350° C for silicon types.

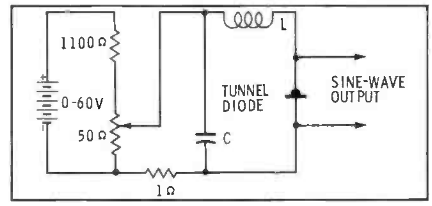


**Fig. 6. This tunnel-diode oscillator produces output at approximately 11 mc.**

Two of the most widely-used tunnel-diode circuits are oscillators and amplifiers.

#### Oscillators

Since the tunnel diode is a two-element, two-lead device, circuitry is relatively simple. (See Fig. 6). The output frequency is dependent somewhat on diode size, but is primarily determined by the LC values of the tank circuit. A relatively large-area diode (100 square mils) was used in this oscillator; however, much higher frequencies can be attained when smaller-area diodes are used.

#### Amplifiers

A unique amplifier, demonstrating the flexibility of a single tunnel diode, is shown in Fig. 7. The requirement here was to provide a tuned 30-mc amplifier to operate between two lengths of a 50-ohm coaxial transmission line. The heavier lines across the top of this circuit show the AC path, which includes resistor R to stabilize the circuit by preventing oscillation. The bias section (light lines) is connected between the diode and ground, and includes L1 (an RF-decoupling choke for the bias supply). Such an amplifier can easily attain a gain of 30 db at 30 mc for a bandwidth of 10 mc.

Other applications for tunnel diodes are still being found, and it would appear that these devices will soon be seen in many different types of industrial, commercial, and home-entertainment equipment. ▲

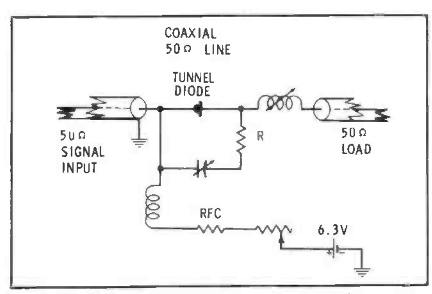


**Fig. 7. Resistor is used in this 30-mc amplifier to prevent oscillations.**

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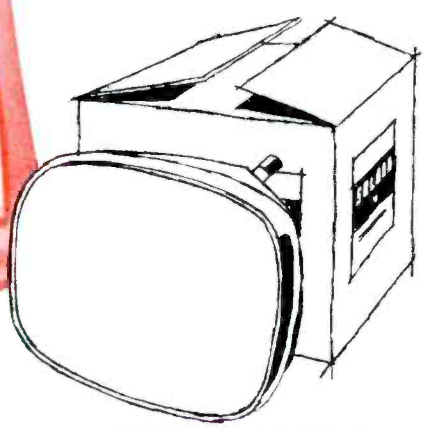

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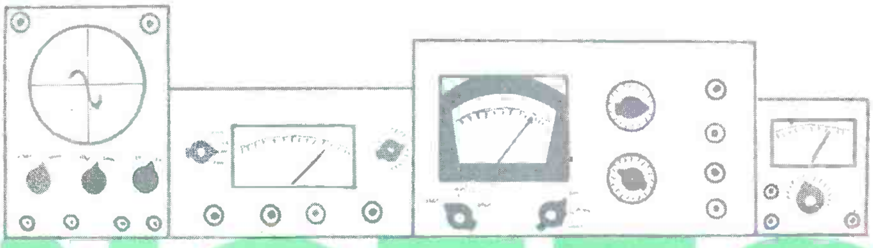

# NOTES ON TEST EQUIPMENT

**by Les Deane**

## Deflection Sharpshooter


**Fig. 1. New instrument simplifies the troubleshooting of deflection circuits.**

Many technicians rely on guesswork when they approach a sweep-system defect. Usually, the reason is a lack of understanding of deflection-circuit operation, or of suitable troubleshooting procedures. The Sencore Model SS-117 *TV Sweep Circuit Analyzer* shown in Fig. 1 takes the guesswork out of these jobs by making it possible to quickly pinpoint troubles in either horizontal or vertical deflection circuits.

Specifications are:

1. *Power Requirements — 110-120 volts AC, 60 cps; 15 watts when using the oscillator and yoke-drive outputs.*
2. *Peak-to-Peak Voltmeter — from 0 to 300 or 1000 volts peak to peak; function switch makes connection for measuring internal oscillator output; scale calibrated from 0 to 50°, 70°, and 110° for flyback-efficiency check.*
3. *DC Voltmeter—from 0 to 300 or 1000 volts DC; function switch makes connection for measuring horizontal - output screen voltage with socket adapter.*
4. *DC Milliammeter—from 0 to 300 ma; function switch makes connection for measuring horizontal-output cathode current with socket adapter.*
5. *Horizontal Signal Output — a 15,750 - cps sawtooth, amplitude variable from 0 to 300 volts peak to peak, output measured by meter; can be locked to station sync pulse of either polarity (provided by set being tested).*
6. *Vertical Signal Outputs — 60-cps sawtooth waveform for grid or plate drive, amplitude variable from 0 to 280 volts peak to peak, synchronized to power line; vertical-yoke test signal, a sine wave of about 6 volts rms, applied through a 5.6-ohm resistor.*
7. *Panel Meter—3½" face; 300-ua, 300-ohm movement; over-all accuracy about 3% of full-scale reading; two linear numerical scales, 0 to 300 and 0 to 1000; one scale calibrated in degrees of yoke deflection.*
8. *Terminals and Controls—pin jacks and* FUNCTION/RANGE *switch for external voltmeter - milliammeter; pin jacks and control push button for horizontal yoke and flyback test; substitute - yoke adjustment button; selector switch and test push buttons for horizontal-output tube measurements (via adapter); horizontal-vertical oscillator selector switch,* OUTPUT *control, metering push button, and horizontal-frequency control; pin jacks for external horizontal-sync signal input; pin jacks for vertical yoke test-signal output.*
9. *Special Features—roll chart provides data on most popular horizontal-output tubes; mirror in detachable cover; supplied with all necessary test leads, socket adapter, and high voltage probe.*
10. *Size, Weight, and Price—10¼" x 9¼" x 3½"; 10 lbs; $89.50.*

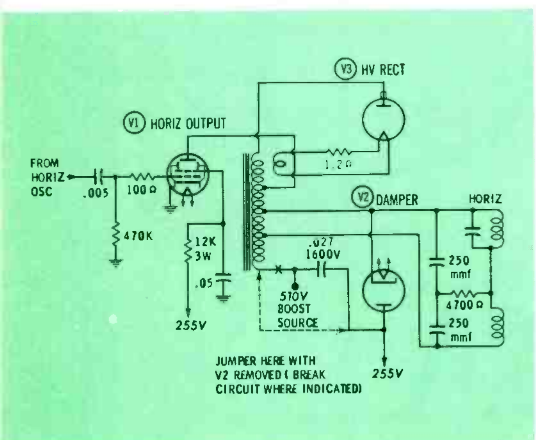


**Fig. 2. Substituting B+ in place of boost voltage isolates faulty component.**

The SS-117 provides the necessary signals and/or components for isolating any ordinary trouble and most of the unusual troubles in deflection circuits. For many technicians, the most difficult part of troubleshooting horizontal deflection circuits is deciding if the horizontal flyback transformer or yoke is defective. Since the flyback-yoke circuit is the basis for so many functions, it is difficult at times to pinpoint the fault to a specific component. Here is how it was done in our lab with the SS-117, on a set which had no raster.

The first step was to find out if the horizontal oscillator was performing as expected. One way to do this with the SS-117 is to use the peak-to-peak meter to measure horizontal drive at the grid of the output tube. An alternate method, which we chose, is that of substituting the SS-117's oscillator for the horizontal oscillator of the TV set. When we applied the horizontal test signal to the grid of the horizontal-output tube, a normal sweep and high voltage system would have caused the raster to appear on the CRT screen, thus isolating the trouble to the horizontal oscillator. But, in this case, the test produced no raster or high voltage.

Next, we applied the horizontal signal from the analyzer to the plate circuit of the horizontal output tube. For this test, the output control setting had to be increased to maximum, but still no raster appeared on the screen. This indicated that the trouble had to be somewhere between the horizontal-output tube plate and the deflection yoke.

The problem now boiled down to determining if the flyback transformer or the yoke was defective, or if there was a fault of some sort in the damper or high-voltage circuits. The high-voltage circuit was quickly ruled out by temporarily disconnecting the plate cap from the high-voltage rectifier. Since this made no difference in the set's operation, we decided to try substituting for the yoke. Even if the yoke proved to be okay, this check enabled us to make connections which we could use for later tests. We unsoldered the leads to the high side and center tap of the horizontal yoke and connected the substitute yoke of the SS-117 to the flyback transformer. Moving the yoke-inductance control on the *Analyzer* still failed to produce any high voltage. Even if the high voltage had been restored, a complete raster would not have appeared on the screen; with the horizontal yoke leads disconnected, only a bright vertical line would have been produced.

With the connections unchanged, we then pressed the button which connects the meter into the circuit, and measured the amount of deflection energy in the flyback transformer. The meter barely moved from the "zero" mark, indicating that so little energy was being developed across the transformer as to be insignificant.

The SS-117 had now ruled out every source of trouble except the damper circuit and the flyback transformer itself, so the next step was to decide which of these was at fault. By leaving the *Analyzer* connected as before, we found that any fault in the damper circuit could be isolated by a step-by-step procedure. This method consists of disconnecting all circuits from the boost line, except those going to the horizontal oscillator and output circuits. Still, there was no meter indication during the flyback test. If the meter had shown normal deflection energy, we would have known that a short on the boost line was causing the trouble.

As a final check, we disconnected the boost line from the horizontal-output circuit and, using a jumper, substituted a DC voltage directly from the B+ supply (see Fig. 2). This produced no positive results, so we then knew for sure that the flyback transformer was defective. Had the flyback been okay, the meter would have indicated that the transformer was capable of transferring energy, even though the meter reading would have been less than normal. If such had been the case, we would have known that some component in the damper circuit (usually a capacitor) was faulty. As it turned out, installing a suitable replacement for the flyback transformer resulted in normal set operation.

We now used the horizontal-output test adapter to meter the circuits while making final adjustments in that stage. After plugging the adapter into the output-tube socket and the tube into the adapter, we measured the peak-to-peak voltage at the grid. It was slightly low, but a new horizontal-oscillator tube brought it up to normal. The screen voltage checked normal according to the roll chart (see Fig. 3), so after setting the switch to monitor the cathode current, we adjusted the linearity coil for minimum current with optimum linearity.

Compared with the horizontal stages, vertical sweep circuits usually offer fewer problems. The SS-117 permits the same signal-injection procedures to be used. The vertical-signal output of the *Analyzer*

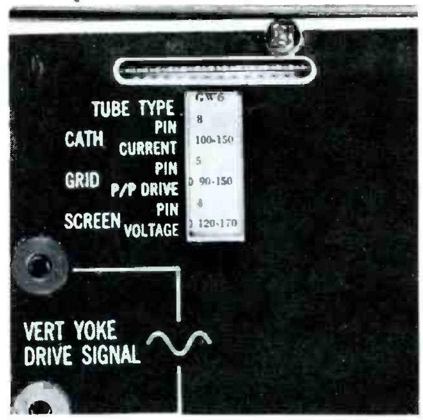


**Fig. 3. Roll chart indicates important horizontal-output tube characteristics.**

can be substituted for either the oscillator stage or the output stage. In addition, a 6-volt sine-wave test signal is supplied for direct application to the yoke. Of course, the raster developed by this sine wave will be nonlinear, but the test signal will quickly determine if the yoke is functioning.

The horizontal-signal output of the SS-117 is developed from a 15,750-cps blocking oscillator. The signal is amplified and shaped into a modified sawtooth, so it can be directly applied to the sweep stages. The vertical-signal output, on the other hand, is developed from a sine wave obtained from the power transformer. The dual-purpose tube which served as a horizontal oscillator-amplifier is now switched to function as two stages of vertical amplification. Waveshaping networks form the signal into the sawtooth needed to drive a vertical deflection system.

The vertical sweep signal of the SS-117 cannot be synchronized exactly with the station signal, since it is locked to the local line voltage; but synchronization is not necessary to troubleshoot vertical sweep troubles. However, the *Analyzer* is of little help in servicing off-frequency troubles in the vertical oscillator.

The horizontal sweep signal can be synchronized with station pulses by connecting the sync input jacks of the SS-117 to any of several points in the receiver being serviced. Judicious use of this feature can assist in tracing horizontal-sync pulses in a TV set; the procedure is outlined in the manual furnished with the instrument. After proper familiarization with the instrument, many otherwise hard-to-find circuit troubles can be located simply and easily with the SS-117.

# Calling the Signals

One of the basic test instruments for any radio or TV shop is an RF signal generator. The Model E-75 (Fig. 4) newly-introduced by Precision Apparatus Co., Inc., is stable and accurate enough for all general shop purposes, including use as a marker generator for FM or TV alignment.

Specifications are:

1. *Power Requirements—105 to 125 volts AC, 60 cps; approximately 5 watts.*
2. *RF Output—seven bands from 160 kc through 120 mc on oscillator fundamentals; one band of 120 mc through 240 mc on calibrated harmonics; unmodulated, or modulated by internal 400-cps generator; output voltage in excess of 0.1 volt rms.*

3. *AF Output—400 cps; available independently or as RF modulation; output (or modulation percentage) controllable; available audio signal in excess of 15 volts peak to peak.*
4. *Controls and Terminals — Function-selector switch to choose RF, AF, modulated RF, or externally-modulated RF;* RF BAND-SELECTOR *switch;* AUDIO MODULATION - OUTPUT *control (also controls modulation percentage except on external modulation); two pin jacks for inserting external modulation or obtaining 400-cps output; RF output coaxial connector;* OUTPUT *and* LEVEL *controls to adjust RF output. Calibrated frequency dial with vernier scale on plastic dial cover.*
5. *Size, Weight, and Price—7¾" x 11½" x 6" overall; 6 lbs.; $49.95.*

The Model E-75 is a smart-appearing instrument, with sharply-contrasted panel markings which facilitate the reading of functions, frequencies, and level settings. It uses a 6AU6 pentode in a stable electron-coupled oscillator circuit to cover the range of RF frequencies. Bands A through D have a frequency-coverage ratio of 3:1, while the remaining bands use a ratio of 2:1. This means that the higher frequencies are more widely spread over the dial, making it easier to set the generator on a specified frequency. In addition, use of such low ratios increases the stability of the generator, an important consideration when higher frequencies are being used.

The sample instrument we examined in the lab demonstrated several characteristics which deserve comment. The dial calibrations were checked against a calibrated frequency meter and found to be slightly high over most of the dial; that is, the frequency was slightly lower than the dial reading. The calibration error was slight, and for most uses was insignificant, but should be remembered when the E-75 is used for marking TV sweep-alignment curves. Each instrument would have to be checked individually for this characteristic, since it probably would vary from unit to unit.

The dial can be set much more accurately than usual by use of the vernier

**Fig. 4. Signal generator can be used for both alignment and troubleshooting.**

scale. When it is used in conjunction with the 0-100 "logging" scale, and precise settings are logged for specific frequencies, accuracy is much greater than that usually obtainable.

The warm-up time was only about 15 minutes, after which the unit stabilized very well. Following a 30-minute warm-up period, the drift was not more than 0.1% on all bands, a very satisfactory rating for any general-purpose generator. At frequencies above band D, even very slight movements of the instrument, or pressure on the case, were found to alter frequency. This should be considered when the instrument is used for adjustments at precise RF frequencies.

The LEVEL and OUTPUT controls (see Fig. 5) affect the amplitude of the RF signals. The LEVEL control determines the amount of signal fed from the 6AU6 oscillator to the output control. There are a couple of advantages to using this type of output network instead of a simple one-control system. For example, once the LEVEL control is set, varying the OUTPUT

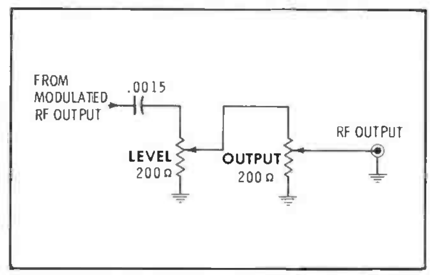


**Fig. 5. Output-control system helps to prevent stray radiation from the unit.**

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| Spring—For anode resistor | 1 | 105028 |
| Yoke—Deflection yoke | 1 | 109457 |
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| Magnet—Blue beam lateral | 1 | 103172 |
| Clamp—For convergence cable | 1 | — |
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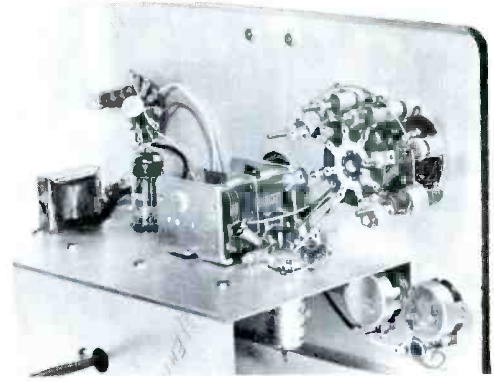


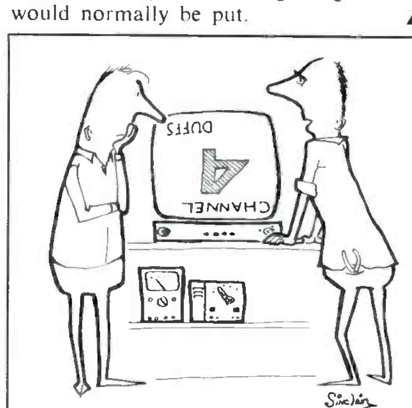
**Fig. 6. Square drive pulse is needed to produce a sawtooth current in yoke.**

control will not change the oscillator load and thus will have little effect on frequency. The other advantage is less RF leakage across the controls, and better control is provided over the generator output.

The proper method of using this dual-control output network is to set the OUTPUT control for maximum, adjust the LEVEL control for the maximum signal which will be needed for a particular job, and then use the OUTPUT to control the lesser amounts needed during the various steps in the alignment or troubleshooting procedure.

The 400-cps audio oscillator is a Colpitts circuit, using a 6C4 tube. The audio signal is coupled through the FUNCTION SELECTOR switch either to the audio output jacks, or to the suppressor grid of the 6AU6 RF oscillator. The suppressor grid is held at a slightly negative potential by a voltage obtained from a power-supply tap. The audio signal, either from the internal 400-cps oscillator or from an external source, is used to suppressor-grid modulate the 6AU6. The percentage of modulation obtained from the internal oscillator is adjusted by the AUDIO OUTPUT-MODULATION control, but any external audio source must contain its own control to prevent overmodulation. About 15 volts (peak to peak) of audio will cause 100% modulation of the E-75 output.

The Model E-75 can be used for aligning AM, FM, and TV, for signal-injection troubleshooting in any of these units, and for any other use to which a good-quality RF-AF signal generator would normally be put. ▲

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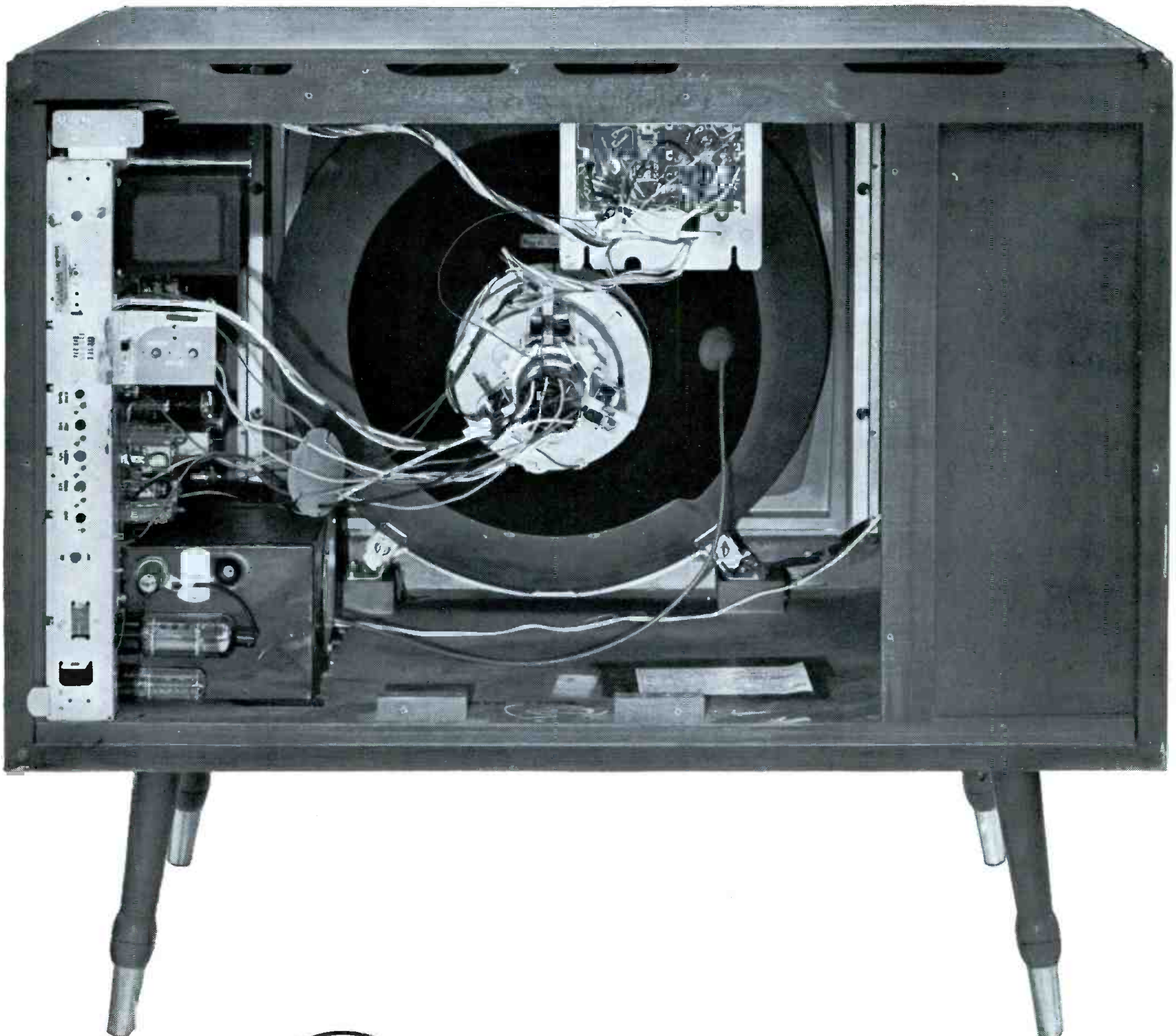

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# THE TROUBLESHOOTER

*answers your service problems*

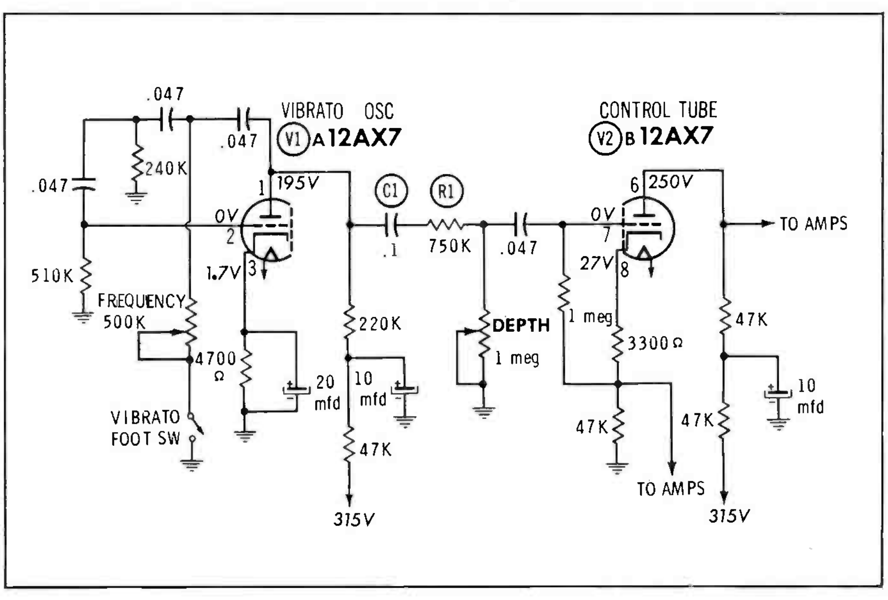
## Guitar Minus Vibrato

In a Gibson Model GA-83S *Stereo-Vib* guitar amplifier, the vibrato is inoperative. I've checked all parts and wiring, and have substituted all tubes. What have I overlooked? Please explain how the circuit works and what I can do to isolate the trouble.

JOSEPH J. MOMENO
St. Louis, Mo.

*One section of a 12AX7 (V1A on the schematic) functions as a low-frequency phase-shift oscillator. Its output is fed to V1B, which is connected to the amplifier tubes in such a way as to control their gain. Therefore, the volume is caused to fluctuate at a rate set by the vibrato oscillator. This rate is adjustable by means of the* FREQUENCY *control, and the amount of vibrato signal impressed on the grid of control tube V1B is adjusted by the* DEPTH *control. The vibrato can be cut in or out with a foot switch.*

*The first step in isolating this trouble is to make sure the vibrato oscillator is functioning. You can probably do this most easily by setting the* FREQUENCY *control for the slowest possible oscillation, and using a DC voltmeter to read the output at the junction of C1 and R1. If the meter is not too highly damped, the pointer will swing at the vibrato rate. The control tube, which acts as a phase splitter, can be checked in the same manner; you should find about the same amount of meter fluctuation at both the plate and the cathode of V1B as at the grid. Be sure the* DEPTH *control is set for maximum during these tests. Once you isolate the defective section, voltage and resistance measurements should pinpoint the faulty components.*



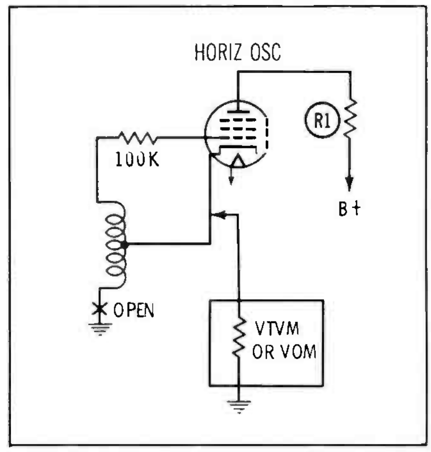

## Meter Deception

I've just finished reading Paul Goldberg's "Circuit Voltages Tell the Story" (December issue), and found it very interesting. One thing bothers me, though, and I would like an explanation. In his example of horizontal trouble in the Zenith Chassis 16E20, he states that grid voltage read zero volts and cathode voltage read +35 volts when there was an open ground connection on the horizontal oscillator coil. The grid and cathode are connected by a 100K-ohm resistor, and with no grid current, it seems to me both elements would be at the same potential. Why aren't they?

R. H. GRAY
Covina, Calif.

*They probably are—until you bridge the open connection by touching a voltmeter probe to the cathode. Then the meter-input circuit, the tube, and plate-load resistor R1 form a DC voltage divider across the B+ source. The current through the circuit is small, but it produces a large voltage drop across the comparatively high resistance of the meter. Thus, a fairly substantial positive voltage is indicated at the cathode.*

*This case illustrates the wisdom of using a high meter range for an initial check of cathode voltage. If you're using a low range, and happen to hit an open cathode circuit in a stage with low plate resistance, the meter pointer may wrap itself around the end stop.*




## Car 54, Where Art Thou?

We are experiencing a little difficulty with the sound system at the church I attend. Police calls and radio signals come through the speakers during the pastor's sermon. While not too loud, they are objectionable.

The State Police transmitter, operating at 40 mc, is about five blocks from the church. What would you say is the most logical and effective attack on this problem? Would it be better to install small bypass capacitors on the power line or on the input to the amplifier?

G. E. LANTZ
Little Rock, Ark.

*Bypassing both the power line and the amplifier input is an excellent idea. Try connecting a .05-mfd, 600-volt capacitor from each side of the power line to an unused tie point; then run a wire from the junction of these two capacitors to an external ground point (the outlet conduit box, if it is grounded). At the input of the amplifier, a 470-mmf capacitor should bypass the unwanted RF signals to ground. If this proves ineffective, a tunable trap can be purchased from your local electronic-parts distributor. Installed at the amplifier input, this trap will shunt the 40-mc signals to ground without attenuating the audio signals.*

*You may have an extreme case of trouble in which the RF is being picked up by the circuitry within the amplifier. If you find this to be your problem, the best solution is to build a copper-screen cage to shield the amplifier unit. This is seldom necessary, and you should explore all other possibilities before resorting to such a step. If you do build a cage, be sure to connect it to an external earth ground.*

## Nonstop

I'm having trouble finding out why the power-tuning motor in an Emerson Model 1494 won't stop running when the remote button is pushed to change channels. The only way to turn off the motor is to remove all power from the set, disconnect the wire going to the motor

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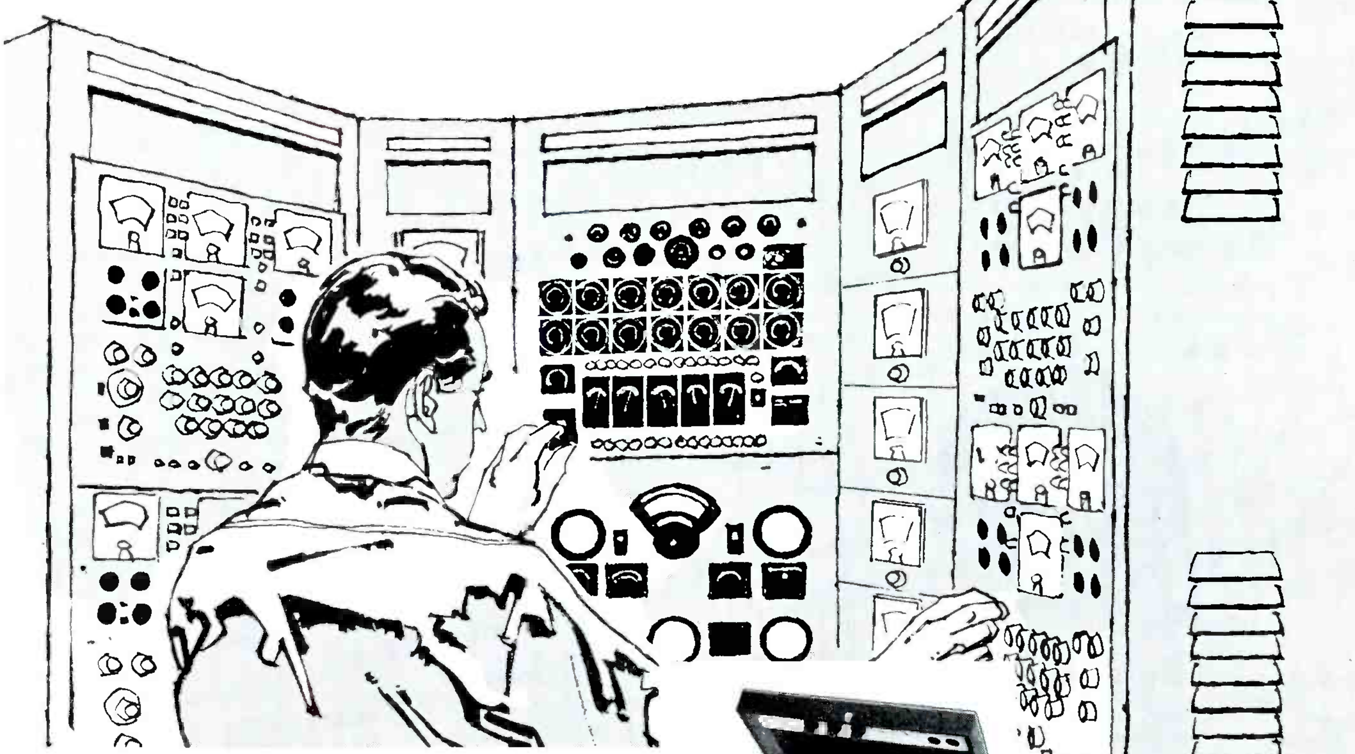

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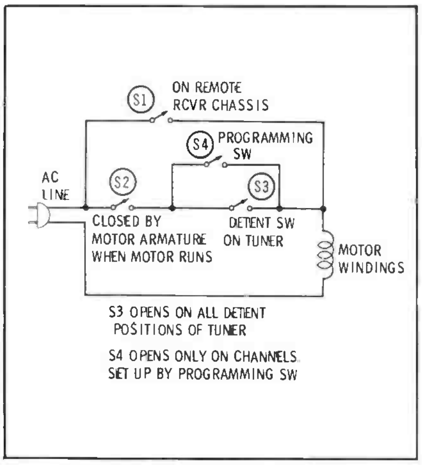



winding, or manually hold the armature switch open. Once stopped, it will stay off until the remote button is pushed again. Will you please explain the operating cycle of the four switches on the motor?

FREDERICK J. SEIDEL
Freddy's Electronics Service
Hamburg, Pa.

*Remote-relay switch S1 applies power to the tuning motor only momentarily. As soon as the armature starts to turn, its forward thrust closes S2. The tuner shaft also begins to rotate, and a mechanical cam system closes both S3 and S4. To remove power from the motor, both S3 and S4 must be opened. The cam on the tuner shaft will cause both switches to break contact when the tuner reaches the next channel position, unless the programming switch has been set up for bypassing this channel. In that case, S4 will remain closed, and the motor will continue to run.*

*Evidently, either S3 or S4 is being held closed at all times. The trouble could be either stuck contacts or a misalignment of the cam mechanism. S1 isn't defective; if it were, you wouldn't be able to stop the motor by opening S2.*

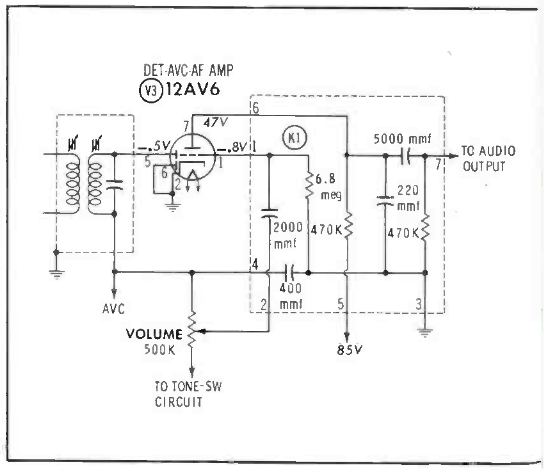
### Radio Trails Off

A General Electric Model T125 radio plays normally for a short time (this period varies), and then the sound gradually fades out. The only voltage change that accompanies the fading is a gradual rise in plate voltage on pin 7 of the 12AV6. Starting at the normal 47 volts, it finally reaches 85 volts and stays there as long as the radio is silent.

I've changed the tubes, K1, and the IF output transformer; also, suspecting an open condition inside pin 2 of the 12AV6 socket, I've run a wire up inside this terminal from the printed board. All these tests have been to no avail.

WARREN MOORE
Grafton, Ohio

*So far, your troubleshooting procedure has been correct. Continue to check out the other socket connections to the 12AV6 by inserting jumpers directly from pins 1 and 7 of the tube to the proper points on the printed board. Likewise, look very carefully for a crack in the printed foil*




*conductor between lead 1 of K1 and pin 1 of the 12AV6.*

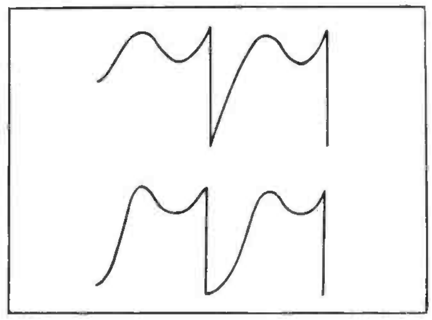
*If these checks don't locate the trouble, recheck the connections of K1 against the schematic. Also check pin 1 again with a VTVM to make sure the tube is not being blocked by build-up of a negative voltage at the grid.*

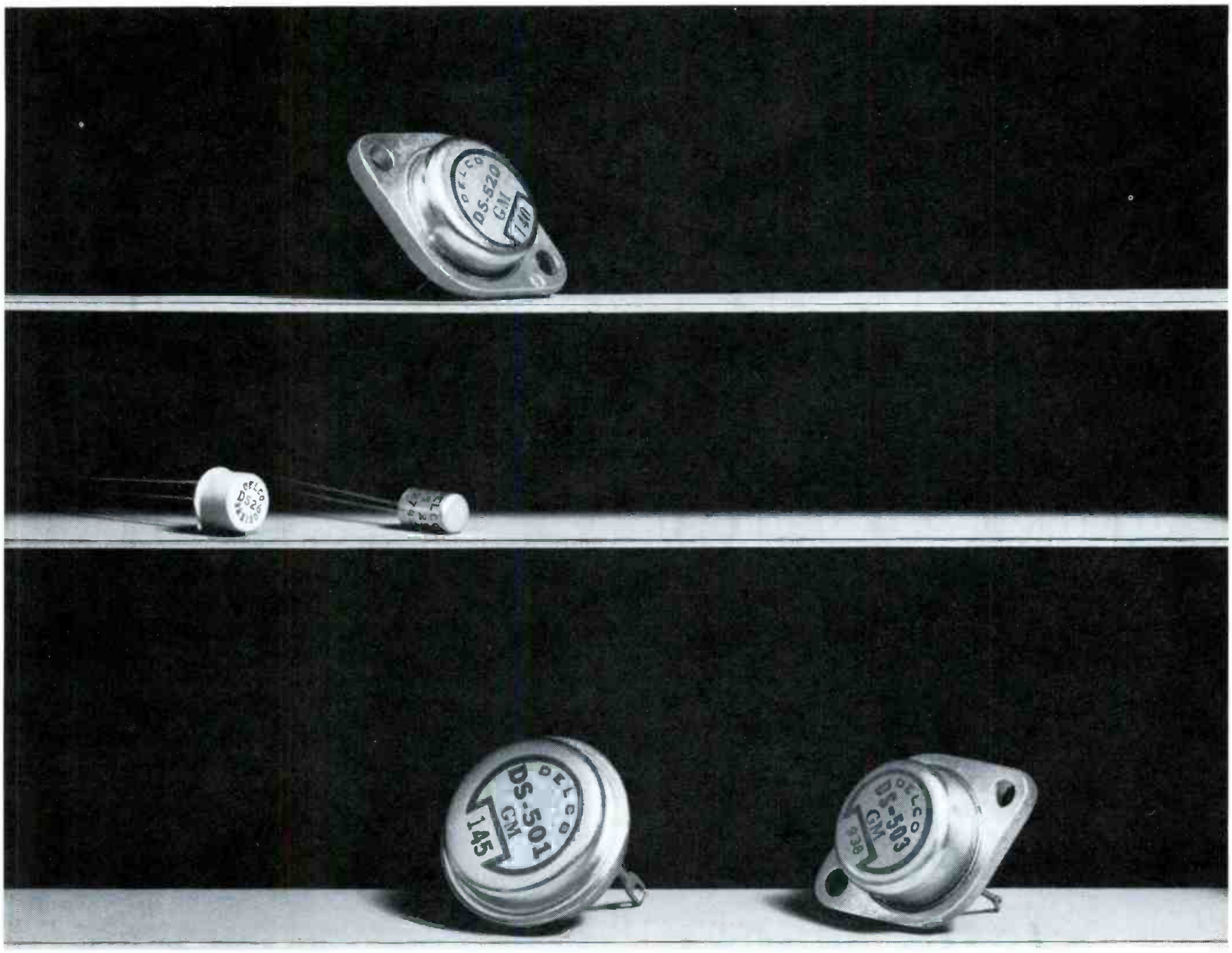
### Warped Waveform

A 21" Olympic TV with a *Synchroguide* horizontal oscillator has a narrower-than-normal horizontal-hold range. The scope trace across the waveform coil in the oscillator-plate circuit doesn't look just right. Instead of having the normal shape sketched at the left, it appears as in the right-hand drawing; the negative peaks look wider than any I have ever seen before. Is this the cause of the somewhat critical hold in this set?

EDWARD J. KIMMEL
Louisville, Ky.

*It might be. Since you didn't mention any lack of sweep or high voltage, I assume that the peak-to-peak amplitude of the signal across the waveform coil is correct, or nearly so. If it is, the odd shape of the waveform indicates that the operating frequency of the sine-wave ringing circuit (including the waveform coil) is too high. Perhaps both the waveform slug and the horizontal-frequency slug are badly detuned. It is sometimes possible to lock in the picture under such conditions, but horizontal sync will be more steady if you realign the horizontal oscillator as outlined in service data. If this doesn't help, try replacing the resistor and capacitor across the waveform section of the horizontal oscillator coil. As a last resort, you could replace the entire oscillator transformer; the trouble might possibly be due to shorted turns in the waveform-coil section.*

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### Hum-Free

I've had the same trouble as Mark H. Smith (December *Troubleshooter* column) concerning hum in auto radios being bench-serviced, but I don't agree with his suggestion about shunting the antenna with a 10K-ohm resistor. The simplest remedy for hum caused by an AC-powered battery eliminator is to connect the radio chassis to a true AC ground.

I prefer to use a capacitive connection. Here's how to hook it up: Take a neon bulb having test leads, grasp one lead with your finger, and poke the other lead into either side of an AC outlet at the bench. The bulb will light faintly when contact is made with the "hot" side of the line, but not when plugged into the grounded side. Connect a wire to the AC lead that goes to ground, and terminate it with a .05-mfd, 600-volt capacitor having an alligator clip attached to the free end. By connecting the clip to the chassis of auto radios being serviced, you will be able to suppress even the most severe cases of battery-eliminator hum.

Bob Powers

Columbia, S. C.

*Thanks for the suggestion — I'll have to try it myself next time!*

### Tamed by Alignment

A T601 *Pilotuner* gave me the same trouble as Mr. Paul Smith relates in January *Troubleshooter*, but I was able to put the local oscillator "back on the track" by changing the alignment procedure. The sequence recommended by Pilot—adjusting the oscillator padder first and trimmer second—doesn't seem to work. I used the following method:

With the tuning gang wide open, set the pointer exactly horizontal at the left end of the dial scale. Then tune the pointer and generator to 106 mc, and peak the oscillator trimmer capacitor (on the gang). Reset the pointer and generator to 90 mc, and peak the oscillator padder (under chassis). Recheck several times; the dial should track and cover the band easily.

V. R. Evans

Newark, Ohio

*Since your method is the same as I would use on a normal set, I tried it when I ran across this trouble in another T601. In my case, it did not succeed in stopping the odd-ball oscillation; nevertheless, any other readers with this trouble would do well to try your suggestion.*

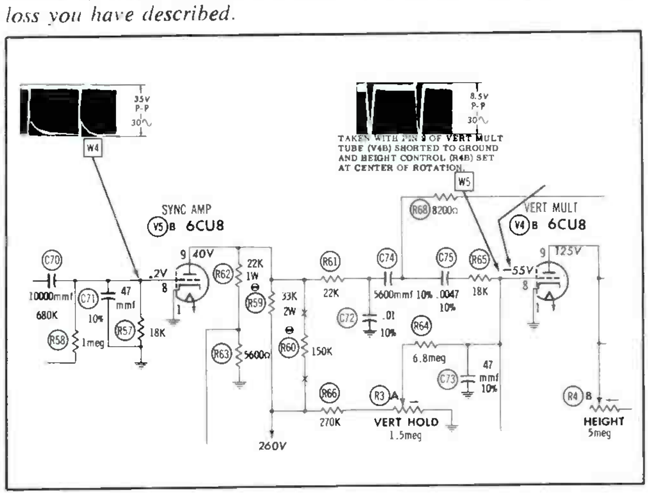
### Rolls Like Mad

I have a problem with an RCA Chassis KCS109 portable TV (covered in PHOTOFACT Folder 392-3). After the set has been operating for about 15 minutes, the picture develops continuous vertical rolling. This can be stopped with the hold control, but for only about a minute at a time. The trouble appears on all channels. I've tested everything I can think of, but this problem has me stopped.

Angelo Cioffi

Everett, Mass.

*According to the Howard W. Sams book, "Video Speed Servicing, Vol. 3" (VSM-3), capacitor C71 in the sync-amplifier circuit of this chassis is a common cause for the type of sync loss you have described.*



*If replacing this capacitor doesn't help, your next move should be to determine whether the trouble is due to vertical-multivibrator frequency drift or to a weakening of the sync signal. Find out by continuously observing W5 as the rolling develops. If the waveform amplitude decreases, go back through the sync and video stages, and make similar scope tests to find the origin of the trouble. If the sync waveform shows no change in amplitude, some component in the vertical sweep circuit is probably drifting in value with temperature change. With the trouble present, try cooling individual components with a chilling spray, and watch for the rolling to stop suddenly.*

### Persistent Buzz

I took a Sylvania Chassis 1-533 (covered in PHOTOFACT Folder 319-13) into the shop for repairs to the sync noise-inverter circuit. This problem has been cured, but the sound still has a buzz which cannot be completely removed except by killing the signal. It can be minimized by very careful adjustment of the fine-tuning control, but is still noticeable. Incidentally, the sound has normal volume.

I've replaced all tubes in the sound, tuner, IF, AGC, and video sections, checked all voltages in these stages, completely realigned the sound IF and detector, checked the B+ filters and the 2-mfd ratio-detector stabilizing capacitor, disabled the sweep and high-voltage circuits, and even checked the ground strap on the picture tube.

A strange thing, which may be of some significance, is that the buzz can be partially cleared up by turning the AGC control to produce a darker picture—just the opposite of the action noted in ordinary buzz troubles due to overloading.

E. DURKIN

New York, N.Y.

*The AGC and fine-tuning controls both indicate by their action that a slight misalignment of the video IF strip is allowing the 41.25-mc sound carrier to receive too much gain. By moving either control, you are shifting the IF response so that 41.25 mc falls closer to the trap notch on one side of the response curve.*

### Chug Chug—Bounce Bounce

A war-surplus power plant at my summer camp provides a 115-volt, 60-cps AC output capable of furnishing 3500 watts. When I try to watch TV the picture bounces up and down in perfect rhythm to the beat of the power plant. What's the best way to solve a problem like this?

LOUIS F. MCMURTRY, JR.

Stoneham, Mass.

*Since the flicker keeps step with the power plant, there seems little doubt that voltage fluctuations are producing the trouble. One of the best ways of overcoming this is to operate the receiver from a line-regulating transformer. Such units are readily available from electronics parts distributors.*

## Transistorized TV Circuits

*(Continued from page 33)*

to operate in high-gain stages without oscillating. (Note the neutralizing capacitor Cn in Fig. 1.) Because of variations in power gain and interelectrode capacitance among transistors (even those of the same type), the neutralizing circuit may occasionally have to be modified to restore best performance. If you ever find it necessary to reneutralize an IF stage, the following procedure is suggested:

1. Remove the transistors preceding and following the stage to be neutralized, and connect a signal generator to the primary of T1 through 10K ohms as shown in Fig. 1A.
2. Connect a scope to the secondary of the output transformer through a 10K-ohm resistor in series with a demodulator probe. Also connect a 100-ohm resistor across the secondary.
3. Adjust the generator for an output level which does not overdrive the stage, and tune T1 and T2 for maximum waveform amplitude on the scope.
4. Connect the signal generator to the secondary of T2 through the 100-ohm resistor, as shown in Fig. 1B, and place the scope probe on the base of the transistor.
5. Increase the generator output until a usable sine wave is obtained on the scope, and change the value of Cn until minimum signal voltage is indicated. Increase the generator output, and again find the value of Cn which gives minimum signal. Continue this process until the generator output is at maximum, at which time the scope indication should be very weak. The stage is now neutralized.

### Video and Sound

Transistorized TV sets have crystal-diode video detectors of the same type used in tube sets. However, the demodulated signal is not fed directly to the video output stage, but is first passed through a *video driver* circuit (Fig. 2). This is a common-collector circuit (a transistorized counterpart of a cathode follower); it does not amplify the video signal, but is used mainly for proper matching between the detector and output stages. If the low-impedance base circuit of the output stage were shunted across the detector load, it would considerably reduce the output that could be obtained from the detector.

A useful fact to remember is that the take-off point for the intercarrier sound signal is usually located in the output circuit of the driver stage. The sound section generally includes one or two sound IF's, a discriminator or ratio detector using crystal diodes, an audio amplifier, and a push-pull audio output stage.

Most sound-circuit troubles can be pinpointed by signal injection, voltage analysis, or alignment checks. On the other hand, probably the most useful method of isolating trouble within the video section is signal-tracing with a scope. The voltage amplitude of the video signal is particularly important. Although the picture tubes used in transistorized sets require less video drive than conventional CRT's, the required peak-to-peak voltage output of the final video stage is still quite high by usual transistor-circuit standards. The required DC operating voltage, higher than that available from the main power supply, is

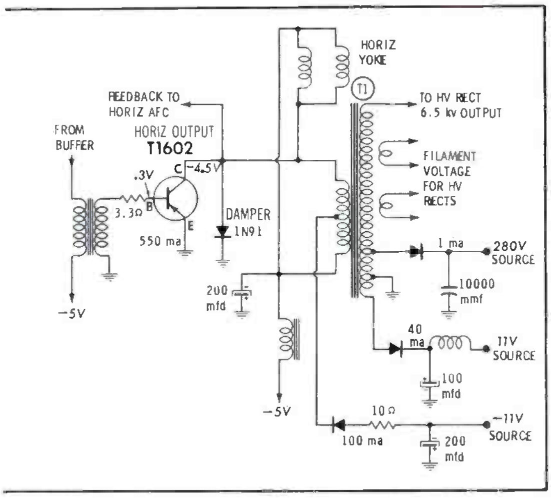



**Fig. 5. Flyback circuit produces several rectified voltages, but no boost.**

furnished by an auxiliary diode circuit that rectifies the horizontal flyback pulses. In addition, the transistor is a special unit with unusually high emitter-collector voltage ratings. Since this transistor is operated fairly close to its maximum voltage limits, it can be expected to develop leakage more easily than most transistors; this is an important possibility to consider when a set has insufficient contrast. Because this trouble may show up only under the elevated voltages found in the video circuit, direct substitution of the transistor is a more positive test than checking it on a tester.

### *Sync Section*

A transistorized sync separator acts as a switch; it is driven into conduction by sync pulses in the input signal, and is nonconducting at all other times. Various biasing arrangements are used to keep the transistor cut off between pulses. One of the simplest circuits is shown in Fig. 3. The transistor is of a type which can be driven from cutoff into saturation by a composite-video input of less than 0.5 volt peak to peak. The sync pulses in this signal are negative—the correct polarity to produce conduction of a PNP transistor. When saturated, the transistor has a very low internal voltage drop between emitter and collector, and positive pulses with an amplitude almost equal to the supply voltage are then developed across the collector-load circuit.

Transistor conduction also places a small positive charge on C2 in the base circuit. This component, together with R1, C1, R2, and R3, forms a dual-time-constant "baseleak" network that maintains a slight reverse bias on the transistor in the interval between pulses. The bias is self-adjusting to compensate for changes in input-signal amplitude, just as in a sync-separator tube circuit. Any trouble that removes the reverse bias will allow video to appear at the collector; the same fault could also be caused by compressed sync pulses in the input. If there is too much reverse bias, the input signal is very weak, or the transistor develops high internal resistance, the stage will not reach saturation when it conducts, and the result will be weak output.

Some transistor TV sets have additional sync stages—most often a phase inverter following the separator, Noise limiters or clippers, using transistors or crystal diodes, may also be included.

Scope waveforms give the most accurate picture of sync-circuit operation. Because of the extremely low voltages involved, DC voltage readings have to be interpreted very cautiously to be of any value in troubleshooting anything but an obvious "open-and-short" case. In all servicing procedures, be extra careful to avoid applying too much reverse bias or pulse voltage to sync transistors, since they are among the most voltage-sensitive types in the whole set.

#### *Vertical Sweep*

Blocking oscillators are currently favored for generating vertical sweep in transistorized receivers. The oscillator usually supplies a signal directly to an output amplifier, as shown in Fig. 4—although these two stages are supplemented by an intermediate driver transistor in some sets.

Note that all the waveforms in Fig. 4 appear "upside down" in comparison with conventional tube-circuit scope traces; this is due to the use of PNP transistors. The positive spikes in the oscillator-base signal occur as X14 is driven into cutoff. At the base of X15, the negative-going slope of the sawtooth waveform indicates a progressive increase in forward bias, which steadily increases the conduction of the output stage. Sudden cutoff of X15 produces the negative spike in the collector waveform and causes vertical retrace of the CRT electron

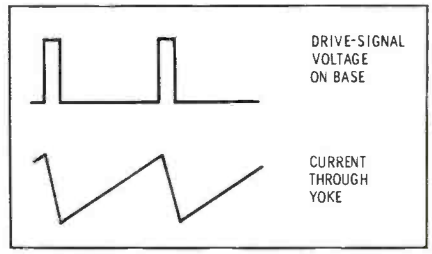



**Fig. 6. Square drive pulse is needed to produce a sawtooth current in yoke.**

beam. These observations are examples of how sweep troubleshooting will call on you to "transistorize" your thinking, and analyze voltages and waveforms in terms of their effect on transistor conduction.

Capacitance and resistance values are fairly critical in order to maintain the proper RC time constants in the vertical section. Incidentally, note that very high capacitance values are used, to make up for the small resistances required in transistor circuits.

#### *Horizontal Sweep*

You're likely to find a familiar type of dual-diode horizontal AFC stage in a transistorized receiver. The horizontal sweep signal is usually generated by a blocking oscillator, and is fed to a *driver* or *buffer* stage, which not only isolates the oscillator from the horizontal output circuit, but also amplifies the drive signal to some extent. A typical output stage (Fig. 5) has several features in common with tube circuits, and also some interesting differences. Flyback pulses are generated, as in a tube system; these are stepped up to several thousand volts by a secondary winding on T1, and then rectified to furnish anode voltage for the picture tube. The circuit also utilizes a damper diode to control the current through the yoke while the beam is tracing across the left side of the CRT screen. The damper merely shunts the output transistor, since there is no need to develop any boost voltage. The resulting circuit simplicity is welcome news to servicemen, and so is the fact that all AC and DC voltages (exept on the high-voltage secondary of T1) are low enough to be safely measured with ordinary test equipment.

The drive signal applied to the base of the output transistor has the basic waveshape shown in Fig. 6. The positive pulse drives the PNP transistor into cutoff and triggers horizontal retrace. In the circuit of Fig. 5, the pulse amplitude is only 5 volts peak to peak. Between pulses, the drive signal applies a constant forward bias to the output transistor; in effect, it simply closes a switch that allows current to flow through the flyback-yoke circuit. Since this circuit consists almost entirely of inductance, the current builds up gradually and produces a sawtooth wave of yoke current as illustrated in Fig. 6. (Actually, the beginning of this sawtooth is formed by damper current, plus a small amount of reverse current through the output transistor.)

A transistorized horizontal output circuit, like a tube circuit, can be damaged by removal of the drive signal. In normal operation, the trace portion of this signal tries to drive the transistor into saturation. This has the effect of reducing the internal resistance of the transistor, and thus allows it to pass heavy current without exceeding its maximum power-dissipation rating. However, loss of drive may allow an increase in internal resistance, without a proportional decrease in collector current. The transistor then may overheat and become shorted, exposing the flyback and yoke to damage.

Before replacing a burned-out component in the output circuit, check for a normal drive waveform. This can be conveniently done by removing the output transistor and temporarily inserting a resistor (a 15-ohm, 1-watt unit will do) between the emitter and base terminals. If a voltage pulse of normal amplitude does not appear across the resistor, check for oscillator or driver defects.

### *Power Supplies*

The term, "all-transistor TV set" is not quite accurate, even if you exclude the picture tube. Present sets use one or two tubes to rectify the anode voltage for the CRT, pending the development of suitable high-voltage semiconductor diodes. The circuit of Fig. 5 feeds a doubler that employs two 5642 subminiature rectifier tubes.

The other DC source voltages derived from the flyback pulses serve almost the same function as the boost source in an all-tube set. Although they are not essential to the operation of the horizontal output circuit, they may develop certain defects (such as shorts) which could interfere with horizontal sweep and high voltage. The highest rectified-pulse potential is applied to the accelerating and focusing grids of the picture tube; others are used as supply voltages for the video output and other circuits.

The main power supply of a transistorized portable TV set includes a rechargeable battery, a rectifier to permit operation from the AC power line, and provisions for charging the battery through the rectifier. This relatively complex system presents some problems in tracing through the switch circuits, but also aids in trouble isolation by providing a choice of two independent power sources.

### Conclusion

As you can see, working on transistor TV will require you to cultivate some new servicing habits. These can be developed by blending your knowledge of transistor fundamentals with your present TV-troubleshooting know-how. ▲

## Test Equipment

*(Continued from page 27)*

being drawn from the supply.

### Multi-Function Equipment

For those technicians who prefer to have all their instruments combined into one unit, several manufacturers are producing complete transistor-radio testers. Many of these units contain facilities for performing all the tests and troubleshooting techniques mentioned previously. In addition, some instruments contain the necessary circuitry for performing *in-circuit* tests. This method saves the technician time and trouble in that he does not have to remove the suspected component from the circuit in order to obtain a go—no-go evaluation.

With multi-function test equipment such as this, a technician should be able to repair any transistor radio without moving from his chair. Such equipment lends itself to mass-production troubleshooting techniques.

### Basic DC Tests With an Ohmmeter

Some basic tests can be performed with a VOM or VTVM. While DC tests are not always conclusive and cannot indicate such conditions as a slight decrease in gain, they will usually indicate open leads and leakage. Only VOM's with a 20,000 ohms/volt rating should be used.

***Choosing the Correct Range***

There are two precautions to observe in using an ohmmeter to check transistors:

1. Do not use the R x 10K or higher scale. In most ohmmeters, from 9 to 30 volts is present at the test leads when these scales are being used. Needless to say, this voltage is above the rating of many transistors, and damage might occur if the rating is exceeded.
2. Check the R x 1 scale for current output. A separate milliammeter, capable of reading 100 ma, should be connected across the ohmmeter leads. In most meters, the current will read close to 100 ma. RF and IF transistors with a low diode resistance could draw almost this much current from

the meter and become damaged. In general, the R x 1 scale should be reserved for audio power transistors.

If these two precautions are observed, an ohmmeter can normally be used without fear of damaging transistors.

In performing the following tests, the type of transistor being tested will determine the range of the ohmmeter to be used. In general, the R x 100 scale (or R x 1000 if R x 100 is not available) should be used on all transistors normally found in portable transistor radios.

#### Open-Lead Test

This test can be performed while the transistor is still in the circuit, and is based on the fact that a transistor is similar to two diodes connected back to back. The procedure is as follows:

1. If an open transistor lead is suspected, remove power from the circuit, apply the ohmmeter test leads to the base and emitter as shown in Fig. 3, and obtain a reading. (The polarity of the test leads is not important.)
2. Reverse the leads and again note the reading on the ohmmeter. There should be a marked difference in the two readings.
3. Perform steps 1 and 2 with the leads connected between the base and collector.

If the two readings in each case are not different, chances are that one of the transistor leads is open. Since the elements are usually shunted by circuit components, the actual values of the readings obtained are unimportant and should not be interpreted as the front-to-back ratio of the diode section of the transistor in question. A difference (even though slight) is enough to indicate that diode action is occurring and there are no open leads.

One exceptional case in which the preceding test will not work is in some transistor-radio output stages. On some sets, a low reading in both directions may occur. When this happens, the transistor should be disconnected from the circuit and tested as described next.

#### Front-to-Back Test

For this test, the transistor should be removed from the circuit. The ohmmeter leads are connected between the base and emitter and then reversed (the R x 100 scale should be used in each case). In one direction, the resistance should read near the top of the scale; in the other, the reading should be below 1000 ohms. The same procedure is then used to obtain the front-to-back reading between the base and collector.

If the readings obtained in the tests vary greatly from those ob-

"Okay — so you're the best TV serviceman at the shop. Do you have to crow about it every morning?"

tained with a normal unit, the transistor is probably faulty.

*Leakage Test*

This test is also performed with the transistor out of the circuit. The ohmmeter is connected between the emitter and collector (the base is left open )and a reading obtained. The leads are then reversed and another reading taken. It is unimportant whether readings are considerably different or exactly the same, as long as they are both above the minimum acceptable value. Normally, the IF-RF types will read above 5000 ohms in both directions, while audio transistors may read as low as 500 ohms. Some transistors may read almost maximum resistance on the R x 100 scale. This is all right, provided the previous tests did not indicate an open lead.

A unit which reads lower than the minimum specified above is considered excessively leaky and should be replaced.

### Individual Needs

The test equipment available for transistor-radio work seems to be keeping pace with the radios themselves. With such a wide variety of test equipment on the market, a technician should be able to pick and choose the type most suited to his own ability and need. In fact, a complete transistor - radio repair center can be set up at a minimal cost and with a relatively small inventory of test equipment and spare parts. ▲


"What do you mean, there'll be a slight additional installation charge!?"

## Auto Radio

*(Continued from page 24)*

lector of the driver transistor. Only a weak output will usually be heard, since a signal fed in at this point goes through only one stage of amplification. Progressing from the collector of the driver stage to the base, you can expect some increase in signal output; any lack of gain here probably indicates something wrong. Going on to the collector of the IF stage, you may hear little or nothing when you inject a signal, since the harmonics produced in the IF range by the noise generator may be too weak to be audible without some IF amplification. This should not be a reason for suspicion just yet.

Go ahead and apply a signal to the base of the IF transistor; if you hear a good output signal, all is well. The output should be about the same when a signal is fed to the collector of the converter transistor. Going on to the base circuit of this stage, you will probably notice an increase in output volume. Although some further gain may also be evident from collector to base of the RF stage, there is a good chance of finding no gain (or even a loss), since the impedance match between the signal injector and the base of the transistor may not be too good.

Injecting a signal at the antenna socket to check out the antenna circuit, you will probably observe slightly less output than when the signal is fed directly to the base of the RF transistor.

### DC Conditions

Once a trouble has been isolated to one particular stage, you can directly attack the problem of finding the exact defect. Don't be too quick to suspect the transistors, since they are just as reliable as many of the

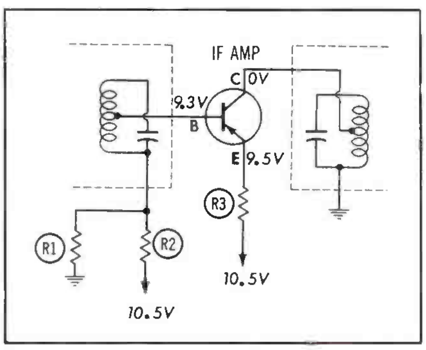



**Fig. 2. DC voltages in transistor circuit are valuable troubleshooting aid.**

other components — perhaps more so.

The first step is to check out the DC conditions (both current and voltage) in the suspected circuit. The majority of troubles will cause some disturbance in DC readings. Collector, base, and emitter voltages alone can tell almost the complete DC story, and can often point directly to the solution of a problem.

Let's take the IF stage shown in Fig. 2 as an example. As far as DC circuits are concerned, almost all transistorized stages used in auto radios are very similar to this. Standardization is aided by the almost exclusive use of PNP transistors, and by the general adoption of 12 - volt, negative - ground electrical systems in cars.

The voltage on the base is determined mainly by a voltage-divider network (R1 and R2), connected from ground to the 10.5-volt source. R1 has a much higher resistance than R2, and the base voltage (9.3 volts) is almost as high as the source voltage.

The emitter is connected to the 10.5-volt source, and transistor conduction produces a voltage drop across emitter resistor R3 which keeps the emitter voltage slightly lower than the source voltage. Note that the 9.5 volts on the emitter is .2 volts higher than the base voltage. This difference is the forward bias necessary to maintain normal conduction of the stage. In various other low-power stages, the forward bias may range from about .1 to .3 volts, except in the converter stage —which may have any value from .2 volts of forward bias to .2 volts of reverse bias (base voltage higher than emitter). Since the base-emitter bias is often the key to explaining abnormal conduction of a stage, this should be the first voltage checked.

The DC collector voltage depends on two factors — the collector current and the resistance of the collector-load circuit. In Fig. 2, the collector is returned to ground through the low resistance of a coupling transformer. The small current through this IF transformer produces an insignificant voltage drop across the load; thus, the collector voltage is virtually zero, and is of no practical use in gauging transistor conduction. However, in stages where either the current or the load resistance is greater, a DC collector voltage — proportional to the current through the transistor — will be found. This reading is especially useful in the most common type of output stage, where a transistor current of several hundred milliamperes produces a voltage drop in excess of one volt across the output transformer in the collector circuit.

On the other hand, little or no collector voltage is developed in most RF - IF stages, so another method must be used to determine transistor conduction. The easiest

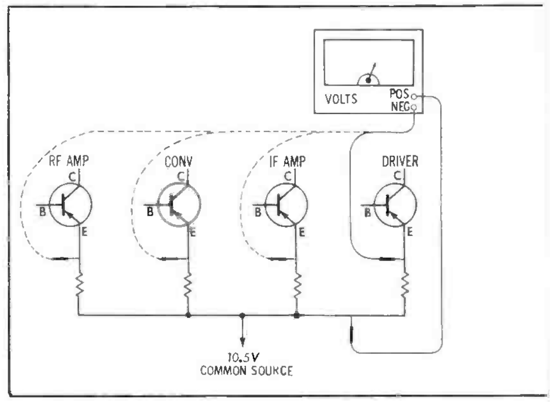



**Fig. 3. Voltage drop across emitter resistors gauges transistor conduction.**

way of doing this is to measure the voltage drop across the emitter resistor of each stage. This can be done by connecting a voltmeter as shown in Fig. 3, or almost as quickly by measuring the emitter voltage with respect to ground and subtracting the reading from the *actual* source voltage. The drop should generally be on the order of one volt. If it is very much greater, the transistor may be shorted. If there is no reading, the transistor is not conducting — either because it is defective or because some component in the stage is open.

Somewhat greater than normal conduction could be due to leakage, which is one defect that does occur in small transistors. In DC checks, the voltage drop across the emitter resistor would be high, the emitter voltage to ground would be low, and the forward bias would appear to be high.

#### Resistance Checks

When voltage checks lead you to suspect a leaky, shorted, or open transistor, you can then turn to a transistor tester — or you can use simple ohmmeter checks to help bring the trouble into the open. You can measure between the base and emitter leads, or between the base and collector, just as if you were checking a germanium crystal diode; in fact, reference is often made in service literature to the "emitter diode" and "collector diode."

Typical results of ohmmeter tests are summarized in Fig. 4. Note that the R x 100 scale is used; higher ranges should be avoided, to protect transistors from too-high test voltages. The resistance of each diode section is measured, with the transistor left in the circuit; then the ohmmeter leads are reversed, and the measurements are made again. A considerable difference in readings should be noted for each diode. This difference, the *front-to-back ratio,* will vary greatly according to the shunting effect of the external circuit; but the readings will probably be within the ranges shown in Fig. 4. If the two resistance readings for a diode section are both about the same, and both high in value, the diode is probably open. If the readings are both low, the diode section is possibly shorted or leaky.

Try out this test on good transistor stages, and see what results you obtain with your own meter. It might be helpful to record these readings.

#### AGC System

The results of some DC measurements are affected by AGC action. In fully transistorized auto radios, the most common method of developing AGC is to take a signal from the collector of the IF transistor, rectify it, and feed it back to the base of the RF and/or IF stage as a positive DC voltage. When a strong station is received, an increase in base voltage causes a decrease in forward bias, in turn decreasing the gain of the transistor. A simplified AGC circuit is shown in Fig. 5. An easy check for proper AGC action is to measure the voltage drop across the emitter resistor of the affected stage while dialing through a strong station. If the AGC action is normal, the voltage drop will decrease considerably.

The main cause of trouble in AGC circuits is failure of the diode or diodes which rectify the IF signal. Check the front-to-back ratio of these diodes with an ohmmeter, or test them by substitution.

### AC Conditions

Sometimes a stage will appear weak or inoperative in signal-tracing tests, but no abnormal DC measurements will be noted. In such cases, look for troubles which would primarily upset AC operating conditions — for instance, an open coupling or bypass capacitor.

A fairly frequent cause of weak amplification in an IF stage is an open capacitor in one of the IF transformers. This bad component can be detected by a trial alignment —if one of the transformers cannot be peaked, a capacitor across one of the transformer windings may be at fault.

### Sample Trouble

Now is a good time to apply some of the above procedures to an actual troubleshooting problem. This case concerns a radio that has slightly weak output, with distortion on strong stations. The servicing procedure includes five steps, as indicated in Fig. 5. These can be further described as follows:

1. If gain checks cannot pinpoint the trouble, the distortion on strong stations should cause suspicion of the stage to which AGC voltage is applied. In this case, trouble in the RF stage deserves consideration.

2. The first thing to check is DC conduction through this stage. The voltage drop across the emitter resistor is found to be much too low, with or without a signal applied—indicating a lack of normal conduction. The problem now is to determine the cause of this poor conduction.

3. Remember, the forward bias controls the conduction under normal conditions. Measuring the voltage between base and emitter proves that it is less than the normal .2 volts. Why?

4. Either the base or the emitter voltage could be off. On measuring the base voltage, it is found to be higher than normal. What could cause this voltage to be high?

5. Don't forget that the base voltage is determined principally by a voltage-divider network. Since AGC is developed in this network, something in the AGC circuit might be defective. The component most

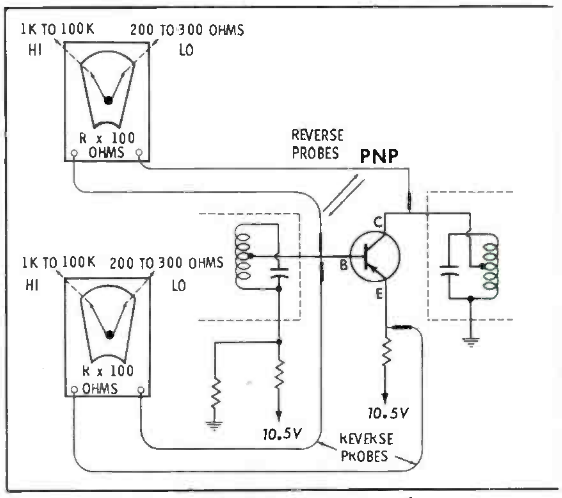



Fig. 4. Transistor can be checked with ohmmeter in same way as crystal diode.

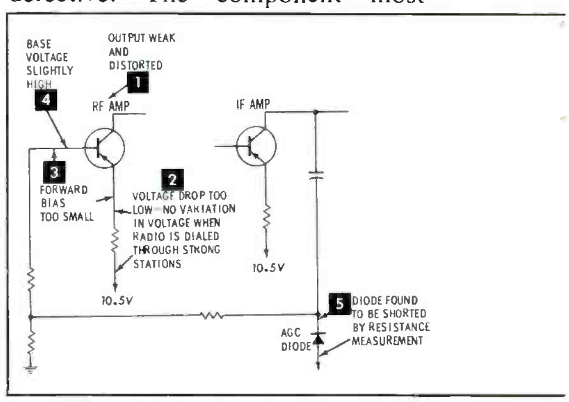



Fig. 5. Steps in troubleshooting an AGC fault in all-transistor car radio.

likely to be at fault is the AGC diode. To check it, a simple measurement of front-to-back resistance should be sufficient. In this case, low resistance readings in both directions indicate a shorted diode.

### Troubleshooting In Brief

Here is a condensed review of a logical step-by-step procedure for repairing transistorized auto radios, which can make them quick and easy jobs rather than profit-losers.

1. *Isolate the Trouble to a Stage* —become familiar with one piece of signal-injection equipment, so you will know what output to expect for a given input.

2. *Check for Normal DC Conduction*—in most stages, it's easiest to use the emitter-resistor voltage drop as an indication of current through a transistor.

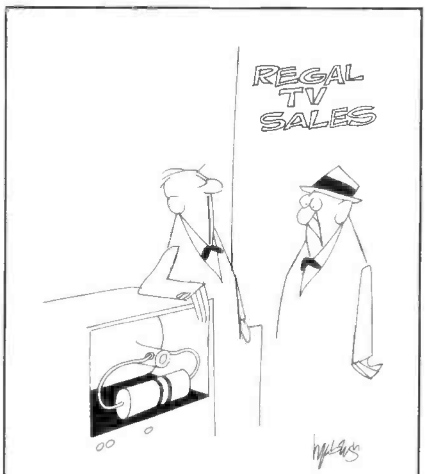
3. *Check Emitter-Base Forward Bias*—if no conduction was evident in the previous test, this check helps you to determine why.

4. *Check for Open, Shorted, or Leaky Transistor* — an ohmmeter check of front-to-back ratio in the emitter and collector diode sections will usually do this job.

5. *Check Out AC Circuits* — if open capacitors are suspected, try bridging them with known good units.

6. *Check Tuned Circuits* — trial alignment of the IF transformers will uncover troubles that prevent proper peaking.

Remember that careful observation of the emitter, base, and collector voltages — and of transistor conduction — can take you a long way toward solving many problems in transistorized auto radios. ▲



"This model's fully transistorized"

## Mobile Radio *(Continued from page 31)*

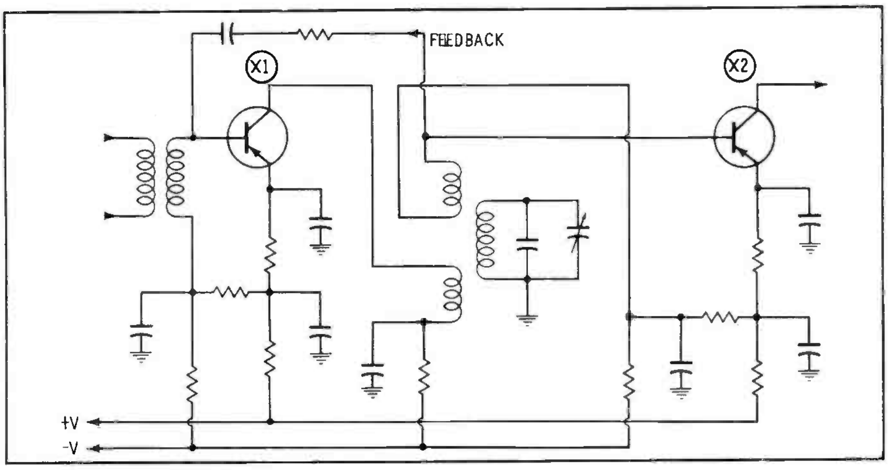



**Fig. 3. Tunable high-IF stage is neutralized by feedback from transformer.**

exactly like that of the PNP transistor in Fig. 2A, but the polarities are reversed. Notice that the A– terminal of the power supply is grounded, whereas A+ was grounded in Fig. 2A. In this case, the base is approximately 0.3 volt more positive than the emitter, and the collector is about 4 volts more positive than the emitter. In Fig. 2B, the incoming signal is developed across C1 and R1, and the amplified output is developed across R4 and C3. An example of a tunable high-IF amplifier is shown in Fig. 3. In this PNP amplifier, the RC combinations used in the base and emitter circuits provide correct operating bias as well as temperature compensation. The collector circuit of X1 contains a three-winding transformer which couples the signal to the resonant secondary and also to the input of X2. The phase shift inherent in the transformer circuit presents a convenient means of supplying feedback of the correct phase for stage neutralization.

***Audio Circuits***

Transistors are commonly used in the audio sections of both transmitters and receivers. As shown in Fig. 4, the discriminator of a receiver is followed by a transistor audio amplifier (X1) and output stage (X2 and X3). The combination of X2 and X3 constitutes a push-pull amplifier. This stage operates on the same principle as a tube circuit; however, since the gain of the transistors is affected by temperature changes, a thermistor is used to stabilize the circuit by decreasing the base-emitter forward bias as the temperature rises.

You are undoubtedly familiar with the background-noise output of an FM receiver tuned between station frequencies. In an FM communications system, this background noise level rises sharply whenever the transmitter being monitored is

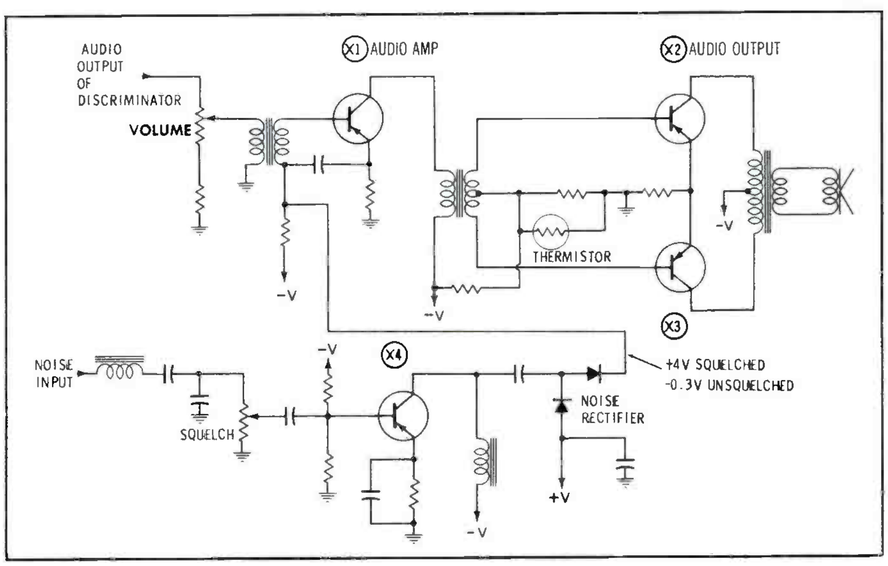
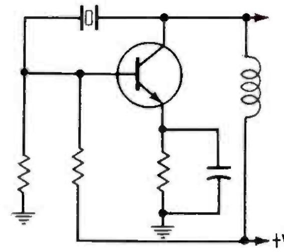
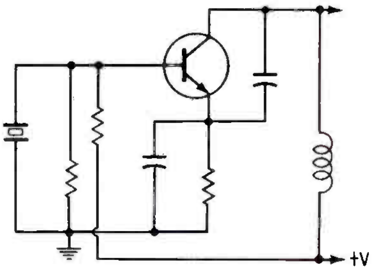



**Fig. 4. Audio section with adjustable squelch and stabilized output circuit.**




(A) Fundamental-mode Pierce type.




(B) Overtone type for high IF.

**Fig. 5. Crystal oscillator circuits.**

off the air. To reduce the annoyance, a squelch circuit is employed. Usually, this circuit cuts off one of the audio stages when no signal is being received, and the presence of a signal turns on the audio amplifier so that the incoming message can be heard. PNP transistor X4 in Fig. 4 is a noise amplifier. When no carrier is being received, noise pulses are supplied to the base circuit of the transistor through a suitable filter. After amplification, the noise components are rectified to produce a positive DC bias level for the first audio amplifier. By use of the squelch control, the positive DC voltage developed by the noise rectifier can be adjusted to achieve cutoff of the first audio stage. When a carrier signal is received, limiting action prevents noise signals from reaching the squelch circuit. Therefore, the noise-rectifier current is reduced; then the audio amplifier stage is permitted to conduct and amplify the audio coming from the discriminator.

The schematic diagrams for two-way radio units show typical voltage readings at key test points. Some also provide voltage and resistance charts. Thus, a DC VTVM can be used to locate faults in the transistor circuit, and the operation of a squelch circuit can be checked by making measurements with and without an applied carrier signal.

***Crystal Oscillators***

Representative high- and low-frequency crystal oscillators used in two-way equipment are shown in Fig. 5A. The type of circuit illustrated in Fig. 5A, a Pierce oscillator for use with fundamental-mode crystals, is employed in the transmitter oscillator and in the low-frequency second oscillator of the receiver.

The configuration shown in Fig. 5B, an overtone or harmonic-type crystal oscillator circuit, is a generally-used high-frequency local oscillator circuit of the receiver. This type of oscillator operates at a relatively high frequency in order to supply the proper signal to beat with the incoming RF and produce the high-IF frequency. Third-harmonic crystals are often used; in other words, the crystal itself and the associated circuit are designed to produce a strong third-harmonic output. With this mode of operation, a crystal of reasonable physical size can be used to generate a high-frequency signal. Efficient harmonic generation depends on the proper amount of feedback. In the circuit of Fig. 5B, the split-capacitor Colpitts feedback arrangement is used for this purpose.

At operating frequencies where the receiver oscillator tends to become unstable, such as in the

400-mc operating range, its output frequency is deliberately kept as low as possible in order to provide the high degree of stability required. The oscillator output is then multiplied to a higher frequency before being mixed with the incoming RF to provide the high-IF frequency.

#### FM Transmitters

The two-way radio transmitter is crystal-controlled for operation on one or two frequencies. Modulation is most commonly achieved by altering carrier phase (rather than frequency) to obtain an FM resultant. As shown in Fig. 1, the phase modulator is the next stage following the crystal oscillator. In this type of FM, the phase-modulation process is rather simple because only a limited deviation of the crystal-oscillator frequency is required. (Depending on FCC assignment, the maximum deviation of the transmitter output frequency may not exceed 5 kc or 15 kc.)

The audio section of the transmitter consists of a speech amplifier and audio clipper. The audio clipper (limiter) prevents overmodulation (excessive deviation) of the carrier due to sharp rises in voltage from the microphone when loud noises are picked up.

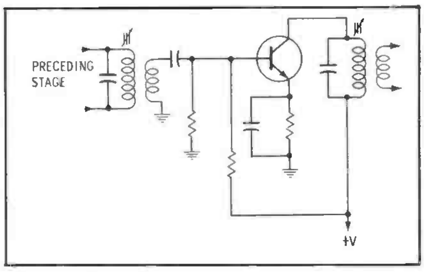



**Fig. 6. Class-C stage for transmitter uses combined external and signal bias.**

The multiplier and driver sections of the transmitter "multiply" the oscillator frequency and modulation deviation to the desired carrier frequency and deviation; then the power amplifier gives a final boost to the RF signal before it is fed to the antenna.

Although transistors are most frequently used in the audio circuits of transmitters, they are sometimes found in the RF sections of hand-held units and some portable pack sets. They are also used in the exciter section of higher-power transmitters.

A typical Class-C transistor amplifier for a two-way transmitter is shown in Fig. 6. In vacuum-tube Class-C stages of the low-power variety, only signal bias is used; higher-power stages are usually the only ones to use a combination of signal and external bias. A few transistorized Class-C amplifiers also use signal bias by itself, but a combination of signal and base-emitter bias is more often used because of the temperature compensation provided by external biasing.

The excitation to a transistor Class-C stage can be judged by measuring either base or emitter current. As the RF excitation from the preceding stage is increased, the base current will rise. Inasmuch as the base current also flows in the emitter circuit, there will be a corresponding rise in the emitter current.

The collector current can be used to evaluate the tuning of the collector tank circuit. As it is brought into resonance, there will be a dip in the collector-current reading. Since the collector current also flows in the emitter circuit, the emitter-current indication will likewise dip when the collector tank circuit is tuned through resonance. As in the

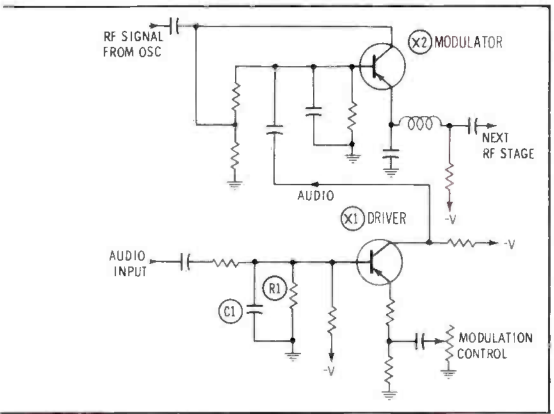



**Fig. 7. Driver prepares audio signal for application to phase modulator X2.**

vacuum-tube counterpart of this stage, any load placed on the output tank circuit will cause a rise in the DC component of current flow. In other words, the collector current and the emitter current will rise when the next stage or an antenna is coupled to the collector tank circuit.

It is apparent that the tune-up and servicing of a transistor Class-C amplifier does not differ too much from the procedure followed with a vacuum-tube circuit. Meter reading can be used for tune-up purposes and for tracing the presence of signals through the transistor RF stages.

A typical audio driver and phase modulator are shown in Fig. 7. The input circuit to the base of driver X1 contains a pre-distortion (post-clipper filter) network, which removes spurious high-frequency components that may be generated in the normal voice-peak clipping process. In addition, this network provides the particular audio-equalization characteristic needed for generation of a proper FM wave using the phase-modulation technique. In a pure phase-modulation process, the resultant modulation deviation for an audio signal of a given magnitude is greater at high audio frequencies than at low frequencies. The pre-distorter network, by reducing the relative amplitude of the higher-frequency components, makes certain that the deviation of the FM wave is relatively uniform for all audio-frequency components of a fixed amplitude over the desired voice-frequency range.

The amplitude of the audio applied to the phase modulator is determined by the setting of the modulation control in the emitter circuit of X1. This control determines the amount of degeneration present in the audio driver, and therefore controls the amplitude of the audio signal supplied through the coupling capacitor to the base of the modulator.

In aligning a transmitter, this control is adjusted only while the transmitter output is monitored on a modulation meter. With an audio input signal of a given amplitude, the control is varied until the deviation is at a recommended level. Remember, it was explained that in some two-way radio services the maximum permissible deviation on voice peaks is 15 kc, while in others, the maximum deviation allowable is only 5 kc. The setting of the control is an important service adjustment. If inadequate deviation exists, the quality of transmission is reduced. If there is too much deviation, the transmitted frequency is likely to exceed the FCC-specified tolerance and cause interference on adjacent channels.

The modulator in Fig. 7 operates as an inverted common-base circuit. The audio signal is applied to the

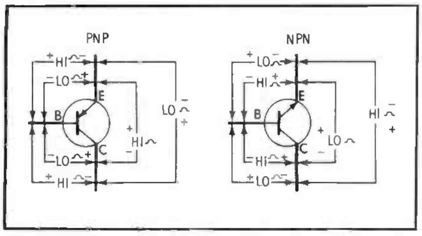



**Fig. 8. Expected results of ohmmeter reading between two transistor leads.**

base, while the RF signal is present at the collector and the base. The amount of phase shift of the RF wave depends on the changes in base voltage with audio modulation. The output FM wave is then passed on to the next amplifier of the transmitter.

### Servicing Methods

Techniques similar to those used in troubleshooting and aligning ordinary transistor radios can also be used in the transistor stages of two-way radio equipment. In-circuit transistor testers are very useful because they can check not only the transistor parameters, but the associated components and wiring as well. This type of tester often includes a signal source that is useful for tracing continuity through the printed circuits usually employed in transistorized equipment.

If convenient, transistors can be checked by substitution. Resistance readings from base to emitter and base to collector are also helpful, if they are wisely interpreted. In a normal transistor, the resistance reading will be low if the two elements are biased in the forward direction by the battery in the ohmmeter, or high if reverse-biased. The results to be expected are summarized in Fig. 8. (For additional transistor testing information, see "Test Equipment for Troubleshooting Transistor Radios" in this issue.)

Do not remove or replace transistors while the power is on, and be extra careful to avoid accidental short circuits which may cause transistor damage. If a transistor being replaced is part of a heat-sink assembly, make certain that the installation is made properly and securely. Sometimes a heat sink is electrically insulated by anodized aluminum spacers. Be on the alert for such features, and follow replacement instructions carefully.

Actually, transistors are dependable enough that frequent testing and replacement is not necessary. Hence, the serviceman should concentrate on other possible defects before routinely checking transistors. Be certain to check the voltages at all transistor terminals in suspected stages; also, use signal-tracing to isolate your suspicions to a particular stage.

The use of key test points and test sockets in two-way radio equipment is particularly helpful both in tune-up procedures and in troubleshooting. Most units include test points for checking key supply voltages, thereby providing a fast means of isolating trouble to the transmitter, receiver, or power supply. In the receiver, test points are almost always included at the limiter and the FM demodulator output, and others are often available for conveniently checking the audio output of the receiver and the squelch circuit. Test points are also provided in the transmitter for measurement of important base or emitter currents. It is usually easy to evaluate the excitation to each RF stage in the transmitter. These plentiful test points greatly simplify signal-tracing, alignment, and isolation of trouble. ▲

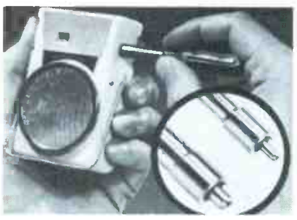
# PRODUCT report

*For further information on any of the following items, circle the associated number on the Catalog & Literature Card.*

### Capacitor Checker (40L)

Capacitors can be checked either in or out of circuit with the **EICO** Model 955. The tester includes a Wien bridge to allow in-circuit capacitor measurements even when shunt resistances are comparatively low. Capacity is read from a 4" lucite dial after it has been adjusted to a "null" by an RC Balance Control. The control is calibrated in RC product, and has two ranges—.6 to 10.5, and 7.0 to infinity. Price of the kit is $19.95; the wired unit is $39.95.

### Transistor-Radio Wrench (41L)



Designed to release the spanner nut found on external antenna and earphone jacks of many imported transistor radios, a special wrench manufactured by **Xcelite** is available in two sizes. Both the ¼" and the 5/16" size have a plastic handle and a pocket clip. A guide pin centers the tool and two projecting keys fit slots in the spanner nut, which must be removed before the chassis can be lifted from the case for servicing. Price is 80c for either size.

### Transistor Transformers (42L)

Three new transistor transformers — a driver, an output, and a power unit are available from **Stancor.** The driver unit (TA-61) has a turns-ratio primary to secondary of 1:1 and a DC resistance of 1.8-ohms/winding. TA-62 is an output transformer with a 4-watt power rating. It has a 25-ohm primary and a 4-ohm secondary. Maximum primary DC ma is 400. The third unit (P-8196) is a capacitor-input-filter power transformer that will deliver 45 VDC from a 117 VAC line.

### Multiband Portable (43L)

The "Trans-World" Model 6523 is a 10-transistor 3-band portable by **Channel Master.** In addition to the broadcast band, the radio covers the range from 2-18 mc in two additional bands. The unit features a monopole "telescoping" whip antenna, a push-button dial light, and a high-low tone control switch. The "Trans-World" operates on four 1½-volt "C" batteries and lists for $74.95.

### Auto Radio Transistors (44L)

The serviceman's assortment (No. 5PT) of five replacement power transistors from **Semitronics** includes five PNP types consisting of a high-wattage, medium-wattage, and low-wattage units, a replacement for 2N155 and 2N176 types, and a PT501 replacement for high-wattage stud types. In all, more than 100 transistors can be replaced by the assortment, as shown by the interchangeability guide included with the package.

### High-Power Portable CB (45L)

Transmitter power of the **Osborne** "Duo-Com 120" pocket Citizens band transceiver is one watt. The 11-transistor unit includes a double-conversion superhet receiver with noise-immune squelch circuit; power is furnished by a rechargeable nickel-cadmium battery. A regular CB license is required for operation. Size is 1⅝" x 4" x 4¾"; weight is 28 oz; price is $149.50, less battery.

### Power Supply (46L)

Intended for servicing all types of auto radios and personal transistor sets, the **Delco** P-612 offers two output ranges: 0-8 volts at 8 amps, and 8-16 volts at 5 amps. Featuring less than .01% ripple at full load, the supply has front-panel meters for both voltage and current. The unit operates on 105-120 VAC at 120 watts and measures 11¼" x 5¾" x 5¾".

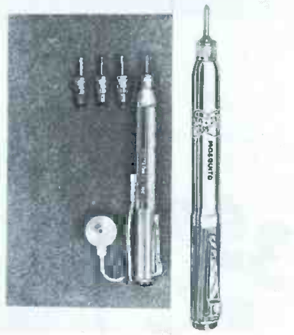
### Heavy-Duty Soldering Kit (47L)


A new utility case made of polypropylene is offered by **Weller** in the 8250AK heavy-duty soldering kit. The self-hinged case encloses a 250-watt soldering gun, a smoothing tip, a cutting tip, a wrench, and a supply of solder. List price for the complete kit is $14.95.

### Transistorized Amplifier (48L)

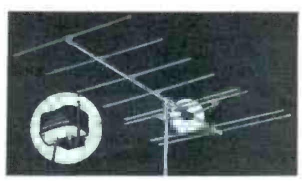
No input transformer is required for telephone line input to the **McMartin** Model LT-80 transistorized audio/PA amplifier. The unit is rated at 20 watts peak power (8 watts continuous) and has a frequency response of 50-10,000 cps at 8 watts. Measuring 9" x 7" x 4½", the Model LT-80 has provisions for 4 inputs and various output impedances from 4 to 600 ohms. List price is $94.00.

### Transistorized Service Aids (49L)



Two pen-size service aids are available from **Don Bosco.** The "Mosquito" is a transistorized signal injector which weighs one ounce and can be coupled without leads to magnetic pickups and circuits. Featuring a wide frequency range (mid-audio to high RF), it is especially useful for transistor-radio servicing. The "Stethotracer" is a miniaturized signal-tracer which will demodulate and amplify signals in the microwatt range and is useful for locating hum, oscillations, ground loops, and breaks in printed circuit boards. The "Mosquito" is priced at $9.95, and the "Stethotracer" is $29.95.

### FM Antenna (50L)



Minimum gain of 26 db over a folded dipole is featured in the "Stereo-Tron" transistorized antenna by **Winegard.** The unit is gold anodized and has a frequency response of 88 to 108 mc within ¼ db. The "Stereo-Tron" is available in two models: PF-8 for 300-ohm twin-lead or PF-8C for 75-ohm coax.

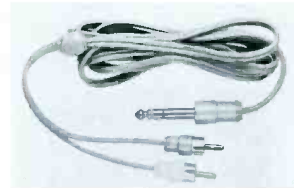
### Radio Parts Kits (51L)

Several transistor-radio parts kits are available from **Components Specialties Co., Inc.** A four-speaker kit (SPK-4) includes 2", 2¼", 2½" and a 2¾" 8-ohm speakers. Three different subminiature electrolytic-capacitor kits contain values from 5 to 100 mfd. Also available is a plastic box containing 21 polycarbonate capacitors. A complete line of earphones is also offered.

### Tube Manual (52L)

The latest edition of the **RCA** Tube Manual (RC-21) contains 480 pages of data on over 900 receiving tubes. Also included is data on more than 100 types of black-and-white and color picture tubes. The circuits section has been expanded and contains 26 circuits: included are several broadcast receivers; two-channel stereo amplifiers; preamplifiers, mixers, and tone control circuits; and an intercom set. Price of the manual is $1.00.

### Stereo Cable (53L)



No tools are needed to install the new **Switchcraft** molded cable assembly. Used to connect a stereo mixer to a stereo or monaural tape recorder, the assembly features color-coded molded plugs that fit a standard phono jack. Constructed of tandem stereo cable with individual shields, the complete unit (Part No. 10FK25) has a list price of $4.00.

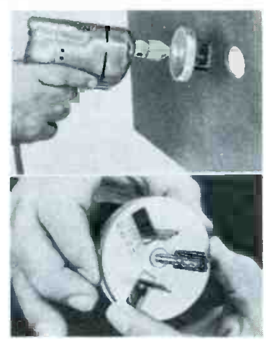
### Wiring Tool (54L)

Available in three sizes, **Twirl-Con** makes quick, neat, secure connections of resistors, capacitors, and pin plugs and wire ends. The tool is especially useful in printed circuits and tight spots such as TV tuners. Other uses include repair of leads broken off close to transformer windings and lengthening pigtails. The tool is priced at $2.00 for any of three available sizes—No. 1 fits 18-gauge wire, No. 2 fits 16-gauge wire, and No. 3 is used for 13-gauge wire.

### Mulitple Adapter (55L)

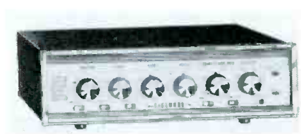

Four tubes and a germanium diode are employed in the **Bogen** PX60, a multiplex adapter which provides a frequency response from 50 to 15000 cps ±3 db. The unit features distortion of less than 1%, and a hum level of –60 db. It measures 4½" x 9" x 4½", and weighs 7½ lbs. Built-in filtering suppresses interference from commercial multiplex signals. Price of the PX60 is $69.50 (slightly higher in the West).

### Adjustable Hole Cutter (56L)



An adjustable tool which cuts holes of any diameter between 1⅛" and 2½", the **Zoron** Z-saw fits any drill that employs a ¼" chuck. Supplied with the saw is an extra set of blades for cutting metal. To adjust the size of the cut, the lock nuts at the top can be loosened to permit the bottom plate to be rotated until the blades are set at the desired diameter shown on the scale. The cutting action is performed with the tool square to the surface to be drilled.

### Stereo Amplifier (57L)

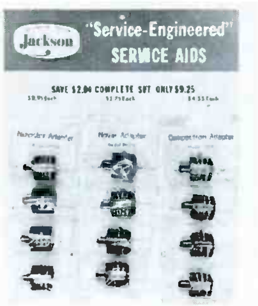


A presence-rise switch that boosts frequencies near 2800 cps to dramatize vocalists and certain instruments, is featured in the **Sherwood** Model S-5000 80-watt stereo amplifier-preamplifier. Other features include: a 12-db/octave scratch and rumble filter; low hum and noise level, 60 db down at 80 watts on the phono channel; and 1.2-millivolt phono sensitivity. Four low-level and eight high-level inputs are provided in the S-5000 which has a net price of $199.50 ($204.50 with case).

### PA Loudspeakers (58L)

A power-handling capacity of 25 watts allows the **Electro-Voice** LR-4 and LR4S line radiators to be used in a wide variety of both indoor and outdoor installations. Unwanted high-frequency radiation at the ends is controlled in the LR4 by its curved design, while the LR4S contains an electrical filter network which restricts reproduction of higher frequencies to the central loudspeakers. In addition, the LR4S is weatherproof.

## Tube Tester Adapters (59L)




Three socket adapters for use in checking new tube types (Nuvistors, Compactrons, and Novars) with **Jackson** tube tester Models 648, 658, and 598, are now available from distributors. The adapters plug into existing sockets and can be purchased in a "package" at $9.25. If purchased separately, the Nuvistor adapter is $2.95, the Novar unit is $3.75, and the Compactron adapter is $4.55.

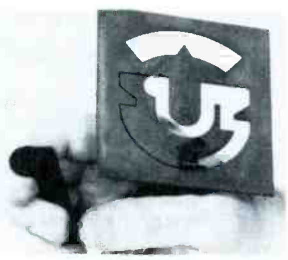
## Two-Speed Tape Recorder (60L)

Among the features offered in the **Sampson** Model SFC62N tape recorder are: fully automatic 2-speed (3¾ & 7½ IPS) control, a tone control that operates on both record and playback, a neon recording-level indicator, a pause and edit control, and separate jacks for microphone, external speaker, and radio-phono. The unit, which weighs 16½ lbs., has a frequency response of 150 to 8500 cps at 7½ IPS, and is priced to sell at under $100.00.

## Crystal Switches (61L)

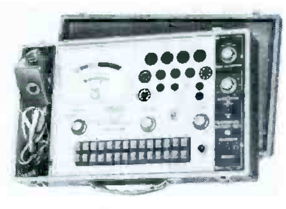
Designed to increase the available transmitting channels from two to six on Model CB-27 transceivers, the **Regency** CS-6 crystal switcher provides push-button selection for instantaneous channel changes. Either fixed or mobile stations can be adapted to push-button operation. In fact, the unit may be used with other CB transceivers to add crystal-controlled receiving channels. The case measures 6¼" x 3" x 1¼" and has a nickel-plate finish. Net price of the CS-6 is $19.95 (less crystals).

## Nibbling Tool (62L)



A hand-operated tool that cuts round, square, or irregular holes to any size over 7/16", the **Adel** Nibbling Tool can be used to cut holes for mounting components on chassis. The cut is started by drilling a 7/16" hole. The cutter is then inserted and the hole is "nibbled" to size. The tool can also be used for notching clearance on flanges of airducts or cabinets.

## Tube Tester (63L)



A new dynamic mutual conductance tube tester from **Mercury** is characterized by push-button settings. Known as the Model 1200, the unit will test tube types with all basing arrangements, plus black-and-white picture tubes, transistors, and batteries. In addition to transconductance tests, the Model 1200 tests for shorts, leakage, gas, and grid emission. Price is $119.95.

## Replacement Transformers (64L)

Several replacement transformers have been added to the **Merit** line: FM 259 (10.7 mc FM IF) replaces Westinghouse 235V058H01; TV157 (second sound IF) replaces Philco 32-4745-2; TV-158 (4.5-mc trap and transformer) replaces Philco 32-4688-10; TV232 (sound discriminator) replaces Philco 32-4735-1; TV-234 (4.5-mc quadrature coil) replaces Westinghouse 230V007M02; TV235 (4.5-mc ratio detector) replaces G-E WT56X41; TV-237 (sound take-off) replaces Admiral 72C132-19; and TV-238 (4.5-mc second sound IF) replaces Olympic CL4021.

# INDEX TO ADVERTISERS

**March, 1962**





# CATALOG AND LITERATURE SERVICE

## ANTENNAS & ACCESSORIES

1L. *CUSH CRAFT*—8-page catalog (No. 62) describing complete line of amateur communication antennas; both UHF and VHF types listed.

2L. *GAM*—Catalog sheet giving specifications on miniaturized TG-2-R VHF mobile antenna that is designed to mount on top of vehicle or in other restricted spaces.

3L. *JFD*—Descriptive and promotional literature plus sales aids for new "Transis-Tennas"; also complete set of specifications for outdoor and indoor TV antennas and accessories, including exact replacement antenna data. *See ad pages 44-45.*

4L. *WINEGARD*—Factfinder No. 201 giving complete specifications for Model PF-8 "Stereo-Tron" antenna for FM multiplex receivers; includes schematic diagram. *See ad page 68.*

## AUDIO & HI-FI

5L. *EICO*—New 32-page catalog of test equipment, kits and wired equipment for stereo and monophonic hi-fi, Citizens band transceivers, ham gear, and transistor radios. Also, "Stereo Hi-Fi Guide," and "Short Course for Novice License." *See ad page 79.*

6L. *FISHER*—"Fisher Handbook" (normally priced at $1.00); a guide to custom stereo installations; also lists stereo equipment and specifications. *See ads pages 88, 93.*

7L. *NORTRONICS* — Brochure describing Model T60-T2 bias-oscillator transformer; also contains specifications and description of Model RA-150 transistorized recording amplifier.

8L. *PRECISION ELECTRONICS* — Specifications for Model 25MPA transistorized mobile PA amplifier that operates from cigarette-lighter outlet. *See ad page 94.*

9L. *SWITCHCRAFT* — New Product Bulletin #115 describes "Littel Key" small panel lever switch for PA, amateur, and test equipment.

10L. *UNIVERSITY*—12-page catalog describing PA loudspeakers; also 4-page brochure giving information on F-107 transistorized mobile siren and PA system; also 20-page catalog containing complete list of Hi-Fi speakers and systems.

11L. *UTAH* — Engineering-data sheet listing complete line of PA speakers; also includes architects' specifications. *See ad page 66.*

## COMMUNICATIONS RADIO

12L. *VOCALINE*—Catalog sheets describing the "Commaire" Model ED-27M CB multi-channel transceiver, Model PT27 long-range portable CB unit, and Model CC60 wireless intercom.

## COMPONENTS

13L. *BUSSMANN* — Compact new 64-page *BUSS* Television Fuse List, Form TVC, giving servicemen a quick reference for fuse replacements in old and new TV sets; includes fuse information for car and truck radios. *See ad page 63.*

14L. *COMPONENTS SPECIALTIES* — 4-page catalog No. 62A "Universal Replacement Parts for Transistor Radios and Phonos," on complete line of replacement speakers, controls, earphones, subminiature electrolytics, ¼- and ½-watt resistors, etc.

15L. *CORNELL-DUBILIER*—*Service Selector*, a 40-page quick-reference catalog of capacitors, vibrators, power supplies, antenna rotators, and test instruments, prepared especially for radio and TV service technicians. *See ad page 17.*

16L. *SPRAGUE*—46-page catalog listing complete line of capacitors, resistors, printed circuits, filters, and capacitor analyzers; includes pricing information. *See ad page 12.*

17L. *STANCOR*—Bulletin #605A listing complete line of line-matching transformers; includes a schematic layout of a typical 70.7-volt line distribution system. *See ad page 91.*

18L. *TRIAD*—TV62 transformer replacement catalog; also PTM4 "Service Bulletin for the Professional Television Man."

## SERVICE AIDS

19L. *ARCO*—Literature on kit of precision miniature capacitor standards, containing 32 plug-in standards ranging in values from .0001 to .4 mfd, tolerance ±0.1%. *See ad page 42.*

20L. *BERNS*—Data on 3-in-1 picture-tube repair tools, on *Audio Pin-Plug Crimper* that lets you make pin-plug and ground connections for shielded cable without soldering, and on *ION* adjustable beam bender. *See ad page 90.*

21L. *CASTLE*—Leaflet describing fast overhaul service on television tuners of all makes and models. *See ad page 83.*

22L. *CHEMICAL ELECTRONIC ENG'G.*—Leaflet on *Hush* TV-tuner cleaner, *Ever-Quiet* contact restorer, *Plastic Sealer* spray, *Ever-Kleer* glass cleaner, and *Sure 'n' Easy* wire connectors. *See ad page 81.*

23L. *DON BOSCO* — Literature sheets describing the "Mosquito," a pocket-sized, transistorized, signal injector, and the "Stethotracer," a pen-size detector complete with earphone, used for signal tracing. *See ad page 76.*

24L. *INJECTORALL*—Catalog of electronic chemicals, including new No. 20 *Lens Kleen* (for removing scratches from plastic TV safety windows) and No. 30WC *Renew Spray* (for polishing cabinets and removing scratches); also pocket-sized catalog, "Open the Door." *See ad page 84.*

25L. *PRECISION TUNER* — Information on repair and alignment service available for any TV tuner. *See ad page 66.*

26L. *SARGENT-GERKE*—Catalog of service chemicals in aerosol spray cans; also spray-paint color cards. *See ad page 92.*

27L. *YEATS* — Literature describing *Appliance Dolly* and padded delivery covers. *See ad page 86.*

## SPECIAL EQUIPMENT

28L. *CROWN* — Literature on "Defender" burglar alarm that creates an electronic shield around objects, rooms, or whole buildings; also information on distributor and dealer franchises available to qualified service companies.

29L. *ELECTRO PRODUCTS LABS*—Bulletin EC262 describing two low-ripple versatile DC power supplies for auto and personal transistor-radio servicing; supplies sell for $29.95 and $39.95 complete. *See ad page 97.*

30L. *TERADO*—Catalog sheets on power converters for obtaining 110-volt AC from auto battery or other mobile DC supply; information on battery chargers also provided. *See ad page 80.*

## TECHNICAL PUBLICATIONS

31L. *GRANTHAM* — Booklet entitled, "Careers in Electronics," outlining training courses available. *See ad page 15.*

32L. *HOWARD W. SAMS*—Literature describing all current publications on radio, TV, communications, audio and hi-fi, and industrial electronics servicing, including 1962 Book Catalog and descriptive flyer on 1962 Test Equipment Annual. *See ads pages 50, 55, 64, 84.*

33L. *SYLVANIA* — 12-page booklet, "The Service Dealer's Path to More Profits" (ET-1349), describing 5 Sylvania-sponsored RTTA home study courses—Shortcuts to TV Servicing, Complete Business Practices for Service Dealers, Transistor Servicing, Color TV Course, and Advanced Radio Servicing. *See ad page 61.*

## TEST EQUIPMENT

34L. *B & K*—Catalog AP18-R, giving data and information on Model 960 *Transistor Radio Analyst*, Model 1076 *Television Analyst*, *Dynamic 375* VTVM, *V O Matic* 360, Models 700 and 600 *Dyna-Quik* tube testers, Models 440 and 420 CRT Cathode Rejuvenator Testers, Model 1070 *Dyna-Sweep* Circuit Analyzer, and B & K *Service Shop*. *See ads pages 25, 56.*

35L. *PRECISION APPARATUS* — Catalog describing complete line of test equipment for industrial electronics, audio, FM and AM radio, and B & W and color TV; includes prices and specifications. *See ad page 92.*

36L. *SECO* — 4-page reprint of technical article on transistor testing; shows how to perform tests with various test instruments. *See ad page 85.*

37L. *SENCORE*—New booklet, *How to Use the SS117 Sweep Circuit Troubleshooter*, plus brochure on complete line of *time-saver* instruments. *See ads pages 39, 49.*

38L. *TRIPLETT* — Catalog sheet describing Model 800 VOM, a versatile instrument with 70 ranges, a 7" scale, and overload protection. *See ad pages 1-2.*

## TOOLS

39L. *XCELITE* — Bulletin 1261 describing transistor-radio Terminal Wrenches used to remove spanner nuts on external-antenna and earphone jacks.

# USE THE HANDY CARD BELOW TO OBTAIN FREE CATALOGS & LITERATURE

As a service to its readers, PF REPORTER makes this postpaid card available for your convenience in obtaining current manufacturers' literature.

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b. Print your name and address and check your occupation in the spaces provided.

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Note the deadline date — Requests received after this cannot be handled.

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| 33L | 34L | 35L | 36L | 37L | 38L | 39L | 40L | 41L | 42L | 43L | 44L | 45L | 46L | 47L | 48L |
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## PF REPORTER SUBJECT REFERENCE INDEX—MARCH, 1962



Note: "T" means *Troubleshooter* item.

Important News for Independent TV-Radio-HiFi Service Dealers...


# RCA Announces A Major New Program

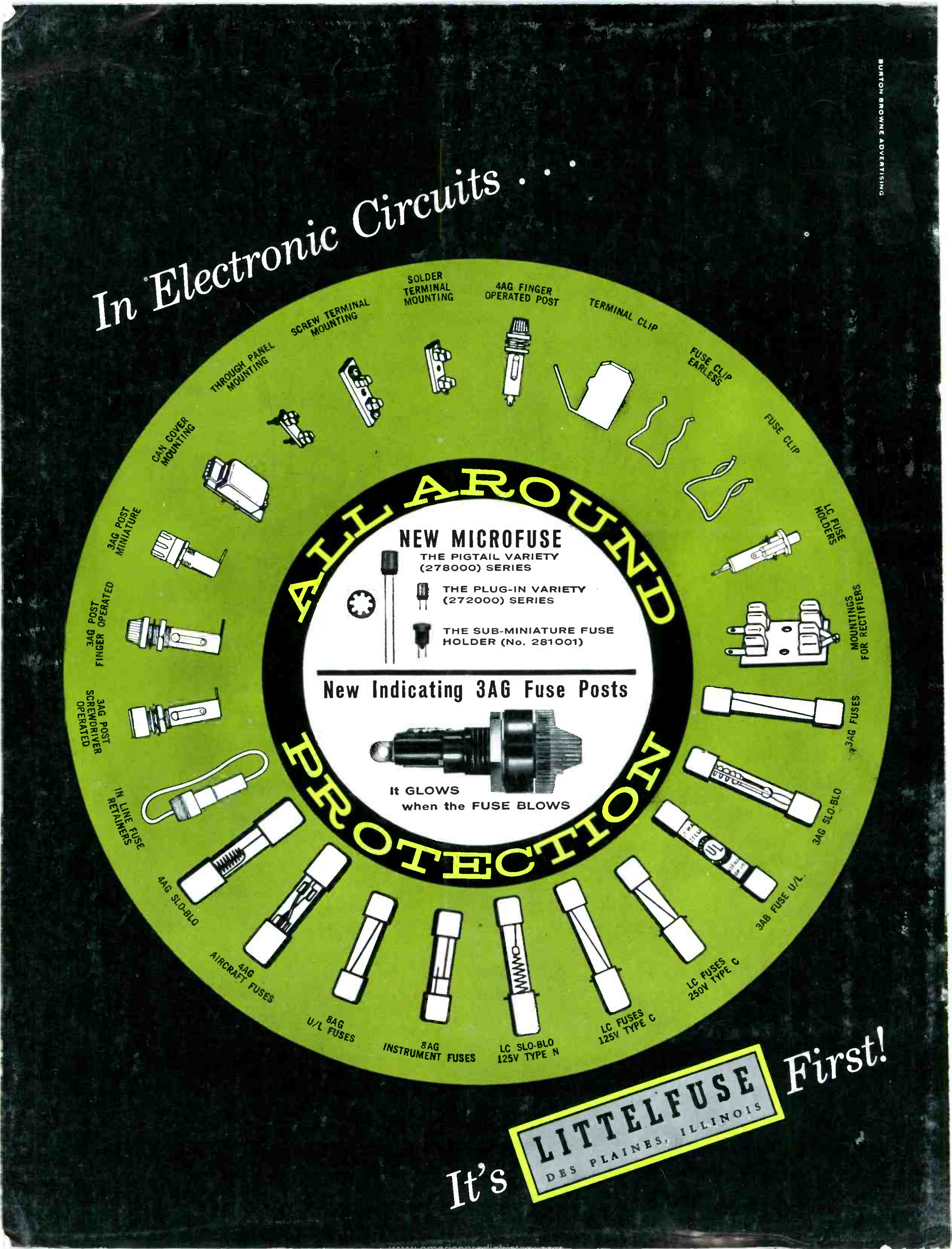
THIS PROGRAM WILL...

- Identify You as a Trusted Service Dealer
- Highlight Your Technical Competence
- Enhance Your Community Prestige
- Symbolize Your Professional Integrity
- Build Your Public Recognition and Acceptance
- Help Increase Your Business Volume and Profits

See your Authorized RCA Tube Distributor for full details on how you can participate in the RCA *Key to Trusted Service Program,* which is heavily advertised to consumers through TV Guide and NBC-TV.

RCA ELECTRON TUBE DIVISION, HARRISON, N. J.

The Most Trusted Name in Electronics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THE SUB-MINIATURE FUSE HOLDER (No. 281001)
New Indicating 3AG Fuse Posts
It GLOWS when the FUSE BLOWS
SOLDER TERMINAL MOUNTING
4AG FINGER OPERATED POST
TERMINAL CLIP
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MOUNTINGS FOR RECTIFIERS
3AG FUSES
3AG SLO-BLO
3AB FUSE U/L
LC FUSES 250V TYPE C
LC FUSES 125V TYPE C
LC SLO-BLO 125V TYPE N
8AG INSTRUMENT FUSES
8AG U/L FUSES
4AG AIRCRAFT FUSES
4AG SLO-BLO
IN LINE FUSE RETAINERS
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