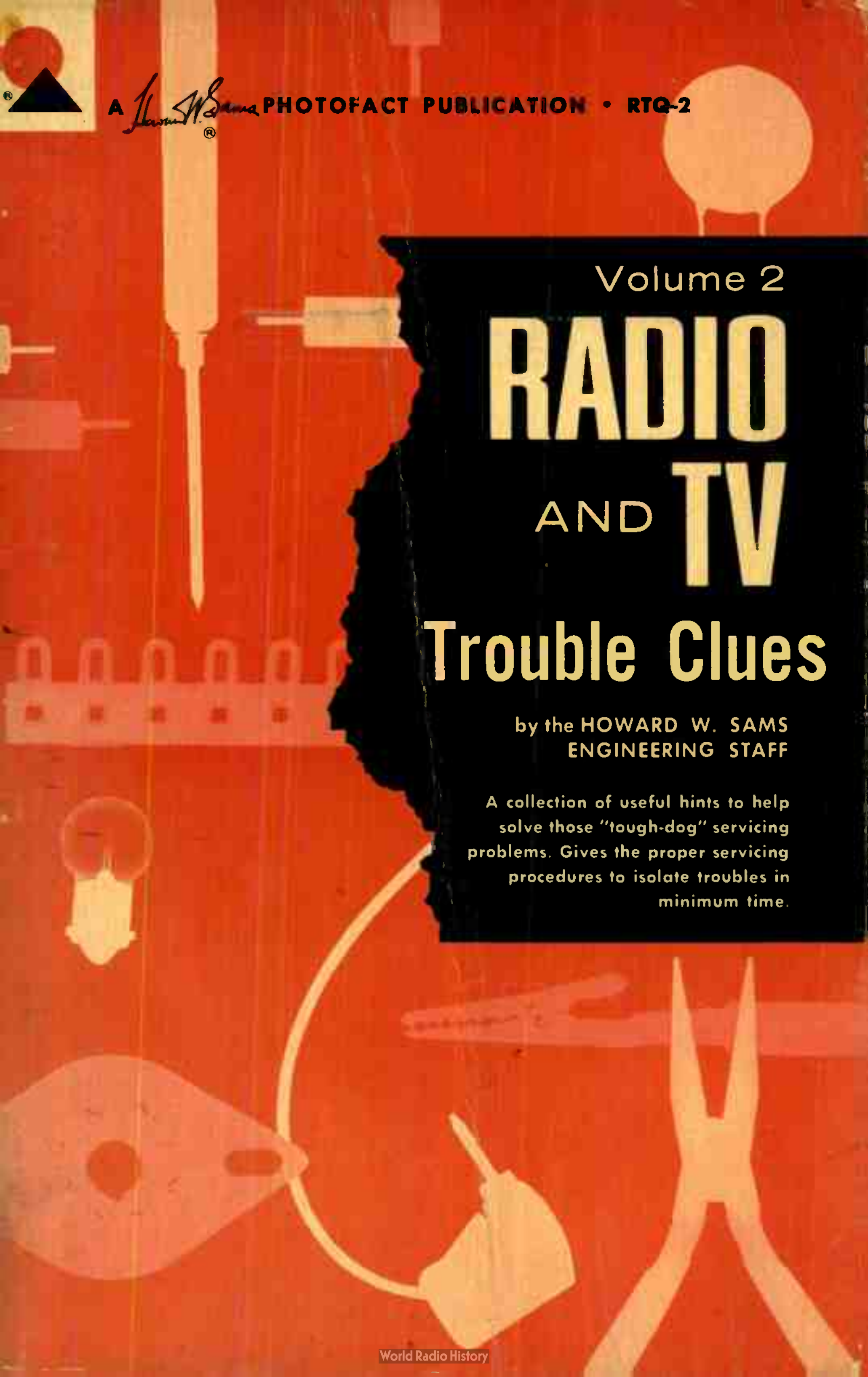

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Volume 2

# RADIO AND TV Trouble Clues

by the HOWARD W. SAMS ENGINEERING STAFF

A collection of useful hints to help solve those "tough-dog" servicing problems. Gives the proper servicing procedures to isolate troubles in minimum time.

$1.50
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# RADIO and TV TROUBLE CLUES

## VOLUME 2

by

The Howard W. Sams
Engineering Staff

HOWARD W. SAMS & CO., INC.
THE BOBBS-MERRILL COMPANY, INC.
*Indianapolis • New York*

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RADIO AND TV TROUBLE CLUES—VOLUME 2



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## SECTION 2



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# Preface

The technician's prime objective in the servicing of any piece of electronic equipment is the same—getting it repaired in a minimum of time for maximum profit. The thousands of technicians who purchased the first volume of *Radio and TV Trouble Clues* have indicated that it aided them in reaching this objective. Like the first volume, this volume is based on material from the "Quicker Servicing" column of PF REPORTER magazine. It gives the proper procedures to quickly and accurately diagnose many additional "tough-dog" servicing problems.

The book is arranged in three sections. Section 1 is devoted to general troubleshooting hints. It covers the need for establishing a set procedure in any servicing job instead of haphazardly jumping in without thoroughly analyzing the problem. The three easy steps given can cut hours from the time spent locating the trouble. Numerous helpful methods of locating intermittents are also included in Section 1. The section concludes with a discussion of the many types of servicing chemicals in spray cans—how they can aid you in locating and repairing troubles faster.

TV circuit troubles from the antenna to the picture tube are covered in Section 2. Many helpful hints to speed the diagnosis of those hard-to-locate troubles are given here.

The final section is devoted to troubles in radio circuits. Methods are given for rapidly locating the trouble in AC/DC superhets as well as transistor radios, and a complete discussion on servicing FM stereo adapters.

This book will serve as a handy reference guide in the diagnosis and repair of those difficult-to-service "tough-dog" TV's and make radio servicing a quick and easy, profitable operation.

January 1965

Howard W. Sams

## Section 1

# Troubleshooting Hints

### ANALYZING TROUBLESHOOTING

That's a strange-sounding heading, wouldn't you say? Troubleshooting *is* analyzing, so how are you going to analyze analyzing? Well, the answer is: We're going to analyze just what it takes to troubleshoot a piece of electronic gear—that is, the kind of *thinking* it takes. Sound unusual? Maybe so, but when you realize that troubleshooting is 80% thinking and 20% manual labor, perhaps it is time we did a little talking about the mental efforts of troubleshooting.

This is not going to be a long, drawn-out discourse on philosophy; instead, a practical way to think your way through a tough dog, quickly and easily, will be given. This is needed more often than you might imagine. So, let's talk about troubleshooting; you may be surprised how much easier troubleshooting can be when your thought processes are functioning in as good order as your VTVM and scope.

#### What Is "Troubleshooting"?

A customer brought a set into the shop and hoisted it onto the counter. He explained briefly that it had quit suddenly, that he was in a hurry, and that he would stop by for it in a couple of days; then he hustled out. There the technician stood, open-mouthed, without the slightest idea of his complaint. It was obvious he was going to have to start from scratch; that is, to fix this set, he would have to begin at the very beginning.

Where's that, you say? Well, it so happens this technician has a definite ceremony he goes through before he even takes the back off a set. These steps are as follows:

1. Learn the symptoms, preferably by asking the owner.
2. Verify the symptoms yourself.
3. By careful analysis of the primary symptoms, make a quick diagnosis of which section is at fault.
4. Note any secondary symptoms and diagnose their probable cause.

Since the customer had gone, the technician skipped the first step and proceeded to the second. The symptom turned out to be a case of "sound, no video." Now this is a relatively easy fault to track down, and it is an excellent one to demonstrate the thinking processes that make for effective troubleshooting. The chassis was an older model, and an examination of the schematic revealed the video section shown in Fig. 1-1. The thinking processes went something like this (remember, thinking these things takes much less time than telling about them):

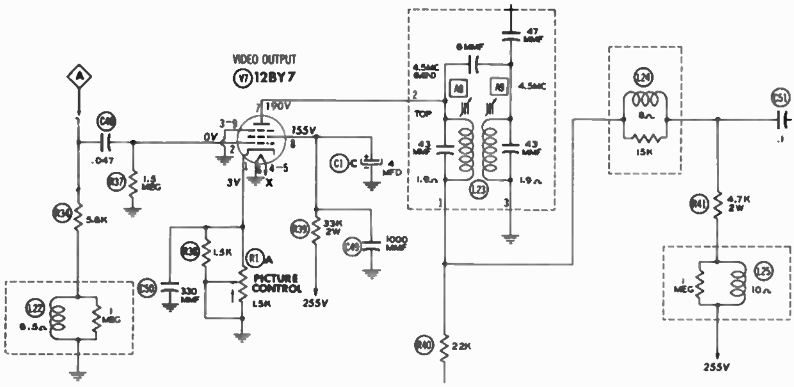



**Fig. 1-1. The video stage of the receiver being repaired.**

. . . The raster is okay; so that eliminates the probability of trouble in the horizontal, high voltage, or vertical stages. The sound comes through plainly, so it can be assumed the tuner and IF stages are working, and the sound stages are all functioning. All that's left is the sync, AGC, and video. (The technician started removing the back, at this juncture.)

Since the sync section can't be checked until the video is restored, it is ignored for the time being. Either the video stages are bad, or the AGC is overloading and blanking the video—not an uncommon trouble in sets like this one.

(Reaching into the chassis, the technician pulls the video tube and reinserts it.) Not the slightest flash on the screen, so the technician assumes the video circuit is bad between this point and the screen. So, instead of looking into the AGC circuit—or any other of the stages eliminated earlier—he turns immediately to the video stage and hunts the trouble. . . .

Digging into the underside of the chassis, he quickly finds an open peaking coil, and the mental part of the job is done. Elementary? Nothing to it, you say? That's right, but without the thinking process first, it wouldn't have been so easy—would it? And that is the exact point. A logical approach will make any service job easier, faster, and more profitable.

## Three Easy Steps

That's all there are—just three! And they are the keys to efficient troubleshooting. Learn to apply them, and you'll soon be taking the "tough" sets right in stride; in fact, you'll probably be taking on sets from technicians who are less experienced and knowledgeable, and haven't learned how to use logical procedures yet.

*Inspection*—Inspection can encompass several facets—a look at the screen, a glance at the tubes on the chassis, a visual inspection of the components under the chassis, tracing a burnt odor with your nose, or listening carefully for a characteristic noise from the speaker or from some component. This careful inspection is first on the list of servicing steps for every top-notch technician.

The efficient technician learns to do this automatically. He probably is still busy removing the screws from the back when he starts inspecting tubes to see if they're lit. He may be cleaning the face of the CRT while he's observing the screen to see what the picture symptoms will tell him. He may lay the chassis on its side the instant he puts it on the bench, to have a view of both top and bottom while it warms up. These timesaving procedures are the sign of a good technician; he makes every movement count toward finishing the job.

The complete inspection will usually take less than five minutes of his time, but it will tell him many things; it will even lead him straight to the trouble in almost half the sets he encounters. You can put the routine inspection to work for yourself. Get the habit; it will make you money.

*Isolation*—To be able to locate a defective part, you must have some idea where to look.

Frequently, a faulty component looks deceptively okay. This is where the technique of isolating the defective stage comes into play. Once the faulty stage is located, other techniques can pin down the bad part; therefore, if an inspection fails to turn up a specific defect, use stage isolation as your second big step.

As you've no doubt surmised by this time, in the previous example the stage was closely isolated in the preliminary inspection. Only two stages were left to check by the time the inspection was completed.

*Pinpointing*—The final step is to pinpoint the faulty part. This is the aim of every troubleshooting step—a fact that should be remembered. No matter how many or how few steps you take, finding the defective component is the ultimate goal. The fewer steps, and the quicker you accomplish them, the sooner the job is done and the greater the profit in your pocket.

Consequently, you can now summarize these three steps, keeping the common goal in mind. (1) *Inspect* the set thoroughly as you disassemble it; perhaps you can see, smell, or hear the faulty component; (2) *Isolate* the faulty stage, by reasoning or by instruments, and perhaps a closer inspection of that specific area will reveal the fault; and (3) *Pinpoint* the defect by proper use of instruments within the faulty stage.

## Using Logic

You can consider every stage in any piece of electronic gear as acting on some other stage, or being acted upon by some other stage. Fig. 1-2 shows an action diagram of a typical television receiver; a similar diagram can be drawn of every electronic device. Don't mistake this for an ordinary block diagram, for it isn't. It contains arrows to show how each stage acts on another, and the arrows are coded to indicate the type of action.

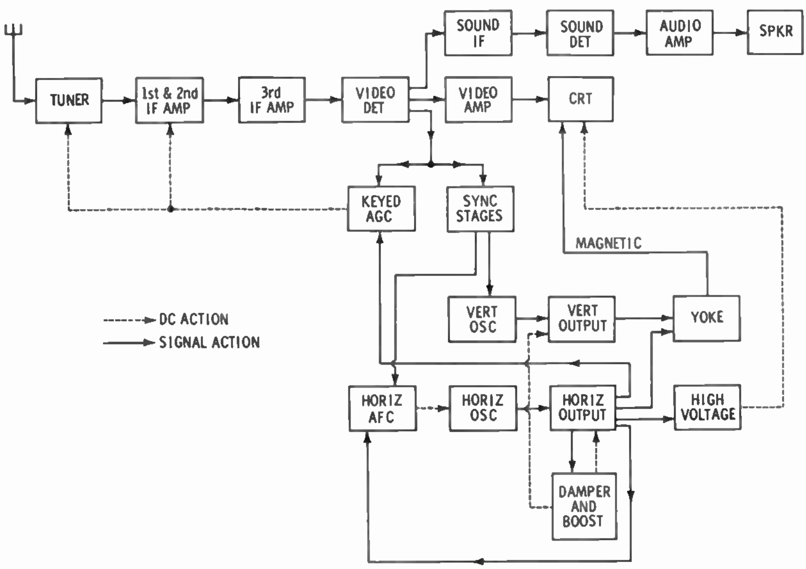



**Fig. 1-2. An action diagram of a typical TV receiver.**

Two types of stage interaction are possible: signal action and DC (or controlling) action. The former is indicated by solid lines in the diagram; DC control in indicated by dashed lines. Notice how easy it is to understand the workings of a complex piece of equipment through such a diagram. You may want to learn how to lay out such a diagram for just one section of a receiver. It's easy; listen to the explanation of circuit action later, and you'll see.

The arrows show the direction of action. For example, the antenna acts upon the tuner, by feeding signal voltages into the input. (The tuner could be further broken down into its stages—RF, mixer, and oscillator—if that would help in troubleshooting.) The tuner sends signals through the video IF stages to the video detector. Here, at the detector, the diagram shows graphically the division of the signal into three segments: video for the CRT, sound IF, and video for the sync and AGC stages. The sync and AGC signal is divided into two equivalent portions, to perform their action in both the sync and the AGC sections.

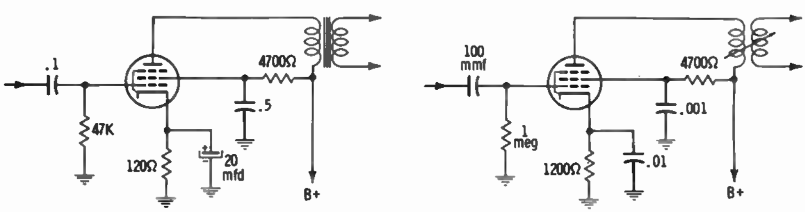
One interesting aspect of such a diagram is its ability to show the source of action for a stage, and the next action in sequence. For example, take the AGC. Even if it were not labeled as a keyed type, the signal path from the horizontal output stage would be a giveaway. And the action of the stage? According to the arrows, the output is a DC voltage fed back to the first two IF stages and the tuner.

A similar action-reaction chain is demonstrated in the horizontal AFC circuit. The action diagram indicates that signals are received both from the sync stages and from the horizontal output stage. The two signals are compared, and develop a controlling DC voltage for the horizontal oscillator, to hold it on frequency. Sure is easy to see when it's drawn out like this, isn't it?

## Analyzing Stages

Now comes the part that really gets you into the real thing—troubleshooting within the stage, and finding the actual defective part. There are two ways you can look at a stage from a troubleshooting standpoint, and it is very important that you remember these two classifications; your success as a conqueror of tough dogs could very well rest on learning to apply the facts in this discussion.

*Signal Handling*—Almost every stage of any electronic device processes signals in some way or another. Even if its output is DC (like a rectifier stage), it handles some form of signal. The signal may be 60-cps line voltage, or it may be UHF television frequencies; the point is: in some way or another, nearly every stage handles signals.




(A) Low-frequency circuit. (B) High-frequency circuit.

**Fig. 1-3. Using component values as key to circuit operation.**

The manner of handling a signal is invariably determined by the components—their type and value. For example, look at the two simple amplifier stages in Fig. 1-3. They are very similar, except for parts values. The signal in Fig. 1-3A must be a fairly low frequency, because of the large coupling capacitor and the large values of the bypass capacitors; also, the output load is an iron-core unit generally associated with low-frequency signals. The stage in Fig. 1-3B, on the other hand, would not handle low-frequency signals. The small-value coupling capacitor will pass only higher frequencies; the bypass values are such that low-frequency signals entering the stage encounter serious degeneration. Lastly, the output coupling device is an air-core transformer, suitable mostly for higher frequencies. Thus, a quick look at the component values by an experienced technician would tell him instantly whether the stage would pass or attenuate audio signals.

Now, let's examine the various portions of a stage, and see how signals are handled within the stage. If we know how to follow the progress of a signal within a stage, we can tell when this path of progress is broken; this is the secret to isolating the defective stage. Fig. 1-4 shows how a signal progresses through a normally functioning stage.

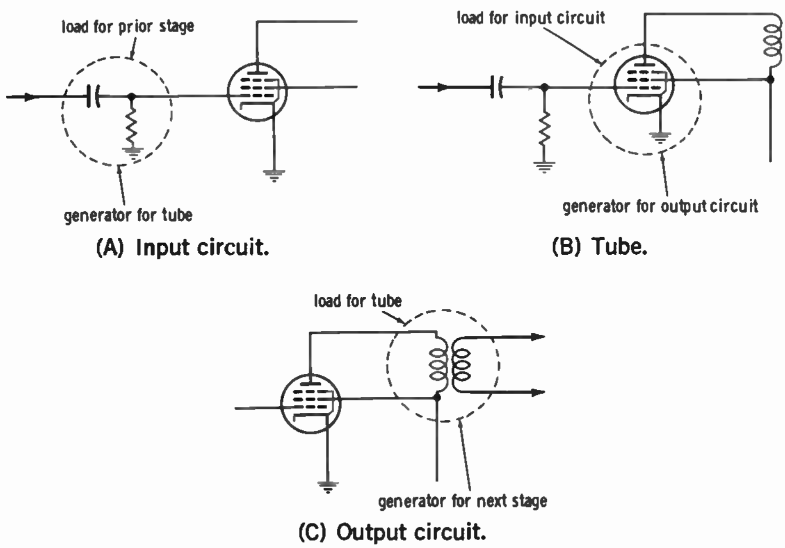



**Fig. 1-4. Considering each portion of a stage separately for analysis.**

First, consider the input circuit of the stage as the load for the previous stage (Fig. 1-4A). The input could be a coil or transformer, or an RC network as shown. The important thing is that the input circuit receives some form of signal from the preceding stage. When troubleshooting, be sure the signal is being delivered properly to the input portion of the stage.

Next, the input circuit can be considered as a generator of signals for the stage. Ignoring the prior stage, you can now treat the input circuit as the source of signals which are being applied to the grid of the tube.

The tube (Fig. 1-4B) is a signal-passing device (a transistor would serve the same purpose in a transistor set). It may amplify the signal, it may mix several signals, it may eliminate certain signals, (as a sync separator eliminates video), it may change the signal to DC, or it may simply pass the signal along without amplification (like a cathode follower). In any case, it acts as a load for the input circuit; it must receive and process the signals being fed to the input. In processing the signals, it then becomes the "generator" of signals for its output load circuit. In troubleshooting, therefore, you must be sure the tube first receives the correct signals, and then passes the correct signals on to the output load.

Fig. 1-4C shows the output circuit and the two ways of considering it. It acts as a load for the tube, on the one hand. On the other, it can be considered as the "generator" of signals for the input circuit of the next stage.

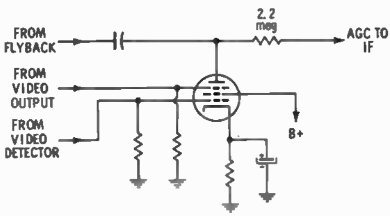



**Fig. 1-5. Simplified schematic of a keyed AGC circuit.**

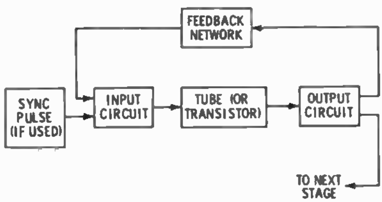



**Fig. 1-6. Action diagram of an oscillator circuit.**

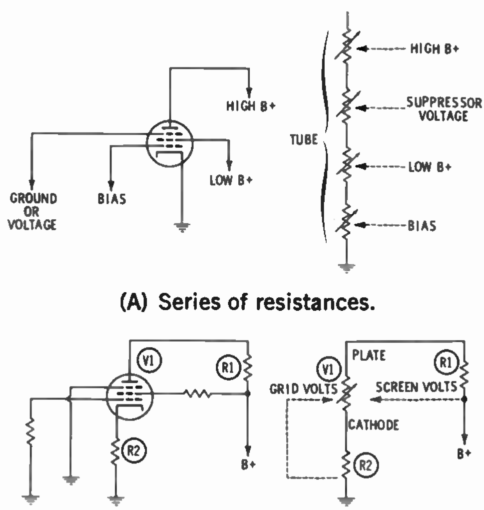
The simplified schematic in Fig. 1-5—a noise-cancelling keyed AGC system—shows how several forces can act upon the same stage. But you'll notice you can still apply the reasoning outlined previously: The tube is the load for the input circuits, but it is also the generator for any signals (or, in this case, the DC voltage) passed on to the output circuit or to the next stage. The tube in Fig. 1-5 is a load for three different signals: negative-going video (and sync) at the grid, positive-going video at the suppressor grid, and the horizontal-frequency keying pulse at the plate.

You'll notice that both an input and an output are connected to the plate. Here is an example of how components can affect the way a signal (or voltage) is handled: The high-value resistor keeps signal voltages from entering the DC output path to the IF amplifier, while the capacitor keeps DC out of the keying-signal input path from the flyback.

Thus, no matter how complicated the stage, it can be broken down into individual signal-handling circuits. This method of considering every portion of the stage as either a signal load or a signal generator can help trace the action in any stage. Even an oscillator is simply an amplifier that provides its own input signal. Sketch an action diagram of an oscillator; it should look something like Fig. 1-6.

*DC Handling*—While every stage can be considered as a signal-handling device, it can also be analyzed from the viewpoint of how it handles DC supply voltages. While tracing the signal is the quickest way to localize the stage in which a fault lies and may occasionally help pinpoint a faulty component, the remainder of faults will be tracked down by applying a knowledge of how power-supply voltages affect the tube, and how the stage affects the voltages.

Take a look at Fig. 1-7A. The various voltages are shown as they are applied to an ordinary pentode tube. The tube is also represented as a group of variable resistances in series. The voltage effects on plate current are as follows: The B+ applied to the plate makes the resistance of the tube lower (increases plate current), as does B+ applied to the screen. The grid bias is negative, and thus increases the re-




(A) Series of resistances.



(B) Grid and screen effects.

**Fig. 1-7. Analysis of DC distribution in a stage and effects of voltage changes.**

sistance (lowers the plate current) as it becomes more negative. The suppressor voltage can increase or decrease plate current, depending on whether it is (respectively) positive or negative; at ground potential it merely suppresses secondary emission.

Fig. 1-7B shows the actual circuit with the signal-handling components omitted; only those parts are shown that affect DC voltage distribution within the stage. The tube is represented as one resistance that is variable depending on the values of screen voltage and grid voltage. These two voltages are the only ones considered, because they have the most effect on current within the circuit; *plate* and *cathode* voltages depend mostly on plate current, and not vice versa. In fact, plate and cathode voltages can shift considerably without great effect, *provided* the grid and screen voltages are held constant. Remember this fact; it will be used many times in the troubleshooting of electronic equipment.

Thus, if the plate voltage of V1 is low, look for some fault that has increased the current through the tube—causing the constant resistance of R1 to reduce the voltage at the plate. Possible causes would be an increase in screen voltage or a reduction in grid bias. Finding which it is will put you on the track of the defective part.

Suppose cathode resistor R2 were to open. Since no current could flow, there would be no drop whatsoever across R1, and the full plate voltage would appear at the plate of V1. The same result would occur if the grid suddenly became very negative, cutting off the plate current within the tube. A quick check at the cathode would tell which actually was causing the lack of plate current; if R2 is open, most of the plate voltage will also appear at the cathode pin of V1.

It is easy to see that many possible faults could affect the DC distribution within any stage. It is necessary only to know what normal voltages exist, and the abnormal ones can be traced to a cause. If bias is dependent upon signal, lack of it may indicate that signal is not being provided by an earlier stage. On the other hand, it may indicate that a leaky coupling capacitor is reducing the bias. In either case, the lowered plate voltage points to reduced bias, which in turn leads toward the cause.

## Practical Troubleshooting

Now let's see how you can apply this way of thinking about troubleshooting, and turn it into cash in your pocket. You can do so by using this form of thinking to help you troubleshoot every electronic device you're asked to service—the simple radio, a tough-dog TV, or the complicated radar system on an ocean liner. The rules are the same for all: (1) Make a brief thorough *inspection.* (2) *Isolate* the inoperative section by analyzing the sequence of actions from input to output of each stage, and from stage to stage. (3) *Pinpoint* the defective part, either by tracing signals or by analyzing the DC distribution within the stage.

Once you've mastered this technique, you'll rapidly become known as an expert—the guy who can service anything. And you'll be handling most of your troubleshooting with your brain (which almost always can work more quickly and profitably than you can with your hands).

## MONITORING INTERMITTENTS

The revenue of an electronics service shop depends mostly on the operator's ability to use his time productively, so any step taken to reduce the amount of wasted time is bound to improve the profit situation.

Servicemen know, all too well, that one of the greatest causes of lost time is intermittent troubles. Customers naturally aren't agreeable to paying a serviceman just to sit around and wait for an intermittent to "act up." To recover the cost of his time, he must make a direct attack on the problem. The time-honored method of beating on the chassis with a screwdriver, although it may make the serviceman feel better, has only limited usefulness; a more scientific approach will get quicker and surer results.

You can begin troubleshooting this type of malfunction as soon as the customer calls for service. If the customer's complaint indicates an intermittent condition, you should inquire how often the trouble occurs. If it has appeared only once or twice, it would be advantageous to delay making the service call until the existence of a defect has definitely been established. Explain to the customer that it might be very difficult to pinpoint the trouble unless it occurs with some regularity. However, instruct the customer to call back if the same pattern of trouble persists.

If the customer's description gives clear evidence that the trouble is chronic, find out more about the case by asking a series of leading questions. It is important to phrase them in terms that are familiar to the customer. The questions should probe for the following facts:

1. Exactly what happens? Does the picture roll, or twist out of shape? Does it disappear? If so, is the screen still lit? Are the picture and sound both affected?
2. How long does the set operate before the trouble occurs?
3. When the symptom appears, can the customer do anything to alleviate the condition, and if so, just what?
4. Has the set been serviced before for the same or a similar condition?

After all the information is gathered and the call is accepted, arrange for the customer to have the set turned on for a predetermined length of time before you arrive. This will give the set a chance to act up, so you can verify the complaint. After diagnosing the symptoms, try new tubes in all suspected circuits, reinstall the rear cover of the set, and allow the chassis to come up to normal operating temperature. If the trouble reappears, suggest to the customer that further repairs should be done in the shop, where you can use special techniques to solve heat-induced problems more quickly and satisfactorily than in the home.

Radio-TV servicemen can learn a lesson from commercial broadcasting stations, which strive to protect their revenues by staying "on the air" every second of every broadcast day. To aid in holding "down time" to a minimum, the transmitting equipment has built-in meters for use in monitoring key check points. Potential troubles can be detected, isolated, and corrected before they cause failure of the equipment. Such a complex system of built-in monitoring devices is obviously impractical for home entertainment equipment, but the service technician can still adapt certain basic monitoring techniques to his own bench work—especially for dealing with intermittents. A methodical pre-planned monitoring procedure will result in happier customers, greater profits, and more cheerful technicians.

## Why Monitor?

The word "intermittent" suggests that something abnormal is happening to a particular component as a result of changes in operating conditions or temperature. Some reaction to applied voltage or heat is to be expected, and manufacturers allow for this in the design of their sets. But if components change more than the tolerances permit, you've got trouble.

The very nature of these changes makes them difficult to detect by ordinary methods. Heat causes expansion of the materials in components, and unequal movement of different materials may cause an open or short circuit (or a change in value) that will correct itself as soon as the temperature is reduced. In addition, DC or signal voltages applied to a component can produce leakage or shorts that appear to heal when the voltage is removed. Probing the circuit with a test prod is likely to "cure" an intermittent defect, either by mechanically forcing a connection into normal contact, or by creating an electrical pulse that temporarily "welds" the faulty connection. Troubles of this type can be exasperating.

The beauty of monitoring is that it eliminates the problem of shocking the receiver into normal operation. You choose the most important test points in the suspected circuits, and hook your instrument probes to these points *before* turning the receiver on. Then you can let the equipment operate until the intermittent fault shows up, and check to see if any test indications have become abnormal. While you're waiting, you are free to work on other jobs.

## Where to Monitor

The check points used in monitoring are no different from those used in ordinary servicing, but since you can make only a few tests during each monitoring period, you must pick your check points with extra care.

The first step is to try isolating a defect to some definite section of the equipment; once you've ascertained that a certain group of stages is not operating normally, you can monitor various secondary check points in the area to close in on the trouble. In TV work, this initial phase of trouble isolation depends on a shrewd analysis of the picture and sound symptoms—the same method routinely used by all TV men to decide where to begin troubleshooting. However, intermittents cause special complications, because you may have to depend on the customer's description of the symptom (not so much *what it is* as *when it appears*). It's important to get a thorough understanding of his complaint. Sometimes it helps to ask leading questions, such as, "Does the trouble appear only about suppertime?" or "Do you have to reset this control every time you turn the set on?"

The choice of a primary test point may be easy if the set has a symptom such as "creeping" vertical nonlinearity, which plainly indicates a defect in some small area of the set. But quite a few symptoms, like intermittent loss of sync, aren't so easily pinpointed to a stage—or even within several stages. If there is any doubt about the general location of the fault, or if you're not sure of the customer's complaint, you'll find it helpful to begin monitoring at one or more of the four major check points marked on the block diagram in Fig. 1-8:

A—Output of video detector
B—Input to audio detector
C—Output of last sync stage
D—Drive to horizontal output

Using these points, you can break up the circuits into manageable sections, and greatly reduce the number of tests needed.

## How to Make It "Intermit"

Unfortunately, you can't even make that first test until you can coax the trouble to show up. You have several possible ways of doing this, but before doing anything, stop and think. Is the *trouble* really intermittent, or only the *symptom*? Even if the set seems to be acting normally, go ahead and make a few key checks with the scope and VTVM. You may spot some borderline fault such as compressed sync in the video signal, low or poorly filtered B+ voltage, or a misadjusted horizontal oscillator, which may explain why the set's operation is rather erratic.

If the "normal" readings seem correct, you'll have to duplicate the conditions that cause the breakdown, to eliminate the possibility of the set operating normally on your service bench for endless hours. Most customers are unhappy when told the trouble could not be found, and are prone to take such reports as personal affronts to their intelligence. Thus, we repeat: Listen very carefully to their accounts of the trouble. Frequently, the complaint will contain a statement such as, "If I want to watch an 8 o'clock program, I turn the set on at 7," or "It runs about an hour, then off it goes." These are clear signs of *thermal* intermittents caused by changes in temperature. The first type of complaint indicates trouble during warmup, which can be made to appear with comparative ease. The chassis will stay much cooler on the service bench than in the cabinet, thus prolonging the warmup time. If necessary, a strategically-placed fan or two can forestall normal heating. When the trouble does go away, a shot of "freeze spray" chemical will often bring it back; by carefully aiming the spray, you can pinpoint the offending component.

The other type of complaint, a "hot" intermittent, is much more difficult to bring forth, because the chassis may never run hot enough on the bench to induce the trouble. Heat lamps directed at the suspected area have been used effectively for years, but this method has certain disadvantages. The intense heat radiated by the lamp can melt wax and other insulation from components in the area, possibly causing other troubles or even producing a temporary cure of the original fault. A preferred method is to cover the chassis with a material that will hold heat in much the same manner as a cabinet. Ideal for this purpose is a large cardboard box. If you're using a monitoring technique, you've already made the test connections, so you don't need to reach under the box.

Intermittent troubles that can't be tied to temperature variations may be due to component breakdowns that occur under certain line or signal voltage conditions. Such cases demand more observation and experimenting than simple heat problems; again, the important thing is to come as close as possible to the conditions under which the owner operates his set.

Once you've decided which check points to monitor, and how to induce the symptom, you're "halfway home" on conquering the intermittent. To go the rest of the way, let's consider what to look for at particular test points.

## Video Detector

This point is useful for isolating the cause of weak video with no snow, or touchy sync. (This test isn't necessary to troubleshoot the symptom of a snowy picture, which pretty well isolates itself to the tuner or antenna.) A normal video waveform, like that in Fig. 1-8—with constant amplitude and no distortion—proves the entire RF-IF section is free of intermittents. The next step, in this case, is to signal-trace (monitor style) through the video circuits.

If the detector-signal amplitude changes when the trouble appears, follow-up checks should be made of the AGC bias voltage, IF-amplifier plate voltages, and other factors that could alter gain. Signal-tracing through the IF's with a scope and demodulator probe can often be helpful, too.

Intermittent distortion of the detected video, as in Fig. 1-9A, is often a hint to make a complete check of the AGC circuit. Certain faults, like

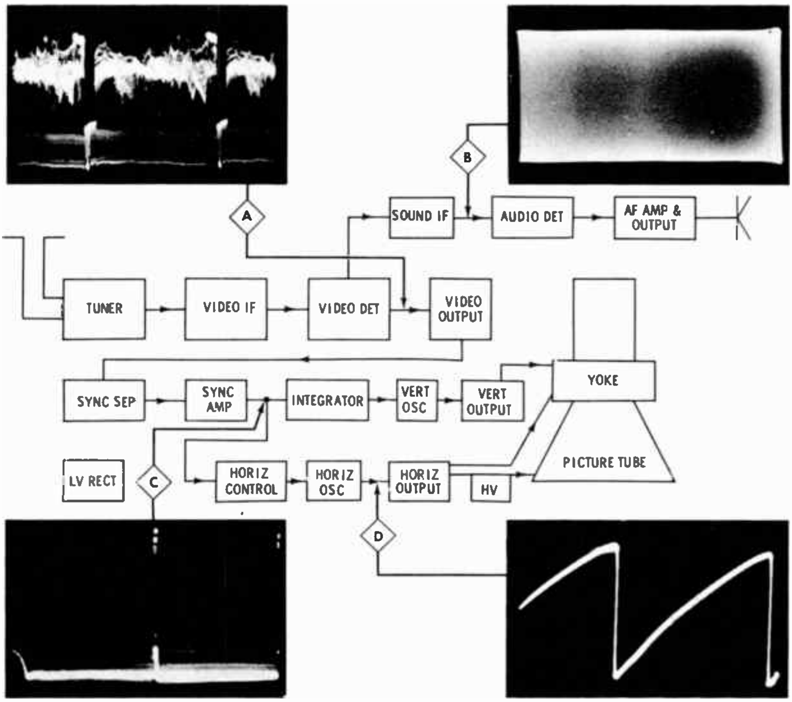
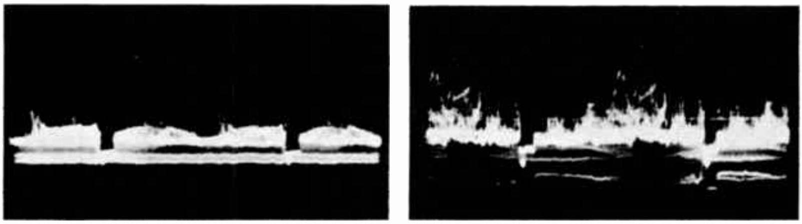



**Fig. 1-8. The four major check points for isolating the trouble to an area.**



(A) Caused by loss of AGC. (B) Caused by misaligned IF.

**Fig. 1-9. Distortion in detected video.**

the "punched-in" vertical pulses in Fig. 1-9B, could indicate drifting of some RF or IF tuned circuit; defects of this sort can be further isolated by using a visual alignment setup for later monitoring tests.

## Audio Detector

This point is helpful in troubleshooting complaints that the sound "cuts out" or erratically changes in volume. We're not overlooking the volume control as a convenient point for dividing the sound section into two blocks for trouble isolation, but the sound IF and detector are such common offenders that we recommend a prompt attempt to divide one from the other.

An ordinary wideband scope will display the 4.5-mc detector-input signal well enough to let you check its amplitude; see Fig. 1-8 for the characteristic pattern. If a normal signal is reaching the detector, you can continue to signal-trace with the scope until you find the erratic stage.

## Sync Output

Scoping this point is essential for analyzing the cause of bending, rolling, jitter, and related troubles. The output pulses at the last sync stage should be strong, steady in amplitude, and free from all but the slightest trace of video. In a two-stage sync circuit, positive pulses like those in Fig. 1-8 are normal; but negative pulses can be expected if the sync separator is the only sync stage.

If any distortion or fluctuation of the trace is seen when the trouble appears, try to "box in" the fault by monitoring other points as far back as the video detector.

In cases of unstable *vertical* sync, you need a true picture of the signal actually reaching the vertical oscillator; thus, the output of the integrator is a better spot than point C for initial monitoring. Follow instructions in service data for disabling the vertical oscillator to get a clearer view of the sync pulse. Sometimes you'll find nothing wrong with the sync input; this is a clue to drifting of the oscillator. Monitoring voltages, as well as waveforms, in this stage should help you determine which part of the oscillator circuit is defective.

## Horizontal Drive

Most servicemen have more difficulty with the horizontal sweep section than any other part of a TV receiver. The problem is multiplied by interaction between the horizontal oscillator and output stages, especially when an intermittent trouble is present. Thus, the most important check point associated with the horizontal section—and perhaps in the entire receiver—is the grid of the horizontal output tube. It's a waste of time to do much work on the flyback, boost, and high-voltage circuits without first making sure the grid is receiving a constant drive waveform of normal shape and amplitude.

If the drive signal is unstable, a "vicious circle" involving all the horizontal stages may have to be broken before you can go on. Grounding or disabling the AFC input to the oscillator will let you see if the oscillator can run steadily enough to develop a constant drive signal.

In receivers that use boost voltage as a plate supply for the oscillator, trouble almost anywhere in the horizontal circuit can complicate matters by varying the plate voltage. A positive method of isolating the defect is to connect the proper DC voltage to the oscillator plate from an outside source. Should this eliminate the intermittent problem, the output circuit can be assumed to be at fault and you can choose the next point to be monitored—perhaps the screen of the output tube, or the boost line.

### Wrap It Up

All later steps in monitoring should have the object of picking out individual components or networks that might be defective. More specific methods of isolating individual components are given in the following discussion.

## THERMAL INTERMITTENTS

Heat-induced component failures that occur in receivers after several hours of operation can cause some of the most difficult servicing problems encountered by TV technicians. A defect of this type may cause any of the usual service complaints, with the added complication of timing.

When the chassis is brought to the shop, certain bench procedures can speed up finding the intermittent fault. The system of monitoring described previously will aid in isolating the faulty stage. Get out the schematic and familiarize yourself with the circuits most likely to be involved in the problem.

### Typical Component Faults

Before proceeding, it is well to remember the behavior patterns of different components when they are heated. Resistors usually change slowly in value—they rarely cut in and out. Resistors carrying a fair amount of direct current (such as cathode, screen grid, bleeder, decoupling, and B+ units) are more likely to change value than are others which have only signal voltages applied. Especially susceptible to change are resistors across which high voltages, such as B+ boost, are impressed. Potentiometers often develop burnt spots after a few years, causing erratic operation.

Capacitors may cut in and out (develop intermittent shorts or opens), or they may change slowly in value. Units in high-frequency pulse circuits—such as horizontal sweep stages—are particularly susceptible to this latter fault. Some capacitors can, by developing minute leakage, upset RC networks and thereby alter circuit operation.

Printed-circuit boards may develop slight cracks that expand when hot. This can cause the equipment to cut out and then return to normal operation when the set is allowed to cool slightly.

### Trouble Hunting

Keeping these points in mind, you can now try to locate the trouble —remembering to check first those components that would ordinarily cause the symptoms being observed. The only difference in troubleshooting a "heat" intermittent and a so-called "normal" trouble is in the need for controlling the temperature to bring on the symptom. If a cardboard "hot box" is fitted over the chassis to simulate the cabinet, removing the box for access to the circuitry may reinstate normal operation; when this happens, heating lamps can sometimes be used to speed up the recurrence of the complaint. A small, hand-held hair dryer can also be used for the same purpose; hot air from the nozzle can be concentrated on a small portion of the suspected circuit.

If a certain resistor is suspected of changing value, turn the set off and connect an ohmmeter across the resistor. Apply heat to the resistor and see if the meter reading varies appreciably. If it does, the resistor is defective and should be replaced.

Capacitors may be checked for an intermittent open condition by gently pulling on the terminal leads; but if leakage or a change in value is suspected, temporary substitution of a good component is a more conclusive test. Cut one lead of the capacitor in the set—leaving a small stub for reconnection—and tack in a replacement. To check the results, apply heat to the circuit, using the same method that previously made the trouble show up.

You may have to heat and cool the set any number of times, depending on how many steps are necessary to pinpoint the faulty component and on whether you can make test-equipment connections without turning off the set.

## Case Histories

A not uncommon type of intermittent picture distortion can frequently be traced to overloading of the first video IF. Fig. 1-10 shows the circuit. After the set has played for some time, the 100-mmf coupling capacitor between the tuner and the IF becomes leaky. A positive DC reading on the first IF grid is the clue. Unsolder the IF end of the

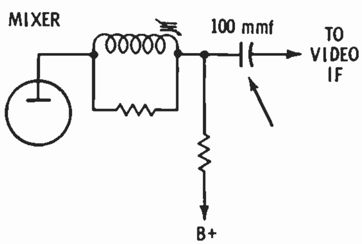



Fig. 1-10. Leakage in this grid capacitor will reduce bias on first IF and cause overloading.

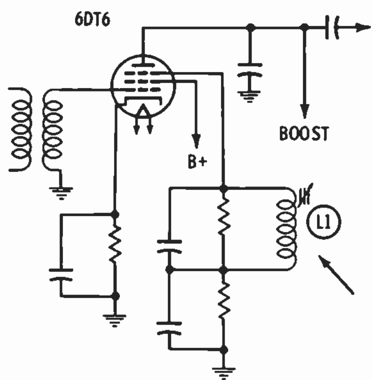



Fig. 1-11. The quadrature coil is a major suspect in any case of intermittent sound trouble.

capacitor, connect the voltmeter probe to the free lead, and heat the circuit; if the reading goes positive, this is a sure indication of leakage.

In one case that involved a smeary picture and distorted sound, a leaky coupling capacitor between the video amplifier and sound IF was responsible. Again, a leakage test using a voltmeter was conclusive.

Intermittent sound is another complaint that can frequently be traced to thermal problems. Quadrature coils (Fig. 1-11) have been common offenders. In one case, the sound was distorted *until* the set had been on for a while; then it gradually became normal. Due to changes in circuit components over a long period, the coil had become detuned. Retuning the coil was all that was necessary in this case, but the solution is not always that simple. Poor solder connections at the coil terminals are common in certain chassis. The tubular ceramic capacitor across the coil is also a frequent troublemaker; if you replace it, use an NPO type.

Trouble in the quadrature coil sometimes causes either weak sound or buzz instead of distortion. If the simple remedies mentioned here are ineffective, replacement of the entire coil may save a great deal of time.

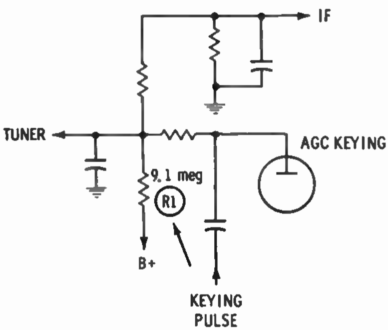



**Fig. 1-12. The AGC delay resistor frequently causes intermittent trouble by changing value.**

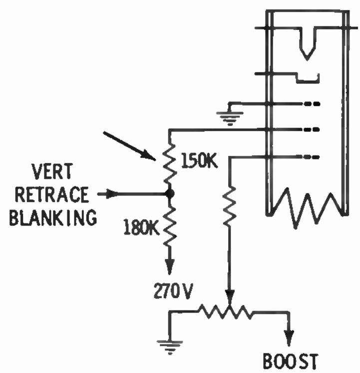



**Fig. 1-13. The loss of accelerating voltage on CRT, due to open resistor, blanks out raster.**

In the type of AGC circuit shown in Fig. 1-12, the delay resistor (R1) going to B+ has been found to change value with heat. An increase in its value can cause snow that gets worse as signal strength increases; a decrease may cause video overload or complete loss of video. Your voltmeter, connected across this unit, can detect the change as the set operates; this particular resistor will seldom shift value with only an ohmmeter supplying the voltage.

Fig. 1-13 illustrates a typical "hot" intermittent that causes loss of brightness, simulating the effect of a faulty picture tube. The 150K resistor in the accelerating-anode circuit opens up, removing voltage from the anode. Your voltmeter, guided by a little reasoning, will help you find this one.

### Other Regular Offenders

Filter capacitors that lose capacitance or develop leakage between sections at high temperature can cause a multitude of troubles—such as sound bars in the picture, hum in picture or sound, and even sync troubles. Filters are particularly suspect in sets using "stacked" B+ supplies or in series-filament receivers using voltage doublers. Your scope will reveal any excess signal voltage across the filters.

In several instances dirty height and vertical linearity controls have been found responsible for thermal intermittents. Lightly tapping the shaft, or the control body itself, will disclose the trouble. Injections of cleaning fluid will sometimes help temporarily, but the best solution is relacement of the control.

Sync troubles are more difficult to diagnose. A scope is usually necessary to find out just where the sync pulses are being lost or suppressed. A low-capacitance probe will disturb the circuits as little as possible. After determining where clipping is occurring, you can substitute the suspected components.

If probing the circuitry "kicks" the set back into normal operation, or if a heat lamp can't keep the chassis warm enough to maintain the abnormal condition, try leaving test probes hooked to key test points and covering the chassis with a "hot box" as explained previously.

## SERVICING CHEMICALS IN AEROSOLS

This is the age of the aerosol—an era in which the spray method of contact cleaning, component lubrication, and similar applications has proven to be a major aid to today's technician. The engineer, TV service technician, and hobbyist have become as dependent upon spray products as has the American housewife.

The photos in Fig. 1-14 illustrate a few common applications of aerosols. Manufacturers of cleaners and lubricants for the service trade have developed more efficient, safer, and easier-to-use chemical products, often paralleling advances in equipment development.

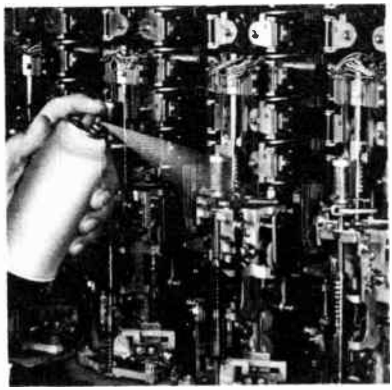
Many useful chemicals are supplied in 6-ounce cans for convenience on the bench, in the home, or in the service caddy. Many have a flexible plastic tube 6″ to 10″ long that permits access to hard-to-get-to spots in TV's, small radios, etc., often without dismantling the chassis.

Let's investigate aerosols and see what chemicals are available and how they can serve you more efficiently.

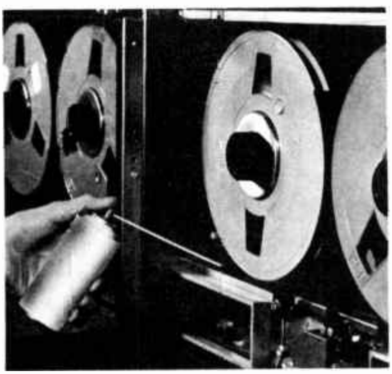
### Cleaner-Lubricant Sprays

Numerous manufacturers have products designated as tuner cleaners, control cleaners, contact cleaners, etc. Although similar in formulation, many sprays have special characteristics. Some have a light oil base combined with a strong solvent that is most effective for lubricating and renewing contact efficiency on heavy-duty equipment switches, relays,

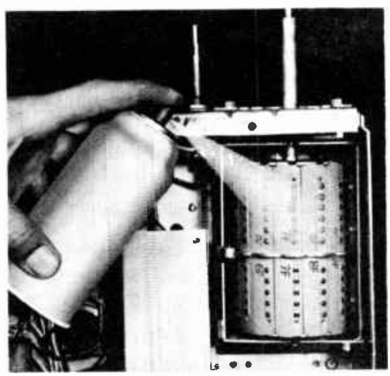
(A) Controls.



(B) Relays.



(C) Tape guides.



(D) Tuners.

**Fig. 1-14. Some typical uses for pressure sprays in cleaning and lubricating.**

and volume and tone controls. Others contain silicone compounds and are formulated to lubricate electrical contacts and controls on radio and television equipment. These are highly effective for use on TV tuner assemblies. The silicone compounds assure effective heat-resistant lubrication and extended protection to small electrical contacts and heavy-duty controls alike.

Most service chemicals are nonflammable and, unlike carbon tetrachloride, leave no deposit. When choosing a compound for application to high-frequency circuit components, however, care must be taken. Be sure to select a compound that will not alter the response of the circuit.

## Antistatic Sprays

Antistatic compounds are used primarily for cleaning safety glasses, picture tubes, and cabinets. Several manufacturers offer a similar cleaner for use on phonograph records; others provide a single compound for both purposes. These fluids dry rapidly and leave a protective film that reduces the attraction of dirt and dust.

## Insulating Compounds

Insulating sprays act as an electrical insulator. They are recommended for use in television high-voltage circuits to control corona discharge and arcing. Acting as a coating for coils and transformers, sealing electronic components from humidity and moisture, these products have a very high dielectric strength.

## Component Coolant Sprays

Chemicals of this type aid in locating heat-caused intermittents in electronic equipment through local cooling of capacitors and other components while the set is in operation. This method can save countless hours needlessly wasted through trial and error. Heat-sensitive transistors and phono cartridges can be cooled prior to soldering. Coolants are also useful in obtaining inactive resistance readings of thermistors.

## Lubricating Solvents

These sprays may be applied in TV sets at the junction of the yoke and picture tube for loosening frozen yokes without damage to the CRT or yoke windings. Another use is in record-changer and tape-recorder mechanisms to prevent rust and corrosion and to remove corroded control nuts and screws.

## Miscellaneous Products

The remaining frequently used aerosols include varnishes and enamels in many colors for use on porcelain, plastic, metal, and wood. They dry in minutes, are lead-free, and contain no propane or butane. Various transparent and stain sprays are also available. Grease, cement, or ink can be washed from the hands with an aerosol hand cleaner. These cleaners normally contain lanolin and germ-killing solutions, with no harsh, irritating chemicals.

## Choose Carefully

Today's technician may choose from literally hundreds of service sprays stocked by his local electronic parts distributors. Remember: Poor quality products can take a heavy profit toll through repeated service callbacks. Careful evaluation of a new spray should be made before it is used on expensive electronic equipment.

## Caution!

Spray cans contain a liquid gas that can be *very dangerous* if the container is exposed to extreme heat or is punctured. Many users have been badly, even fatally, injured by the explosion of such cans. The can of contact cleaner or other aerosol now on your service bench, *empty* or *otherwise,* should never be exposed to heat. Even after the chemical has been exhausted, the propellant is still active, and sufficient increase in temperature will explode the can.

Before disposing of an empty spray can, it's wise to eliminate the pressure inside; *it's a necessity* if you burn your trash. Reduce the pressure by wrapping the can substantially with heavy rags and storing in a cold place for several hours (overnight in the refrigerator is suitable). With the pressure reduced, make an opening in the wrapping to expose the bottom of the can. Puncture it with a can opener while the end is pointed away from you. Once the pressure is released, the can is safe—and so are you.

## Conclusion

Chemical cleaners, conditioners, and lubricants are here to stay. Research and development continue to produce finer products in this area to fulfill the needs and demands of today's service technician. Modern aerosol spray chemicals can mean better service to the consumer through better service procedures, if they are properly handled.

## Section 2

# TV Circuit Troubles

## ANTENNA TROUBLES

There are many times when a serviceman checks and double-checks a receiver, only to find the trouble is caused by a weak signal applied to the antenna terminals. A few quick and simple checks will localize faults in antenna systems and eliminate the unnecessary receiver checking.

### Analyzing Complaints

When a prospective customer phones, saying, "The picture on my set sometimes flashes and gets snowy," do you stop to consider that this could be an antenna problem? A few simple questions over the telephone can often confirm or dispel your suspicion. First, is an indoor or outdoor antenna used? Second, does the trouble occur only on windy or stormy days? Third, is the trouble noticeable on more than one station? Fourth, how long has the present antenna system been in use? It may take a little extra time to obtain this information, but it is time well spent if it means one service trip instead of two. Unexpected antenna work may necessitate a second trip, because very few servicemen carry antenna equipment on the same vehicle that is used for service calls.

If your customer complains of interference—such as ignition noise from passing vehicles—remember that the symptoms may have existed before, and merely remained unnoticed until recently. On the other hand, also remember that these interfering signals may be appearing as the result of a faulty antenna system. If the station signal picked up by the antenna system suddenly becomes weaker than the interference signals, the set will show a very noticeable difference.

Flashing, snow, and ghosts are possibly the most confusing of all service complaints; they can be caused by either the receiver or the antenna, thus making it difficult to be sure which is at fault. Whenever a service call is made for any of these symptoms, it's easy to make a quick visual check of the antenna system before entering the home.

You should look for broken, bent, or loose elements on the antenna; also make sure the lead-in isn't broken, worn, or frayed. If everything appears visually satisfactory, proceed with the preliminary checks of receiver operation.

## Flashing

You can isolate flashing by shorting the antenna terminals of the set, and noting whether the trouble diminishes or ceases. If the complaint indicates that wind affects the problem, it may be necessary to have someone shake the antenna or the lead-in to make the trouble appear.

In extreme cases, you may have to disconnect the lead-in from the receiver and twist the loose ends together. It may even be necessary to move the lead-in completely away from the set, since the noise signals from severe flashing can be induced into the set by a lead-in lying in close proximity to the receiver. Flashing can be caused by a variety of different things. The top end of one lead-in conductor might be broken loose and rubbing on the other lead (or making intermittent contact with some other part of the antenna). It is possible the line has an intermittent break; these usually occur near a standoff, at the rotator loop, or where the lead-in enters the building.

Flashing can also be caused by loosened or corroded mechanical connections on the antenna. Much attention should be given to the lead-in connections, even though they appear mechanically sound; corrosion between the metal surfaces can act as a partial insulator. To remove all suspicion, the connections should be loosened, thoroughly cleaned, and retightened.

## Ghosts

Ghosts can be caused by a multitude of conditions, and may be slightly difficult to interpret and remedy. However, there is one excellent way to determine whether the ghost is being caused by the set or by the antenna: If you can alter the ghost considerably by adjusting the fine tuning, the fault generally lies within the set; if the ghost isn't tunable, the problem is with the antenna or lead-in.

Excessive antenna wire behind a receiver is a common cause of ghosts—especially to UHF areas. Once in a while you see an installation where an abundance of lead-in was left over, so the customer has rolled this into a neat coil and placed it behind the receiver. Result —ghosts. The cure is obvious.

Another cause of ghosts is the standing-wave effect produced by an open or a mismatched antenna. This type of ghost is very stable; it cannot be tuned, nor does it vary any appreciable amount during viewing. This latter fact helps prove that the ghost is not a "normal" ghost caused by reflections from buildings, hills, and similar large objects.

The fixed ghost will generally be caused by a fault within the antenna system; the varying ghost can also be caused by the antenna system, but it can just as well be caused by poor antenna orientation or by circumstances which cannot be controlled. The solution to external ghost problems—those not caused by antenna faults—will vary with the particular problem. The main things to try are: reorienting the antenna, elevating it, or replacing it with a more directional type.

## Snow

Snow in a TV picture is usually the result of insufficient signal reaching the tuner. The lack of signal voltage can be caused by an open lead-in, by a faulty antenna, or simply by too much distance between the antenna and the TV transmitter.

If you suspect the antenna or lead-in, a fairly simple test can help you decide. Disconnect one side of the antenna lead at the receiver, and observe the picture. If the picture is clearer with only one lead connected, one side of the twin lead is open. It may be necessary to try both sides to determine which one is bad. If the picture is just as good without the antenna as with it, the lead-in or the antenna is definitely at fault.

A field-strength meter (FSM) can be used for determining whether sufficient signal is present at the receiver. The accuracy of the meter is unimportant, since the main point is the relative amount of signal needed by the set to produce a snow-free picture. You can "calibrate" your FSM by taking a series of readings with the FSM connected to your shop antenna, and comparing the reading with desired picture standards. Connect a TV receiver and the FSM to the same antenna, and provide some means of varying the signal (Fig. 2-1 shows a way). You will be able to determine the amounts of signal necessary for a slightly snowy picture and for a snow-free picture. With this information available, it will be easy to determine if the lead-in or the antenna is providing sufficient signal at a customer's home.

Another test instrument that comes in handy for checking antennas and lead-ins is the ohmmeter section of your VOM. The lead-in connected to a folded-dipole antenna can be checked with a VOM simply by connecting the ohmmeter leads across the line. Make sure the line is disconnected from the receiver, so the antenna matching coils won't cause a false reading. There are certain limitations to this test method; for example, conicals and other antenna types having "open" elements will be impossible to check in this way. This problem can be remedied when the antenna is installed, by placing a 100K resistor across the terminals. You can then measure the resistance between the leads from the receiver end, and thus discover whether the lead is open, shorted, or okay. The resistor value is high enough to have little effect on the signal.

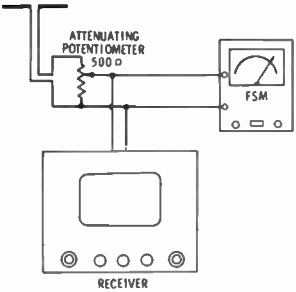



**Fig. 2-1. Arrangement for calibrating field-strength meter.**

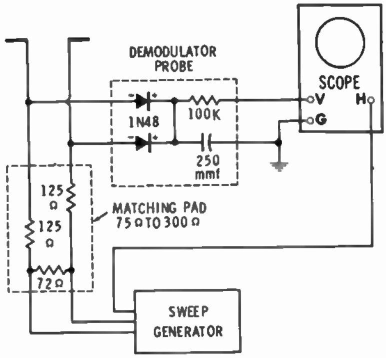


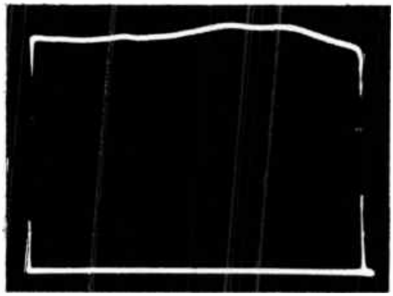

**Fig. 2-2. Test setup for checking antenna response curve.**

If an intermittent lead is suspected, connect the VOM across the leads and have someone shake or move the antenna and lead-in back and forth while you observe the meter. If the meter shows no continuity, an open lead is indicated; any reading considerably less than 100K indicates a short. Whenever the lead-in is strongly suspected of being defective, a safe bet is to replace the entire lead instead of wasting valuable time trying to pinpoint exactly where the fault might be.

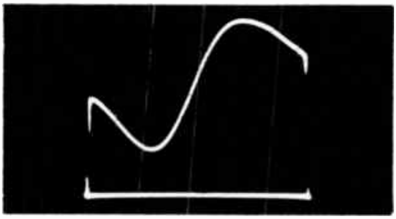
Probably the most accurate and thorough practical test of an antenna system can be made by the sweep-analysis method, using a sweep generator, a scope, and a balanced demodulator probe. The time and effort involved are greater than for the quick checks described above, but the results are far more conclusive, and many slight faults can be revealed that will show up in no other way.

The procedure consists essentially of checking the response of the entire system at television-channel frequencies. Fig. 2-2 shows the connections for the equipment. The sweep generator is connected to the antenna lead-in and set to sweep the frequency or band of frequencies the antenna should cover. (If your generator has limited sweep width, you can move the center-frequency dial through the TV band, noting the system response at all the various channel frequencies.) The balanced demodulator probe is connected to the lead-in as shown, and its output is applied to the vertical input terminals of the scope. The scope and generator are otherwise interconnected in the same way as for checking alignment response.

The key to these tests is to note any irregular response in the television band, especially sharp dips in the response curves. Fig. 2-3A shows normal response curves that may be seen on the scope during such tests, and Fig. 2-3B shows the effects of antenna-system faults. The antenna system should be perfectly tuned to a certain broad range of television frequencies, depending on the particular design of the an-



(A) Normal.



(B) Faulty.

**Fig. 2-3. Antenna response curves.**

tenna. If a lead-in is broken, or a rivet is corroded in an antenna joint, or a phasing bar is defective, the pattern will become very irregular—indicating the need for further checking of the system. As you see, this test can reveal faults that might otherwise not be found.

## LOCALIZING IF REGENERATION

Physicians dub some diseases "the great deceivers," because their bewildering variety of symptoms can be misinterpreted so easily as signs of other assorted illnesses. In TV service work, the condition called *IF regeneration* is similarly confusing; this trouble wears many false faces, and is likely to be diagnosed offhand as a fault in any one of several other circuits. (See Fig. 2-4 for several examples of picture distortion or interference caused by regeneration.)

Fortunately, there is one *quick test* which identifies IF regeneration 99 times out of 100. This test consists of simply applying the output from a pattern generator to the receiver input terminals, and watching the test-pattern reproduction as the RF signal is reduced from a high level (such as 100,000 microvolts) to a very low level. In case the picture distortion is being caused by IF regeneration, the distortion characteristic changes greatly. The most rapid changes occur as the input signal level approaches low values.

A rough approximation of this test may be made by checking reception of both strong and weak station signals, to see if the trouble is worse on the weakest channel. If no distant station signals are available, disconnect the antenna to provide the weak signal.

Occasionally—in perhaps one case out of a hundred—picture analysis will fail to detect the trouble. However, the regeneration can still be spotted by checking the frequency-response curve of the IF strip, using a conventional alignment setup. Just as the test pattern "does the twist" as the input signal level is changed, so does the frequency-response curve go through weird alterations in shape as the AGC-

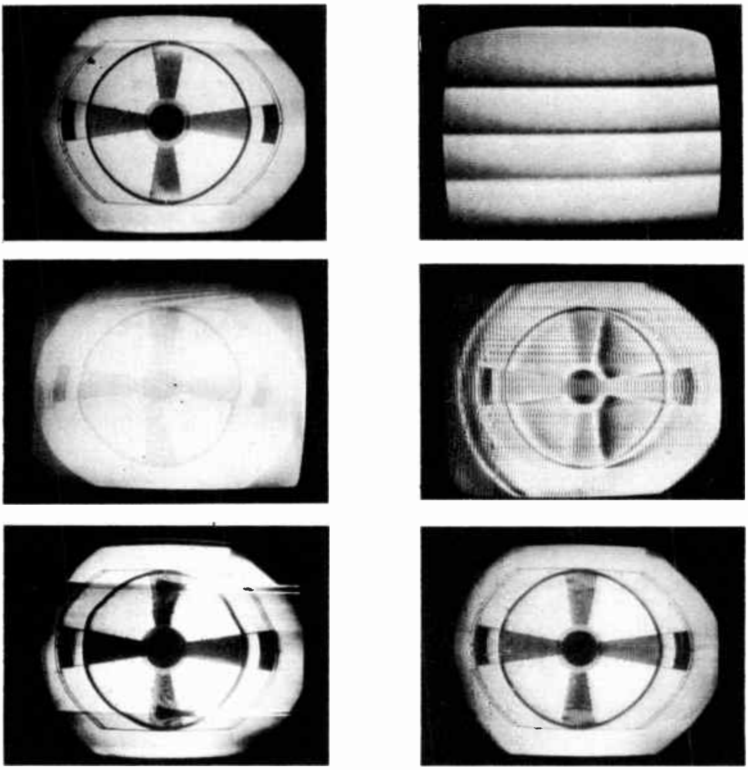
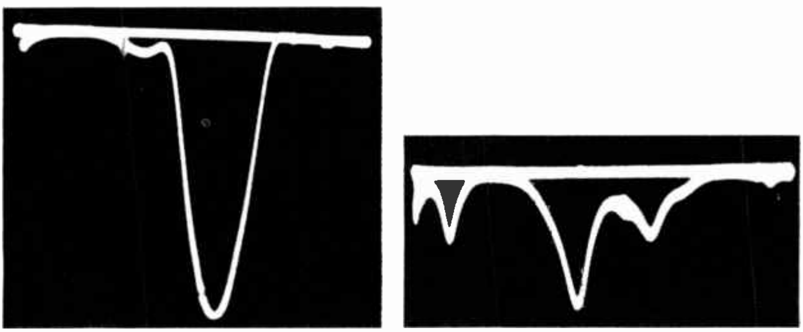


**Fig. 2-4. Six sample types of IF regeneration troubles.**

override bias is varied. Substantial changes in response curves *always* occur with bias variation when IF regeneration is present. Also, as a rule, the bandwidth of the IF amplifier is reduced, causing a narrow and peaked response (Fig. 2-5A). In some cases, the curve breaks up



(A) Narrow peaked response. (B) Jagged, erratic peaks.

**Fig. 2-5. Regenerative IF response curves.**

into erratic, jagged peaks like those in Fig. 2-5B. The decrease in bandwidth results in poor picture detail, often with separation of picture and sound. Peaked response may cause ringing, or "repeats" in the reproduced picture. The IF gain is abnormally high, and is concentrated at certain frequencies within the pass band.

As the gain of the IF strip is increased by reducing the AGC bias, the amount of positive feedback (another term for regeneration) increases. The feedback may take place over one IF stage, over more than one stage, or from an IF stage back to the mixer. When feedback passes a critical value, the IF amplifier starts to oscillate. This oscillation injects a spurious CW signal into the IF channel, which produces herringbone interference in the picture. At high levels of oscillation, the picture can disappear completely, leaving a naked screen. The response curve collapses, and only a large "marker" appears in the scope pattern—as shown in Fig. 2-6.

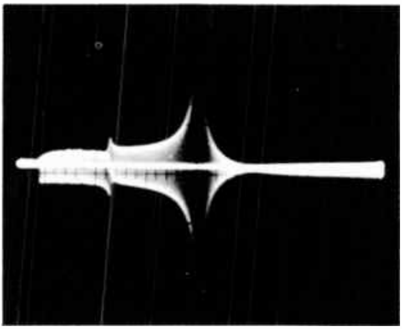


**Fig. 2-6. Response curve showing IF oscillation.**

What is the oscillating frequency? This depends upon the Q of the various tuned circuits within the regenerative feedback loop. In any system, oscillation takes place around the circuit with highest Q.

## Slight Regeneration Is Normal

Contrary to a popular notion among servicemen, a weak tube in a stagger-tuned IF strip will *not* necessarily cause a change in the shape of the response curve. Its only effect will be to reduce the gain uniformly across the entire pass band—*provided* there is no regeneration whatsoever in the IF strip. Here's the catch: few IF strips are completely free from regeneration. A 40-mc strip generally shows more residual regeneration than a 20-mc strip, and an economy-type receiver usually shows more regeneration at low signal levels than a deluxe receiver. The standard of comparison in this regard is the 20-mc stagger-tuned IF amplifier in RCA's old 630-TS chassis. If you still have one of these around the shop, you can familiarize yourself with the characteristics of an IF amplifier which is practically free from regeneration. Plug a weak tube into any of the IF stages; you will see the height of the response curve go down, while its shape remains the same. Or, advance the contrast control (which sets the IF bias) for maximum sensitivity—the height of the response curve will go up, again with no effect on its shape.

## Trouble Isolation

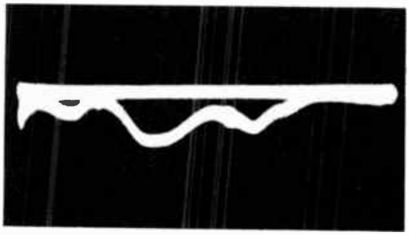
When regeneration rises above the residual level and becomes a nuisance, the first step in finding the source of trouble is to locate the abnormal feedback loop. An oscillating or highly regenerative stage can usually be pinpointed simply by touching your finger to the grid of each tube in turn, or even by bringing your hand close to each individual tube. Either method can swamp or detune the regenerative circuit, causing an unmistakable change in the picture. A VTVM connected across the video-detector load resistor will indicate from −10 to −30 volts when oscillation is present in the IF strip, but the DC reading will take a nose dive to 1 volt or less when you "kill" the oscillating stage.

You'll find some regenerative situations that fail to respond to this test. In such cases, try a touch-up alignment of the IF strip, carefully watching the response curve for abnormal reactions to the various slug adjustments. Be especially critical if the receiver has been previously serviced for the same complaint, or if you suspect a "diddler" has been at work; correcting a botched-up alignment may be the only repair needed.

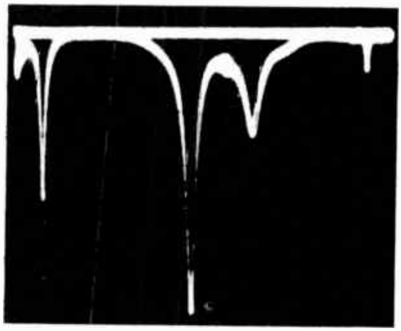
Any IF stage becomes regenerative (and may oscillate) in case the tuned circuits are misaligned with the plate and grid coils tuned to the same frequency, because the stage then forms a tuned-plate/tuned-grid system. In theory, the stage should remain stable (as in a radio receiver), but it does not. At 40 mc, it is practically impossible to obtain complete isolation of plate and grid circuits without utilizing elaborate circuitry. Hence, enough residual feedback is present to make the stage act as a TPTG oscillator.

When regeneration hinders your attempts to correct serious misalignment, IF stability can usually be improved by increasing the AGC clamp voltage. Use as much as 6 volts if necessary. In turn, a higher output will be required from the sweep generator to get a usable deflection on the scope screen. After making preliminary alignment adjustments, it may be possible to reduce the AGC clamp voltage to normal, without IF oscillation.

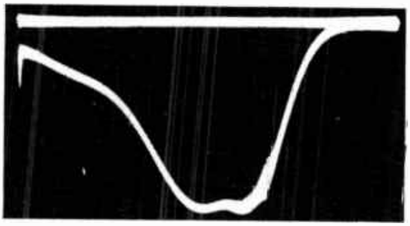
When you're analyzing regeneration by means of an alignment check, make sure you don't cover up trouble by deliberately misaligning one or more stages. The appearance of the curve can sometimes be partially "cleaned up" without actually curing the defect. For instance, the sharp peaks in Fig. 2-5A were rounded into the shape displayed in Fig. 2-7A—at considerable sacrifice in gain—by detuning the second IF interstage transformer. However, attempting to peak this transformer at its correct frequency of 45.5 mc (indicated by marker) resulted in the exaggerated peaks shown in Fig. 2-7B. The transformer turned out to be faulty. When it was replaced, the combined response of all stages from the second IF to the video detector was as indicated in Fig. 2-7C.



(A) One interstage coil detuned.



(B) Same coil peaked to resonance.



(C) Normal curve after repairs.

**Fig. 2-7. Modifications of the curve in Fig. 2-5B.**

Although IF coils and transformers sometimes go bad (as in the case just described), regeneration troubles are more likely to be caused by open decoupling or bypass capacitors. Therefore, bridging these components in the suspected stage is one of the first tests normally made, following the preliminary localization of the trouble.

Many other, less common conditions can be responsible for IF regeneration. Some of these clock-and-dagger villains merit an extended discussion, because the average technician doesn't fully understand how they do their dirty work. Since IF-regeneration troubles involve feedback of VHF signals, it's necessary to "read between the lines" of the schematic and consider all the stray circuit paths that might be present at high frequencies.

## Capacitor Complications

If a capacitor is at fault. but is not open, a baffling situation will surely arise. For instance, there are cases on record in which the mixer stage in a tuner is involved in a regenerative loop, and the feedback can be stopped only by replacing the supply-voltage bypass capacitors (such as C18 in Fig. 2-8). If these have insufficient capacitance, the mixer can break into oscillation, although all capacitors are "good." It's advisable to use replacements with values twice as large as originally employed, to insure adequate capacitance even if the replacement should be at the low end of the value-tolerance range.

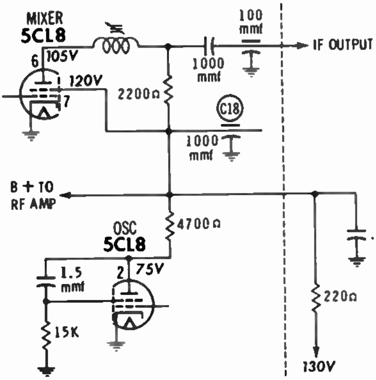



**Fig. 2-8. Bypass capacitors can cause troubles.**

This type of trouble was especially prevalent in one production run of chassis using feedthrough-type bypass capacitors in the front end. Most of the chassis performed satisfactorily; however, a few in which "everything checked okay" had to be sent back to the factory with the complaint of oscillation on weak signals. The blame was pinned on insufficient total capacitance, due to "stacking up" of tolerances in individual feedthrough units. The problem was cured with a redesign order for larger capacitance values.

Another baffling capacitor trouble was brought to light by a complaint that the picture on a certain receiver disappeared whenever a station was tuned in by rotating the channel selector counterclockwise. Rotation in the other direction produced completely normal operation. Acting purely on a hunch, we bridged a capacitor across the RF branch of the AGC line, and the trouble disappeared. This was just another instance of cumulative tolerance effects, complicated by switching transients. An investigation of the AGC system showed that it was a bit "hot" with IF and RF voltages, which formed a standing-wave pattern along the lead. The expedient solution (it could not be called a design cure) required that the added capacitor be connected at a suitable point along the AGC line.

## Proper Grounding

When a capacitor or other component is replaced in a 40-mc IF amplifier, be sure to observe the original grounding point and lead length. Otherwise, the "low end" of a bypass capacitor, coil, or bias resistor may not be completely grounded for RF, although the ground connection is mechanically solid, and effective at low frequencies. Circulating RF ground currents or excessive lead inductance can then cause the stage to become objectionably regenerative at low bias levels.

Mixer grounding can be improved in some cases by connecting copper braid (which has a large surface area) between the tuner chassis and the main chassis. Supplementary service notes for a receiver sometimes specify this redesign measure, aimed at establishing an IF ground plane throughout the system insofar as possible.

## Oscillator Precautions

Should the local-oscillator tube be disabled during IF alignment procedures? The answer may be either yes or no, depending upon the sweep and marker generators you are using. If both instruments have pure fundamental outputs, there is no necessity for killing the local oscillator—it will not introduce crossbeats that distort the curve shape and/or generate spurious markers. On the other hand, if the generators have substantial harmonic or feedthrough frequencies in their outputs along with the desired test signals, it is often essential to disable the local oscillator.

There is at least a small advantage in letting the local oscillator operate, if possible. When it is killed, the plate resistance of the mixer becomes much lower; in turn, the source impedance of the IF amplifier is made lower than normal. This change occasionally causes a slight distortion of the IF response curve. However, if problems due to crossbeats arise, the lesser of the two evils is simply to disable the local oscillator.

## Mixer TPTG Regeneration

The mixer plate operates at IF, while the mixer grid operates at RF; nevertheless, residual feedback in the mixer stage can cause regeneration. Since the grid tuning changes as the channel-selector switch is rotated, the regeneration fluctuates from channel to channel. This effect shows up easily in visual IF alignment as a change in the shape of the IF curve.

While it may not be practical to obtain complete mixer stability, the point is that the IF curve should remain acceptable on all positions of the channel-selector switch. In case it does not, you must investigate the mixer stage for a defect which is causing excessive feedback. Bypass capacitors are the prime suspects. Once the regeneration has been reduced to a suitably low level, make compromise IF alignment adjustments to obtain the best average curve on all positions of the channel selector.

## Video-Detector Troubles

Self-interference effects in a TV receiver, such as those seen in Fig. 2-4, may be due to detector radiation rather than to marginal IF oscillation. The detector is a nonlinear circuit, so in addition to generating the difference frequencies between the picture carrier and the video sidebands, it generates sum frequencies. These are prevented from entering the video amplifier by means of a low-pass filter (C20, L6, and following circuitry in Fig. 2-9), but they can still escape via radiation and feed back into IF leads. Receiver manufacturers usually enclose the detector circuitry in a shield to prevent this problem. In the event someone has removed the shielding and discarded it, regeneration can shape up as a most perplexing problem.

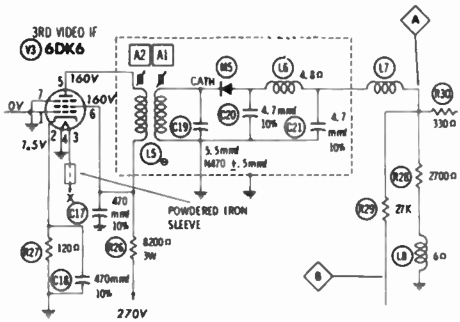



**Fig. 2-9. Shielded video-detector circuit.**

Sometimes an IF can is utilized as a detector shield; in other chassis, a U-shaped structure is fitted over the detector circuitry. Still other chassis utilize a simple baffle plate between the detector and the IF section.

In analyzing regeneration problems, remember that the limiter and sound detector are also harmonic generators which can produce feedback interference. Of course, if some of the tube shields have been discarded, your problem is likely to be aggravated.

Regeneration problems are among the most difficult situations encountered in TV service; they surely separate the men from the boys! But, don't cuss the next regenerative chassis that finds its way to the bench—approach it confidently, because you have the know-how. Keep a cool head and calculating approach, and you will also have the can-do!

## TV ALIGNMENT WITH SIGNAL GENERATOR

Television alignment is neglected terribly. Partly, this is because it is deemed a difficult job, requiring special sweep alignment equipment. Too, many technicians shy away from alignment because they haven't been trained properly in the fine techniques of a good alignment job. Finally, alignment—and the training to accomplish it—is neglected because of the popular fable that TV sets seldom need alignment. Is this really true? Let's examine the question in detail.

No conscientious service technician would think of sending a table radio or a transistor portable out of his shop without "touching up" the alignment. And why not? . . . it's such a simple thing to do, takes little extra time, and keeps performance at its peak. And, after all, IF transformers and RF coils *do* age from year to year.

On the other hand, television alignment is ignored completely by many of those same technicians. Don't the coils in a TV set age? "But," they say, "the sets do show pictures, and the sound comes through loud enough on commercials!" So the difficulty of aligning a TV receiver tempts the technician to overlook the need for "touching up" the adjustments. Old-timers are fond of saying, "Leave well enough alone." However, this does not change the fact that the servicing job would be more complete if alignment were touched up, even though thorough sweep alignment jobs are left to those more technically skilled and properly equipped.

## Sweep Alignment vs Touchups

At this point, some will say that TV alignment is better left alone unless equipment is available for sweep alignment. And they are right, *if* the technician isn't trained in how to align a receiver properly. However, a technician armed with a knowledge of correct tuning action, and who knows how to attain this action, can perform a satisfactory touchup job in most TV receivers without sweep generator or scope. The procedure doesn't take very much time, and the result is a set that operates far better than one left to drift off alignment from year to year with no attention whatsoever. The instruments required are a signal generator and VTVM.

Don't take this to imply that sweep alignment is not important. It is. In fact, a thorough alignment job, with sweep generator, marker adder, scope, and accurate marker generator, cannot be equalled by the simple procedures we're going to outline here. Never overlook the advantages of performing any job with the best equipment available. However, don't let *badly needed* alignment go undone just because you don't have special equipment or because your sweep generator or scope happens to be temporarily out of order.

## Need for Alignment

How can you decide whether a set needs alignment? This is important, for you may be faced with the decision to align or not to align, and you'll want to be reasonably sure it's needed before you proceed. Of course, the easy way is to use your sweep equipment to look at the response curve; but we've ruled that out for this discussion, since your sweep generator or scope is out of order. . . . Therefore, we will have to depend on other clues.

First, consider set sensitivity. Most modern TV sets have considerable gain in the IF stages. When the set is off-channel (not receiving a sta-

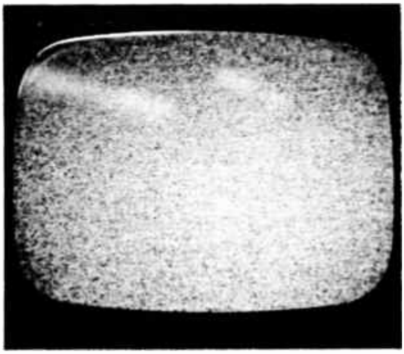


**Fig. 2-10. Snow when IF stages are at high gain.**

tion) the RF and IF stages run at maximum gain, and noise in the RF and mixer stages will appear on the screen as snow (see Fig. 2-10). If this snow is missing, especially on lowband channels, the set is suffering from poor gain. Make sure weak tubes are not causing the trouble; substitute for the RF, mixer, and IF tubes (you might check the video stage, too, just to be safe).

(A) IF gain high, RF gain low.

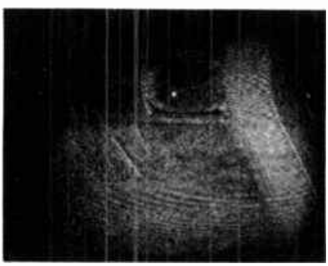
(B) IF gain diminished.

**Fig. 2-11. Difference in picture when lack of gain is in IF or RF stage.**

Next, check the set on weak stations. (If you have only locals, try padding the signal down to simulate a weak station.) A bit of experience with signals at your shop will tell you whether or not the set should show a good picture. A weak picture, through lots of snow (Fig. 2-11A), usually points to RF trouble; the same weak picture, but accompanied by very weak snow (Fig. 2-11B), usually denotes poor IF sensitivity. Since tubes are not the trouble, make sure the supply voltages are normal. Also check AGC voltage to make sure it's not cutting down the IF gain on *weak* signals (it's supposed to reduce gain only on strong signals).

Finally, set the channel selector to a fairly strong local station. The picture should be sharp and clear, with no ringing (tunable ghosts) and no smear. Try the fine tuning control. It should move the response of the set sharply from good sound with no picture (Fig. 2-12A) to a point of sharp picture with good sound (Fig. 2-12B). As you turn it farther, the sound should diminish slightly, and the picture may get fuzzy (Fig. 2-12C).

If you see ringing, and turning the fine tuning control causes the ghosts to shift radically across the screen, sometimes changing to smear as well, the set probably needs alignment. When there is smear caused by poor IF alignment, off-station snow will probably appear in streaks (Fig. 2-13) instead of as in Fig. 2-10. If the fine tuning control seems



(A) One end of control; sound is strong.

(B) Center of control; note clarity of picture.

(C) Other end of control; picture softened; sound weaker.

**Fig. 2-12. Testing alignment by observing the effect of fine-tuning control on the picture and sound.**

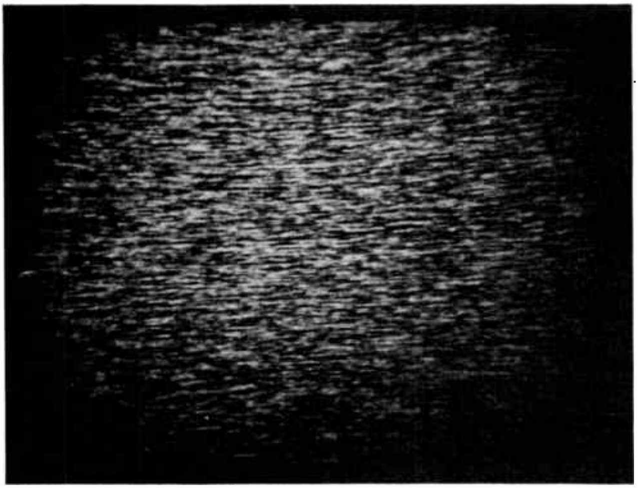


Fig. 2-13. Elongated snow caused by misaligned IF stages in the receiver.

too broad, and has very little effect on the picture, misaligned IF stages are probably the cause; this particular symptom is often accompanied by very weak snow on vacant channels.

Any or all of these symptoms can indicate the need for alignment. Remember that other troubles in the RF, oscillator, mixer, or IF stages can be responsible for symptoms such as these, but a rapid way to pinpoint such faults is to go through a quick alignment. If other types of trouble exist, they'll reveal themselves as soon as you start alignment of the set.

## Alignment Setup

Assuming that you suspect alignment, setting up is relatively easy. (This advantage makes troubleshooting by alignment rather attractive.) Let your signal generator warm up for a half-hour or so while you check tubes and clean out the chassis; don't let warmup drift confuse alignment procedures.

Most tuners provide a convenient test point that connects to the mixer grid; this is a good spot to connect the generator for IF alignment. Use a .001-mfd capacitor in series with the hot lead to prevent any possibility of grounding mixer bias through the generator output circuit. Set the generator output at zero, to start with.

Connect your VTVM to the video detector output, so it will measure the negative DC voltage developed by the signal. This will be your indicator during alignment. If you prefer, you can connect directly at the video crystal output, but it is often more convenient to connect to a point past the peaking coils; the crystal is sometimes in a can and hard to reach. Check the schematic to be sure you connect to a point that isn't blocked for DC by a coupling capacitor.

Next, use the alignment instructions with the service notes to identify the coils and determine the frequency to be used with each. Most instructions are for sweep alignment, but the information can be used just as well for signal-generator alignment, if you know what to look for. For *sweep* alignment, a marker generator shows various frequency points along the curve. Each marker frequency is affected most by only one or two adjustments in the IF strip; the instruction sheet always indicates which markers are affected by which adjustments or coils. This is your clue to which signal generator frequency you will use with each IF adjustment.

An easy way to keep track of the adjustments is to pencil the frequencies right on the schematic, with an arrow pointing to the proper coil or trimmer, and with a notation to tune for minimum or maximum. This labelling eliminates turning back and forth to the alignment instructions, schematic, and layout drawing (for locating adjustments). Anything that saves time makes this servicing procedure even more effective as a troubleshooting aid.

## Aligning the IF's

The alignment itself is simple and quick. Carefully set the generator to the frequency for the first adjustment in the IF strip, turn the output control wide open, and note the VTVM reading. Reduce the generator output until the reading drops to minimum; set the generator output for a reading slightly above this minimum and adjust the coil (or trimmer) for maximum reading. If the reading gets very high—as when alignment is 'way off—reduce the generator output and adjust again.

Proceed on through the remaining adjustments according to the foregoing instructions, changing the generator frequency and output settings to suit each adjustment. Remember: Set the generator frequency first; then find maximum and minimum VTVM readings and set the generator output for a reading between these extremes; lastly, adjust the slug for maximum indications.

The exceptions to this procedure are those trap adjustments marked to be tuned for "minimum." With most of these, you'll have to use maximum generator output to get a VTVM reading. Simply set the generator frequency to the specified frequency, turn the generator output wide open, and adjust the trap for minimum meter indication on the VTVM.

We said earlier that other troubles will often reveal themselves during IF alignment. This is true, and you should watch for symptoms. For example, a certain adjustment may fail to show a peak. This may indicate the coil is defective, a bypass capacitor associated with it is open, or perhaps the tube itself is poor (even though it tests okay). The point is, of course, to investigate the failure of any adjustment to peak or dip properly. Move each slug slightly in both directions to make sure tuning action is definite.

By using this troubleshooting method, which is popular among transmitter technicians, many troubles can be found that would be otherwise very difficult to track down. A broken slug in an IF coil, or a few shorted turns, can be especially hard to pinpoint in any other way. Even an open decoupling capacitor may slip past you unless you try tuning the coil whose "low end" it holds at RF ground.

Other faults can reveal themselves during IF alignment. A set that intermittently breaks into oscillation can often be cured by alignment. A faulty decoupling or screen bypass capacitor can be uncovered by the tendency of a stage to oscillate when it's peaked. Thus you can see—a quick alignment procedure may also be a quick troubleshooting procedure in the IF stages.

## The Sound Channels

Sound IF alignment is even simpler than video IF alignment. Even the most elaborate system usually consists of only one stage of 4.5-mc amplification before the detector. (We're considering only intercarrier sets, since split-sound sets are seldom seen anymore.) While you are adjusting the sound IF, you can also adjust the sound takeoff coil and the 4.5-mc traps that follow the video detector.

A good spot for connecting the generator is at the video detector output (where the VTVM was connected for video IF alignment). The best indicator is your VTVM, equipped with a demodulator probe. This combination can be connected across the output winding of the sound detector coil during most adjustments. However, you'll have to connect somewhere else when you align the detector coil itself.

Set the generator for 4.5 mc, without modulation, and the output control for enough signal to cause a reading on the VTVM. Adjust the takeoff coil and the IF coils for *maximum* indication on the meter.

Move the probe and VTVM to the cathode (or grid, if that is the driven element) of the CRT and increase generator output until again you get a meter reading. Tune the 4.5-mc traps in the video circuit for a *minimum* indication.

Final adjustment for sound depends on the detector circuit, but you can make a reasonably close approximation as follows: For a discriminator or ratio detector, tune the primary for maximum station sound (don't try using a generator with AM modulation); then tune the secondary for maximum *undistorted* sound. For a quadrature type demodulator, tune the grid coil for maximum; then adjust the quadrature coil for maximum undistorted sound. Always use a station signal for final sound adjustment, as an AM generator will generally mislead your ear. The AC portion of your VTVM can be used as an indicator across the speaker voice coil, but station sound isn't always steady enough to be very reliable. Your ear will be reasonably accurate; if in doubt, just tune for a reduction in volume in either direction, and then center the adjustment exactly between these two points.

## Finalizing IF Alignment

Sometimes, this generator-VTVM system of alignment results in a set that is *almost* aligned properly, but not quite. (Of course, this can happen with sweep alignment, too.) What do you do in these cases? Don't just drop it at that point, for there is a touchup technique that will let you develop exact performance. Here's how it works.

Tune to a strong local station and carefully check the action of the fine tuning control. Make sure the oscillator slug is set so that fine tuning range extends to a point just beyond the picture, with sound okay, as in Fig. 2-12A. As the fine tuning control is turned back toward a normal picture, the video should appear crisp, with highlights, as in Fig. 2-12B. Rotation just a little further should smooth out the video, with very little change in the sound level. If IF alignment is still slightly wrong, control action will *not* be as we've just described; rotation will cause ringing or smear in the video, or excessive loss of sound as the control is turned.

To remedy this, start with the first adjustment in the video IF, carefully noting its setting so you can return it to that point if necessary. Tune the adjustment slowly to either side, while "rocking" the fine tuning control back and forth through its range. If adjustment improves the fine tuning action, you are nearing the proper IF response. If no improvement results, return the first slug to its original position and try the next one.

Very seldom will it be necessary to tune more than one or two of the IF adjustments during this "rocking" procedure. If it appears that more slugs than two are wrong, your initial alignment is probably not correct, and you should go through the entire procedure once again. Once you're thoroughly familiar with the way a set *should* tune, you can check and finalize your alignment job down to a very fine degree.

## Wrapping It Up

Check each station the set is supposed to receive. Be sure the oscillator slug for each active channel is correctly adjusted. Always start with the highest channel (this is absolutely necessary for some sets, so make it a habit with all). Set the fine tuning control at midrange, and tune the oscillator slug for that channel until a crisp picture appears—as in Fig. 2-12B. Try the fine tuning control; it should cause the picture to look like Fig. 2-12A at one end, and should tune smoothly to a sharp picture about midway of its rotation. Set the control for the grainy highlights seen in Fig. 2-14, and leave it there for a reference point; don't move the fine tuning at all during any of the remaining oscillator adjustments.

Proceeding from the highest channel toward the lowest, use station signals to set the oscillator slug for each active channel to a point where

**Fig. 2-14. Grainy highlights which make a good reference point during oscillator adjustments.**

the picture looks just like Fig. 2-14. As you rotate the channel selector to the several stations, they should all appear the same at this setting of the fine tuner. Then, with fine tuning control near midrange, a clear picture—with good sound—should appear on every station without your having to touch the fine tuning control. This is the very best way to leave a set—so the owner has as little to do as possible to receive each station.

As was pointed out earlier, don't substitute this type of alignment for a thorough sweep alignment if a thorough sweep alignment is what a set needs. But, for those sets that need only touchup, or when a sweep generator and scope aren't handy, this system of alignment with a simple signal generator will get the job done in fine form. Try it a couple of times; you'll master the technique easily.

## VERTICAL CREEP

There's a stealthy rascal lying dormant in many television sets, just waiting for the opportune moment to start active trouble. When it does, it often appears and disappears with annoying irregularity, calculated to drive a conscientious serviceman to distraction. This inconsiderate troublemaker is a symptom called vertical "creep."

This symptom can be more accurately described as a gradual change in vertical linearity or height, or both. It wouldn't be so bad if this problem would simply come to stay, like an ordinary symptom; a competent technician could wade in confidently, locate the trouble, and fix it. But not so, with this villain. It usually appears only when the set has been on for awhile; or perhaps after it has been off for awhile; or only in the evening; or maybe once a week, just before a favorite show. There's just no telling when or where this aggravating malady will crop up.

Fortunately, however, there are ways to outwit even the most sneaky of television symptoms, and the vertical creep is no exception. Taming this particular demon requires a knowledge of two basic techniques: handling thermal intermittents, and analyzing vertical sweep circuits.

Most cases of vertical creep turn out to be some form of thermal intermittent—a defect that occurs with changing temperature, usually as the set becomes hotter and hotter during operation. The techniques for servicing intermittents pointed out in Section 1 of this book are extremely useful in tracking down vertical creep. Heating and/or cooling components artifically can help speed up the isolation process. But to attack the problem intelligently, and win the battle in the shortest possible time, you need also to know the most likely causes of these peculiar symptoms; and that comes from an analysis of vertical circuits.

## Localizing the Troubled Area

A little deduction will save the day. Consider the vertical deflection system as a whole: The main purpose of the oscillator or discharge stage is to develop a 60-cps sawtooth signal, while the output stage concerns itself mainly with amplifying that signal and shaping it into the trapezoidal waveform needed to operate the yoke. The yoke, in turn, sweeps the CRT beam in a linear manner from the top of the screen to the bottom. Faulty components in the oscillator stage generally affect frequency, while those in the output stage affect the amplitude (height) and shape (linearity) of the sweep waveform.

Take the circuit in Fig. 2-15, for example. You'll notice the controls and components that affect size and linearity are in the output stage.

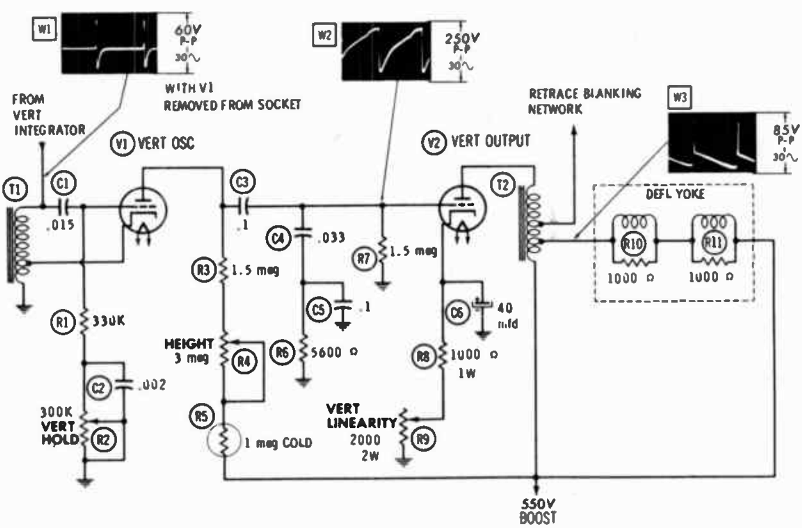



**Fig. 2-15. A typical vertical circuit.**

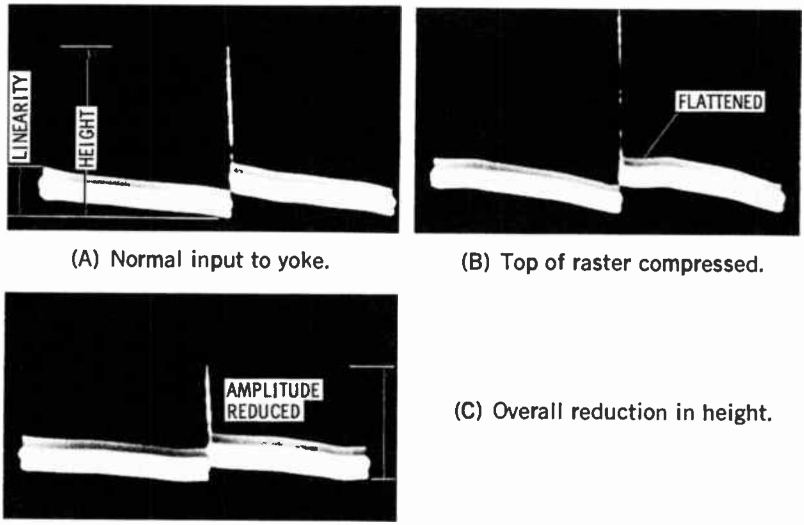
(The height control, although connected to determine the DC plate voltage for the oscillator, actually sets the amount of vertical drive signal applied to the grid of the output tube.) From all these facts, you can safely deduce that most linearity and height defects will center around the output stage.

Analyzing circuit operation can save hours of fruitless searching in the wrong spot for a defect. There are two ways to check circuit operation: with your scope (by far the more sure way) and with your VTVM or VOM. Once you know how different symptoms affect circuit operation, you'll have little difficulty pinpointing the exact cause.

## Scope Analysis

The scope is usually the best instrument to begin troubleshooting with, since it can show you exactly what is happening to the signal waveform; and, after all, that is the most important consideration in checking vertical creep. There is one very important fact to consider about vertical sweep troubles that affect size and shape of the waveform: *Linearity* problems are almost invariably the result of shifts in DC operating voltage; on the other hand, faults that change the *height* of the picture usually affect signal voltages only, with little change in output-stage supply voltages.

This is why your scope is so helpful in pinpointing the cause of vertical creep problems. If the trouble happens to be one that doesn't affect DC voltages, you may find it difficult to get a clue with just the VTVM. But creep troubles all affect the waveshape in one way or another. By testing the effects of the vertical linearity and height controls on the




(A) Normal input to yoke.

(B) Top of raster compressed.

(C) Overall reduction in height.

**Fig. 2-16. Effect of height and linearity changes on waveform.**

waveform displayed on your scope, you can learn to detect which circuit is actually being affected by the creep symptom.

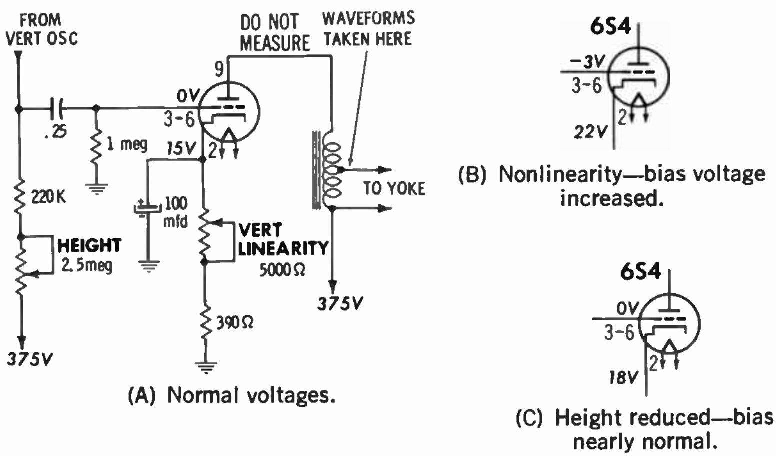
For example, take a close look at the waveforms shown in Fig. 2-16, taken at the output of the vertical transformer. Fig. 2-16A indicates the correlation between waveshape and the control functions: The height control affects the overall amplitude of the waveform, spike and all, while the linearity control has its primary effect on the sloping section of the trapezoidal waveform. Fig. 2-16B shows the same waveform after vertical creep has compressed the top of the picture; in Fig. 2-16C, the creep has affected only the height, so the entire waveform is lowered in amplitude.

## VTVM Analysis

Some technicians prefer to try troubleshooting first with their VTVM or VOM. This approach will probably solve well over half of your vertical creep cases—if measurements are properly interpreted. In the other cases, you'll need a scope, or you'll have to use the time-consuming hit-and-miss method.

There are also two fallacies in using a VTVM in circuits with such high transients as those found in the vertical output circuit: False DC readings are sometimes obtained through partial rectifying of high-amplitude signal voltages. And there's always the danger that a high-amplitude spike will exceed the input rating of the VTVM and damage the range multipliers. (This last danger exists with a scope, too, unless the input capacitor is one with a high breakdown rating.)

Fig. 2-17 shows a typical circuit marked with the voltages as they appear before vertical creep. (This is the same circuit in which the waveforms of Fig. 2-16 were taken, so you can correlate the symptoms



(A) Normal voltages.

(B) Nonlinearity—bias voltage increased.

(C) Height reduced—bias nearly normal.

**Fig. 2-17. Effect on DC voltages when vertical creep develops.**

seen on the scope with the voltage changes.) In Fig. 2-17B, vertical compression at the top of the screen has been caused by an increase in the bias developed across the cathode resistors, overbiasing the output tube. But in Fig. 2-17C, although creep has lowered the waveform amplitude to barely more than half its normal value, the cathode bias has shifted only slightly.

## Practical Solutions

Unfortunately, cases of vertical creep are seldom so well defined as those just given. More often, the shift is very slight. It is very common for creep symptoms to appear so gradually that the set owner doesn't even notice them until the fault becomes quite pronounced; if so, your job will be easier.

However, it is equally common for this culprit to become most noticeable a few days after you've cured some other complaint. The very nature of the brute—a slowly developing condition—tends to help it keep hidden while you service the set. If the set was on awhile when you made your service call, you probably made slight corrections with the controls and considered everything okay; but when the customer turned the set on the next day, he was unpleasantly surprised by having to wait an hour for the picture to assume full height or normal linearity.

If one of these "dogs" falls your way, don't waste time readjusting it and hoping for the best; pick it up and get it on your bench where you can monitor its actions. A customer who is unhappy at the idea of having the set gone for a few days will be even more unhappy (and so will you) if you have to come out to his house every few days to make adjustments. So get the set on your bench and do the job right to start with.

Besides the general techniques we've already described to help you corner the culprit, there are some short cuts that experienced technicians use to pinpoint certain common troubles and solve them quickly. Here are some typical faults with "easy" solutions.

## Top Stretched

This symptom is generally accompanied by a severe compression of lines at the bottom of the raster, making it appear as if a white line borders the picture. In many instances, foldover occurs along the bottom.

This fault is usually caused by a decrease in bias on the output tube. In normal operation, the output stage is biased so the drive signal never makes the grid more positive than the cathode. When bias is insufficient, two things happen: The early portion of the sweep (near the top of the picture tube) is over-amplified because of suddenly increased gain in the output tube. The later portion of the vertical sweep, however, doesn't fare so well; when the grid is driven positive, the tube saturates and can't amplify at all—with the result shown in Fig. 2-18.

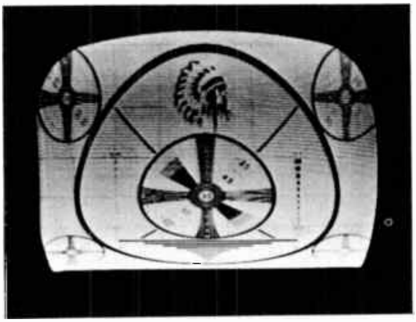


Fig. 2-18. Appearance of a common type of vertical creep.

The causes? There are two very common ones, each with its own peculiarities. The more common of the two will frequently cure itself *after* the set warms up for awhile. A special clue is that the effect is worse after the set has been idle for some time, like during vacation. The culprit in this case is nearly always the electrolytic cathode-bypass capacitor in the output stage. What happens is that the unit deforms during periods when no polarizing voltage is applied, then heals itself —at least temporarily—when the set is turned on again.

The same component can perform just the reverse, too. It can develop leakage after the set has been on for awhile, lowering the bias and causing the stretch and foldover mentioned. Whenever cathode voltage on the output tube changes drastically as the set warms up, suspect this troublesome capacitor first, and then, if the trouble is not corrected, check the cathode resistor.

The second cause for decreased bias—and this one is rather common, too—is leakage in the large tubular capacitor that couples the vertical drive signal from the oscillator to the grid of the output tube. Leakage here causes a positive shift of grid voltage. As pointed out before, this is not always easy to measure with a VTVM; furthermore, the more positive grid voltage may cause an increase in cathode current—thus masking any clue you might find by measuring bias between cathode and grid. When the "stretched top" symptom appears, and cathode voltage seems normal or slightly *high,* try disconnecting the grid end of the coupling capacitor and checking with your VTVM for a positive reading; you may even have to temporarily disable the oscillator to get a conclusive measurement.

## Bottom Stretched

This symptom is caused (as you may suspect) by exactly the opposite trouble from that just mentioned; with this symptom, you can almost always expect an increase in bias. "Bottom stretch" is often, but not always, accompanied by compression at the top of the raster, denoting that the tube is nearly cut off during the first part of its conduction cycle.

Fig. 2-17B pointed out one classic example of this fault, where the cathode resistor had increased in value. Of course, the control itself could become defective (and often does), changing value with heat. This is particularly common with certain printed-type controls.

In other types of circuits, the fault may be from some other source. If there's a grid-circuit linearity control to govern the negative voltage picked off from some fixed source, it's possible the resistor that grounds one end of the control is rising in value with heat.

However, if you run into the type of circuit that takes the negative linearity-control voltage from the hold-control circuit, don't worry too much about this network being a cause of linearity trouble; any fault will usually affect the vertical-oscillator frequency first.

## Shrinking

Lastly, there's that elusive fault that causes the raster to creep up from the bottom *and* down from the top, with little apparent change in linearity. And, lo and behold, the voltages and waveforms in the output stage look good. What now?

This trouble is less common than those mentioned earlier, but is equally important to understand, for there are several possible sources of trouble. In all cases of vertical creep, it is wise to start by replacing the vertical sweep tube (or tubes), which most technicians do anyway. But here's a symptom where it pays to try another output tube; some just don't have what it takes for certain circuits.

Next, check the supply voltages, especially in those cases where the vertical stages take power from the boost source; you might have a horizontal trouble contributing to your vertical problem. Check any decoupling resistors or capacitors for a possible shift in value. (The resistor will affect supply voltage, while an open capacitor will contribute degeneration and thus reduce signal amplitude.) If the set uses a pentode tube, be sure to check the screen-circuit components.

## It's as Easy as That

That covers the most likely faults, but not quite all the possibilities. There are still the transformer and yoke. We've saved them for last, because they are the least likely of any component to develop the peculiar symptoms associated with vertical creep. When coils go bad, they usually just go bad and that's it.

Generally speaking, you will have to check the yoke and output transformer by substitution; any defect that would cause creep would be next to impossible to measure with service-type instruments.

However, don't forget there are a couple of resistors in most yokes; these may shift value enough to case trouble. In modern 110° yokes, a thermistor is generally used to counteract any natural tendency of the vertical output system to "creep." Check it; be sure it is changing value with temperature as it is supposed to.

So you see, vertical creep is nothing to fear; it is merely something for which you should be constantly alert, because you may run into it at any time. And if you attack it with common sense and understanding, you'll join the ranks of technicians who no longer lose money to this sneaky offender.

## INTERMITTENT SWEEP TROUBLES

Have you ever wondered if there was an easy way to find intermittent trouble in sweep circuits? Every technician, at one time or another, has spent long hours trying to isolate a horizontal or vertical sweep intermittent, only to find that the cause of the trouble was so simple it should have been obvious from the start.

There is an excellent way to troubleshoot intermittent sweep with only three items: common sense, a high-quality VTVM, and a comprehensive schematic diagram with voltage and resistance measurements.

Common sense is very important. If you watch the behavior of the set—both before and after the intermittent symptom appears—and apply some common-sense reasoning, you should be able to at least localize the area of the trouble. Sad to say, this is an area of thinking the average serviceman often omits, because the temptation to dig into the set immediately is so strong he overlooks the basic groundwork.

### Thinking It Out

Most vertical and horizontal sweep troubles fall into a narrow range of categories. *Vertical* symptoms are usually: no deflection, poor linearity, insufficient height, or foldover. *Horizontal* faults reveal themselves as: insufficient width, no raster, foldover (including drive line), or trapezoidal (wedge) effect. Often, the *timing* of the intermittent is significant. It may require several minutes to occur, or it may happen every second or two (like a jitter). It may happen slowly, or appear suddenly. Before analyzing which components commonly contribute to these troubles, let's review briefly the operation of typical sweep sections.

### Vertical Sweep

In the familiar circuit of Fig. 2-19, both sections of V1 are included in a free-running multivibrator that is synchronized by positive sync pulses applied to the grid of V1A. Grid bias for this section is developed by the network consisting of C1, C11, R1, R11, and hold control R2. In normally operating circuits, the value of the bias voltage is usually in the range from approximately −30 to −50 volts. The output of V1A is shaped into a sawtooth waveform by C3, C4, C6, R5, and the height-control circuit. Height control R3, connected in series with plate-load resistor R4, varies the amplitude of the output at point B.

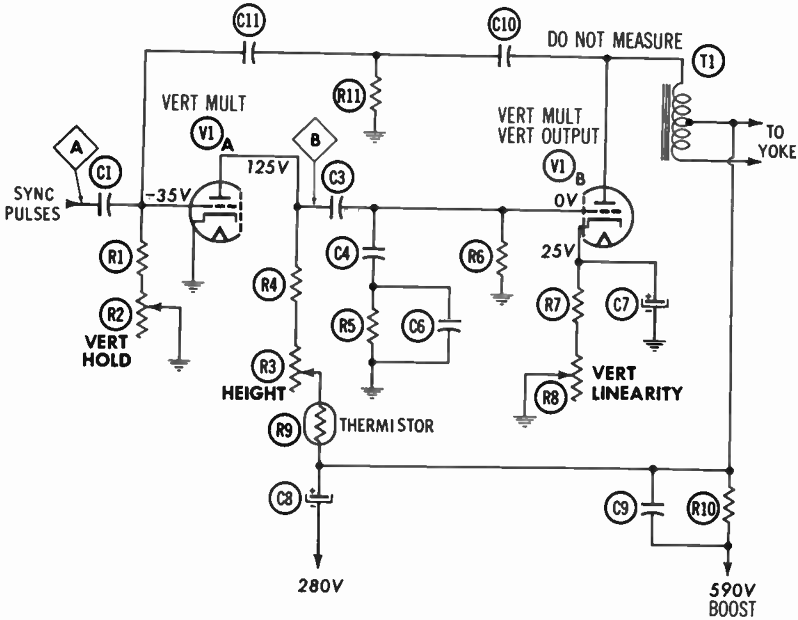



**Fig. 2-19. A typical vertical sweep circuit.**

Linearity control R8 is a variable cathode resistor that controls the bias of the output stage.

The amplified sawtooth at the plate of V1B is transformer-coupled to the vertical windings of the yoke. Transformer T1 is essentially an impedance-matching device between the yoke windings and the vertical output stage; mismatch caused by shorted windings in either T1 or the yoke can cause deflection problems.

## Horizontal Sweep

A typical horizontal sweep section is composed of an oscillator, output stage, damper, and high-voltage rectifier—as diagrammed in Fig. 2-20.

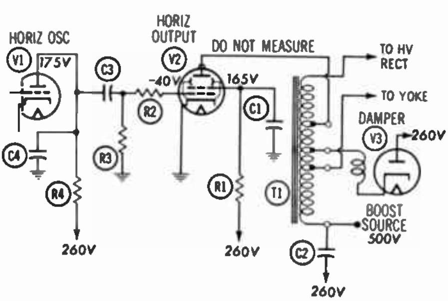



**Fig. 2-20. A typical horizontal sweep circuit.**

The horizontal oscillator develops the 15,750-cps signal which is shaped into a sawtooth and applied to the grid of V2. Considerable grid-leak bias is developed on V2, to prevent tube conduction during the first part of each sawtooth cycle and set the baseline for the drive signal. Insufficient bias can allow tube current to increase to the point where the plate glows red. If this happens, current through the flyback increases dangerously, and damage can easily follow.

Coupling capacitor C3, from the oscillator plate to the output grid, is a common troublemaker. Many horizontal sweep troubles start with this capacitor, and replacement is usually advisable merely on general principles.

Flyback transformer T1 develops high-amplitude pulses for the high-voltage rectifier. Damper V3 damps out secondary oscillations in the flyback and, in conjunction with C2, develops the boost voltage. C2 usually has a high breakdown rating, but also has a tendency to be intermittent. The symptoms caused by a defective C2 can appear as intermittent width reduction, linearity changes, or no raster at all.

In analyzing symptoms, don't overlook the flyback transformer; this is one component in which almost anything can happen. High-voltage corona, caused by high humidity or worn insulation on outer windings, can give intermittent symptoms ranging from Barkhausen oscillations to picture blooming. Also, shorted turns on the flyback windings can cause intermittent sweep, poor linearity, or blooming.

Most intermittents are caused by thermal breakdown of components or connections, undesirable value changes in parts that have become temperature-sensitive, or component breakdown brought on by voltage transients. Components in sweep circuits are more prone to change value than those in other circuits, because peak (transient) waveform amplitudes often considerably exceed average or effective values: this constantly changing stress (especially in the horizontal stages) places a terrific strain on the dielectric of capacitors and on the carbon structure of resistors.

## Voltage Transients

Voltage transients are most likely to damage components which are underrated, especially if they are filters or coupling capacitors. An example is filter capacitor C8 in Fig. 2-19, which is connected between the B+ line (280 volts) and the boost voltage (590 volts). Before the oscillator and output sections start operating, the voltage across the filter is greater than 300 volts; under some conditions, the applied voltage can even exceed 400 volts. Even though the 450-volt filter may seem properly rated, aging or deterioration of the electrolytic—considering the large pulse voltage it must bypass—may eventually result in a shorted, leaky, or intermittent filter. A defect of this type can lower the plate voltage of both tubes enough to cause poor linearity, intermittent vertical deflection, or no vertical deflection at all.

You might find the same thing in a horizontal sweep circuit; for example, screen bypass C1 or boost capacitor C2 in Fig. 2-20 might become leaky. In a case of narrowed width, both of these capacitors should be considered.

Troubleshooting for intermittents such as those just described is fairly simple. In some cases, you can listen closely as the intermittent occurs and hear a "crack" as the filter shorts and recharges. In others, a careful voltage check will be needed to isolate the defective component. The best method, although perhaps not the fastest, is to temporarily replace the suspected component and see if the condition is remedied. An effective way of checking components which are suspected of being temperature-sensitive is to hold a heat lamp or hot iron near the suspected components and watch the raster for possible changes, thereby pinpointing the defective part.

## Thermal Problems

Heat-induced conditions affect resistors primarily, although some capacitors can become quite temperature-sensitive. In one set, coupling capacitor C3 (Fig. 2-19) developed slight leakage as the set heated up. After a short while, the picture would come up from the bottom and shrink from the top. As the leakage increased, the vertical output grid became more positive, the drive decreased, and the picture shrank. A voltmeter connected to the vertical output grid showed the positive bias, indicating that the coupling capacitor needed replacement.

In most sets, however, it is usually a resistor that becomes temperature sensitive and causes intermittents. One prime example in many older sets (and in some newer ones) is the resistor between the vertical hold control and the vertical oscillator grid—R1 in Fig. 2-19. This particular resistor, as it ages, often becomes so sensitive to temperature changes that frequent adjustment of the vertical hold control is required as the set warms up. What happens is that the resistance of R1 increases with the set temperature, requiring less series resistance from the hold control. Usually, replacement of R1 clears up the problem; use a higher wattage rating, and if possible choose a location with better ventilation.

In many sets the height will decrease as the set warms up. The most common cause is series resistor R4 between the height control and the oscillator plate. It will increase in resistance, as the temperature rises; the increased resistance lowers the plate voltage, diminishing the drive-signal amplitude.

Some models compensate for normal temperature variations by using a thermistor in critical circuits. Due to the design of a thermistor, its resistance varies inversely with temperature changes. Its cold resistance might be 1 meg; as the temperature increases, the resistance may drop to 500K or lower, keeping the plate voltage of the oscillator more or less constant.

In horizontal sweep circuits, one resistor is likely to give the most trouble—the output screen resistor, R1 in Fig. 2-20. Check the value of this resistor both cold and hot; and check the voltage drop across it during both temperature extremes. Whenever space permits, always replace this resistor with one having a heavier wattage rating; this will save you many future callbacks.

Another unusually sensitive component in horizontal sweep circuits is the capacitor used with the oscillator frequency or waveform coil. Because of the unusual stresses mentioned earlier, this component is especially prone to trouble, and accounts for most oscillator-drift problems. When replacing this part, use a type that is not sensitive to temperature changes.

Width problems frequently develop from leakage in the coupling capacitor between the oscillator plate and the output grid. The easiest way to check this failure, which results in reduced horizontal drive and consequent overheating of the tube and flyback, is to disconnect the capacitor at the grid and check the free end for even a slight positive voltage. Also, with the capacitor reconnected, use your VTVM to make sure a heavy negative bias (at least −30 volts) is present. If the bias voltage is correct, look for an off-value screen resistor or leaky cathode-bypass capacitor (if used).

Troubleshooting for temperature-dependent intermittents is probably one of the more aggravating aspects of a bench technician's work. The most effective system is a careful check of all operating voltages in the suspected circuit both before and during the trouble. If you can't get readings before the set cuts out, try comparing each of the circuit voltages (while the trouble is occurring) against those shown on the schematic diagram.

Lastly, check especially the following clues:

1. Are any components obviously overheating or showing signs of previous damage?
2. Is the negative drive voltage at the oscillator grid high enough?
3. Will a hot iron held adjacent to suspected components cause any change in circuit measurements?
4. If a printed circuit board is involved, will probing the board with an insulated tool correct the condition or change any circuit measurement?
5. Is the intermittent more likely to occur with the chassis positioned in one way than in another? If so, has the printed board (or chassis wiring) been thoroughly checked for poor terminal connections?

One last word on troubleshooting and repairing intermittents—don't lose your temper! Cool, calm reasoning and observation will solve even the most exasperating troubles.

# WIDTH AND HORIZONTAL LINEARITY PROBLEMS

How many times have you replaced a tube in the horizontal stages, and opened up a Pandora's box of troubles and complaints? Or, worse yet, replaced the picture tube and found conditions that weren't visible before you replaced the tube?

Width and linearity problems can arise from a multitude of sources, to tax the ingenuity of many a competent serviceman. Replacement of a high voltage rectifier may have increased the high voltage, thereby reducing the width; a new picture tube, operating at normal brightness settings, could have introduced a slight width reduction, if the higher settings used with the weak CRT had caused enough blooming to fill the screen. These are only a few examples of the many peculiarities that may result in "sudden" horizontal sweep trouble when servicing troubles in another section of the receiver.

## The Basics

At this point it would be well to discuss the design of width and linearity circuits and the philosophy of their troubles. Increasing the waveform amplitude across the horizontal windings of the yoke will increase the width. Greater high voltage speeds up the CRT electron beam, in effect "stiffening" it, thus narrowing the raster. Therefore, width will be affected by a fault of either sweep amplitude or high voltage.

Carry the analysis a bit deeper, and we find that sweep amplitude can be reduced by altering DC voltages in the horizontal stages, or by somehow changing the signal waveform itself. Control of width is handled in either way, as we'll soon see.

Linearity is a bit more complicated. It is achieved by insuring that sweep voltage fed to the yoke is a smooth, linear sawtooth. Linearity control starts at the horizontal oscillator, but the greatest influence is usually exerted by a special linearity network associated with the output stage, damper, or yoke.

Width problems are most aggravating when just a wee amount of width is lacking. A serious lack of width can usually be traced quickly to a truly defective component, but the real braintwister is to find some way to increase width when only slight fringes show. A slight lack of width may be due to a loss of Q in the width coil, the horizontal output transformer, or the yoke. Time, dust, grease, moisture, and the repeated heating and cooling of these inductances can reduce their efficiency. In some width-control networks, capacitors and resistors may change value slightly. Individual units may not change enough to warrant replacement on their own, but the accumulative effect of small changes in several components may be enough to impair circuit effiiciency.

## Outside Troubles

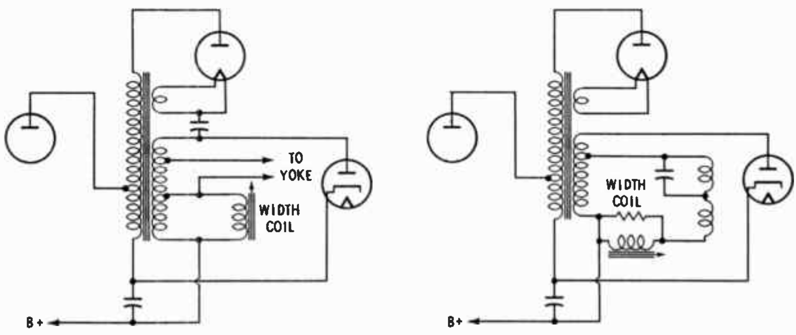
The place to start servicing for a width problem is at the AC input. Line voltage can affect width. A few volts lost in the plug, line cord, or interlock might be enough to decrease the width materially in an already borderline sweep circuit. A small line voltage reduction could represent several volts of B+ or quite a large reduction in boost voltage.

If the AC input to the power supply is normal, yet B+ is low, replace the low voltage rectifier tubes and watch for an increase in B+. If semiconductor rectifiers are used in a doubler circuit, the B+ should read 250 volts DC or better; single rectifiers develop about 130 volts DC.

Early in the service procedure, the horizontal tubes should be changed. Special consideration must be used when exchanging the horizontal output tube: If the new tube *reduces* the width, it may not have the proper characteristics for the circuit, or it may have boosted high voltage enough to decrease the width. Check the high voltage under both conditions; if necessary, try several tubes.

## Width Circuit

The next thing to check is the circuit containing the width control. Some width controls—usually coils—are "losser" devices; greatest possible width is achieved when their effect is removed from the circuit entirely. Fig. 2-21 shows two circuits of this type.




(A) Shunt type. (B) Series type.

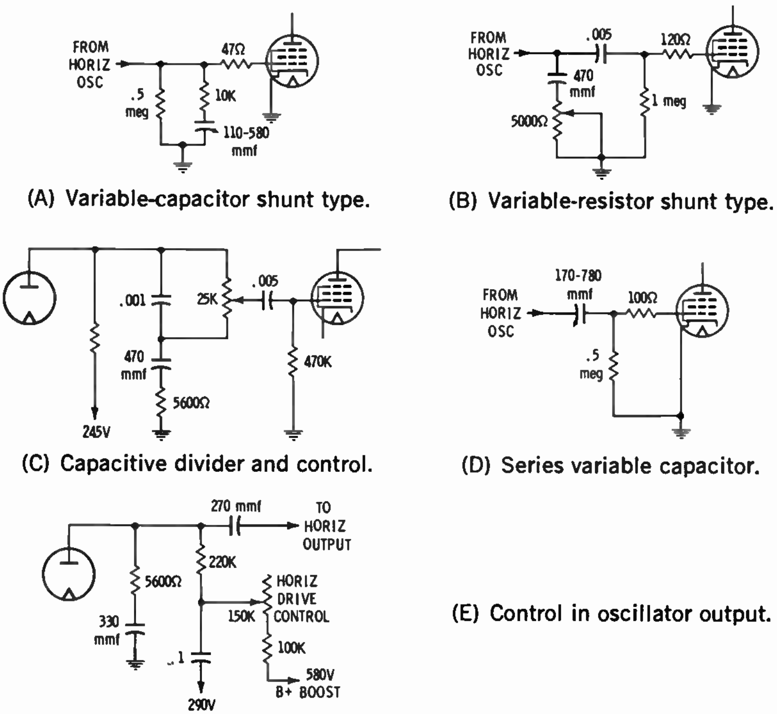
**Fig. 2-21. Two methods of using inductances to control width.**

In Fig. 2-21A, the coil absorbs flyback energy that would otherwise be developed across the horizontal windings of the yoke; this absorption decreases the sweep waveform amplitude. In Fig. 2-21B, sweep amplitude is reduced by increasing the series impedance (inductance and resistance).

The simplest check for trouble in "losser" circuits is to remove the controls from the circuits. For Fig. 2-21A, disconnect one side of the coil; for Fig. 2-21B, simply short it out. Either way, maximum possible width will be determined. If there still isn't enough to fill the raster, other trouble is certain. If too much width is gained with the controls removed, reconnect them and reduce their effectiveness by shunting them with small values of capacitance ranging from .0001 to .005 mfd (1600-volt ratings are best). For the circuit in Fig. 2-21B, a lesser value of shunt resistance will accomplish the same purpose.

Some words of caution: In many sets, the width coil may also be used as part of the AGC arrangement; care must be exercised not to disturb the AGC connections. Another point to check when width changes are made is the cathode current of the horizontal output tube; be sure the maximum rating is not exceeded (the tube manual or circuit diagram will give you a clue to normal ratings).

Fig. 2-22 shows some older circuits in which width is controlled by various systems of horizontal drive adjustment. The idea in all of these is to regulate the amount of signal fed from the horizontal oscillator or multivibrator to the output tube.




(A) Variable-capacitor shunt type.

(B) Variable-resistor shunt type.

(C) Capacitive divider and control.

(D) Series variable capacitor.

(E) Control in oscillator output.

**Fig. 2-22. Drive-control arrangements.**

Fig. 2-22A shows the shunt or bypass method of controlling drive. As capacitance is increased, more signal voltage is shunted to ground; thus less of the waveform reaches the grid of the output tube, reducing drive. The circuit in Fig. 2-22B is similar, except that adjusting a resistance in series with the capacitor accomplishes the same result; waveshape is affected, but the basic effect is a reduction of drive. In Fig. 2-22C, this control over drive is obtained by using a potentiometer and a capacitive divider network. In Fig. 2-22D, the value of the coupling capacitance is varied.

Fig. 2-22E is considerably different, although the end result is the same. The amplitude of the drive signal is made greater by increasing the DC voltage fed to the plate of the horizontal oscillator. The consequence is greater signal voltage fed to the output stage, and more width.

Fig. 2-23 elaborates some of the circuits using inductance to control width. In Fig. 2-23A, the horizontal deflection coils and a width coil are connected by a switch to various taps on the output transformer. As the switch is turned, the sweep voltage applied to the yoke is varied. The relative effectiveness of the width coil is also controlled by the same switch, working with a tap on the inductance. In one position of the switch, the width control is removed from the circuit entirely.

Fig. 2-23B shows another method. Here, an inductance may be connected or disconnected, or a capacitance shunted across the flyback, to alter the width. We've discussed how the coil reduces width. The capacitance increases width by raising the Q of the horizontal output load, thus increasing the waveform amplitude.

Fig. 2-23C shows another way to solve the width problem. Instead of a coil, a 250-ohm potentiometer is used in series with the deflection coils.

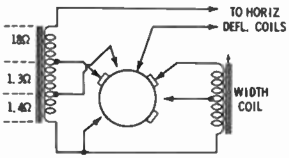
In one 24″ set, a standard 21″ flyback is used; however. a .22-mfd capacitor shunts the 33-ohm resistor that ties the flyback windings together at the "cold" end. Additional energy is developed by shunting the horizontal deflection coils with a 47-mmf capacitor. Fig. 2-23D shows this system.

A simple method for controlling width is shown in Fig. 2-23E; the screen grid voltage of the output tube is varied with a rheostat, thereby controlling output to the flyback transformer.

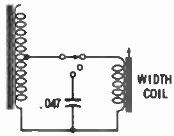
## Linearity

Linearity problems are not so easily attacked. For one thing, it is difficult to check variations in linearity without using some form of linearity pattern. Linearity is controlled most effectively with a coil in the damper circuit, or with RC networks in the yoke circuit. However, component values which control waveshape in the horizontal output and oscillator stages are frequently involved. In extreme cases, particularly when the width coil must be disconnected to achieve necessary width, nonlinearity may occur only on the right side of the screen.

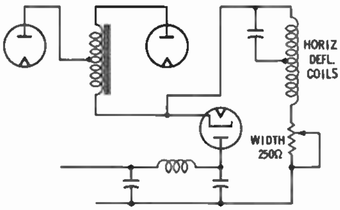
Taping small magnets to the bell of the picture tube will help stretch the picture, the degree of stretch depending on the placement of the magnets.



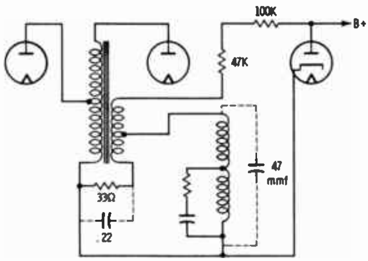

(A) Switch activated system.



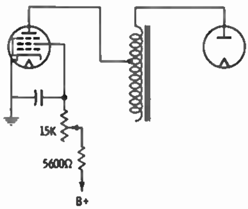

(B) Inductive or capacitive control.




(C) Series resistive control.




(D) Two ways of increasing width.

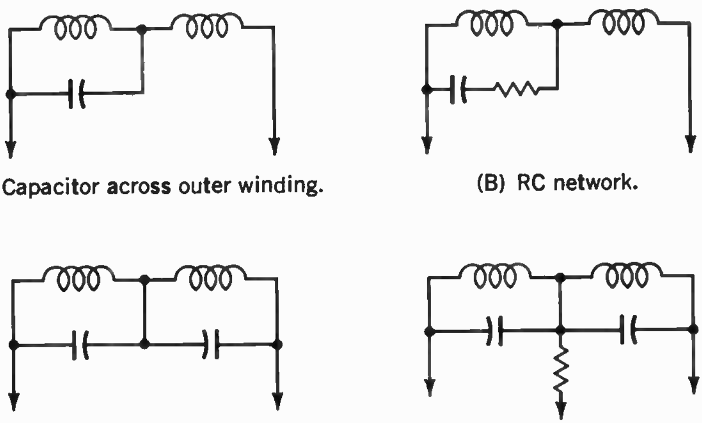



(E) Screen-control method.

**Fig. 2-23. Some unusual approaches to width control.**

Fig. 2-24 shows some yoke configurations. Resistors and capacitors equalize the Q and balance the distributed capacitance of the yoke segments. Aging yokes and flyback transformers may develop ringing and crosstalk, which may in turn necessitate changing the values of shunt capacitance and resistance. A handy device for determining the best values is shown in Fig. 2-25. It consists of two variable tuning capacitors and a 5-watt, 2500-ohm potentiometer. The unit is connected the same as the original network, and the values juggled for best linearity and minimum ringing. Equivalent fixed values are then substituted.

In some yokes, a wire is connected to a center tap on the horizontal windings, wrapped around the vertical yoke leads, and the end taped. This wire is a form of shield; attaching additional wire, extending its



(A) Capacitor across outer winding.

(B) RC network.

(C) Balancing capacitors.

(D) Isolating resistor.

**Fig. 2-24. Compensating yoke windings for difference in Q and capacitance.**

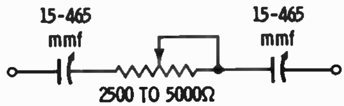



**Fig. 2-25. Device for ascertaining best values of needed components.**

length, or wrapping it more tightly around the vertical wires will sometimes increase its effectiveness in curing ringing and crosstalk.

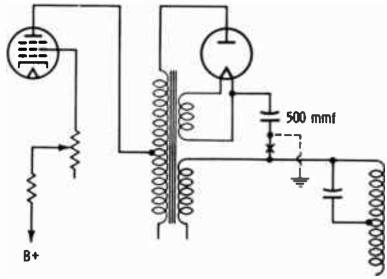
Another component that frequently changes value with age is the resistor at the yoke center tap. You can check for best linearity and width by substituting a 5-watt control. Be careful in handling it (as well as the previous device) since the voltages are high enough to shake you up considerably. When the correct value is found, wire the proper value of 5-watt resistor in place of the control.

## Servicing Tips

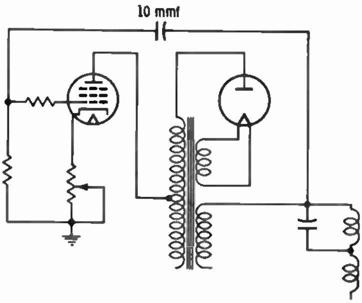
In the study of width and linearity control system design, ways can be discovered to cure service problems quickly. Fig. 2-26 shows some typical examples of short cuts to width and linearity servicing.

In Fig. 2-26A is shown how output waveform amplitude may be optimized by inserting a control in series with the screen grid and varying it for maximum performance. (Be sure the current rating of the tube is not exceeded.) Also, the 500-mmf high voltage filter capacitor may be returned to ground instead of to the high side of the yoke; this increases width. Conversely, to reduce width, a filter that returns to ground can be changed to the connection shown.

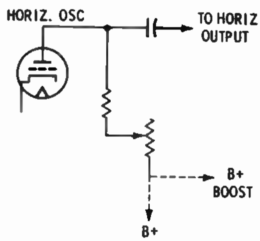
Fig. 2-26B shows a method of feedback that can increase both high voltage and sweep. Be sure the capacitor has at least a 3-kv rating, and



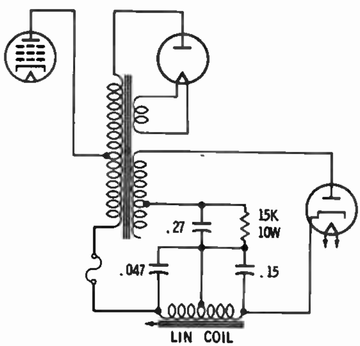

(A) Screen-grid control.



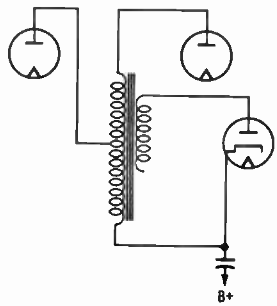

(B) Adding positive feedback.




(C) Changing oscillator B+.




(D) Pi-type linearity system.




(E) No linearity control.

**Fig. 2-26. Five ways width can be altered in existing circuits.**

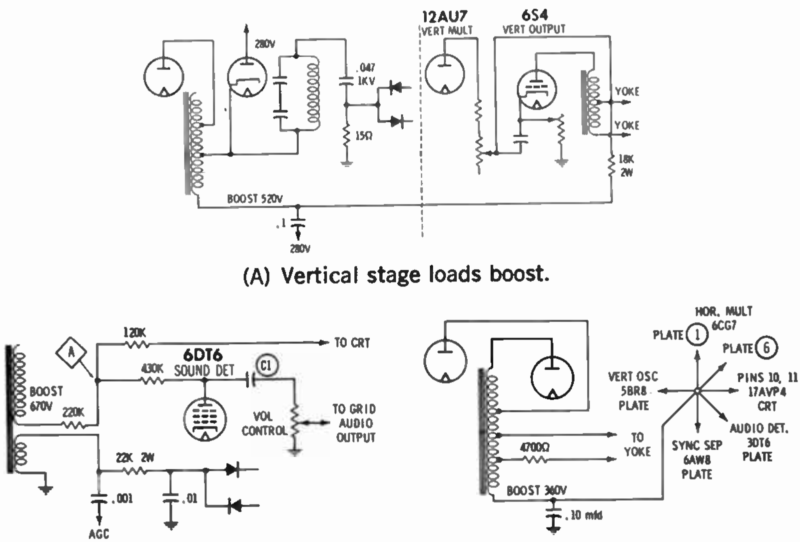
stick to very low values—15 mmf or less. Also shown is a method for increasing output by reducing the value of the cathode resistance—unless the cathode is grounded. (Again, tube rating must be considered carefully.)

In Fig. 2-26C, additional drive is achieved by returning the horizontal oscillator plate resistor to boost instead of to B+. Be sure the change doesn't affect oscillator stability or waveform shape.

Fig. 2-26D shows a typical pi-network linearity circuit, working with the damper tube. The input capacitor has its greatest influence on the boost voltage, while the output filter capacitor is mainly responsible for linearity. A similar circuit is displayed in Fig. 2-26E, but without the linearity network. The damper cathode filter is expected to establish the boost voltage and maintain linearity, so its value may be somewhat critical.

## Case Histories

In a few cases, the reason for lack of width will be found rather remote from the horizontal network. Fig. 2-27 shows three such instances; the troubles in these circuits fooled one very competent technician for quite a while. Studying them will give you an insight into how external circuits can affect the horizontal linearity and width, if the circumstances happen to be just right.




(A) Vertical stage loads boost.

(B) Volume control loads boost.

(C) Many circuits load boost.

**Fig. 2-27. Three case histories of trouble.**

A trouble in an Admiral looked as if it might be caused by a power-supply defect, since the entire raster was shrunken. Examination of the schematic revealed the circuit arrangement shown in Fig. 2-27A; the vertical circuit takes power from the boost circuit. It developed under testing that leakage in the vertical output transformer was loading the boost, causing raster shrinkage and poor focus.

Another Admiral came into the shop with its volume control acting more like a brightness control; that is, varying the volume always changed the brightness of the raster. The trouble was found by examining the circuit design, a simplified version of which is shown in Fig. 2-27B. Boost voltage powers both the sound detector and the accelerator grid of the CRT. Coupling capacitor C1 had developed considerable leakage. As the volume control was varied, the load on the boost line was changed, and the voltage at point A was altered. This voltage change was transferred to the CRT, causing a change in brightness.

In a Magnavox that was brought into the shop with boost quite low, the possibilities for overload were checked. Fig. 2-27C shows that there were six different possibilities for overload, because there were that many circuits being powered from the boost line: vertical oscillator, audio detector, sync separator, picture tube focus and accelerator anodes, and both sections of the horizontal oscillator tube. Disconnecting the first four was easy enough, but removing connections to the horizontal oscillator didn't prove anything, since without the oscillator the boost couldn't function anyway. The fault was finally isolated by furnishing B+ for the horizontal oscillator from an external supply, thus relieving the boost line of its entire load. As it turned out, the trouble was only a faulty boost capacitor, and overload was not the problem after all.

## Common Faults

There are certain types of trouble common to width and linearity circuits. The screen grid of the output tube can be a prime source of trouble. The resistance value is very important, and any change will seriously affect width, brightness, and linearity. Width controls in this circuit are particularly prone to failure. Coupling capacitors that are leaky will usually cause trouble to the right side of the picture, as will drive capacitors that become shorted.

Filter capacitors on B+ lines feeding the horizontal stages can create hum defects, picture bending, poor horizontal linearity, loss of width, or almost any type of horizontal trouble. Substitution is about the only such check, since bridging electrolytic filters will not always give a conclusive indication.

Another source of difficulty to watch for is the pulse resistor or capacitor feeding the AGC or AFC. Resistors will sometimes arc internally under load, causing intermittent width loss as well as wrinkles on the left side of the raster. Capacitors may break down under stress and load the output transformer heavily.

Any capacitor on the "high" side of the output transformer will eventually fall under suspicion. The very high pulse voltages present may cause breakdowns that will not show up in conventional tests; in these cases, substitution seems the only sure answer.

A few really unusual circuit arrangements might fool the technician who is unaware of them. For example, one set uses a foil patch on the neck of the CRT to achieve proper linearity; when the tube is changed for any reason, the patch must be transferred to the new one. In another set, a .1-mfd capacitor connects to ground from the linearity coil; removing the capacitor and shunting the coil with an 18K resistor is a common cure for drive lines that may occur in this set.

### Recent Changes

The TV sets of recent years are a new breed. The wider deflection angle has introduced problems in width and linearity that are far different from those in older models. New techniques have been incorporated in the design of width and linearity networks and components.

A check of 69 typical recent models reveals the following systems: 17 used a width coil, 8 did it with potentiometers, 13 had yoke sleeves, 2 employed width jumpers, and 29 had no device at all for controlling width.

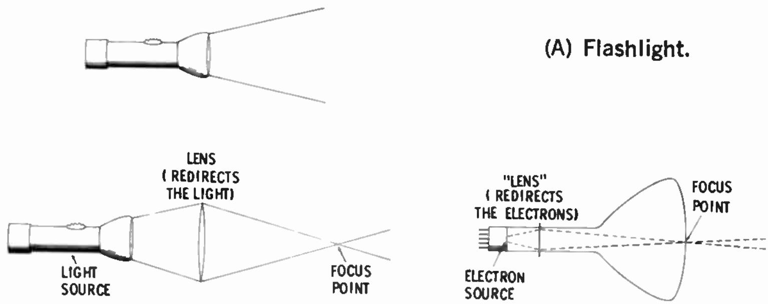
The trend is unmistakable. For the technician, this means width loss will more often be due to aging components. Linearity will depend even more on accurate component values. Keep abreast of the circuit designs each year, and you'll find the servicing suggestions for the older sets can be applied to the new.

## FOCUS TROUBLES

Some years ago, focusing of most black and white picture tubes was done magnetically, either with a bulky, electrically driven coil or with heavy magnets mounted on the CRT neck. Now CRT's are all focused electrostatically, with voltages—usually 700 volts or less—applied to an internal focus element. Considering this simplification, it might seem that focus problems would simply boil down to whether or not the proper voltage is present at the focus anode of the picture tube. Actually, focus problems can still be quite complex, depending on conditions.

### What Is Focus?

Focus, whether of light or of an electron beam, is simply a matter of directing the points of light or the electrons so they converge at a specified point and concentrate their force in one place. This is shown graphically in Fig. 2-28, using a flashlight as an example. The rays of light from the flashlight will *normally* continue in their original direction (as in Fig. 2-28A), and the light will never be concentrated at one point. However, if we insert a lens (as in Fig. 2-28B), we can redirect these light rays along different paths that will intersect at a point called the *focus point*. Thus, we have concentrated the light into




(A) Flashlight.

(B) Lens added.

(C) Electron beam.

**Fig. 2-28. Comparison between focusing a flashlight beam and the electron beam of a TV picture tube.**

a beam, which will be extremely small and highly concentrated at the focus point. At this point, therefore, we have the condition we call "in focus."

The electron beam in a TV picture tube is formed in much the same manner. (The focus point is on the phosphor face—as in Fig. 2-28C.) But, in focusing electron beams, other factors than position or dimensions of the "lens" are involved. In fact, the many electrical factors that affect electron-beam focusing explain why the problem of locating focus troubles involves more than merely checking the focus voltage.

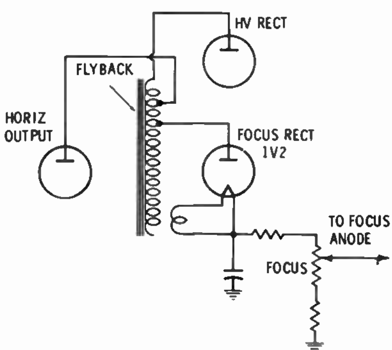
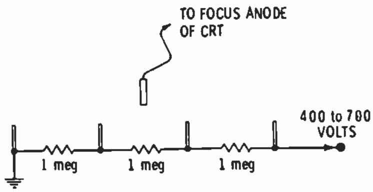


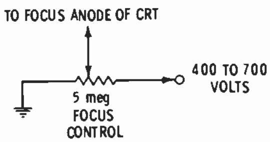

**Fig. 2-29. An older circuit, seldom used in monochrome sets but popular in color TV.**

The first picture tubes to use electrostatic focusing required a high voltage (several kv) on the focus anode. This high voltage was supplied from an extra HV rectifier utilizing a portion of the flyback pulse from the horizontal output transformer—see Fig. 2-29. The focus adjustment was a potentiometer across the DC output circuit. A more elaborate version of this type of focusing is still used with color TV picture tubes.

Modern black-and-white picture tubes use electrostatic focusing derived from B+ or boost. The voltage for the focus anode may be supplied through taps on a power-supply bleeder (as in Fig. 2-30A) or from a high-resistance focus control (as in Fig. 2-30B). Or, it may be supplied by a jumper at the picture tube socket, connecting the focus anode to the first anode of the picture tube, to some other element, or




(A) Tap on power-supply bleeder.




(B) Focus control.

**Fig. 2-30. Two most common circuits for focusing the CRT.**

perhaps even to ground (one side of the heater)—whichever point offers the best focus. A few picture tubes have the focus anode connected internally to other elements, which supply the focus voltage; these are called self-focusing tubes. Small test CRT's are good examples of this type of focusing.

## Causes of Poor Focus

Obviously, poor focus can be caused by incorrect focusing voltage, or its complete absence. For example, it is easy to forget the jumper across the socket when replacing a picture tube. Sometimes, when the focus anode is connected to a tap, the connection may have simply become loosened from the correct terminal. Occasionally a focus pot will open, and correct focus will be virtually impossible to obtain.

Perhaps the next most common cause for poor focus is incorrect adjustment of the ion trap. Actually, many electrostatic tubes don't use an ion trap, but on those that do, the ion trap adjustment is most critical for proper focus. If this is the problem, the cure is simply a matter of rotating the trap for best brightness, while at the same time checking for best focus.

Needless to say, the use of an ion trap on a tube which requires none can upset the focus quite noticeably. When replacing an older CRT with one of the newer, straight-gun types, a technician may unthinkingly place the ion trap on the new tube only to find the focus terrible, even though the brightness is ample.

Often overlooked as a cause of poor focus is the effect of incorrect voltages on *other* CRT elements—for example, the first or second anode. CRT focus is dependent upon *all* the electrical factors in the tube; therefore, the element voltages all interact to some extent, affecting the focus. Inadequate high voltage, for instance, may first appear as poor focus on the picture tube screen. Always check the high voltage (with a voltmeter and HV probe) when you suspect it to be the cause of focus trouble.

Defective picture tubes sometimes cause the appearance of poor focus, usually accompanied by a reduction in brightness. A good CRT checker will almost invariably spot this trouble. Rejuvenation may increase the apparent brightness, but sometimes at the expense of sharp focus. This is because the control-grid aperture of the CRT becomes enlarged and no longer has much control over the electron beam. As a result, the beam tends to splatter, making it next to impossible for the focus anode to perform its task. For this reason, it may be wise to try a brightener before rejuvenating. If you do try rejuvenation, be careful not to overdo the process; otherwise you may damage the tube beyond usability.

## An "Apparent" Cause

More than one technician has been embarrassed when he replaced the CRT only to find he still had the same trouble—a milky, poorly focused raster. The actual cause is a restriction of frequency response in the video amplifier. This sort of trouble has been found a number

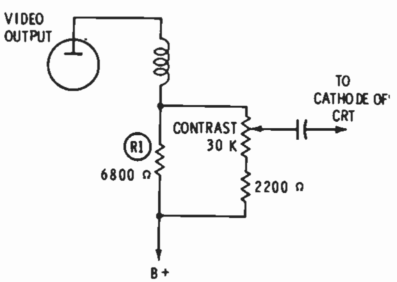



**Fig. 2-31. A high-level contrast control circuit which can cause unusual symptoms.**

of times in a circuit similar to that in Fig. 2-31. If the 6800-ohm plate resistor (R1) opens, the video amplifier will continue to operate after a fashion, since plate voltage is still applied through the 2200-ohm resistor and the 30K contrast control; but, because the load resistance is now considerably increased, the high-frequency response of the video stage is severely restricted. The focus then *appears* defective.

## Conclusion

When focus trouble is indicated, first make sure the trouble really is a matter of focus, and not caused by some trouble elsewhere in the set. After that, pinpointing the fault is simply a matter of checking a few things: the focus adjustment (or tap), jumpers, the ion trap (if used), voltages on the CRT, and the CRT itself. The possibilities are really not so many, when you know what you're looking for.

Section 3

# Radio Circuit Troubles

## RAPID SUPERHET REPAIR

Repairing the "lowly" AC/DC table-model radio—ungraciously dubbed the *superhet*—is the most dependable sideline of well-organized service shops, and represents an income not to be ignored. On the other hand, all is not so simple that the matter can be easily dismissed. Many technicians, however competent they may be at TV repairs, have failed to develop a quick logical approach to servicing these small "enigmas." This discussion is devoted to describing how superhets *can* be repaired profitably.

The techniques described here were developed during many years' experience with "flat-fee" radio repair. No matter how high the stack of ailing superhets became, the pay rate remained in the vicinity of $2 per cure—whether the repair was a fast squirt of solvent in a noisy volume control or a lengthy session with an intermittent. Needless to say, *speed* was the key to survival.

The system boils down to this: Subject a circuit to a fast series of easily performed checks which will isolate the defective stage or possibly even a single component. "Nothing new here," you may think; but there is—the nature of these tests. They are characterized by their basic simplicity and a minimum use of special bench facilities.

As many possible avenues exist for troubleshooting a superhet as there are servicemen, but the most-favored approach is a general path from the power supply to the audio section, and on to the IF and RF stages. Several symptoms can be serviced by shorter routes; many of these short cuts are listed in Chart 3-1.

First, let's assume that you're confronted by a totally dead set. Since tube failures cause a major percentage of troubles, the tubes are checked at the very start. After this, the set is placed on the bench with the chassis removed from the cabinet.

### Power Section

If the tubes will not light when supplied with AC power, the switch may be at fault. A fast method for detecting this is to short across the two switch contacts on the back of the volume control with the shank of a metal screwdriver, as illustrated in Fig. 3-1. If the tubes light, the defect is obvious; if not, the line cord is the next suspect. Grasp it three or four inches from the plug and gently wiggle it in every direction.

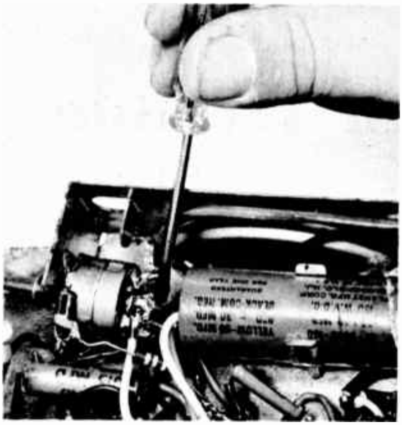


**Fig. 3-1. A quick test for the power switch in a radio.**

Beyond these steps, a conventional ohmmeter test is in order; the probes across the prongs of the AC plug (power switch closed) should indicate resistance ranging up to a few hundred ohms. If the initial test reveals an open circuit, one probe can be left at one side of the plug (point A in Fig. 3-2) while the other is moved consecutively through points 2 to 8 in the filament-circuit path. In this example, a break in the line is pinpointed by a continuity reading at point 4, with no continuity reading at point 5.

The next step is to make a quick search for obvious signs like charred components, the giveaway sounds of sizzling or frying, or the telltale odor of a burnt resistor. If nothing provokes suspicion, listen carefully to the speaker: hold your ear close and listen for the soft hum

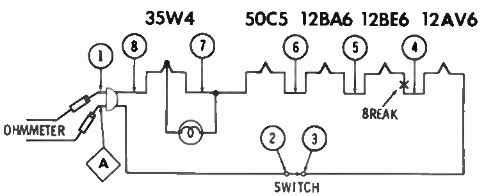



**Fig. 3-2. Step-by-step ohmmeter tests to help locate filament-string defects.**

which arises from 60-cps ripple in the power supply. If it is present, this is fair evidence that the power supply is operating, as well as at least a part of the audio section. It also proves that the audio output transformer and speaker voice coil are functioning.

An unusual amount of hum (with volume control turned down) is a good indication of rectifier or filter trouble—usually the latter. A quick test by bridging with a good electrolytic will tell for sure. Many shops have a filter capacitor, with clips attached, on hand for just this purpose.

## Audio Stages

A quick, conclusive check of the audio section can be made at the volume control by inducing hum at the "high" end as shown in Fig. 3-3. Although the metal tip of a screwdriver is sometimes used, a more dependable probe can be made from a .1-mfd 600-volt capacitor.

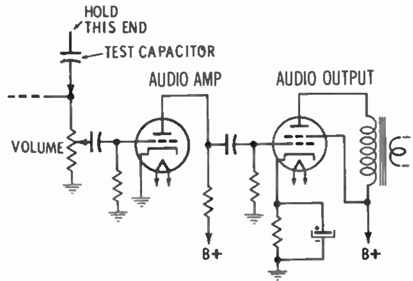



**Fig. 3-3. Using a "test-probe" capacitor to localize audio-circuit faults in a radio.**

To make this test, turn the volume control fully clockwise and touch one lead of the capacitor to each of the three lugs of the control, while holding the other lead between your fingers. A loud hum should be heard in the speaker when the capacitor lead contacts either of the two ungrounded lugs—the quiet one is the ground return.

## RF and IF Circuits

If the power supply and audio stages are okay, you can continue with further tests, still using the .1-mfd capacitor as a probe. With it, you can short, shock, and otherwise disturb signal circuits, while running no risk of burning any components due to DC overload.

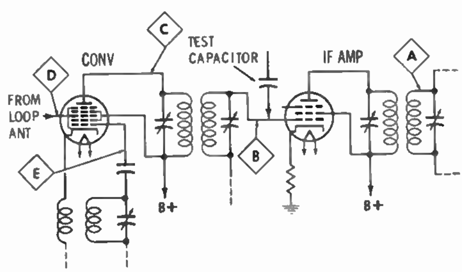



**Fig. 3-4. Using a "test-probe" capacitor to localize RF-IF faults in a radio.**

Specifically, the IF and RF stages should be subjected to what could be termed the "click" test. One lead of the capacitor is touched to the control grids of each of these tubes (see Fig. 3-4) with the volume full up. A click should be heard in the speaker; failure to hear it singles out the stage for closer inspection. As suggested by the schematic in Fig. 3-4, the process should follow a logical order—from IF to RF. It starts at the input to the detector and ends at the oscillator grid of the converter tube.

Though the click test can reveal that each stage is capable of passing a signal, it gives no clue to the condition of the local oscillator. The first sign of a disabled oscillator: No stations are received, but sometimes the hiss and crackle of atmospherics will be audible (though much weaker than usual). In some cases of trouble—usually those caused by a defective oscillator coil—the click test will shock the oscillator into temporary operation.

Determining for sure whether the local oscillator is functioning takes very little time. Two quick methods are commonly used. In the first, a nearby set is tuned to approximately 1400 kc. The set in question is then dialed from the low to the high end of the broadcast band. If the oscillator is working, a whistle will be heard in the nearby set as the tuning dial passes through approximately 1000 kc.

The second method of verifying oscillator action is by measuring the bias developed at the grid of the oscillator tube (point E in Fig. 3-4), preferably with a VTVM. This voltage should be from −3 to −10 volts DC, depending on the tube being used.

## Other Tests

The steps just described deal principally with a dead set. Other symptoms—like squeals or distortion—can also be localized with the aid of the .1-mfd capacitor. In the case of self-oscillation (squeals), one capacitor lead is touched to the radio chassis (or other B− point) while the free end is used as a probe on successive control grids. The offending circuit ceases to oscillate when the capacitor shunts the feedback signal to ground.

When the defective stage is pinpointed, bridging with the capacitor is often helpful. If, for example, an open screen bypass is responsible

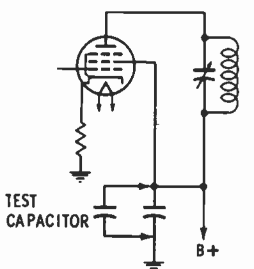



**Fig. 3-5. Curing oscillations by bridging with a capacitor.**

for setting up the feedback path, the test capacitor should stop the squeal when its leads bridge the defective component (see Fig. 3-5).

The bridging technique is pretty much restricted to spotting *open* bypass or coupling capacitors; the .1-mfd unit will not help if the suspected component is shorted or leaky. In the case of filter capacitors, the .1-mfd value will not provide enough capacitance to indicate an open condition; an electrolytic comparable to the original filter should be tried.

## Conclusion

Other short cuts for fast servicing of superhets are shown in Chart 3-1. Each is intended to trim the time between customer complaint and completed repair. All the steps here take more time to describe than to actually perform on the bench. Once they become a part of your standard techniques, your service time on superhets can be measured in minutes.

### Chart 3-1 Common Troubles (other than tubes)

| SYMPTOM | CHECK |
|---|---|
| Dead set | Power switch, line cord and plug, tube-socket contacts. Incorrect power-supply voltages. |
| Steady hum | Defective filter capacitor, open audio-grid resistor, open cathode-bypass capacitor in audio output, open volume control, shorted filter resistor. |
| Tunable hum | Defect in RF (converter) stage, faulty antenna loop and ground connections, lead dress, line-filter capacitor. |
| Oscillation | Microphonic tube, defect in bypass or coupling capacitor, improper grid bias, faulty lead dress, defective filter capacitor, poor wiper contacts on tuning capacitor, incorrect alignment, excessive line voltage, open decoupling capacitor. |
| Distorted sound | Leaky coupling capacitor, incorrect grid bias, incorrect supply voltages, defective AVC filter capacitor, rubbing voice coil, torn speaker cone, oscillation (see above). |
| Poor sensitivity | Misalignment, poor antenna loop or ground connections, dirty tuning capacitor, shorted coils or IF transformers. |
| Intermittents | Defective paper or electrolytic capacitor, cracked resistor, insufficient tension on tube-socket contacts, worn volume control, short between tuning capacitor plates, critical oscillation of local oscillator tube (replace), defective IF coil, faulty solder joints, cracked printed board conductors. |

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. 3-6)

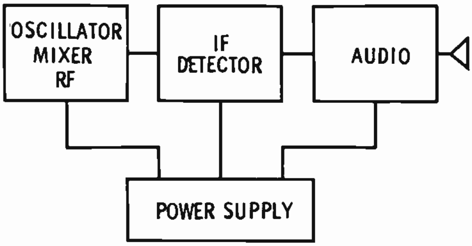



**Fig. 3-6. Dividing the radio into blocks for servicing.**

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,

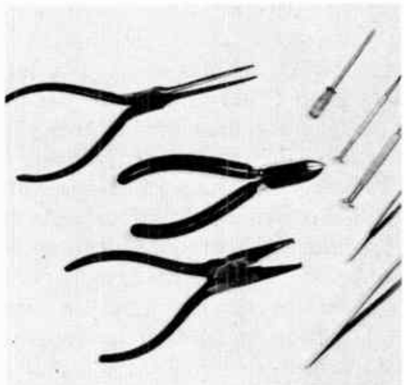


**Fig. 3-7. Small tools for servicing miniature portable receivers.**

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.

The technician who wants to do an efficient, thorough job with a minimum of inconvenience will find certain small-sized tools helpful (see Fig. 3-7). A small pair of diagonal cutters and needle-point pliers, a set of small screwdrivers, a couple of 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.

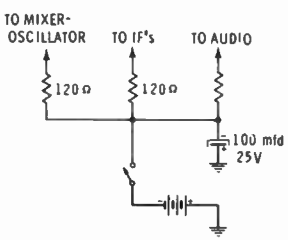
The second method takes a little more time, but it gives a more complete analysis of conditions in the power-supply circuits. Since a transistor radio requires very little power compared with a tube radio, it is very important for voltages and currents to be close to those for which the circuits are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

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

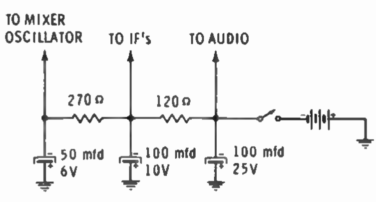
The current drain of the set can indicate troubles which may occur in the power-supply circuits. A shorted transistor or a leaky bypass capacitor will usually result in an abnormally high input current to the radio. This could reduce battery life, even though the set might still play. So this is an important 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. 3-8A, while more elaborate receivers may use several capacitors and resistors to do a more complete job of decoupling, such as in Fig. 3-8B.




(A) Simplest form.




(B) More elaborate form.

**Fig. 3-8. Typical decoupling networks.**

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.

## 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 Stages

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 indicates 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. 3-9. 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

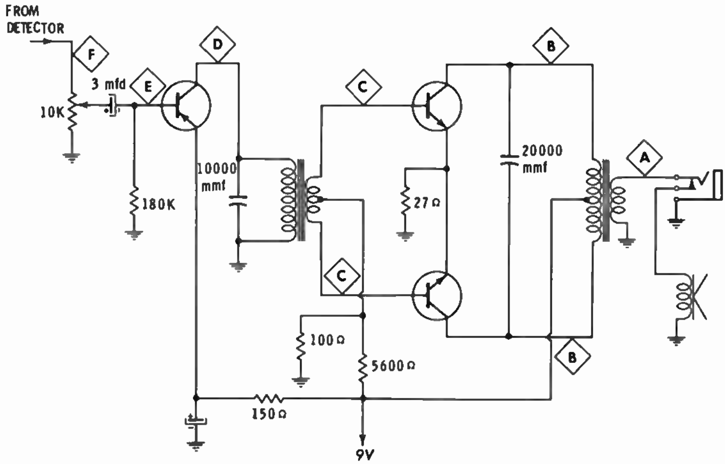



**Fig. 3-9. Key test points for step-by-step servicing procedure.**

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.

## 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 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 peaks at one end of the slug's travel, replace the transformer.

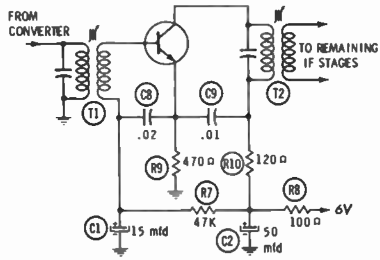



**Fig. 3-10. Decoupling network in a typical IF stage.**

Erratic IF tuning may also be caused by defective bypass capacitors in the IF stages. In Fig. 3-10, for example, if C8 or C9 were to open or lose value, the tuning of T1 or T2 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. 3-11). 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 measure 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

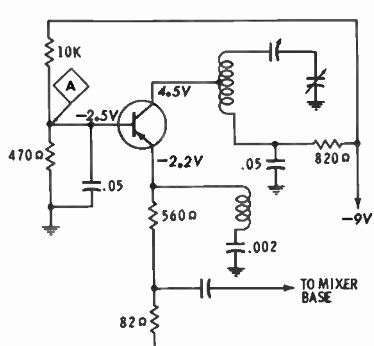



**Fig. 3-11. A typical oscillator circuit.**

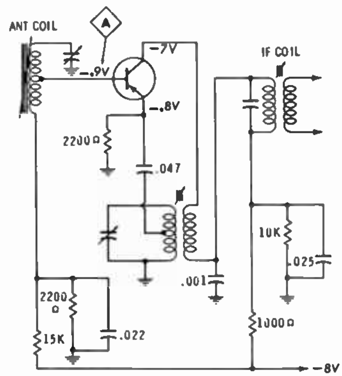



**Fig. 3-12. A typical converter circuit.**

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. 3-11) 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 develop 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. 3-12 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. 3-12). In those sets which have a 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 procedure. 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.

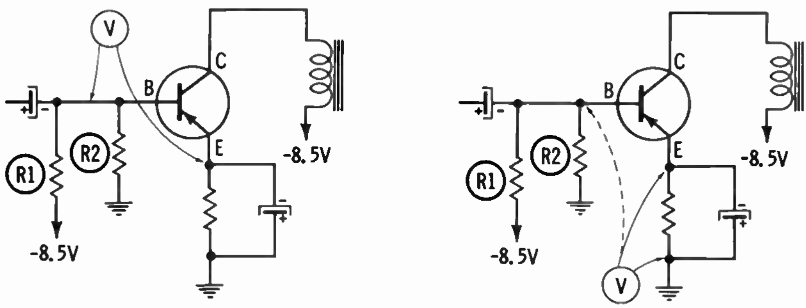
## DISTORTION

It can be generalized that distortion in transistor receivers and audio amplifiers is the result of some defect that upsets bias in an audio stage. It naturally follows, then, that distortion in these units can be cured by correcting the bias problem. Carrying this logic a step further, we can assume that if altering the bias on an audio stage clears up any distortion we hear (or see, with a scope) the fault must lie within that stage. It matters not, from a standpoint of troubleshooting, whether we clear up the distortion artificially—by supplying the correct bias from some external source—or in the usual manner by replacing the defective component. Naturally, the latter is too time-consuming and parts-wasting to be practical as a troubleshooting procedure.

Let's examine this idea from another viewpoint. We can consider two methods of finding in which stage distortion originates: by measuring voltages on each transistor or by artificially altering the bias in each stage until one of them clears up the faulty sound emanating from the speaker. The first method—measuring voltages—makes it necessary for the service technician to know in advance the correct bias for each particular transistor; one pitfall of this system is that not all transistors of a particular type operate the same, even with the same bias. The second method—substituting an adjustable bias voltage and setting it for linear operation—has the advantage of *showing* an immediate and definite result; besides, only a general knowledge of bias values is needed.

## Measuring Bias

To set the stage for our dynamic techniques of troubleshooting distortion problems, let's first take a look at the two ways bias is measured.




(A) Base to emitter. (B) Ground as reference.

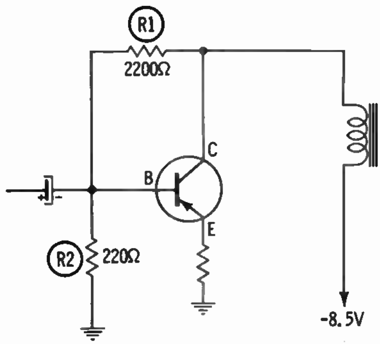
**Fig. 3-13. Methods of measuring transistor bias.**

Fig. 3-13 shows an audio stage using a PNP transistor. Bias can be measured by a sensitive voltmeter connected between the base and emitter as shown in Fig. 3-13A. The voltmeter, preferably a VTVM, must be able to indicate voltages as small as a few hundredths; some transistors operate with less than .1 volt bias. Fig. 3-13B shows another way to determine bias on a transistor—by measuring the voltage at the emitter and then at the base; the difference between the two readings is the bias voltage.

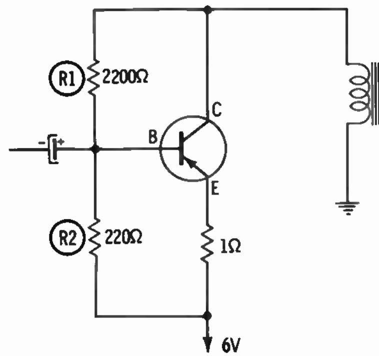
## Developing Bias

Next, let's examine how bias is normally applied to transistor stages. We can still use Fig. 3-13 as an example.

The emitter voltage is primarily a function of total collector current, although a very insignificant amount of base current affects it. The base voltage is determined by divider resistors R1-R2 connected across the main power supply. The ratio of R1 to R2 sets the amount of the supply voltage that is applied to the base of the transistor. Base-emitter current in this PNP unit also has some effect on the final value of base voltage, so the operating value may vary slightly from that computed by the mathematical ratio of R1:R2. Nevertheless, the ratio is a usable clue to the approximate value to be expected.




(A) From collector supply.




(B) Collector at DC ground.

**Fig. 3-14. How bias is derived for base.**

A similar biasing system is shown in Fig. 3-14A; the divider system is connected in this stage directly across the collector supply. In Fig. 3-14B, a still different arrangement is used, but the divider principle remains. You'll find that base-biasing arrangements in most transistor audio stages resemble the divider systems shown here. This being the case, it is easy to alter the bias simply by changing the ratio of the divider resistors. Find an easy way to change this ratio, and you'll have an easy way to change the bias; change the bias without much effort, and you can check the stage for distortion without much effort. Therefore we need procedures for doing this job quickly, and without a lot of intricate desoldering and resoldering on tightly packed printed boards.

## The Bias-Changer

The "tool" we use for distortion-chasing in transistor audio amplifiers —be they hi-fi units with barely measurable distortion or tiny portable radios with fuzzy sound—is shown schematically and sketched in Fig.

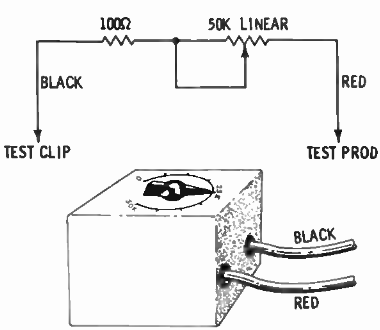



**Fig. 3-15. A "bias-changer" for tracing distortion.**

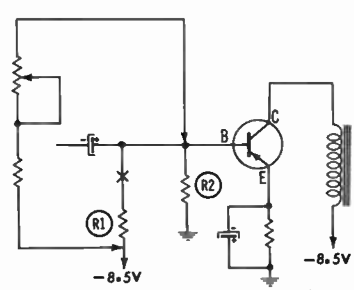



**Fig. 3-16. Using tester to supply variable bias.**

3-15. (The device can be mounted in a box as shown, but it is not necessary. The 50K potentiometer has a linear taper, and the 100-ohm resistor is added to prevent inadvertently shorting some point through the test unit.

Fig. 3-16 shows an example of how the unit can be used to ascertain what bias is necessary to keep the transistor amplifier operating in the linear region. By opening the base-bias supply connection (a razor-blade slit across the printed foil will do it) and substituting the connection shown, the amount of bias can be adjusted or varied while you listen or watch the scope to see when the transistor reaches normal operation. The test potentiometer should be set at maximum resistance for the beginning of each test. After the connection is made and the set turned on, slowly rotate the 50K control so the bias on the transistor is increased.

When a point is reached that clears any distortion, the values of R1 and R2 can be changed to provide this same bias for the transistor; if it is obvious the new values would be considerably different from the original design of the set, you can safely assume the transistor or some other circuit component is causing the problem.

Our "bias-changer" can be used without disconnecting any components or cutting across any printed-circuit foils. How? . . . simply by connecting it across one of the existing resistors, thus reducing the value. Lowering the value of the series resistor in the divider (R1 in Fig 3-16) will increase the base bias; reducing the value of the shunt resistor (R2 in Fig. 3-16) will reduce the value of bias voltage applied to the transistor base.

In many transistor circuits, the technique shown in Fig. 3-16 can be used without the precaution of opening the foil connection to the voltage supply—the "bias-changer" device will override the existing bias network. If there is any doubt of your results, however, play it safe and take time to slit the foil.

## Rapid Component Analysis

Assuming the bias-changing technique has revealed the faulty stage, you'll want next to determine what has caused the unwanted change in bias. Long experience in troubleshooting receivers has shown that their most common fault is a defective capacitor. The electrolytic capacitors generally used in transistor sets cause more cases of distortion than any other single component.

You are now in need of a technique for locating a defective capacitor quickly, and it would be nice if the same technique would point out any faulty resistors or transistors in the process. One useful technique involves monitoring the input current drawn by the set from its power supply (usually a battery). If a capacitor is leaky or shorted, merely disconnecting one end will generally cause a very noticeable change in

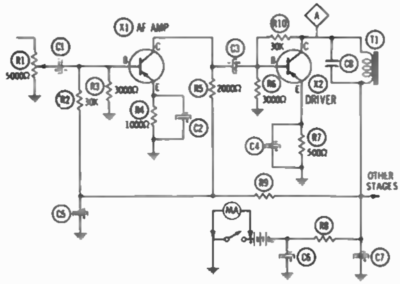



**Fig. 3-17. The audio stages of a transistor receiver.**

the total input current. This is easy to understand if you consider the capacitors in the partial schematic in Fig. 3-17.

Any unusual leakage in C5, C6, or C7 would provide a direct drain on the power supply of the receiver and would appear as a higher-than-normal reading on the milliammeter across the input switch. Disconnecting one end of any faulty capacitor would considerably reduce the drain. The effect of a leaky or shorted C6 would be the most notable, because current through C5 or C7 would be limited slightly by resistors R8 and R9. In either case, however, current drain would be sufficient to result in some change in the milliammeter reading when the defective capacitor was disconnected.

A shorted C1 would upset the bias on transistor X1 since current could easily leak to ground through C1 and control R1. Lowering the bias on transistor X1 would reduce collector current and decrease total input current. A shorted C1 would not affect the current drain directly, even with the R1 tap at ground, because of the limiting effect of R2, a comparatively high resistance. Nevertheless, disconnecting one lead of the capacitor would produce an obvious change in the DC current drawn from the power supply and would be a definite clue if C1 is defective.

A shorted C2 would be noticeable mostly in the collector current of X1. As with C1, the effect on input current is indirect—caused by a change in transistor bias. And again the input current diminishes when the capacitor is disconnected. If the capacitor is normal, there will be practically no change in drain from the power supply. The same applies to C4 in the emitter of X2.

The effect of a leaky C3 on current drain could be considerable, because the current path through R5 and R6 would greatly increase forward bias and thus the collector current in transistor X2. It is even possible that a completely shorted C3 could apply so much forward bias to transistor X2 as to ruin it. Disconnecting C3 will greatly reduce the input current drain, if the unit is faulty. If you find the current is still too high, you'd want to investigate the possibility of a defective X2. To test this, the circuit would have to be broken at point A; but remember that even with a normal transistor some current reduction would occur upon disconnecting divider network R6-R10. To ascertain the exact point of excess current drain, the collector lead could be disconnected right at the transistor, by unsoldering or by the razor-blade method.

Faulty resistive networks can easily be checked out with the bias-changer potentiometer, often simply by bridging a suspected resistor with the test device. Bias faults caused by faulty resistors can thus be checked and eliminated. To determine the exact value for a suspected resistor, simply remove it from the circuit and connect the test device in its place. Adjust the potentiometer until normal operation is resumed. Then it is a simple matter to measure the resistance of the test device and put a correct-value resistor in place of it.

## Summary

The techniques set forth in this discussion are far from the only way to go distortion-chasing in transistor audio stages. However, they have the advantage of being quick and not requiring an undue amount of unsoldering parts for testing. The less soldering you have to do on some of those tiny printed boards, the better.

We've found from our own experience that the bias-changing (or divider-substituting) system is a very quick way to bring a nonlinear stage back into line, thus ascertaining whether it truly is the stage at fault. This method will work well in some of the little transistor sets that "don't sound too good" even when new. It will work with sets that sound poor after batteries are only slightly used. In almost any case of distortion, you'll find this technique fast and accurate for pinning down the stage at fault (and often giving a clue how to fix it).

For detecting leaky capacitors, without having to unsolder both ends for testing or substitution, the input-monitoring system is quick and effective. With the meter connection so easy to make, and having already localized the trouble to a single stage, this technique has proven itself popular among all who have learned to use it.

Distortion chasing is not nearly so difficult with these easy techniques. Use them a few times with your next audio jobs; they'll help make the jobs profitable and the customer happy.

# SERVICING STEREO ADAPTERS

FM stereo has solidly caught hold of its market. What does this mean to the service technician? It means a good deal of equipment has been in use for some time now, and many additional units are being sold each and every day. So, get ready for more and more requests to service FM stereo receivers! The technician who best understands the operating principles of FM stereo reception is the one who will be able to repair these sets quickly, and consequently turn this activity into profit.

Several articles and books have been written dealing with the theory, operation, alignment, and other aspects of FM stereo receivers. It seems that in nearly all these writings, the importance of an FM stereo generator has been stressed. There is no doubt that such an instrument can often be mighty useful. However, *service* can be performed, and performed adequately, without a generator. A stereo transmission has all the signal components needed for checking stereo receiver operation. The main advantage of using a generator rather than a station transmission is the convenience of selecting specific components of the composite stereo signal. The remaining parts of a transmitted signal, of course, cannot be turned off. Therefore, to service stereo decoders without a multiplex generator, the technician must be able to recognize and concern himself with only the portions of the composite stereo signal which seem to be missing or improperly reproduced—a procedure quite similar to the standard practice of using video signals for servicing TV receivers.

## The Transmitted Signal

To best be able to recognize these individual components at the receiver, let's briefly review the signals transmitted during a stereo broadcast and the importance of each.

The stereo signal must serve two purposes. First, it must provide the stereo listeners with separate left and right audio. Secondly, those listeners having *monophonic* FM sets must not encounter any interference from the additional second-channel information, and must still enjoy good quality mono FM when stereo is transmitted. Both these requirements are accomplished in the following manner:

Three separate signals are transmitted during an FM stereo broadcast. The main channel (L+R)—that heard on standard FM receivers—consists of frequencies between 50 cps and 15 kc. The difference signal (L−R) amplitude modulates a 38-kc carrier which is then suppressed (not transmitted). Only sideband pairs 15 kc above and below 38 kc are transmitted. Therefore, in the stereo receiver this 38-kc carrier must be redeveloped. To produce a 38-kc carrier within frequency tolerance and in phase with the original suppressed carrier, a third signal—the 19-kc pilot—is transmitted. Special circuits in the transmitter combine these components and they appear together at the receiver as the composite stereo signal.

Some stations also broadcast a fourth signal—background music service, or SCA—which ranges from 59 to 75 kc. Since this additional carrier is not suppressed at the transmitter, it must be removed by a filter network in the receiver to prevent "beat" interference with the L−R signal.

Enough on the signals that are transmitted. Now, let's see what happens to these signals in the stereo receiver.

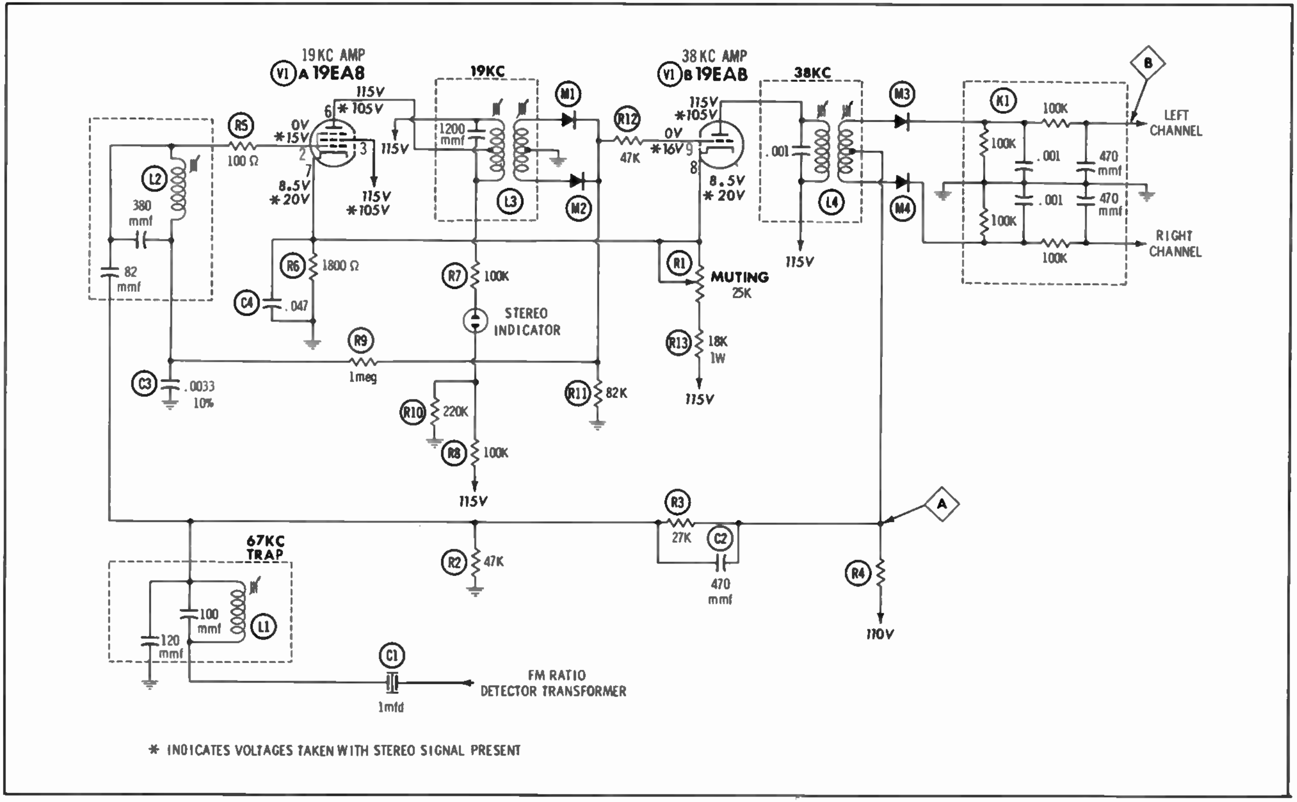



**Fig. 3-18. A modern stereo adapter circuit in which diodes are employed to develop 38-kc carrier.**

## Tracing the Composite Signal

Fig. 3-18 shows a typical stereo adapter circuit. The composite signal is taken from the ratio detector transformer and coupled through C1 to the SCA filter. This trap is tuned to the center frequency of the SCA signal, 67 kc, and has a response sufficient to trap frequencies 5 kc above and below 67 kc. A defect in, or misalignment of, the 67-kc trap network will result in a "whistle" or other interfering noise from the speakers.

The output of network L1 (composite minus SCA subcarrier) is divided into two paths: The L + R (standard FM) and L − R signals are coupled to the center tap of the secondary winding of L4, while the 19-kc pilot is separated from the remainder of the composite signal and applied to the grid of V1A through tuned circuit L2.

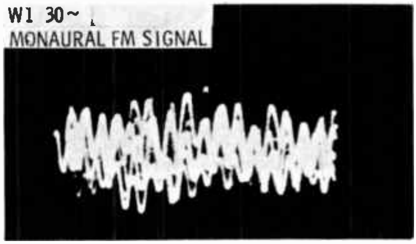
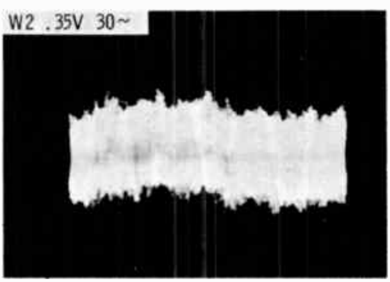


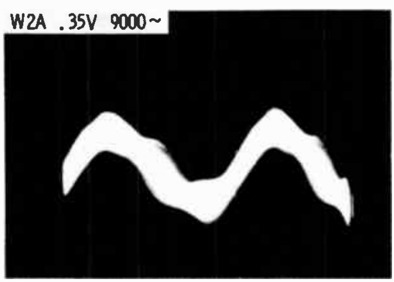

**Fig. 3-19. The monophonic FM signal present at point A.**

Waveform W1 (Fig. 3-19), taken with the receiver tuned to a monophonic broadcast, shows the L + R signal present at point A. When a stereo signal is being received, L + R is again present at A, but accompanied this time by the other components of the composite stereo signal.

The signal at the grid of V1A is depicted in Fig. 3-20. (These and all remaining waveforms were taken with the receiver tuned to a stereo broadcast.) W2 and W2A (Fig. 3-20) are photographs of the same signal; W2 (Fig. 3-20A) was taken with the scope sweep set to 30 cps, W2A (Fig. 3-20B) with the scope sweep set to 9000 cps. In both waveforms you can see the 19-kc pilot as well as audio. Fig. 3-20B, however,




(A) Scope set at 30 cps.




(B) Scope set at 9000 cps.

**Fig. 3-20. The 19-kc pilot signal at the grid of V1A.**

is most important at the grid of V1A, since L2 is tuned sharply to pass 19 kc. The transmitted 19-kc pilot signal is intentionally very low in amplitude to prevent interference in mono-only receivers.

The plate signal of V1A, shown in Fig. 3-21, is the amplified 19-kc signal. Notice the audio information is much less pronounced at the plate; this is because plate transformer L3 to tuned to 19 kc. Each side of transformer L3 secondary feeds a diode, whle the center tap is grounded. The diodes are connected in doubler fashion to produce an output of 38 kc.

The output of the doubling diodes (grid signal of V1B) is shown in Fig. 3-22. This waveform (W4) was observed with the scope sweep set

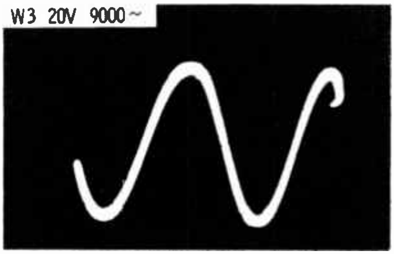



**Fig. 3-21. Waveform at plate of 19-kc amplifier.**

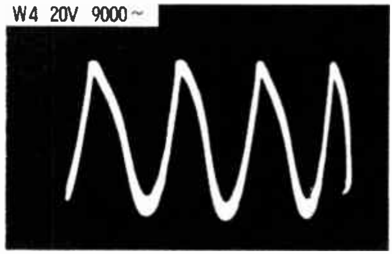



**Fig. 3-22. The 38-kc sine wave at diode output.**

to 9000 cps. Proper doubling action can be checked very easily. Set the scope for two cycles of the 19-kc signal at the doubler input and then, without changing the scope frequency, check the doubler output; four cycles (38 kc) should be displayed. A good indicator of diode condition is the amplitude of the four pulses, which should be constant under normal conditions.

Considerable amplification (about 19 db) takes place in the V1B stage, where plate transformer L4 is tuned to 38 kc. The signal amplitude at the grid is 20 volts peak-to-peak, while the plate signal (Fig. 3-23) is 175 volts.

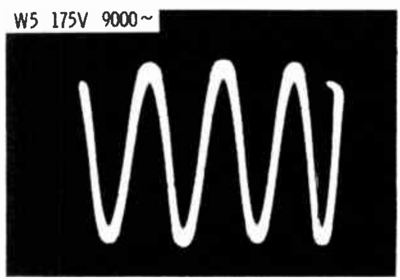
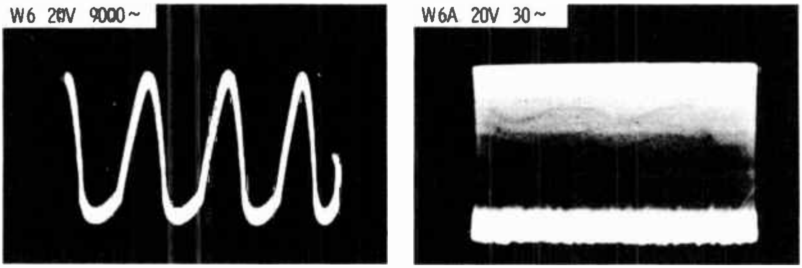



**Fig. 3-23. Waveform at plate of 38-kc amplifier.**

The waveforms (W6 and W6A) in Fig. 3-24 show the signal that appears at the junction of L4 and M3, consisting of L + R, L − R,




(A) Scope set at 9000 cps. (B) Scope set at 30 cps.

**Fig. 3-24. Signal input to the detector diode.**

and the reinserted 38-kc carrier. The matrixing of the audio signals (L − R and L + R) begins at this point and the corresponding junction of L4 and M4.

The outputs of M3 and M4 consist of 38-kc pulses whose amplitudes vary at an audio rate; M3 recovers the left channel audio, M4 the right. The 38-kc carrier still present (W7 in Fig. 3-25) is filtered by K1, leaving only the audio signals for application to audio amplifier stages. The signal taken at point B is W8 in Fig. 3-26.

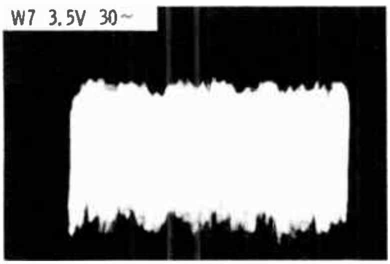



**Fig. 3-25. The 38-kc unfiltered detector output.**

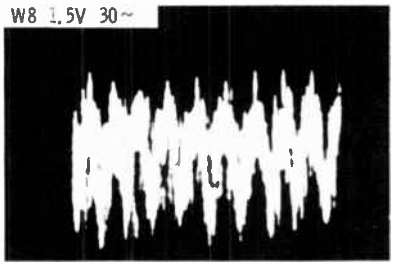



**Fig. 3-26. The filtered output—pure audio signal.**

## Stereo Indicator

Many stereo receivers are equipped with a stereo indicator light. A popular version employs a neon lamp in the plate circuit of the 19-kc amplifier tube; a typical arrangement is shown in Fig. 3-18. The purpose of this indicator is to inform the listener when a stereo signal is being received—therefore, it should not light when the receiver is tuned to a monophonic signal.

One side of the lamp is connected to a fixed DC voltage, while the other side is connected to the plate of V1A through R7 and L3. When a stereo signal is received, a 19-kc pilot is present on L3. The peaks of this signal at the primary of L3 are sufficient to develop firing potential across the lamp circuit.

The muting control (R1) adjusts the cathode voltage and thus the bias on both V1A and V1B. Misadjustment of this control may prevent the neon lamp from firing (if the cathode voltage is too great), or allow it to fire when noise from an FM station is present (if the cathode voltage is too small).

Even with the muting control properly adjusted, the indicator may not light on some stereo stations; this is usually caused by an improper antenna system.

## Summary

Once you have determined that a defect is present in the multiplex stages, isolating the defective circuit can be simplified by the signal tracing procedure we've given here. A waveform analysis of both plate and grid signals is a good starting point. Improper waveforms may be caused by either a defective component or misalignment of the associated coils.

As was mentioned earlier, a station signal should prove adequate in servicing any FM stereo circuit. However, to assure proper separation of the audio signals a generator may be required; the varying levels of a broadcast just aren't suitable for this job.

The circuits in some receivers will not be identical to the one shown in Fig. 3-18. However, they all do the same basic job and their operation is similar. The most important circuit points to look for are the stage in which the 38-kc carrier is redeveloped and the network in which the L − R and L + R signals are matrixed. Once these have been recognized—and you know what the waveforms should look like—you're well on the way to faster stereo servicing.

# RADIO AND TV TROUBLE CLUES

## Volume 2

Time is of the utmost importance to the practicing service technician. If he is to profitably repair all the radio and TV receivers that come across his bench, he must devise ways of quickly diagnosing and repairing each set. Too often, valuable time is wasted in troubleshooting the wrong circuit or using improper servicing methods and tests of little value in the right circuit.

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