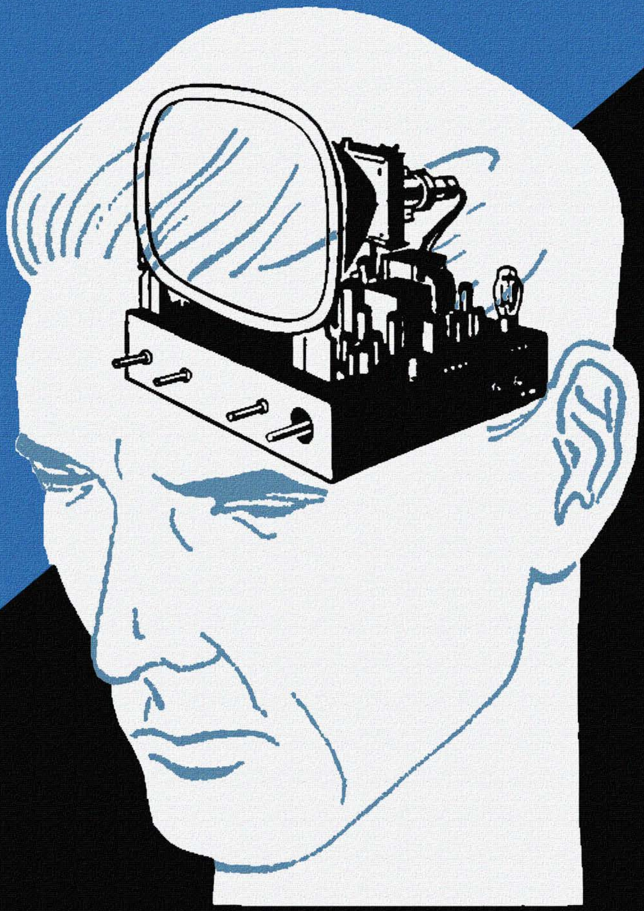
HOW TO No. 152

# TROUBLESHOOT A TV RECEIVER

by J. Richard Johnson



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# HOW TO TROUBLESHOOT A TV RECEIVER

by J. Richard Johnson

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# PREFACE

I*n the long run,* it is the *troubleshooting* part of servicing which takes most of the time and effort. In other words, finding the trouble takes more time than remedying it. Consequently, proper preparation and planning for troubleshooting is one of the most important requirements for successful and profitable TV servicing.

This book discusses how to prepare for troubleshooting most efficiently and how to find the cause of a trouble in a TV receiver in the shortest time. The clear presentation of this subject is not allowed to be complicated by attempts to cover the vastly broader subject of servicing in general, which includes alignment, replacement parts specifications, methods of making replacements, receiver installation, and the selection of antennas and associated equipment. Rather, the coverage sticks to the important fundamentals of deduction and elimination involved in the gathering and interpreting of evidence, in order to determine the cause and location of trouble in the shortest possible time. These fundamentals are applied in a practical way to the actual types of TV receivers now encountered in the field. An important part of the presentation includes lists of the equipment, tools, and accessories without which the technician would not be well prepared to embark upon TV receiver servicing.

TV service technicians are finding it more and more practical to do as much of their repair work as possible in the field. However, there is still a large number of instances when work in the field is not feasible. The text recognizes both these facts, covering many factors from both points of view, and distinguishing between requirements for each.

The author wishes to acknowledge the valuable assistance of Bill Kiefer, who contributed much practical information for this volume.

September, 1953 J.R.J.

## Chapter 1

# GETTING THE MOST OUT OF TV SERVICE DATA

*Television receivers* are of so many different types and models, and the problems of servicing are so varied, that when a given receiver is to be serviced, definite and specific information about that receiver is a practical necessity. No matter how much knowledge and experience the technician may have, and no matter how capable he is at figuring out each circuit simply by examining it, the fact still remains that, from a practical standpoint, he cannot compete with the man of comparable ability who has full service data in front of him to start with.

For the service job in the customer's home especially, the technician must have full information at his fingertips. Working in unfamiliar surroundings with limited space and limited tools and test equipment, the technician has no time for locating components by hit-or-miss methods or for tracing wires to determine circuits. He must concentrate on the actual pursuit of trouble.

However, even with the proper data immediately available, the technician must still be able to use them most efficiently, and even more, to know what additional information and aids are provided for him by the receiver manufacturer or the service data publisher. This chapter reviews the important features of service data available to TV service technicians and how they may be used.

### 1-1. Development of the Schematic Diagram for Service Use

The greatest aid to servicing is the schematic diagram. About it revolves all other servicing information. By examining this diagram, the experienced technician can determine the basic function of each part of a receiver and its trouble-causing possibilities.

Schematic diagrams were first developed for purely theoretical purposes. They were tools of the circuit designer who wished to express on paper the electrical operation of the circuit isolated completely from physical construction or other aspects of the components used. Physical layout diagrams, on the other hand, were developed for the wireman and service man. In these, components were represented pictorially, each with its connecting wires and their locations also shown. But with the development of complex radio and TV receivers, these diagrams became too unwieldy for servicing use, and the service technician turned to the schematic diagram as his base of operations. Experience enabled him to picture the physical appearance of the components expressed schematically in the diagram.

With the growth of the servicing industry, schematic diagrams have been designed expressly for the service technician, with his needs in mind. Such diagrams tend more and more to supply at the appropriate place on the diagram information necessary for making observations and checks to determine the cause of a receiver failure. It is such features in which we are primarily interested in this chapter. With the use of service data covered, we shall then proceed in the following chapters with the methods of putting them to work in troubleshooting TV receivers.

### 1-2. Labeling Values on the Schematic Diagram

It is assumed that the reader of this book is familiar with the basic symbols used in schematic diagrams and how they are integrated into a complete circuit.

In schematic diagrams used for purely theoretical work, symbols only, such as R1, R2, C1, C2, etc., are used to label components so that one capacitor can be distinguished from another, one resistor from another, and so forth. However, in service work, much more information is needed. The basic symbol is still used, but the *value* of the component is also provided. For example, resistor values are usually given in ohms, capacitor values in microfarads or micromicrofarads, etc. Actually, this information is given twice – once on the schematic diagram and again in the parts list for the receiver, which is ordinarily an integral part of the service data. The parts list information is more complete, giving tolerance, working voltage, wattage, and any other information necessary for ordering a replacement. The technician uses the parts list in determining exact specifications for the replacement part.

The values shown on the schematic diagram have a different purpose. They aid in locating specific components in the receiver. When the technician is checking parts of the receiver circuit, he traces the circuit by identifying components by their values as well as by their positions in the circuit.

In the designation of capacitance and resistance values, abbreviations are usually employed to save space on the diagram. Frequently, no abbreviations at all are indicated for the more common units; namely, ohms for resistors and micromicrofarads for capacitors.

Resistance is usually expressed simply in ohms up to either 1,000 or 10,000. For example, a resistor of 100 ohms would be labeled simply "100." For higher values, the symbol "K" is used. It means "thousand" and thus adds three zeros to the value. For example, a 22,000-ohm resistor would be labeled "22K."

Here, a point of possible confusion should be pointed out. On some of the older diagrams and even a few of the later ones, the symbol "M" was used for 1,000 instead of "K." Since "M" is now usually employed to indicate *megohms* (1,000,000 ohms), the situation is naturally confused. However, when the use of "M" for 1,000 is suspected, and there is no notation on the diagram, the technician should check the values of resistors whose approximate value he knows must be within a certain range.

The symbol "M" for megohms is ordinarily used for resistors of 250,000 ohms and larger. Resistors in the range of 100,000 to 750,000 ohms are sometimes expressed with "K" (for example, 100K) and sometimes with "M" (for example, 0.100M).

In addition to the values of resistors, the resistance of other components, such as filter chokes and transformer windings, is often given as a further aid to the service man. In these cases, the units are generally stated to avoid the possibility of mistaking ohms for henries. For example, a filter choke might be labeled "60 ohms."

The values of capacitors are expressed either in microfarads (1/1,000,000 of a farad) or in micromicrofarads (1/1,000,000,000,000) of a farad. When the number is 1.0 or more, it may be assumed that the units are micromicrofarads ($\mu\mu$f). When the number is less than 1.0, it may be assumed that the units are microfarads ($\mu$f). For example, a capacitor labeled "100" would have a capacitance of 100$\mu\mu$f, while another labeled ".001" would have a capacitance of .001$\mu$f.

Other capacitors, whose values do not fall within these ranges, must have the full label including the units. For example, a filter capacitor with a capacitance of 80 microfarads must be labeled "80$\mu$f" since, without the statement of the units, the value might be mistaken as 80$\mu\mu$f.

The values of chokes and coils also are sometimes indicated either in millihenries (mh) or in microhenries ($\mu$h). Thus, a peaking coil may be designated as 120$\mu$h.

These methods of labeling components are illustrated by most of the diagrams in the remainder of this chapter. In all cases it is desirable to look for notes or legends on the schematic diagram in order to be sure just how the labeling is done.

Two more kinds of value labels are also important to the service technician. These are labels of voltage and resistance measurements to (chassis) ground. In early service data, and in some which are more modern, voltages at various points in the circuit were supplied in the form of a chart, listing what the voltage and resistance to ground should be at each pin of each tube socket. However, it is even more convenient if these data are given right on the schematic diagram, so that, as the technician traces through the circuit, he will have at the same time the voltage value at each point where a voltage check is desirable. Accordingly, many service schematic diagrams provide information about the voltages at various strategic points right on the schematic diagram. A

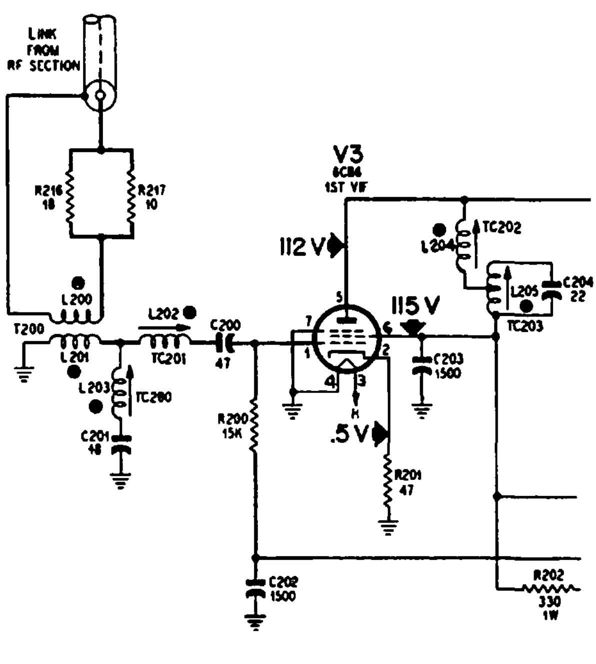



Fig. 1-1. Section of a typical service-type schematic diagram showing particularly how capacitance and resistance values are indicated, and how labels indicate the voltages at strategic points.

*Courtesy: Philco*

typical example of how this is done is given in the section of schematic diagram illustrated in Fig. 1-1. Note the labeling of the d-c voltages at the plate, screen grid, and cathode of the tube.

## 1-3. Schematic vs. Physical Arrangement

Many schematic diagrams designed for service use include data on the physical arrangement and locations of connections to the different components.

For example, transformer windings which are inside a shield can are shown with a dashed line around them to indicate the can. An occasional exception to this are traps in the i-f amplifier section, which are sometimes shown separated from the other windings which are enclosed with them. In this case, the technician must use his judgment in realizing that a wavetrap coil, to be effective, must be coupled to the windings of the transformer to which it is placed nearest. When the transformer is enclosed within a can, the trap must be found in there also. An example of a transformer and two other coils enclosed in a shield can is shown in Fig. 1-2. Note that the shield, indicated by the dashed line, encloses the transformer, the wavetrap, and another winding, all in the same can.

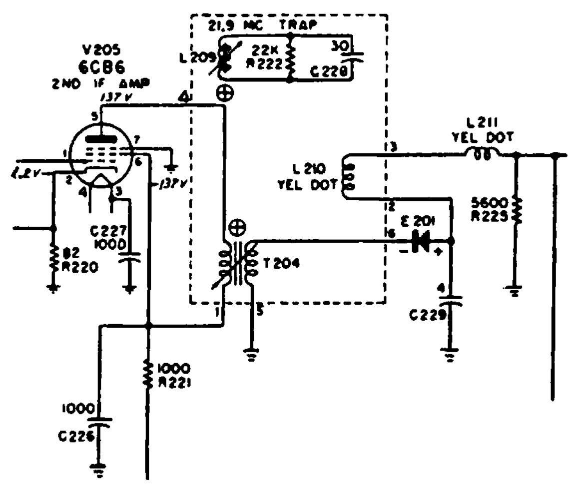



**Fig. 1-2. How coils and/or transformers in the same can may be separated on the schematic diagram but still actually be close physically and have mutual inductance between them.**

*Courtesy: Motorola*

Sometimes i-f transformers are designed so that the primary and secondary windings are *interwound*, that is, the turns of the secondary winding are wound between alternate turns of the primary winding in order to obtain maximum coupling. Figure 1-3 shows how this is indicated on a typical i-f amplifier diagram. Such windings are also called *bifilar.*

To aid in the location of the physical position of connecting points on certain components, and to help in identifying these components, small drawings of the physical appearance are sometimes included on the schematic diagram. Figure 1-4 shows the width-adjusting coil in a TV receiver. Notice how the connecting lugs are each marked with a reference letter. The connections corresponding to these on the schematic diagram are also marked with the same reference letters. The lugs in this case have the same appearance, so their position on the coil is made

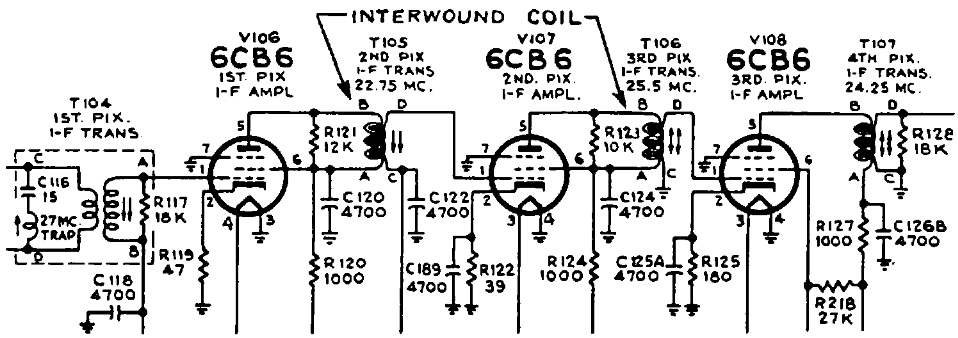



**Fig. 1-3. How interwound, or bifilar, windings of a transformer are indicated on a schematic diagram.**

*Courtesy: RCA*

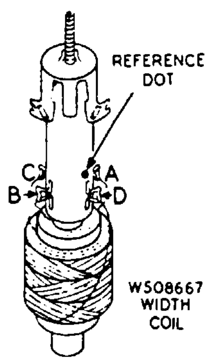



**Fig. 1-4. Drawing used to indicate the physical locations of the connection points on a component. Such drawings are frequently placed alongside the appropriate symbol on the schematic diagram.**

*Courtesy: Sears Roebuck*

definite by placing a small reference dot on the frame, as shown. The relative position of each connecting lug is then easily recognized. Sometimes, lugs of different shapes are used to distinguish between different connections; this is frequently done with connections on filter capacitors. Either the over-all shape of the lug or the shape of a hole punched in the lug is used to designate each connection. Shapes commonly used are circle, square, triangle, and semicircle.

## 1-4. Tube Location Diagrams

An important part of the service data is the tube location diagram. Sometimes this diagram is included on the same page with the schematic diagram and sometimes on a separate page. In any event, it is closely related to the schematic in that it relates the tubes as shown on the schematic to their physical locations on the receiver chassis. Figure 1-5 shows a typical tube location diagram as included in service information. Because most receivers contain a similar location diagram pasted on the cabinet or chassis, its importance in the service data is mainly because the *functions* of the tubes are also stated, which, of course, is very important in troubleshooting. Many troubles can be remedied immedi-

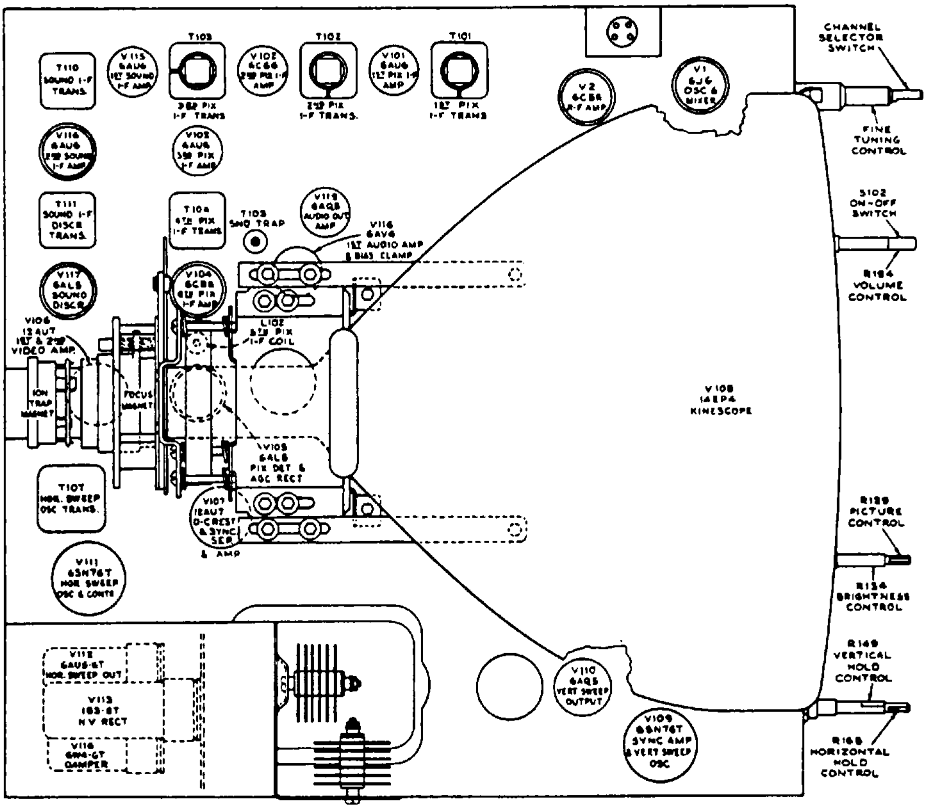



Fig. 1-5. Typical tube location diagram, as provided with the service data for many TV receivers. Note that this diagram includes additional information on the locations of the front controls, adjustments on the yoke, focus, and ion trap magnet.

*Courtesy: RCA*

ately by tube replacement, once the function of each tube is known, because the indications on the screen of the picture tube localize the trouble to a section of only two or three tubes. For example, a single horizontal line on the screen indicates lack of vertical deflection and localizes trouble to the vertical deflection section. A glance at the tube location diagram of the type of shown in Fig. 1-5 tells which two of the tubes are the vertical oscillator and vertical sweep output tubes. Replacement of these tubes one by one indicates whether tube troubles are the cause.

## 1-5. Tube Socket Connection Numbers

Tube sockets have a standard numbering system which identifies each connecting lug on a given type of socket with a number. Examples of this numbering system are shown in Fig. 1-6. This numbering system helps considerably in service work by reducing the confusion in referring to socket connections. Most schematic diagrams designed for service work

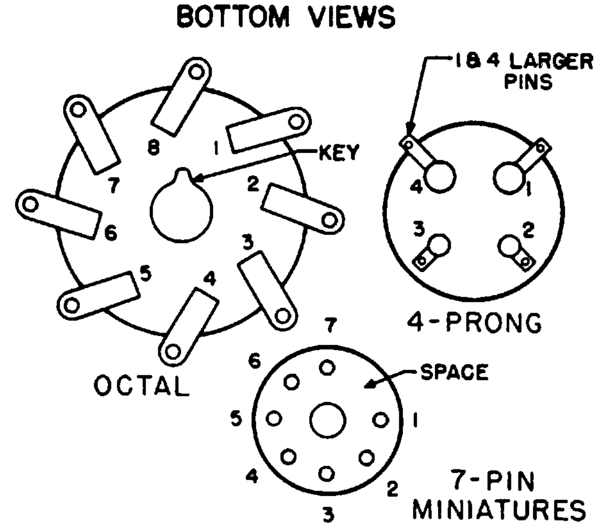



Fig. 1-6. Some of the commonly used types of tube sockets, showing the physical arrrangement of the contacts and connecting lugs from a *bottom view*, and showing how these contacts are numbered for reference to the schematic diagram.

*Courtesy: Sylvania*

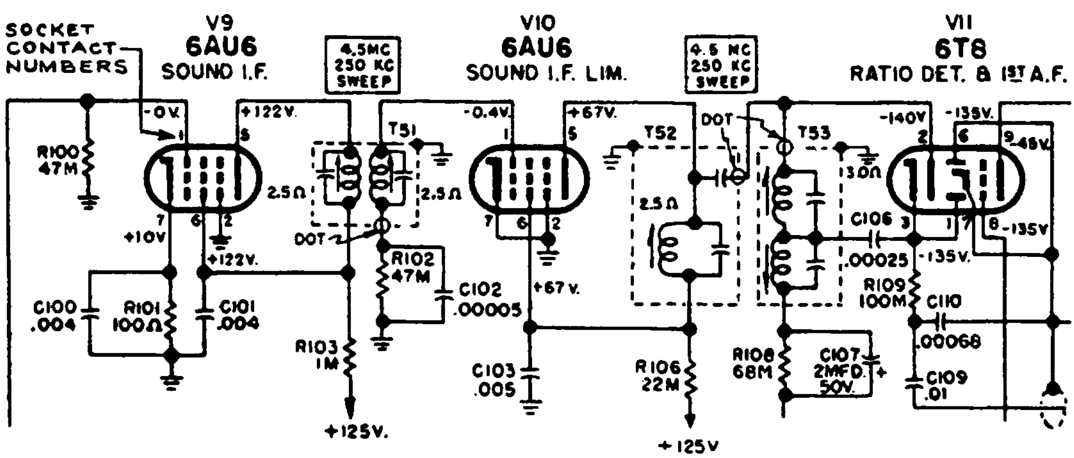



Fig. 1-7. Portion of a TV schematic, showing how the pin numbers of the tubes are indicated on the symbols of the tubes.

*Courtesy: Sylvania*

include the pin numbers right alongside the tube symbols, as shown in Fig. 1-7. By use of the reference numbers, the connections in the receiver can thus be correlated immediately with the connections indicated on the schematic diagram.

## 1-6. Controls

Complete service information usually includes a diagram indicating the location of each control on both the front and the back of the receiver. A typical diagram is shown in Fig. 1-8. Of course, the controls on the front of the receiver are usually labeled on the front panel, but sometimes the back controls are not labeled or are labeled indistinctly,

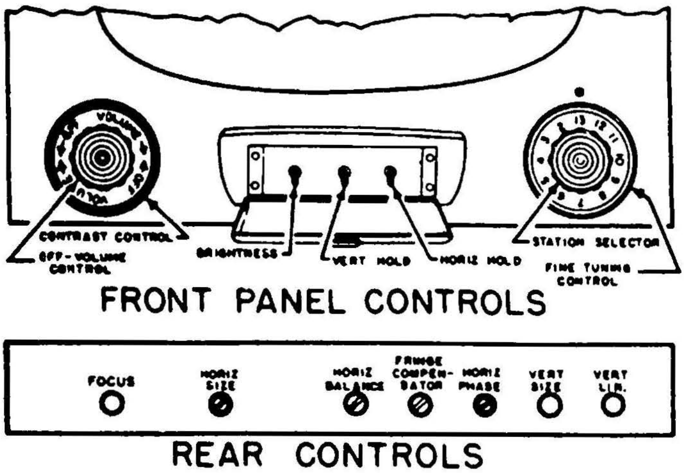


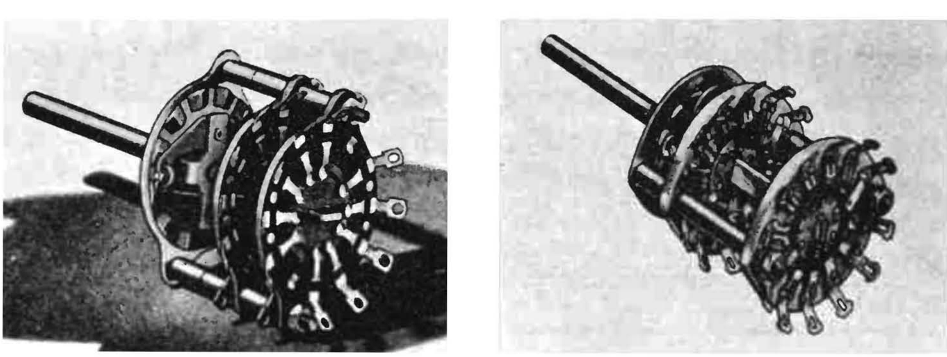

Fig. 1-8. Typical control location diagram.

*Courtesy: Emerson*

making the control location diagram useful when the adjustments described in Chapter 6 are made.

## 1-7. Switches

For channel switching and other purposes, multiposition, multicontact switches of the wafer type are generally used. A typical wafer switch is shown in Fig. 1-9. Examples of how these switches may be shown in schematic diagrams are given in Fig. 1-10. There is nearly always a note on the diagram stating how the switch is drawn, especially whether from a front view or from a rear view. In Fig. 1-10 (A), the note states that switch S1 is drawn as viewed from the *front*. The wafers are designated S1A, S1B, S1C, etc., beginning with the wafer nearest the knob of the switch. Each wafer has contacts on both the front and the back, and usually both the front and the back of each wafer are used



(A) (B)

Fig. 1-9. Typical multisection wafer switch, such as is used in TV receivers for channel selection.

*Courtesy: Mallory*

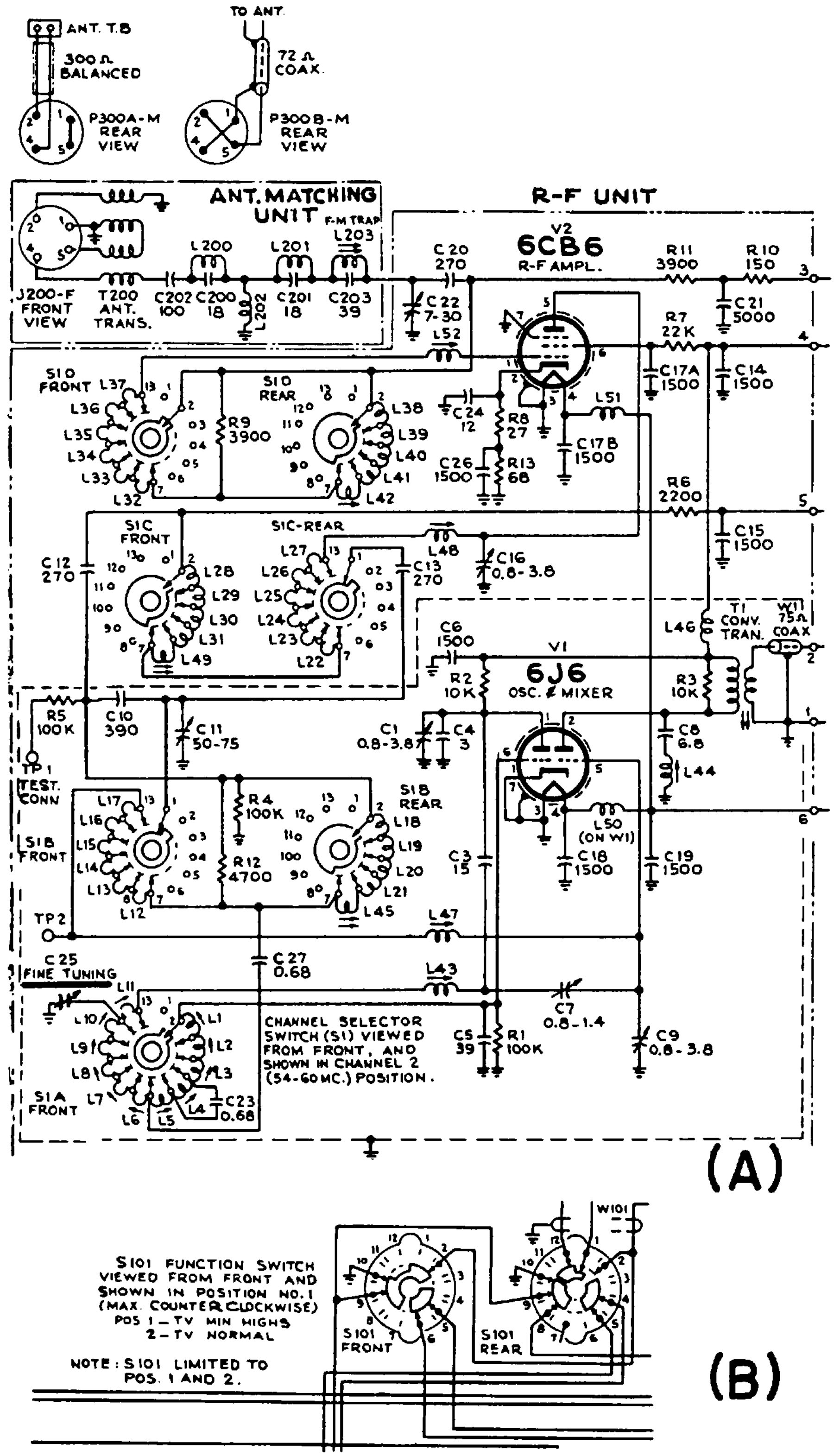



**Fig. 1-10. How wafer-type switches and their connections are shown on service schematic diagrams.**

*Courtesy: RCA*

for a separate circuit. There is, therefore, a separate schematic diagram for the front and for the back of each wafer, when both front and back are used. The diagram shows the contacts in the same relative position as they actually occur around the wafer. Since in this case each wafer is drawn as viewed from the *front,* the rear of each wafer is shown as though the viewer were looking *through* the wafer at the back contacts. Thus contact 1 on the front is also contact 1 on the rear, and the same with the other contacts. Most of these switches are so constructed that contacts in the same position front and rear cannot be insulated from each other. Note that in the example of Fig. 1-10 (A) the contacts used on the front of each wafer are left blank (unconnected) on the rear, except for wafer S1A, of which only one side is used. Sometimes switches are connected so that the connections on each side of the wafer are staggered, so that only alternate contacts are used. Then only six positions may be used instead of 13, and the switch rotates two contact spaces for each position, rather than one.

One contact on each side of the wafers is equivalent to the *moving* contact. It is made a little longer than the other contacts, so that it always makes connection with the metal in the center piece, or rotor, of the wafer. The metal in the wafer rotor then has a small extension which touches one of the other contacts, which one depending on the position of the rotor. The switch thus effectively connects the long contact successively to each of the other contacts as the rotor is turned. All the rotors in the different wafers of the switch are ganged together by means of a shaft which passes through a slot in each rotor. The rotation of the shaft is controlled by a mechanism in the front of the switch, called a *detent,* which allows rotation only in steps. Each step corresponds to the proper alignment of another pair of contacts.

Note that the rotor in the front of wafers S1B, S1C, and S1D has a different shape from that in the rear. On one side, the arrangement is such that the contacts are successively shorted together as the switch shaft is rotated. Thus, in the position shown (for channel 2), all the coil sections are in the circuit. As the switch is rotated, and as more and more sections are shorted, there is less and less inductance in the circuit, as is desired for the higher frequency channels. The fact that the unused sections are all shorted together prevents them from interfering with the used sections by mutual inductance effects.

Figure 1-10 (B) shows another way in which wafers are sometimes shown. The wafers are drawn with their physical outline, although the idea of presentation is exactly the same as in (A).

## 1-8. Wiring Color Codes

Use of a color code for wiring the leads of certain components of a receiver helps the service technician in tracing trouble. In many cases the colors used are indicated right on the schematic diagram. An example is shown in Fig. 1-11. This diagram follows the standard RTMA (Radio and Television Manufacturers' Association) color code, which is almost universally used for power transformers and i-f transformers. It is also frequently employed for loudspeaker connecting leads. For the convenience of the reader, these three color codes are reproduced in Fig. 1-12.

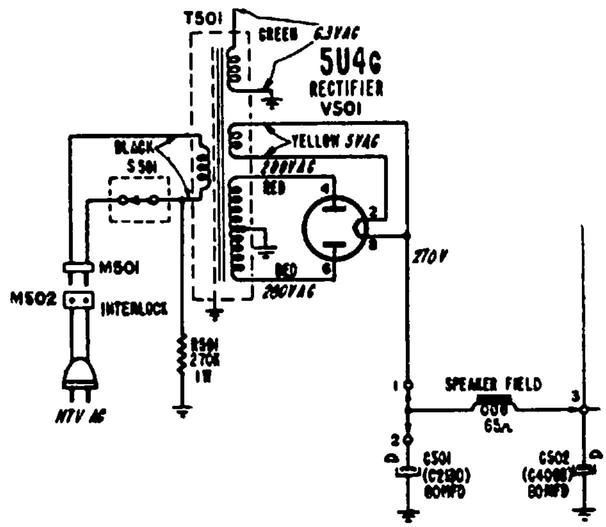



Fig. 1-11. Use of RTMA color code as indicated by the labels showing the colors of the wires coming from the power transformer.

*Courtesy: Admiral*

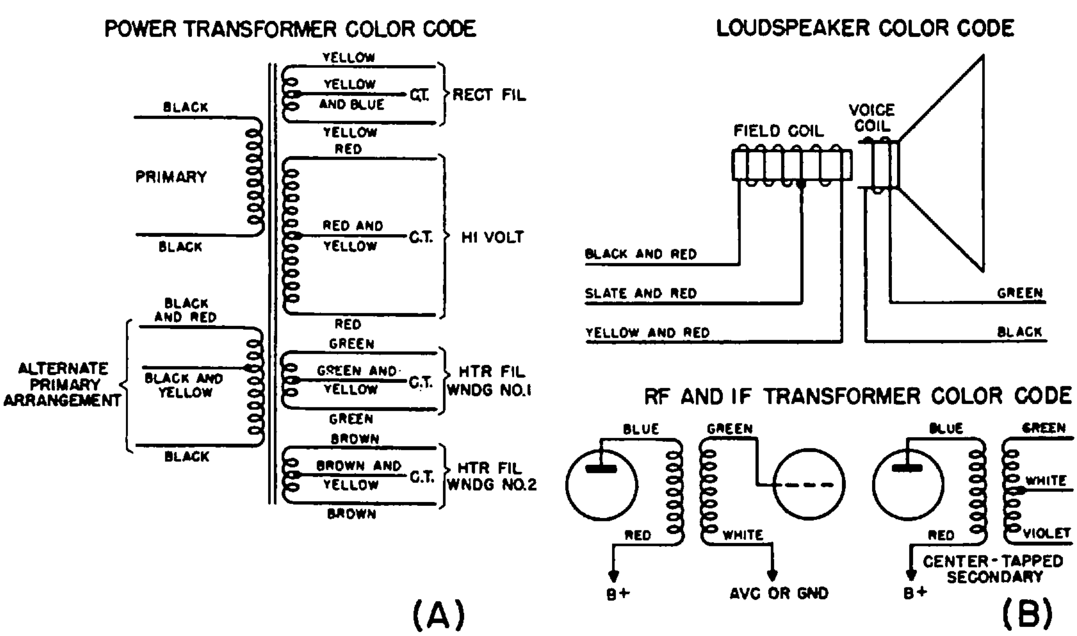



Fig. 1-12. RTMA color codes for wiring of power transformers, i-f transformers, and loudspeakers.

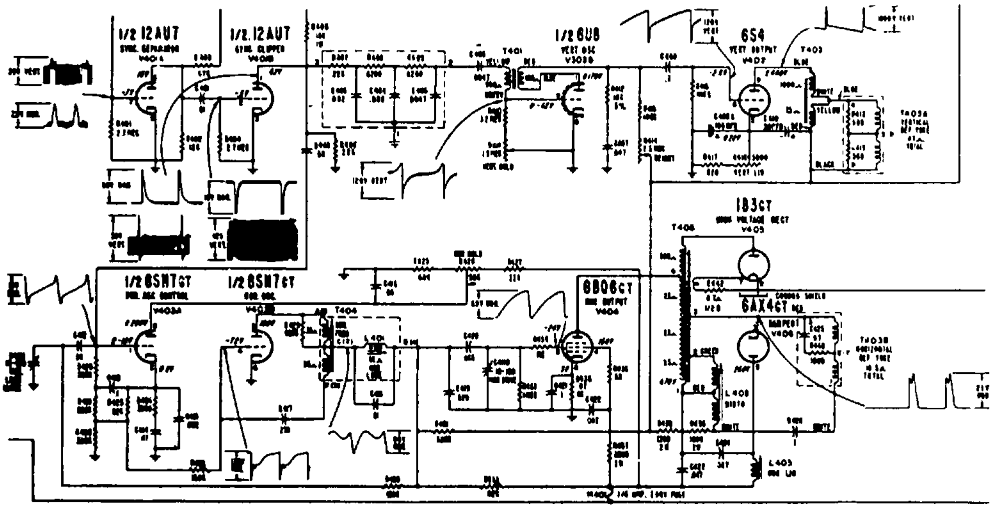



Fig. 1-13. How the waveforms of the voltages at various test points in a receiver circuit are sometimes placed right on a schematic diagram for convenience in oscilloscope testing.

*Courtesy: Admiral*

## 1-9. Waveforms

Many TV service schematic diagrams now include representation of the waveform of the voltage at each of a number of strategic points in the circuit. This information is provided to give the technician using an oscilloscope an idea of what type of waveform is to be expected at each of the points. An example of such a diagram is given in Fig. 1-13. Deviations from the proper waveform can then be noted and traced. In addition, the P-P (peak-to-peak) value of the voltage usually accompanies the waveform illustration, and is used as a reference when the amplitude is measured on the oscilloscope screen.

## 1-10. Heater Connections

With the advent of transformerless power supplies in TV receivers, a large variety of heater connection circuits came into use. To minimize

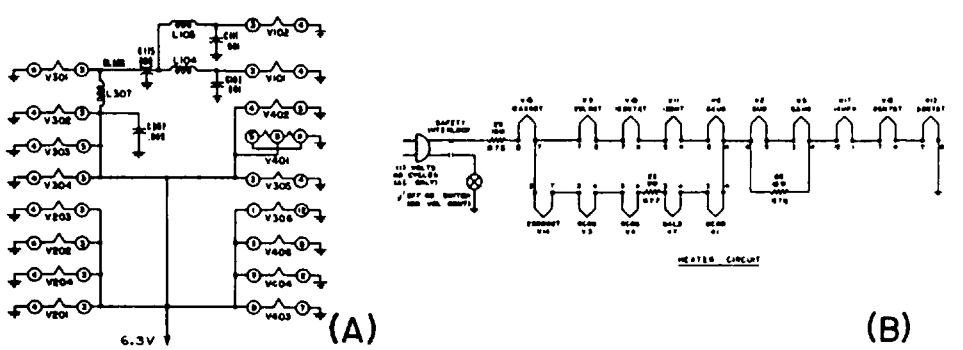



Fig. 1-14. Typical heater circuit diagrams for TV receivers.

*(A) Courtesy: Admiral*
*(B) Courtesy: Motorola*

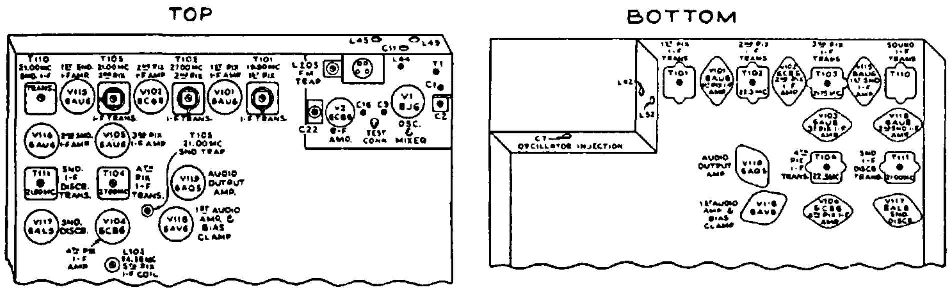



Fig. 1-15. Typical adjustment location diagrams.

confusion on this score, a separate diagram of the heater circuit is frequently included with the main schematic diagram. Examples of a conventional parallel-heater circuit and of a series-heater arrangement typical of transformerless receivers are given in Fig. 1-14. Heaters of many of the "12" series of tubes, such as the 12AT7, 12AU7, etc., can be operated on either 6.3 or 12.6 volts. The heater is composed of two elements in series, tapped at the center, each rated at 6.3 volts. For 6-volt operation, the two end leads are connected together and 6.3 volts applied between these joined ends and the center tap.

## 1-11. Adjustment Location Diagrams and Circuit Description

For many service jobs, the technician must know where the various adjustments for alignment and other purposes are located. A complete set of servicing data includes a comprehensive diagram showing the location of each adjustment and what it is for. Since certain adjustments are ordinarily located on top of the chassis and others are found under the chassis, two diagrams are usually needed to give complete information.

Figure 1-15 shows a typical adjustment location diagram for a TV receiver, including separate top and bottom views of the chassis. In addition to top and bottom adjustments, there are also some at the back, and these are indicated by drawing the chassis slightly isometric for the top view, with the back adjustments shown at the top.

Complete service information usually includes a brief description of the receiver circuit and how it works. It may seem that reading through this information would not be helpful in servicing. However, the special factors brought out in these descriptions often give a clue to a trouble and save much time. Some circuits have special characteristics of operation which make them susceptible to certain kinds of troubles. If the technician reads this information and has it in mind when troubleshooting the receiver, he can recognize such special troubles.

*Chapter 2*

# TV RECEIVER SECTIONS

## 2-1. Purpose of Division into Sections

For successful servicing of TV receivers, the technician must, at least mentally, divide the receiver into definite sections and have a clear idea of the function and trouble indications of each. The reason for this is that each section or functional part of a receiver must normally produce certain results. If results are not proper, the nature of the trouble will nearly always point to the section in which trouble exists. For example, if there is no sound but the picture is normal, trouble must exist in the path of the sound signal through the receiver. But if the picture is also faulty, those parts of the receiver which are common to both sound and picture paths should immediately be suspected. In later chapters we shall consider how the various sections operate together to produce different combinations of troubles, and how we recognize these combinations. First, however, we should discuss what the sections are and how each functions.

We are not interested here in any purely theoretical discussion of receiver design or operation. Many service technicians are very successful with but a meager formal educational background; however, they must have a keen sense of cause and effect. This can be obtained only through a complete understanding of the receiver sections and how each can go wrong. Therefore, in this chapter we review the basic structure of a TV receiver from the standpoint of the practical service technician.

## 2-2. Split-sound vs. Intercarrier Receivers

Fortunately for the service technician, all TV receivers made in the United States are remarkably similar. There is only one difference which divides them into two types: the intercarrier and the split-sound (conventional). This difference is a rather minor one, but it has definite implications in servicing, which are important.

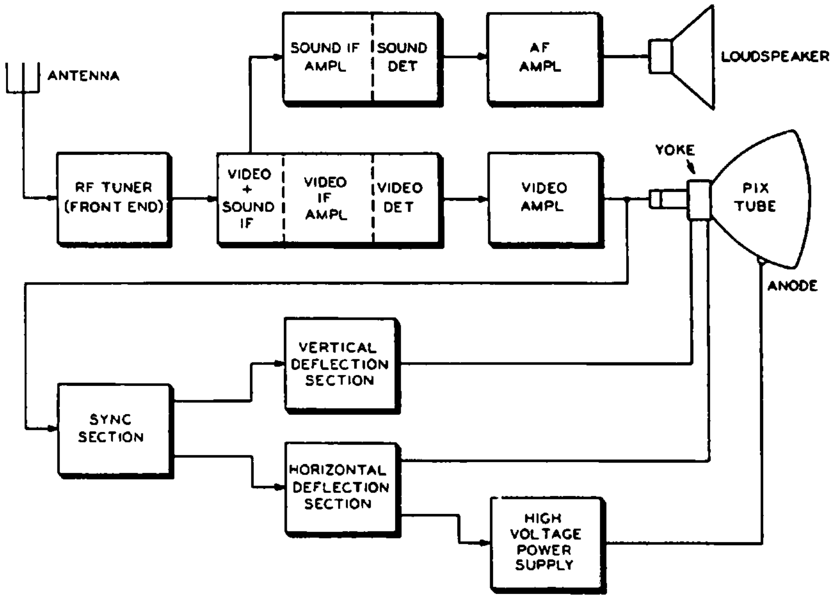



Fig. 2-1. Block diagram of split-sound TV receiver, showing division into sections appropriate for troubleshooting indications.

A block diagram of the split-sound type receiver is shown in Fig. 2-1. It is distinguished from the intercarrier type in that there are two complete *high-frequency* i-f amplifier sections, and the video i-f amplifier is designed to pass only the viedo i-f signal. Both i-f signals are the result of heterodyning the received signals with the local oscillator signal in the mixer.

Now consider the intercarrier type, whose block diagram is illustrated in Fig. 2-2. Note the following important differences:

1. There is only one *high frequency* i-f amplifier section, and this must pass both the high-frequency video i-f signal and the high-fre-

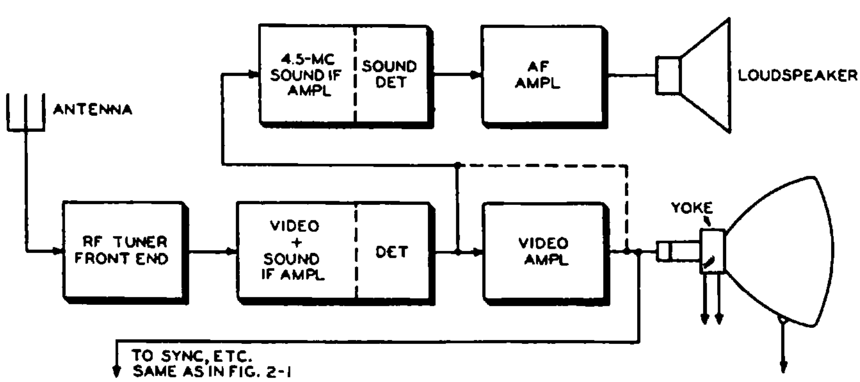



Fig. 2-2. Block diagram of intercarrier type of receiver, with division into troubleshooting sections.

quency sound i-f signal. Both these signals are passed through the same i-f amplifier and are applied to the detector, where they heterodyne to produce a difference beat of 4.5 mc, which is the final sound i-f signal. The sound i-f signal of 4.5 mc is then amplified and demodulated in a separate section.

2. Since the high frequency i-f amplifier must pass both sound and video signals, its response curve must be different from that of the i-f amplifiers used in split-sound receivers. It must be broad enough to pass both signals. At the same time, it must have the proper shape to receive the video carrier at the 50 percent response point and to maintain a desired ratio between the amplitudes of the sound and video signals.[1] The details of how this is accomplished are not important here, but it is well to remember these differences, since different trouble indications can arise in the two types.

## 2-3. The Antenna System

Although the antenna is not physically a part of the TV receiver, the operation of the TV receiver is so dependent upon it that it is just as important as the a-c power which operates the receiver. As far as *troubleshooting* is concerned, the antenna ranks just as high as any other part of the chain through which the received signal must pass. A good installation job will have provided the type of antenna and feed line required for proper operation. However, the thorough service technician does not take this for granted, but will check the antenna system carefully.

A wide variety of antennas is in use. Each type has its own group of enthusiastic supporters. Because the variables involved in checking antenna performance are many and complicated, there is no way to determine which type, if any, is superior to the others. However, certain designs, such as the conical and the double-V types, have gained wide acceptance. For fringe areas, where signals are quite weak, *Yagi* antennas, suitable for one, two, or three channels only, may be the best.

Although the wide acceptance of a type of antenna by dependable installation and service men is a definite indication of its value, the technician himself will develop a preference, resulting from his own experience and from the requirements of his particular area. This is really the only satisfactory way to make a final choice.

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[1] The sound-signal amplitude must be kept to a fraction of the video-signal amplitude. Only then can amplitude-modulation of the video signal be satisfactorily removed from the resulting 4.5-mc heterodyne fed to the sound section.

Just as important as the antenna itself is the lead-in (transmission line) and its connections. Most antennas are now used with a 300-ohm lead-in of the ribbon type, and the receivers are designed for this. Some antenna manufacturers specify that coaxial transmission lines are also satisfactory for their antennas, or for certain models. It must be kept in mind that the impedance of the transmission line should be matched at both the antenna and the receiver.

Since the antenna is the agency through which the received signal is applied to the receiver, trouble in the antenna or lead-in shows up as trouble in the *received signal.* Weak signals may be caused by improper orientation, inadequate antenna gain, or poor location. Intermittent operation may result from loose connections from antenna to lead-in, from lead-in to receiver, or between parts of a multisection antenna. Interference may dictate that coaxial lead-in be used.

## 2-4. The RF Tuner

The tuner section (front end) includes the r-f amplifier, mixer, and oscillator circuits. The impedance of its input circuit is matched to the impedance of the antenna lead-in (usually 300 ohms). Its output is coupled through the first i-f transformer into the i-f amplifier (s). Unless the receiver is one of a few of the intercarrier types, the local oscillator operates *higher* in frequency than the incoming signals; because of this, the video r-f carrier, which is *lower* in frequency than the sound r-f carrier, produces a video i-f (beat) signal of *higher* frequency than the sound i-f signal. In a few intercarrier receivers, the oscillator operates at a higher frequency than the received signals in the low vhf channels (2 through 6) and at a lower frequency than the received signals for the higher vhf channels (7 through 13).

Most modern tuner sections include i-f traps and some kind of high-pass filter to minimize receiver-generated harmonics of lower frequency stations. Also in the tuner section are the channel selector switch (or turret or continuous-coverage tuner) and the fine-tuning control, either of which is often the cause of troubles. Trouble with the channel selector shows up rather easily, since it usually becomes apparent with manipulation of the channel selector knob. Most frequent trouble with the fine-tuning control is failure to bring in sound or to bring a proper picture within the range of the control This is due to a change in oscillator tuning range due to aging, humidity, temperature, etc., and is corrected by tuner trimmer adjustment. Such adjustments are sometimes available through the front of the tuner or underneath the tuner through the cabinet. In other cases, the chassis must be removed from the cabinet.

The tuner section receives signals from the antenna lead-in and then supplies the i-f amplifier (s) with signal. Thus, if the tuner section is not functioning properly, signals will not be properly supplied to the i-f amplifiers and the picture and sound will be weak, distorted, or not present at all. Note that, since both picture and sound signals must come through this section, troubles will affect *both* picture and sound. Hence we know that, with proper trimmer adjustment, trouble having to do only with the picture or only with the sound cannot be in the tuner, since the tuner must handle both. However, it must be remembered that, in cases of weak signal, there is usually more sound signal to spare as compared with picture signal. Due to limiting action in the sound circuit, a weakness of the sound signal may not be noticed, whereas a similar weakness of the picture signal will show up immediately. In addition, since the eye is so much more sensitive than the ear, slight distortions of the sound will pass unnoticed, while slight distortions of the picture will be immediately apparent. If these possibilities are taken into account, it can be safely said that tuner troubles will always affect *both* picture and sound.

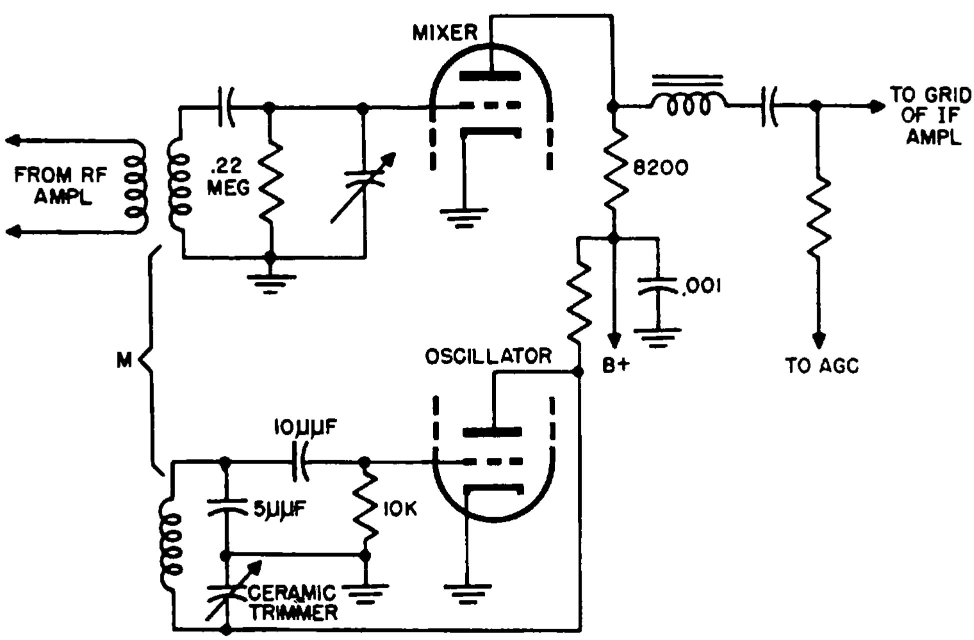



Fig. 2-3. Typical dual-triode mixer-oscillator circuit.

Since the tuner is the section through which most types of interference enter the TV receiver, it is there that filters and traps must be used to eliminate it when such elimination is possible.

The r-f amplifier may be a conventional, grounded-cathode pentode circuit or a grounded-grid triode circuit. Many of the later models employ the "cascode" circuit, in which one section of a dual triode is a grounded-cathode stage and the other section is direct-coupled as a grounded-grid amplifier.

The oscillator and mixer are most frequently the two sections of a dual triode, such as the 6J6 or 6U8. A typical mixer-oscillator circuit is shown in Fig. 2-3, and typical r-f amplifier circuits in Fig. 2-4. These

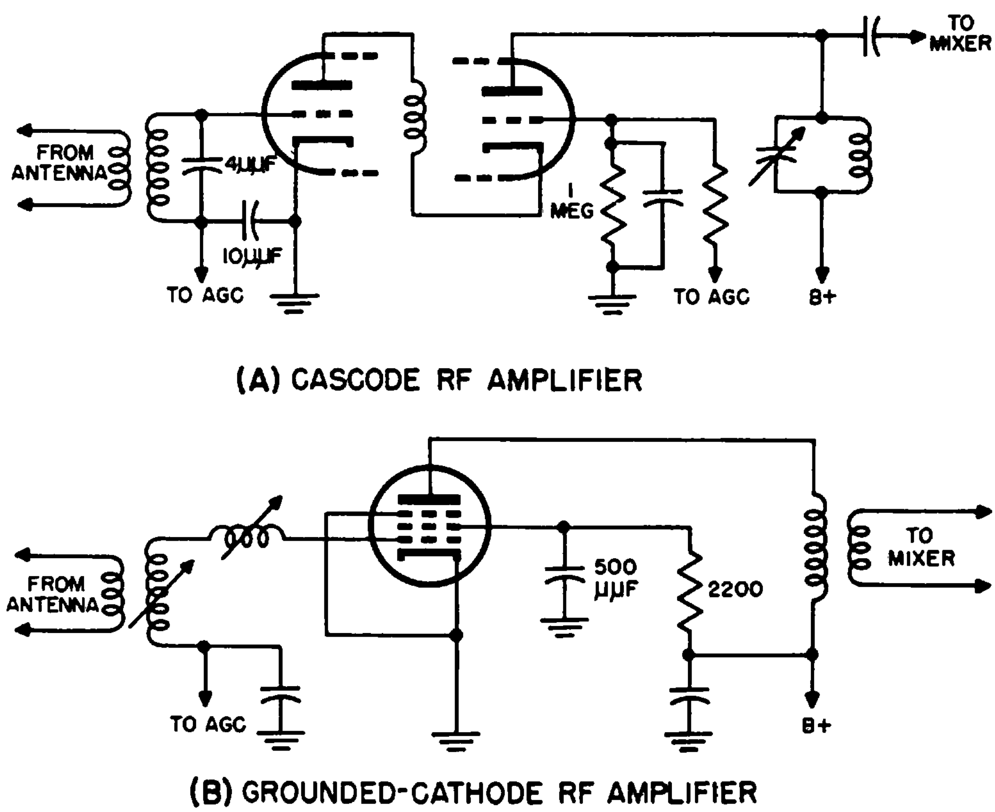



Fig. 2-4. Typical r-f amplifiers used in TV receivers.

circuits are simplified, with the channel switching arrangement eliminated to show the basic circuit. However, the channel switching system is a common source of trouble, and is discussed in Chapter 6. Further information about tubes used in tuner sections is included in Chapter 7.

## 2-5. Video IF and Detector Sections

The exact function of the video i-f amplifier differs slightly in the split-sound and intercarrier types of receivers. In the split-sound receiver the video i-f amplifier(s) amplifies only the video i-f signal and *rejects* the sound i-f signal. When we say this, of course, we are talking about the amplifier section as a whole. Actually, in many split-sound receivers, the first one or two video i-f amplifiers stages handle both sound and picture i-f signals. Then the sound signal is taken off and fed to the sound i-f amplifier section. The remaining video i-f amplifiers then amplify only the picture i-f signals.

On the other hand, in intercarrier receivers the whole video i-f amplifier amplifies both sound and picture i-f signals, and the sound i-f channel (4.5 mc) is tapped off in the video detector or video amplifier stages.

The point where the sound and picture i-f signals are separated is very important in troubleshooting, because certain indications of troubles will point to defects in either the sound signal path alone or the video path alone. Hence, it is important to know where these two paths divide.

Figure 2-5 shows different points at which the sound i-f signal may be tapped off in different receivers for (A) the split-sound type, and (B) the intercarrier type. In split-sound receivers, this point may be either at the output circuit of the mixer or at the output circuit of the first or second video i-f amplifier. Obviously, when there are any video i-f stages *before* the point where the sound i-f signal is taken off, these stages

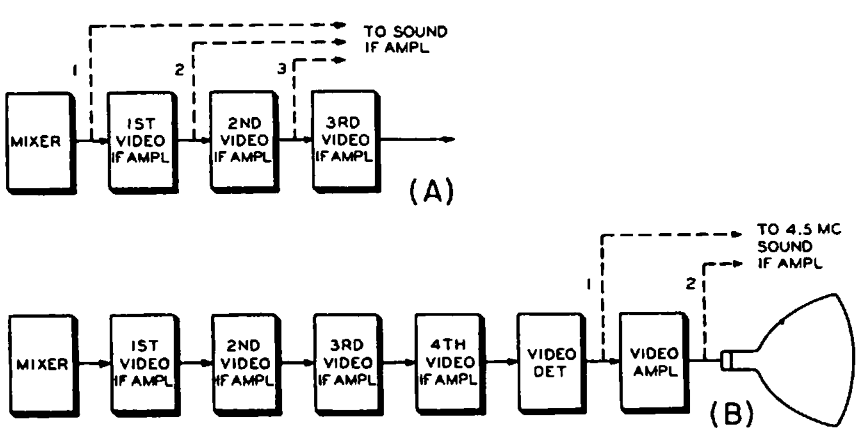



Fig. 2-5. Points at which the sound i-f signal is tapped off in the two main types of receivers: (A) split-sound, and (B) intercarrier. In a given receiver, the tap-off point may be any one of those shown in dotted lines. Where this juncture is found in a serviced receiver is important in determining the source of trouble.

must have a very different response characteristic from those of the remaining video i-f stages, since they must pass both video and sound i-f signals. In intercarrier receivers (B) the sound i-f signal of 4.5 mc cannot be taken off before the video detector, since it is in the latter that the mixing to produce a 4.5-mc carrier is accomplished. Frequently, the sound i-f signal of 4.5 mc is tapped from the output circuit of the video detector; sometimes, it is obtained from the output circuit of the video amplifier stage.

It should be noted that there can be extreme differences in troubleshooting indications, due to the differences in sound i-f take-off point in the two types of receivers. For example, in a split-sound receiver with the sound i-f taken from the mixer, none of the video i-f stages are in the sound path; if there is trouble in the sound reception and not in the picture, all video i-f amplifier stages are eliminated as possibilities of trouble source. On the other hand, in an intercarrier receiver in which the sound i-f is taken from the video amplifier output, the whole video i-f amplifier is included in the sound signal path and trouble in it could affect the sound. Actually, troubles in the video i-f amplifier which affect sound will also affect the picture in nearly all cases.

In intercarrier receivers in which the sound i-f signal (4.5 mc) is taken from the video amplifier output circuit, there is another factor of design which may, in some cases, be important in servicing. That is the fact that the video amplifier must have a response broad enough to include 4.5 mc, so the sound i-f signal of 4.5 mc will pass through it.

Two different methods have been used in video i-f amplifiers to provide the broadening and shaping required of the response characteristic. In one method, all tuned circuits (except, of course, traps) are resonated to the same center frequency; each circuit is response-broadened by resistance-loading and/or overcoupling so that the over-all response meets the required specifications. Much more frequently, the circuits are *stagger-tuned.* That is, each resonant circuit is tuned to a different frequency in the pass band; the individual resonant frequencies are chosen in such a way that their composite effect is to produce the desired over-all video i-f response.

In modern receivers the intercarrier system and the stagger-tuned method predominate, although many split-sound receivers are in use, and a few of them may have resistance-loading and overcoupling.

Thus, it is always important to determine whether a receiver is of the intercarrier type, and at what point the sound i-f signal is tapped off.

## 2-6. Video Amplifier Section

The video amplifier has the same general purpose as the a-f amplifier in a radio receiver or the sound section of a TV receiver. It takes the output from the detector, which is the video signal, and amplifies it for application to the picture-tube grid. Either one or two stages are used. As previously mentioned, in intercarrier receivers the video amplifier section must have a response wide enough to pass all the video components (0-4 mc), and also the 4.5-mc sound i-f signal, when the sound i-f signal is tapped off *after* the video amplifier.

For picture troubles, the indications of video amplifier troubles are generally similar to those in the video i-f amplifier. There may be low gain, giving a flat, weak picture; there may be complete lack of picture; or there may be fuzziness and loss of high- or low-frequency response due to failure in compensating and peaking circuits. In distinguishing between trouble in the video i-f amplifier and in the video amplifier, it may be necessary to feed in a test signal at the video detector, as will be explained in a later chapter.

If the 4.5-mc i-f signal of an intercarrier receiver is tapped off *after* the video amplifier stage (or stages), then the video amplifier is part of

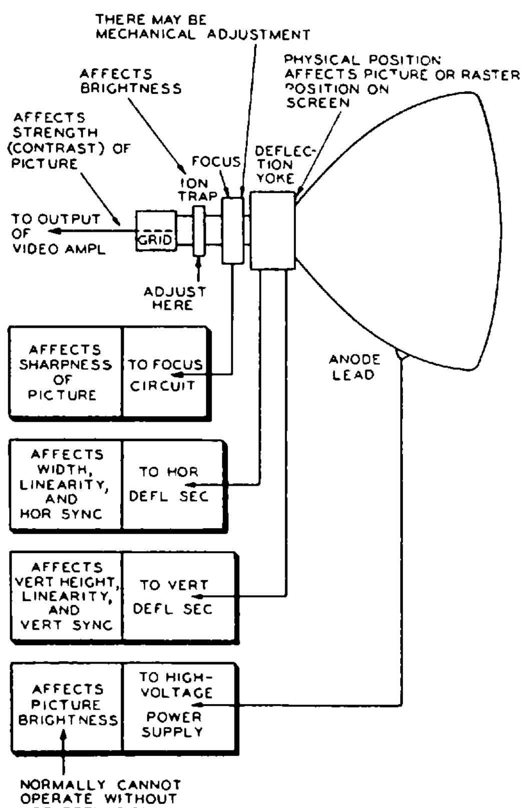



**Fig. 2-6. Block diagram showing the source of each indication on the picture-tube screen.**

both the sound and the picture paths, and can affect either or both. If the tap-off point is *before* the video amplifier, then trouble in the video amplifier will affect only the picture.

## 2-7. The Picture Tube

As far as troubleshooting is concerned, the picture tube (kinescope) is the indicating agency for the picture signal path. It is the end of the video signal path which starts at the antenna and threads through the tuner, video i-f amplifier, video detector, and video amplifier sections. But the picture tube gives trouble indications not only for the video sections, but, by the appearance of its raster and how it holds a picture, it also shows troubles in the sync and deflection circuits, and helps locate high-voltage supply troubles. The picture-tube screen is therefore the first thing to examine in determining the nature and source of trouble.

A wide variety of troubles can be localized by a glance at the picture-tube screen, as will be discussed further in a later chapter. Figure 2-6 summarizes the trouble sources indicated by the picture-tube screen. How these indications are recognized and analyzed to determine the exact sources of trouble are considered in greater detail in Chapters 6, 8, and 9.

## 2-8. Deflection Circuits

Two deflection circuits are used, one for horizontal sweep of the electron beam, and the other for vertical sweep. Each deflection circuit contains an oscillator to generate the sweep signal, and one or more amplifier stages to amplify and shape the waveform for proper deflection of the C-R tube beam. The output from each sweep section is fed to deflection coils in the yoke mounted on the neck of the picture tube. The deflection currents in these coils set up magnetic fields which cause bending of the electron beam in the picture tube as desired, to produce a raster.

Trouble indications from these circuits are rather direct. The horizontal deflection circuit sweeps the C-R tube beam horizontally; thus, failure to obtain proper horizontal sweep can be traced to the horizontal deflection circuit. Similarly, vertical deflection circuit troubles result in failure of vertical sweep action. If the horizontal sweep circuits are operating properly, and the vertical sweep circuits are not operating at all, the picture tube will simply show a horizontal line. Similarly, if the vertical deflection circuit is working but not the horizontal circuit, there may be only a vertical line on the picture-tube screen. However, this last case is seldom met with, because the high voltage in practically all modern TV receivers is obtained from the horizontal deflection output. If the horizontal sweep voltage is interrupted, the high voltage is also interrupted and there is no brightness to provide any kind of pattern on the screen.

Horizontal and vertical deflection circuits may also affect the *linearity* of the vertical or horizontal sweep, so that the picture is either squeezed together or pulled apart on one side or at the top or bottom of the picture.

## 2-9. Sync Circuits

We have previously discussed how the currents necessary for vertical and horizontal deflection of the picture-tube beam are generated, amplified, and shaped in the deflection circuits. These currents must not only be present, but must also be synchronized with the incoming signal pulses. The link between the deflection circuits and the received video signal is the sync section. As shown in Fig. 2-7, the sync section is

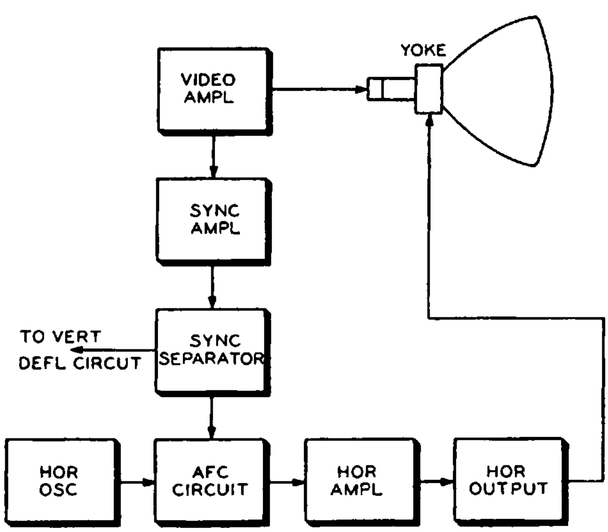



Fig. 2-7. Block diagram showing the horizontal sync section and how it is related to other parts of the circuit.

composed ordinarily of three parts: a sync amplifier, a sync separator, and an automatic frequency control circuit. The sync amplifier gives further amplification to the video signal tapped off the video amplifier for sync purposes. Sometimes no sync amplifier is used. Then the amplified signal is applied to a sync separator, which is a *clipper*. It is biased below cut-off so that only the peak portion of the video signal, containing the sync pulses, is passed. The pulses thus separated are then coupled to a synchronizing circuit, which controls the frequency of the vertical and horizontal oscillators. To control the vertical oscillator, the sync pulses are generally used directly, being applied to the grid of a blocking oscillator that generates the vertical signal. The horizontal oscillator is controlled through a AFC arrangement, which keeps the horizontal oscillator frequency synchronized with the *average* sync pulse frequency and phase, rather than with each pulse. This is necessary to prevent interference to synchronization from random impulses such as ignition noise.

Early horizontal AFC circuits employed a sine-wave oscillator that generated the horizontal deflection signal, which was amplified and shaped into the desired saw-tooth waveform. The frequency of the sine-wave oscillator was controlled by a reactance tube which obtained its control voltage from a discriminator into which both the sync pulses and the output of the oscillator were fed. This method is still used in some of the later receiver models.

In other receivers, the *pulse-width* method is used. A small part of the output voltage from the horizontal output circuit and the sync

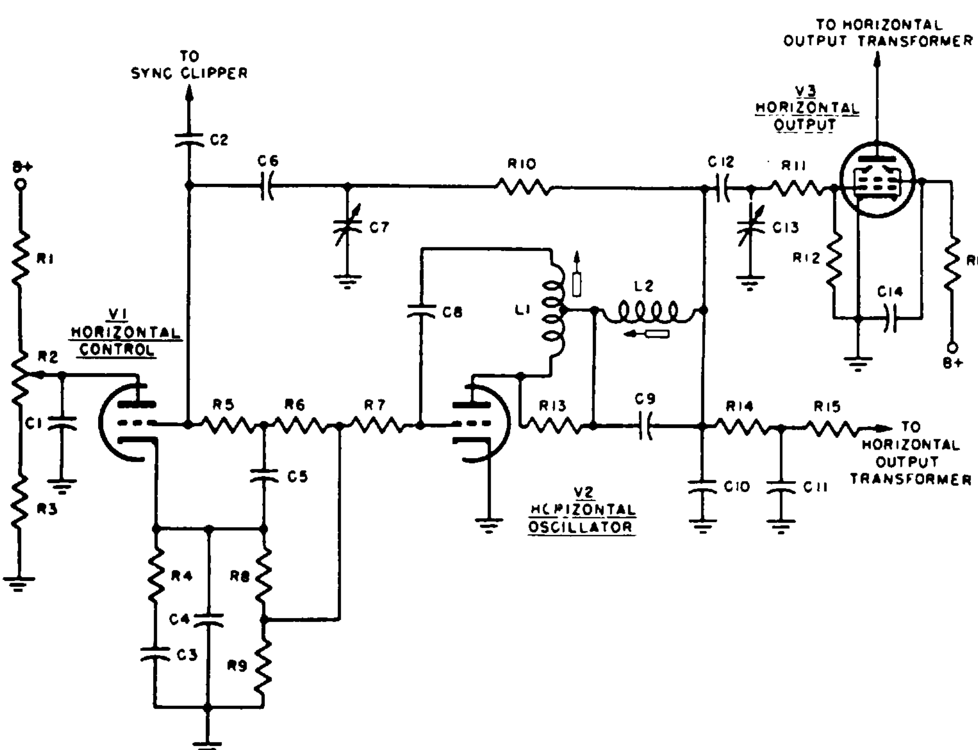



Fig. 2-8. Typical pulse-width horizontal AFC circuit.

pulses from the separator are simultaneously fed to the grid of the control tube. The duration of the pulses of resulting plate current is inversely proportional to the degree of synchronization. In other words, if the two signals are exactly synchronized, the pulses of each occur at the same time and the plate current pulses are shortest. Since the tube is biased for clipping the pulses to a constant level, the plate current is the lowest when the signals are synchronized. A dropping resistor in the plate circuit is used to obtain a voltage proportional to the plate current. This voltage is applied to the grid of a blocking oscillator, which generates the horizontal deflection signal. A typical pulse-width AFC circuit is shown in Fig. 2-8.

The sync section is an important link in the chain of troubleshooting indications. It is important to remember that this section does not *generate* the deflection signals, but merely synchronizes the already generated deflection voltages to the received sync pulses. For this reason, sync section trouble is indicated when the raster is normal but the vertical, horizontal, or both vertical and horizontal sync will not hold for a received signal.

Function of the sync section can be checked by attempting to adjust the hold controls for sync. If the hold control brings the picture into sync, and if it then *stays* in sync, the trouble results from oscillator drift. However, if the hold control permits the deflection circuit to synchronize momentarily, but the picture is unstable and keeps going out of sync, then trouble in the sync section is indicated. Another case is that in which the hold controls (both fine and coarse) are adjusted throughout their range but do not reach any point at which the picture is synchronized. This indicates that the oscillator frequency will not adjust to the desired deflection frequency. In this event, the deflection circuit is defective. On the other hand, if the deflection oscillator will adjust to sync frequency but not hold it, then trouble in the sync section is indicated.

Failure to hold sync may, in some cases, be due to external causes. One common case of this is *low line voltage.* The sync locking circuits are designed to operate within certain limits of plate and heater voltages, and they are often very sensitive to low power-line voltage. Sometimes a drop of 10 percent or less in line voltage will cause serious loss of sync. Thus, before we conclude that there is trouble in the sync circuit, we should check line voltage. A small Variac or line booster transformer can be carried in the service truck for such a contingency.

Another cause of loss of sync, independent of the sync section itself, is weak sync signal in the video amplifier. This can be caused by any circuit in the video signal path, or by insufficient signal from the antenna.

## 2-10. High-voltage Power Supply

A high-voltage power supply is required to provide from 4 to 20 kilovolts for the anode of the picture tube. The higher voltages are necessary for the larger picture tubes. All modern receivers now use what is known as the *fly-back,* or *kick-back,* power supply, illustrated in Fig. 2-9. The primary winding of the horizontal output transformer is designed as an autotransformer, which steps up the peak voltages produced by a collapsing current in the yoke to still higher peak voltage. The latter is applied to a half-wave rectifier, followed by a filter section from which the high d-c voltage required for the picture-tube anode is obtained.

The brightness of the picture on the screen depends on the anode voltage, being more intense for greater voltages. (Brightness also depends upon the condition of the picture tube and the grid bias on it.) Thus when the tube screen is completely dark, failure of the high-voltage

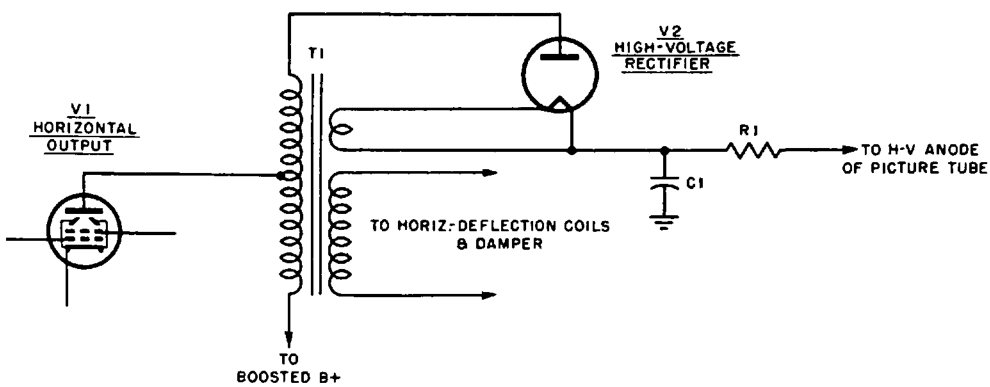



Fig. 2-9. Typical high-voltage power supply circuit.

power supply is indicated as one of the possibilities. If sound is received satisfactorily, then the trouble possibilities are narrowed to the horizontal deflection section plus the high-voltage supply. The latter cannot function without the horizontal deflection signal.

The high-voltage power supply is a high-impedance circuit, and is easily loaded by dust, other foreign matter, and moisture. This loading may lower the high-voltage output so that insufficient brightness or none at all is obtained. Such loading or leakage between high-voltage points and ground may also cause breakdown and arc discharge, especially in damp weather. This will be audible as a sharp snapping and buzzing noise. When the loading or leakage becomes severe enough to cause an appreciable current to flow to ground, the high-voltage rectifier tube may burn out.

## 2-11. Sound IF Amplifier and Detector

In split-sound receivers, the sound i-f amplifier is turned to some frequency between 20 and 45 mc. The signal for this high-frequency sound i-f amplifier is obtained from either the mixer output circuit or the output circuit of the first or second video i-f amplifier. It is then amplified, limited, and demodulated as in any FM receiver. Limiting may be provided in the detector circuit if a ratio, lock-in oscillator, or gated-beam detector is used. If a phase discriminator (Foster-Seeley) is used for demodulation, then a separate limiter stage is ordinarily provided.

In intercarrier receivers, the i-f amplifier and detector of the sound section is similar, except that the operating frequency is 4.5 mc and the signal for the amplifier is obtained from the video detector or the video amplifier.

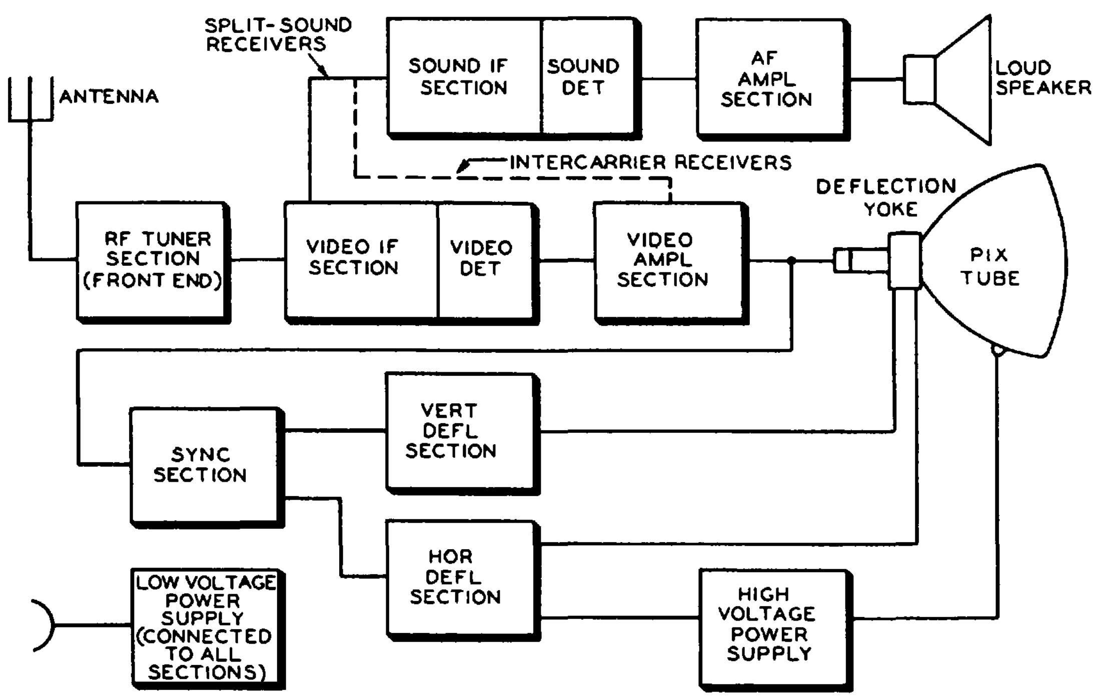



Fig. 2-10. The difference between the division points between the sound and video i-f signals for split-sound and intercarrier type receivers.

It has been pointed out previously that the point at which the sound i-f signal is tapped off is of great importance in troubleshooting indications. At this point in the circuit, the sound path leaves the video path. Thus, if there is trouble with the sound but the picture is perfectly satisfactory, then the trouble is localized only to that part of the sound path *after* the circuit point at which the sound i-f signal is tapped off. In some intercarrier receivers, the tap-off point is at the output of the video amplifier; then sound troubles which occur when the picture is normal must be only in the separate 4.5-mc sound i-f amplifier. Of course, it is possible that some trouble has reduced the pass band of the video i-f and video amplifiers so that the sound is affected but not the video, but this is unlikely and rare. Ordinarily, most troubles in common i-f and video amplifier stages affect both sound and video.

The arrangement most commonly used for split-sound and intercarrier sound i-f and detector sections is shown in Fig. 2-10.

## 2-12. AF Amplifier and Loudspeaker

The a-f amplifier and loudspeaker have the same functions in a TV receiver as in any radio receiver; namely, amplification and reproduction of the sound signal which has been separated from the sound i-f carrier in the sound detector. The a-f amplifier section almost always contains two stages, a voltage amplifier and a power amplifier. The loudspeaker is conventional and varies, for different receivers, from a 3- to 12- or 15-inch diameter, depending on the cabinet design of the receiver model.

Like the other parts of the complete sound path of the receiver, the a-f amplifier and loudspeaker must operate properly to ensure satisfactory sound reception. Many troubles with sound reception cannot immediately be localized either to the sound i-f and detector circuits or to the a-f amplifier circuits. In that case, putting the finger on the grid of either a-f amplifier tube should produce a noise in the loudspeaker if the a-f section is functioning properly.

## 2-13. Low-voltage Power Supply

The low-voltage supply must provide the heater and plate voltages for all tubes in the receiver, except for the high-voltage for the anode of the picture tube. Because there are so many tubes in a TV receiver, the low-voltage supply must handle more power than the supplies in radio receivers. Otherwise, the low-voltage supply is very similar to the power supplies of radio receivers.

A typical TV receiver low-voltage power supply is shown in Fig. 2-11. Note that two duodiode rectifiers are used in parallel to provide

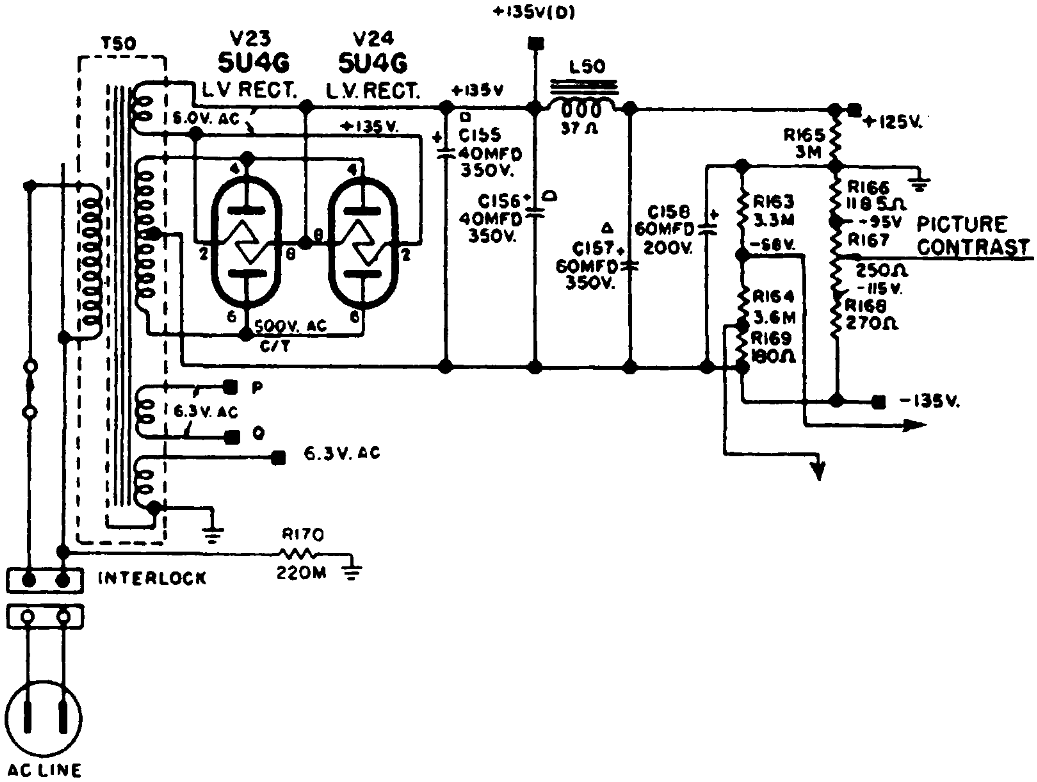



Fig. 2-11. Typical low-voltage power supply.

*Courtesy: Sylvania*

the heavy plate current necessary. Sometimes the tubes are divided into two groups, each group having its heaters connected to a separate heater winding on the power transformer.

The supply of Fig. 2-11 is typical of those in receivers in which a power transformer is used. However, a number of receivers utilizing a

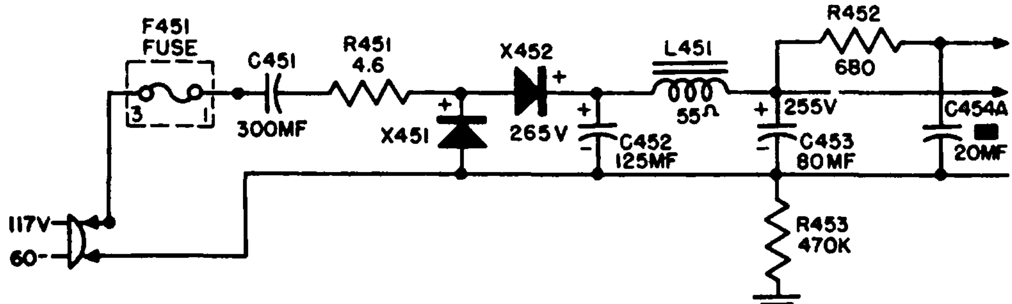



Fig. 2-12. Typical transformerless power supply.

*Courtesy: G.E.*

*transformerless* power supply have been manufactured. An example of this type is shown in Fig. 2-12. Most of these supplies now use selenium rectifiers for rectification, although a few employ tubes. The circuit is a voltage-doubler arrangement, providing from 200 to 250 v. Note that, although this circuit greatly resembles the a-c/d-c type used in many radio receivers, *it is not suitable for d-c operation* since the voltage doubler cannot operate on direct current. It is not correct, therefore, to refer to these supplies as "a-c/d-c."

The low-voltage power supply is significant in troubleshooting because trouble in this section can affect *all other* sections of the receiver. All sections of the receiver, including the high-voltage power supply, obtain plate and heater voltage from the low-voltage supply and can thus be disabled by it. Plate voltage is distributed to the various sections through series resistors in several locations in the circuit. A short circuit on one of these resistors may disable one section but simply lower the voltage of other sections and overload the power supply. There would then be a complete cessation of operation in the affected section and only slight effects in others. If the trouble is in the power supply itself, then all sections are equally affected.

Thus, whenever there is trouble which affects both sound and picture, the low-voltage power supply should be checked. Of course, an important check for power supply operation is for plate and screen voltages and for a-c voltage at the heaters.

Because of the heavy drain, many low-voltage power supplies are designed within close tolerance to the rated output current. For this reason, some manufacturers recommend that, if low plate voltage is encountered, a number of rectifier tubes should be tried in the circuit and the ones with the best output be used.

The heavy current at relatively low voltage makes the low-voltage power supply a low-impedance affair. For this reason, it is necessary to use relatively high values of filter capacitance to obtain proper filtering. This is especially true of transformerless supplies, in which the output voltage is seldom more than about 225 volts. Values of filter capacitance in the transformer types are frequently 40 and 80 $\mu$f, while in the transformerless type they often run as high as 200 $\mu$f. With electrolytic capacitors, leakage is a common trouble, and doubtful ones should be replaced.

In the a-c power leads to the low-voltage supply, a thermal cut-out is frequently provided. This device is designed to open the power circuit when the temperature of the receiver chassis becomes excessive and endangers components. If the cut-out operates frequently, the ventilation of the rear of the cabinet should be checked and some better means of air circulation provided. In fact, the technician should always check that a generous amount of air space is available behind the cabinet to provide ventilation. Receiver manufacturers are squeezed between the necessity for maximum compactness and the need for ventilation, and most chassis are not designed to stay within reasonable temperature ranges when the cabinet is close against the wall.

So far, we have discussed the importance of service data and how to apply them to receiver servicing (Chapter 1), and what the various operating sections of a TV receiver are and how they indicate troubles (this chapter). All this is vital information for anyone who is to service TV receivers. In this chapter we have not been able to cover all the small details of receiver operation, but just the important major sections and their troubleshooting indications. We now change our outlook to consider what the actual troubleshooting and servicing problems are, and how we go about solving these problems. The basic troubleshooting approach is in gradual order, from the most likely possibilities to the least likely ones. However, this is tempered by the advisability of also doing all the quick easy checks first, gambling on being able to eliminate more involved procedures. Thus we start in Chapter 4 with the most obvious troubles and checks, as well as with the basic logic of troubleshooting procedure and the physical requirements involved. In later chapters we proceed to various symptoms of trouble and how we approach each one.

## Chapter 3

# TOOLS, EQUIPMENT, AND ACCESSORIES

### 3-1. Importance of Being Well Equipped

One of the biggest problems in servicing TV receivers is *time*. The basic operations in checking a receiver are not, for the large part, in themselves time-consuming. But it is the surrounding requirements that take up the time. For example, a shorted capacitor can be checked in about three to five seconds, once the capacitor and the checking instrument are available at the same place at the same time. But it is deciding that the capacitor is a definite possibility, taking the chassis out of the receiver in order to get at the capactior, then choosing and making available the proper test equipment and tools that take the time.

Therefore, it is vitally important that the technician *know exactly what he needs and have it available.* Not only does the lack of service data, a tool, or an instrument in itself consume time, but it will also interrupt a line of thought in tracing the trouble, and thus make things more complicated.

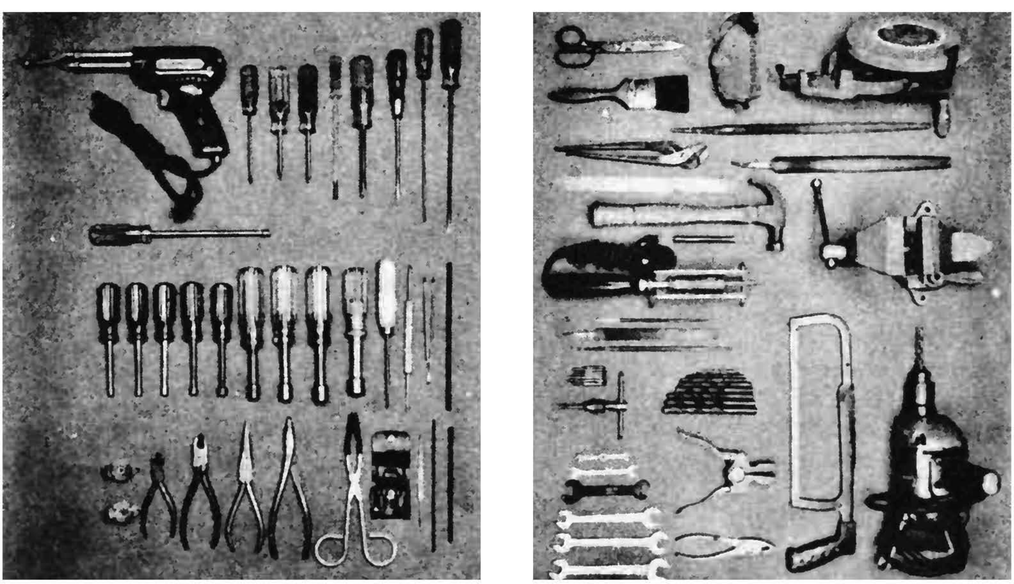
There are four main things the technician should be adequately provided with before starting his work:

1. All the right service data
2. The right tools
3. The right instruments
4. The right replacement components

The importance and the use of service data have been explained in detail in Chapter 1. The successful technician will make sure that he knows as much as he possibly can about the receiver he is to service before he starts to work on it. He may have to gain all this information from the manufacturer's (or technical publisher's) service data. As he becomes more and more experienced, a number of popular models will become very familiar and the technician will have less reference work to do each time. However, in any case, if the make and model of the receiver to be serviced can be known before troubleshooting starts, the technician can profitably brief himself; it is desirable to do this to keep actual time per job to a minimum.

## 3-2. Tools

There is no fixed formula that states *all* the tools which the technician doing servicing in the shop and in the home will require. In fact, there is no point in our making a distinction here for home servicing vs. shop servicing, since no technician can do all his jobs in the customer's home and there will always be a few chassis which will have to be pulled. But he will want to carry a number of tools with him. Many technicians use a tool kit which contains a complete set of tubes and other replacement parts. Whether or not a single kit or other arrangement is used, the technician definitely should provide himself with certain tools on his visits to the customer's home. These are listed in Table 3-1, part A. Additional tools for the shop are listed in part B of this table. A fairly complete assortment of service tools is shown in Fig. 3-1.



(A) (B)

**Fig. 3-1. Assortment of hand (A) and bench (B) tools used in TV servicing work.**

*Courtesy: Electrical Merchandising*

## 3-3. Accessories

Accessories for field use are listed in Table 3-2. These should be carried to the receiver location to prevent delay and to avoid pulling the receiver chassis when it is not actually necessary.

### 3-4. Replacement Parts

The time-saving that should result from doing the service job in the customer's home, or a fast job on the bench, may be lost if proper replacement parts are not stocked by the technician. Finding the trouble but not being able to make replacement is an inefficient business indeed. Therefore, the technician must know exactly, both as to quantity and type, what parts he should have.

Usually it is not practicable to carry all possible replacement components to the customer's home. The component list for home troubleshooting must include only such types as are likely to be needed in the kind of jobs which can be profitably done in the home. That is why the list in Table 3-3 is divided into parts for the field kit and additional ones kept in the shop. A good complement of such components will cover 90 percent of the jobs to be done; complete preparation for every contingency is, of course, impossible. A list of suggested replacement parts is given in Table 3-3. Parts such as horizontal output transformers and power transformers are omitted from the field kit because it is not ordinarily practicable to make replacement of these components in the customer's home. However, if a roving parts truck is used as the parts supply source, only the investment involved limits the variety of replacement parts which are taken to the job.

The most important replacement components are vacuum tubes. Such a large percentage of troubles involve tube failures that a service man without a tube stock would truly be stopped dead. In most cases, the only satisfactory test for a tube is replacement with another known to be good. The problems of tubes in troubleshooting are discussed in detail in Chapter 7, where a list of tube types for various TV receivers is also given.

### 3-5. Test Instruments

Test instruments suggested for the field kit are listed in Table 3-4, part A. The main instrument is, of course, the volt-ohm-milliammeter, which enables the technician to make all such measurements in the receiver itself as are practicable in the customer's home. The instrument should have a-c voltage scales included, so that line voltage can be checked.

Another instrument, the field strength meter, is not really a must, but is highly recommended. This instrument will amply repay its cost in the first hundred or so calls to customers' homes. With it the technician can definitely and beyond a doubt determine whether the signal at the

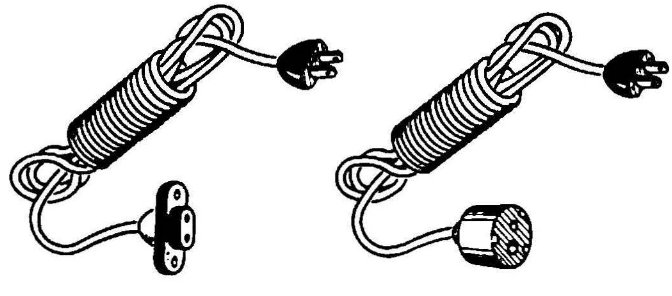


Fig. 3-2. Two types of line-cord interlock jumpers required for TV troubleshooting.

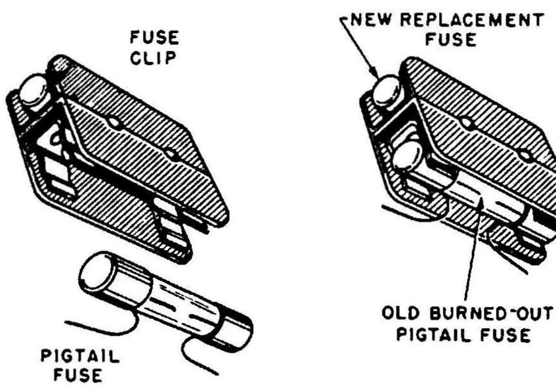



Fig. 3-3. Illustration of use of a fuse clip suitable for replacing pigtail fuses without soldering. One side of the clip slips on the old fuse, still mounted in position, while the other side holds the replacement.


Fig. 3-4. A typical field strength meter suitable for TV troubleshooting work.

*Courtesy: Approved*

antenna terminals of the receiver is sufficient to provide proper reception. It has been found that a really surprising number of cases of weak reception are caused by deterioration of the antenna due to effects of the weather, gases, dust, etc. These can be spotted immediately with a field strength meter[1] before more laborious and time-consuming receiver tests are undertaken. A typical field strength meter suitable for this work is illustrated in Fig. 3-4.

As will be be explained in Chapter 5, the *cross-hatch generator*[1] is an excellent substitute for a test pattern for making observations and adjustments. During a considerable part of the day, no test patterns are available in many parts of the country, and this generator is then a big help. In its present forms it is admittedly somewhat heavy and bulky for carrying about, but its usefulness may make it worth while.

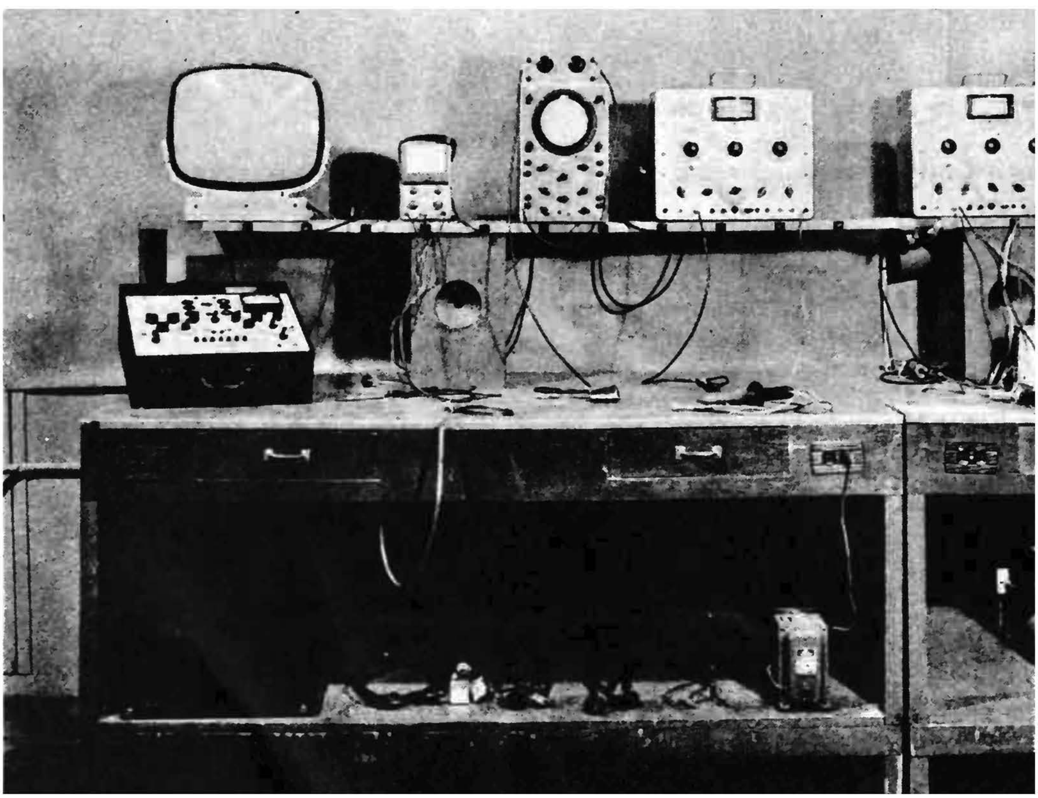


**Fig. 3-5. Test equipment arranged on a service bench. This set-up includes most of the items discussed in the text.**

*Courtesy: Electrical Merchandising*

[1] Editor's Note: Some field service men rely heavily on these units and would not go to a service job without them. Others feel that the size and inconvenience of carrying additional test instruments is not compensated for by the information that may be obtained through the use of these units.

Loudspeaker failures sometimes occur. When a loudspeaker is suspected, there is no test really as fast and conclusive as substitution of a speaker known to be good. The test speaker is therefore a worth-while item to have along on service trips. It can be the complete, commercially available type; or simply an extra speaker from the technician's bench. In the latter case a small 3-inch job (or perhaps two small speakers, one for PM types and one for electrodynamic types) can be used. The PM types predominate in modern receivers, so one of this type will cover nearly all cases.

A good substitute for the test speaker is a pair of headphones. These can be used to check the speaker and to make a stage-by-stage check of the a-f amplifier.

Additional test equipment, which should be available in the service shop for troubleshooting, is listed in part B of Table 3-4. The lists indicate the oscilloscope as a shop instrument; however, it should be noted that small, portable oscilloscopes are made for field use. It may be desirable to have one of these to carry with the field kit.

### 3-6. Combining Equipment, Parts, and Accessories

All equipment discussed in the field kit sections above adds up to great deal to carry about. How it is handled is up to the individual technician. He will find ways of doing things which will fit in best with his pattern of operation. His service truck should be so fitted out that there is a definite place for each thing he needs.

Even though the minimum number of required objects is large, it is important to have them. Like a long chain, there should be no missing links. For this reason it is desirable that the technician keep a "Want Book," in which new and unforseen requirements are entered *as they are encountered.*

After each day's calls, certain replacement parts will have been used and will need to be replaced. If deficiencies are not made up at once from stock in the shop, the technician may find himself wasting trips by going out short to his calls. It is therefore important to institute a *daily check* of all items in kit and in truck, before starting for the calls. The reserve stock in the shop must, of course, also be checked regularly.

Needless to say, proper care and maintenance of tools is important. Also, that having a "place for everything and everything in its place" is nowhere more vital than in the service technician's truck and service kit. In the shop, a misplaced tool may later be found, since it is on the technician's property. But out in the field the chances of recovery are much smaller.

# TABLE 3-1

## Suggested List of Tools for Servicing

*A. Tools for Field-Kit*

*Set of screw drivers*: This should include as a minimum one of medium size, with about a 6-inch blade; one with a long thin blade suitable for making tuner trimmer adjustments; and one small size, suitable for the small setscrews in dials, couplings, etc. One or two other sizes will be found useful.

*Set of nut drivers*: 3/16- to 3/8-inch

*Long-nose pliers*

*Gas pliers*

*Diagonal cutters*

*Phillips screw driver*: 1/4-inch

*Alignment tools*: Include at least one plastic type suitable for use with slotted iron dust cores, plus special types if experience indicates their need. The long thin type, with a projecting blade at one end and blade recessed in a hole at the other is useful for adjusting tuners.

*Soldering gun, solder, and fine sandpaper or emery cloth*: The solder should be of the low-melting variety (50-50 is satisfactory; 60-40, 60 per cent tin and 40 per cent lead, better) so that the heavier soldering jobs can be done in the home with a minimum of effort.

*Set of Allen wrenches*

*Set of Bristo (spline) wrenches*

*Open-end wrenches*: 3/8-inch and 7/16-inch (one each)
1/4-inch, one end straight, the other at 90 degrees (one)
5/16-inch (one)

Open-end wrenches are important since there are nuts in many receivers, not accessible with nut drivers because of lack of depth. They are also useful in the latter two sizes for loosening the screws in the high-voltage section shield of some receivers.

*Small mirror*: For making adjustments in back of receiver while viewing effect on the screen.

*Flashlight*

*B. Additional Tools in the Shop*

*Center punch*

*Electric drill*, with assortment of drills

*Hacksaw*

*Vise*

*Round file*

*Half-round file*, plus other files as desired

*Hammer*

*Electric or hand-driven grinder*

*Socket punches*

*Tapered reamers*

# TABLE 3-2

## Accessories for Field Use

(Note: It is assumed that these accessories in adequate quantities are available in the shop for use there.)

*Jumper cords for a-c power*: These cords are necessary to provide receiver power for tests after the back has been removed and the interlock connection broken. There are two types, as shown in Fig. 3-2; one of each is necessary.

*Power extension cord,* 15 feet

*Volume control lubricant*: An eye-dropper should also be included, but should not be left in the bottle when carried in the kit. The liquid will attack the rubber if the bottle tips over.

*Hook-up wire,* 10 feet

*Spaghetti insulation*

*300-ohm ribbon-type line,* 25 feet

*Cabinet wax or polish*: Never apply wax to the cabinet without asking the customer's permission. Many people are extremely particular about the type of polish used on their furniture.

*Wiping cloth and carbon tetrachloride*: For cleaning the screen of the picture tube and the chassis. WARNING: Never use gasoline or other flammable fluid for cleaning purposes.

*Attenuator pads*

*High-pass filter units*

*Tunable interference traps*

*Indoor antenna*: In strong signal areas this may be substituted for the regular antenna as a quick-check for antenna and transmission-line troubles.

*Pin straightener for miniature tubes*

# TABLE 3-3

## Replacement Parts

*A. Field Kit*

*Tubes*: About 100 (see Table 7-2)

*Capacitors*: 12 assorted small micas, 100 to 1,000 $\mu\mu$f 500 w vdc
12 ceramic capacitors 0.005 $\mu$f 600 w vdc
2 — 20-kv, 500 $\mu\mu$f HV type. These can be used to replace **5-kv and** 10-kv, since the size is the same and the price only slightly more.
12 electrolytics, assorted

*Resistors*: 50 — ½-w and 1-w composition, assorted values.
2 — 2-megohm high-voltage types (such as IRC type DCH)

*Selenium rectifiers*:
2 — 250 ma, square
2 — 350 ma, square
2 — 350 ma, rectangular type

*Vertical output transformers*
1 RCA type 204T2 or equivalent

TABLE 3-3. (Continued)

*Blocking oscillator transformers*:
 1 Stancor type A811 or equivalent
 1 Merit type 3001 or equivalent
*Picture-tube boosters*:
 1 Parallel heater type
 1 Series heater type
*High-voltage anode leads*: Two
*Machine screws, nuts, and lockwashers,* Nos. 6, 8, and 10, assorted lengths
*Lugs and tie-point assemblies*
*Fuses*:
 ¼-amp type 3AG and type 8AG
 ¼-amp pigtail type 3AP
 ¾-amp Sloblow
 3-amp 3AG
 5-amp 3AG

*B. Additional Replacement Parts Kept in the Shop*

*Horizontal output transformers*: Several different types covering most frequently encountered receivers.
*Deflection yokes*: Several 70-degree cosine types covering most frequently encountered receivers.
*Selenium rectifiers*: 100- and 150-ma types, in addition to those listed in (A) above.
*Wire-wound resistors*: Assortment of 10-w units, 10 ohms to 20K.
*Capacitors*:
 .005 at 6,000 v
 80-40-40 $\mu$f at 450 v
 80-40-20 $\mu$f at 450 v
*Variable resistance controls*: One or more broad assortments available as kits from manufacturers of these components.
*Ion trap magnets*: Several, of the *single* type. These are often needed when an old picture tube, with those of the double type, is replaced with a newer type of picture tube.
*Knobs*: Assortment
*Pilot lamps*: Assortment, including types 44, 47, and 51
*Dial cord*: Two or more types
*Tube sockets*: 7- and 9-pin miniature, with and without shields, Octal type. Extra Octal types are useful in providing spare pins for replacement in sockets where pins have broken off.

*C. Additional Optional Items*

(These parts are, for the most part, special for each type of receiver and, for most small shops, would not be stocked but ordered for the job as the need arises.)
*Power transformers*
*Loudspeakers*
*Tuners*
*Picture tubes*

# TABLE 3-4

## Test Instruments

### *A. For Field Kit*

*Volt-ohm-milliammeter*: 20,000-ohms-per-volt, preferably with a-c voltage ranges.

*Field strength meter*: Suitable for checking the strength of signals at the receiver end of the antenna lead-in; indicates whether antenna system is adequate or properly adjusted.

*Cross-hatch generator*: This is an optional item, admittedly bulky for field trips, but it is the only way of getting an accurate check on linearity, focus, definition, etc. when test patterns are not on the air.

*Test speaker*: This is useful when the sound is dead and the loudspeaker is suspected. The condition of the latter can be quickly checked.

*Headphones*: These can be used in place of the test speaker, and besides, are useful in making stage-by-stage checks in the a-f amplifier.

### *B. Additional Test Instruments for the Shop*

*Vacuum tube voltmeter*: This instrument is important in TV troubleshooting because of its high input impedance, especially at low-voltage ranges. This feature makes it possible to read voltages at high-impedance points in the circuit, where an accurate reading with lower impedance meters would not be possible. The VTVM is also particularly useful, because of its adaptability with probes, to read r-f voltages and to make measurements at circuit points at which the r-f circuit must not be disturbed.

*Probes for VTVM*:

*Detecto probe*: This demodulates a signal and allows a reading of the carrier amplitude or the modulation voltage of a modulated signal.

*Isolating probe*: This permits voltage readings with a low-capacitance input to to the probe, reducing reactance loading effects.

*High-voltage probe*: Allows reading of the output voltage of the high-voltage power supply with a high ohm-per-volt sensitivity so power supply is not loaded to make reading inaccurate.

*Oscilloscope*: The oscilloscope is one of the most useful of TV servicing instruments. It is used to trace i-f and video signals, deflection signals, to check sync separators, to check for hum and noise, and for many other trouble tracing operations. It is also a basic part of any visual alignment setup. The following features are important:

*Tube size*: The screen size should be no less than 3 inches; a screen of at least 5 inches is recommended.

*Vertical sensitivity*: A minimum of 50 mv per inch is ordinarily necessary; types with sensitivity as much as 10 mv per inch are generally available.

*Vertical frequency response*: A response flat within 3 db to 150 kc is sufficient. A wider response band is, of course, helpful. However, most units with a greatly extended range (say, to 5 or 6 mc) have less sensitivity than is needed, or are so expensive as to be out of the service technician's financial range. In that case, it is better to have the added sensitivity than the added bandwidth. Sharp cut-off response characteristics are not as desirable for servicing as gradually falling

## Table 3-4 (Continued)

characteristics, even though the bandwidth to the 3-db point is somewhat less for the latter.

*Horizontal sweep frequency range*: This should extend to at least 20 kc.

*Input impedance*: The input resistance should be as high as possible, with about 1 megohm a good value. The input capacitance should be low as possible, $35\mu\mu f$ or less.

*Probes for oscilloscope*:

*Detector probe*: This is similar to the detector probe for the VTVM, and is used to view waveforms of the modulation of an r-f signal.

*Isolating probe*: This minimizes the loading effect of the vertical input circuit of the scope, so that waveforms of signals at high-impedance points can be accurately viewed.

*Sweep and marker generator*: This is the basic instrument in visual (sweep) alignment. It is employed to provide the input signal to the receiver to be aligned; the output from the receiver is applied to the vertical amplifier of the oscilloscope, whose horizontal sweep is synchronized with the generator's sweep action. Important characteristics:

*Frequency range*: Sweep-signal center frequency should be adjustable for at least all possible intermediate frequencies. This would mean from about 20 mc to 50 mc. Sweep output for all r-f channels is desirable although not absolutely necessary. The marker generator should be adjustable to any frequency within the range of the sweep generator, preferably on the fundamental, but alternatively on harmonics.

*Sweep width*: This should be adjustable from 1 mc to at least 10 mc.

*Linearity (Flatness)*: The output voltage of the sweep generator should remain constant within 0.2 db or thereabouts over the sweep range at any center frequency.

*Strays*: Should have minimum leakage and spurious output.

*Output voltage*: Should have a maximum output voltage of 0.1 v or more.

*Leads*: Leads with proper termination to match to 300-ohm-balanced and 72-ohm-unbalanced input circuits should preferably be included.

*Oscilloscope calibrator*: This is a device used to check the voltage of a waveform exhibited on the oscilloscope screen by providing a comparison trace. Sometimes it is included in the oscilloscope itself.

*Isolation transformer*: This is essentially a 1-to-1 power transformer connected in the power lead to the test equipment and receiver being tested. It provides a power source with neither lead grounded. The purpose of this is to avoid danger of personal shock, injury to equipment, and fire resulting from short circuits between transformerless-powered equipment and ground leads. These transformers are available in a wide variety of models and power ratings. A 500-watt rating should be sufficient. Some types also provide a number of taps, allowing adjustment of line voltage as well as isolation.

*Variable line-voltage autotransformer*: This variable transformer can be connected in the power lead to the test equipment and serviced receiver. It is particularly useful when the line voltage in the shop varies widely. A voltmeter (a-c) is connected across the output and whenever line voltage varies from its desired value, the variable transformer is readjusted to correct it.

*Chapter 4*

# PRELIMINARY OBSERVATIONS AND CHECKS—THE TROUBLESHOOTING APPROACH

## 4-1. Basic Philosophy of Troubleshooting

Troubleshooting a TV receiver has but one objective: finding as quickly as possible what is wrong so that it can be remedied. By and large, it will be found that three-quarters of TV servicing time is devoted to *finding* the trouble and one-quarter to *remedying* it. Obviously, then, it is in the search for the trouble, which we call *troubleshooting,* that we can make the greatest gains through logical organization of thought and by efficient execution.

In troubleshooting, the TV technician becomes a detective, and the defective component or condition in the receiver is his "culprit" which must be exposed and eliminated. Roughly, the troubleshooting process involves the following steps:

1. Gathering all possible evidence.
2. Interpreting the evidence and putting it together to narrow the trouble-source possibilities to as small a number as possible.
3. Making tests that eliminate each of these possibilities in turn, until the actual trouble condition alone remains.

The range of time and effort required to accomplish these three steps for different cases is wide. At one extreme is the case in which a particularly significant piece of evidence immediately tells the technician what is wrong and enables him to remedy it immediately. An example of this is the instance in which one wire of the antenna lead-in has broken at the connection to the receiver. A glance at the rear of the receiver immediately reveals this, and it is remedied right away. The other extreme is the case of an intermittent condition which occurs only occasionally. The source of the trouble can be determined only by operating the receiver for long periods of time and painstakingly checking all possibilities each time the trouble recurs.

Even though the amount of time in the two cases mentioned is vastly different, the thought process is the same, with the three main steps listed above necessary in each case.

For troubleshoooting, the technician sets up a set of procedures and tests. Exactly what he does in each case depends on the nature of the receiver defect and the trouble indications. However, the efficient technician has developed a mental *check list.* As he goes down this mental check list, he can eliminate many of the items which do not apply to the symptoms involved in the case at hand. The important thing, however, is that each item on the list has at least been considered.

In this chapter we shall show how to gather evidence which is significant and how to apply that evidence to determine the source of trouble in the shortest possible time. The preliminary observations discussed in this chapter will place the trouble in one of the following categories:

1. Dead receiver
2. Weak or distorted picture
3. Sound troubles

Once placed in one of these categories, it can then be treated in the special way required for that particular type of trouble. The dead receiver is discussed in Chapter 8, distorted or weak pictures in Chapter 9, and sound troubles in Chapter 10.

## 4-2. Starting the Service Job

Practically all TV service jobs follow the same pattern: first is a call by telephone or by a visit to the shop, then the call by the technician to the customer's home. The construction, weight, bulk, etc. of TV receivers, of course, excludes the likelihood of the receiver being brought to the shop by the customer.

Most customers do not know the model numbers of their receivers. Some do, however, so if this information can be obtained (over the phone or in person during report of trouble), the technician can prepare himself more specifically for the case in hand. With a little experience he will recognize the troubles to which certain models are particularly susceptible, and will include in his kit extra items which ordinarily he would not take. Knowledge of the model number allows him to refer to the service information on the receiver and to brief himself on it. In this way he reduces his time at the customer's home and gives a much better impression of efficiency.

Of course, the efficient technician will answer a number of calls in a day, so the same preparation is in order for each one. If the calls involve many different receivers to be serviced, he may have to take notes for each to prevent confusion.

Thus, armed with the right service data, tools, instruments, accessories, and replacement components, the technician is ready to proceed to the customer's home, or to tackle the job in the shop.

### 4-3. Appearance and Conduct of the Technician in the Home

No matter how great his technical proficiency, the technician will be severely handicapped if he does not make a good general impression on the customer. Many a service man has done an excellent job of technical service work, yet failed in his business because he did not have the proper respect for the customer's home. Remember, the customer's home, ordinarily, is more important to him than his TV set (although it must be admitted that sometimes the latter is a close second).

Common examples of misconduct are: failure to wipe muddy feet or to remove rubbers or galoshes when entering the house; bumping against furniture with the tool kit or other objects; improper care when moving the TV receiver; allowing such materials as soldering paste to become smeared around; and dropping solder on the floor or rug. Most technicians carry a kit of tools enclosed in a leather or metal case; tools should be kept in this case except when being used, and should not be left out on the floor or furniture.

Sometimes the way people want things done in their homes may not seem reasonable to the technician, but he must remember that the home is the customer's castle. If anything out of the ordinary is to be done, such as relocating wires, drilling holes, etc., the technician should always obtain the customer's permission. The whole problem is one of attitude, and is not at all difficult if one starts off on the right foot. Once the technician has the customer's confidence, the rest is easy and just a matter of common sense.

### 4-4. Questioning the Customer

We have stated that the first operation is to gather evidence. One of the first ways to do this is to obtain all possible information from the customer himself. While the language may be anything but definite or precise, he can still often impart bits of information about the failure which may save hours of work later. Did the failure take place gradually or suddenly? Was any trouble noticed by the customer before the complete failure took place? This questioning is also valuable in making sure just what trouble is of concern to the customer, when there is more than one thing wrong. For example, there may be a kind of minor picture distortion such as insufficient width or height, slight nonlinearity, etc., and at the same time the volume control may be erratic in operation.

Perhaps the customer has not noticed the picture distortion but is annoyed by the volume control condition. The technician should then point out other deficiencies and suggest that they be remedied.

Such information will usually not be gleaned from the customer without a certain amount of patience. The technician will frequently meet with the customer who would like to solve the problem by wishful thinking, which he does out loud, with "I know it must be only a loose wire, it went off so suddenly," or "I'm sure its only a tube"—and, of course, he knows practically nothing about it at all! These things must be recognized as part of the game, although calls like this at odd hours of the day and night can certainly be irksome. But the ultimate objectives of repairing the receiver and keeping the customer's good will are best obtained by patience and equanimity – and never by "telling the customer off." This does not mean that plain facts should not be frankly and directly presented to the customer; it does mean that it should be done in a way to avoid argument or controversy. The best way is to place the responsibility for and choice of any debatable repairs squarely on the shoulders of the customer.

However, in the first meeting, the main objective is *information.* The technician should find out how the receiver failed and the exact nature of the complaint. He may also be interested in how long the receiver has been installed, and whether the installation has always given satisfaction. Many times it will be found that a trouble with a receiver, such as weak reception, nonlinearity, etc., dates back to the installation of the receiver, and that the customer has not been concerned about it until recently. For example, if weak reception is the complaint, such historical information may lead one to suspect that the antenna and its connections may have deteriorated, or that the antenna system originally installed was inadequate.

### 4-5. Examining the Receiver

Examination of the receiver is usually made after the customer has been questioned about it. However, this is not a hard and fast rule; sometimes the technician may prefer to examine and make his own observations first, feeling that he has a chance of solving the problem a little quicker that way, in the event that there is some obvious fault. In that case, if the trouble is not immediately located, he would begin questioning the customer, provided, of course, that the customer is there at the time.

Although TV receivers contain many more tubes and other components than radio receivers, they are, in some ways, easier to troubleshoot than radios, because there are more indications. Instead of just a loudspeaker as an indicator, there is also the picture tube. The picture tube actually provides a number of separate indications. First, there is the presence or absence of light of any kind on the screen, which we have shown is tied to the operation of the high-voltage power supply (Chapter 2). Then there is the raster, which shows whether horizontal and vertical deflection is present, and sometimes, whether partial defects exist in the deflection circuits. Finally, a test pattern, or a cross-hatch pattern locally produced, indicates vertical and horizontal linearity, focus, high- and low-frequency response, transients, etc. The many different types of pattern and picture indications are discussed in detail in Chapters 5 and 9.

By use of the indications listed above, plus any direct sounds of arcing, sputtering, and signs of smoke or odor, the receiver trouble can be placed in one of the three main categories previously listed: dead receiver, picture or pattern distortion, and sound troubles. A special line of reasoning, deduction, and procedure is used for each of these cases. It is followed after the trouble has been duly classified and after simple routine tests of a general nature have been made.

## 4-6. What To Look for in Trouble Indications

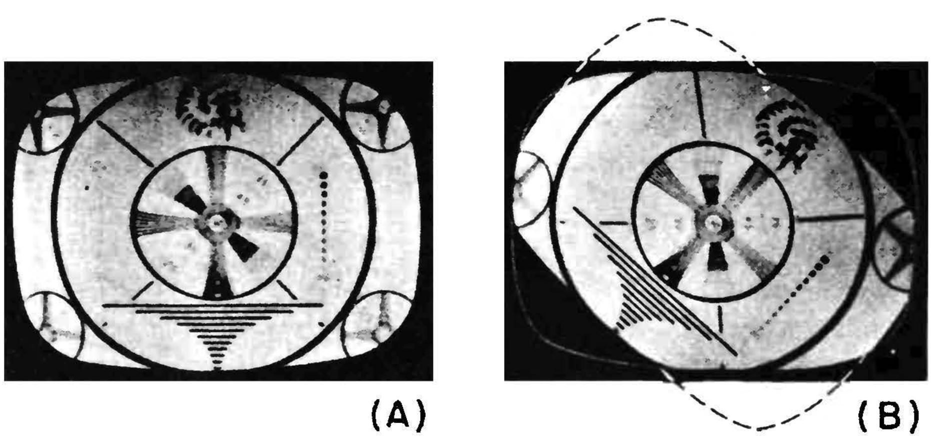
If the customer reports that there was smoke or smell of burning coming from the receiver at the time of failure, examine the receiver carefully. Try to determine visually what components have overheated and then try to find the cause of the trouble without turning on the power, since this may add further troubles.

On the other hand, if there is no evidence that further damage may be done by turning on the receiver, do so and examine the picture-tube screen for evidence. As soon as the receiver has had a reasonable time to warm up, it will be seen whether or not it can be classified as a dead receiver. A dead receiver is one from which there is neither sound nor picture reception. So it should be noted whether the receiver is completely dead or whether the screen is dark but there is some sound reception. Both these conditions are discussed in Chapters 8 and 9.

If the screen is not dark, the character of the pattern present should be noted. There may be a single horizontal line, showing that vertical deflection is lacking. In a few cases of receivers in which the high voltage is not obtained from the horizontal deflection voltage, there may be a single vertical line, indicating loss of horizontal deflection. In most modern receivers this is very unlikely to happen because the failure of horizontal deflection voltage in the horizontal oscillator or amplifier cuts off the high voltage and the screen is dark. However, if there is trouble in the secondary of the horizontal output transformer or horizontal deflection coil, a vertical line will result in any receiver.

If both horizontal and vertical deflection voltages are present, a raster is formed (assuming no other troubles). The raster is the rectangle of light formed by the horizontal and vertical sweeping actions of the C-R tube beam spot on the screen.

The raster should just overlap the edges of the screen mask. It should be level and square with the mask, as shown in Fig. 4-1 (A). Figure 4-1 (B) indicates the pattern obtained when the deflection yoke is improperly tilted with respect to the axis of the picture tube. By examining the horizontal sweep lines of the raster, vertical linearity and focus (which are considered in detail in Chapter 6) can be checked with the raster alone. If the picture is well focused, the sweep lines will show up clearly and sharply when the raster is examined at close range. Proper vertical linearity is indicated by the equal spacing of the sweep lines from the top to the bottom of the raster. Further checks on linearity can be made with either a received station test pattern or a cross-hatch generator, as explained in Chapter 5.



(A) (B)

Fig. 4-1. (A) Test pattern properly aligned with mask. (B) Test pattern tilted, due to misalignment of deflection yoke.

The raster should have normal brightness with reserve left in the range of the brightness control. The proper degree of brightness is something the technician learns to recognize from experience. Remember that the brightness of the screen increases with the strength of the incoming signal.

Observation of a test pattern is the best way to determine the quality of the factors discussed above. However, an actual received picture is the best way to judge such things as weak signals, interference, and sync troubles. If the signal appears weak, a field strength meter will tell immediately whether the trouble is in the antenna system or in the receiver itself.

Lack of sync may not be due to trouble in the sync section but simply the result of a weak signal. When the signal is weak, there is insufficient strength is the sync pulses to keep the deflection circuits stabilized. Thus, one should note whether lack of sync occurs with a strong signal or a weak signal. Lack of vertical sync is characterized by a tendency of the picture to roll or to appear as a series of repetitions of the picture vertically. Lack of horizontal sync is characterized by a number of wide bright horizontal bands separated by narrow black bands. Loss of both vertical and horizontal sync shows up by the picture rolling in both the vertical and horizontal directions. Examples of loss of sync patterns are given in Chapter 9.

After the indications of the picture-tube screen have been noted, we must proceed to the sound section. Here we have three main possibilities: satisfactory sound, weak and/or distorted sound, a d no sound at all. Any of these conditions may apply, along with any of the picture-tube indications we have mentioned. This multiplies the number of combinations greatly, but since each combination usually has a definite significance, it also helps us to get to the source of the trouble more quickly.

### 4-7. Deciding Whether To Pull the Chassis

During the gathering of preliminary evidence, the technician makes his decision as to whether to remove the chassis and do further troubleshooting and repair work at the shop. The decision will depend not only on the factors involved in the job itself, but also on policies adopted by the technician or the shop for which he works. Some service companies make a special effort to do as much service work as possible right in the customer's home, while others believe that in most cases the chassis should be pulled in order to take advantage of the greater facilities in the shop. There does seem to be a definite trend lately toward servicing in the customer's home whenever this is possible.

Arguments in favor of home servicing are the saving of time and expense in transporting heavy TV chassis to and from the shop, the danger of misadjustment or other trouble developing in transit after the receiver has been repaired, and the minimum delay in service for the customer, who sees action being taken on his job immediately.

Arguments in favor of shop servicing are that the facilities for servicing in the home are always poor compared with those of the shop layout, which is designed just for the job, and also that it is not possible to have on field trips all the parts and equipment for all jobs.

It can be seen that the ideal answer probably lies in a combination of the two arrangements. The technician must make his choice for each job in the light of the particular circumstances and the policy laid down for him.

## 4-8. Interpreting and Using the Evidence

In the chapters that follow, we shall show in detail how the evidence available can be used to localize the trouble to one particular section of the receiver. Component tests in that section will then lead us to the one or more guilty components.

In using the evidence, we employ two well-known methods of detective work: deduction and elimination. Unfortunately, we cannot always deduce that the trouble must be just one thing or in just one location, although we can ordinarily place it in one general *section.* Then, by the process of elimination, we eliminate all the possibilities except the real trouble cause. As an example, suppose we are to service a split-sound receiver with the sound i-f signal tapped off at the output circuit of the mixer. The trouble is weak picture but good sound reception. First, we satisfy ourselves that the sound is really fully satisfactory; this we can check by noting the range of fine-tuning control adjustment over which the sound quiets the noise and the signal-to-noise ratio when the sound is tuned in at its best. Since there is a weak picture, the trouble must be somewhere in the path of the picture signal through the receiver, i.e., the tuner, the video i-f amplifier, the video detector, the video amplifier, and the picture tube. However, it cannot be in the tuner, because the sound must pass through the tuner, and the sound is received satisfactorily. Therefore, we *deduce* that the trouble must be in the video i-f amplifier, the detector, the video amplifier, or the picture tube. We then start our process of elimination. We might feed a cross-hatch signal into the video amplifier, and then another into the video i-f amplifier if no trouble is indicated in the first test. Further tests, discussed later, will then gradually localize the trouble into one particular section. When the trouble is fairly well localized, tubes are checked and other elimination tests made to determine the actual component or components at fault, so that replacement or adjustment can be made.

*Chapter 5*

# USE OF TEST PATTERNS AND CROSS-HATCH PATTERNS IN TROUBLESHOOTING

## 5-1. Why Test Patterns Are Useful

If the raster on the screen seems satisfactory but there is some imperfection of the received signal, the trouble can be analyzed further by use of some kind of video information. This is true even of some troubles which affect the raster. A received program from a station is not the best picture to use, because it is constantly changing and is ordinarily not adapted to provide certain important indications. To provide the necessary information, most TV stations send out a standard *test pattern* during certain hours of the day when they do not have programs scheduled. This test pattern can be used to indicate whether control adjustment is necessary and also whether there are other troubles.

As previously mentioned, in many localities TV stations have so increased their program schedule that during a good portion of the day there may be no test patterns on the air. In this event, it may be desirable for the technician to use a cross-hatch pattern generator to produce his own test pattern and to obtain his trouble indications and make his adjustments from this.

## 5-2. Typical Station Test Pattern

A typical TV station test pattern is shown in Fig. 5-1. This pattern can be used to check contrast, brightness, linearity, focus, interlace, and resolution. In the test patterns of other stations, some of the details will be different (the call letters of course!) but the main features are the same. Let us consider each factor and how it is indicated.

## 5-3. Contrast

As the word implies, contrast is the relative difference between blacks and whites in the picture. Electrically, it represents the relative strength of the video signal up to the overload point of the C-R tube grid or other stage of the receiver. When the C-R tube grid becomes more negative, the screen becomes darker; when it becomes more positive, the screen becomes brighter. Actually, these alternations occur rapidly to follow the cycles of the video signal fed to the C-R tube grid, and thus show up as the lights and darks of the picture or pattern. As we shall presently see, the degree of contrast possible depends on the setting of the brightness control as well as on the strength of the received signal.

Lack of contrast shows up as a *flat* picture. For example, in the pattern of Fig. 5-1, the circles and arcs in the center are gradually shaded in varying degrees of light from the center, which is black, to the outside circle, which is white. These circular sections should be clearly distinguishable from each other if the contrast is correct.

It should be remembered that the degree of contrast is a function not only of the contrast control, but also of the fine-tuning adjustment and the strength of the received signal at the antenna terminals.

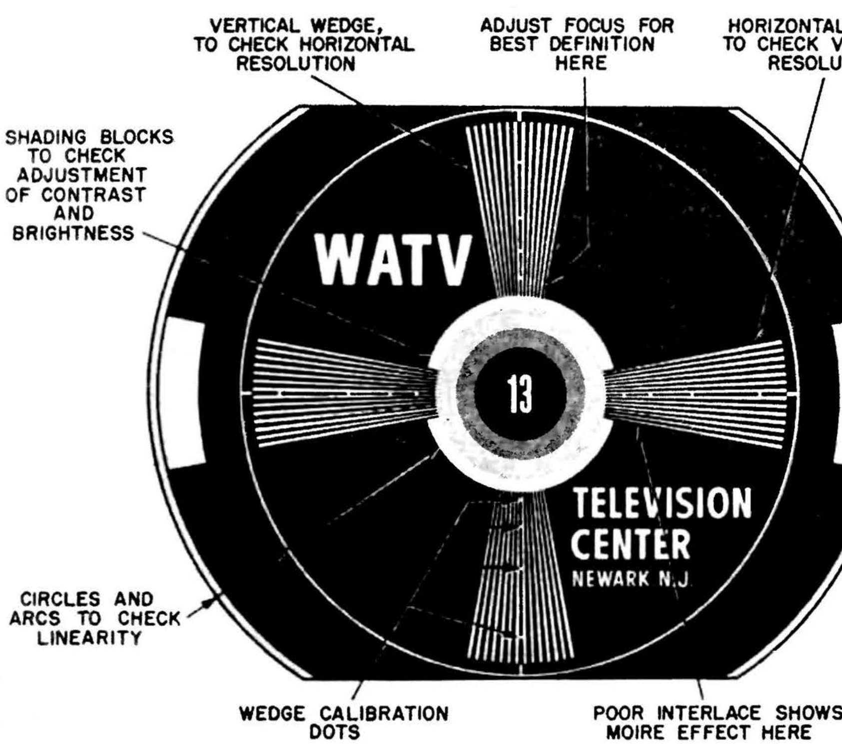



Fig. 5-1. Typical test pattern and the information which it presents.

## 5-4. Brightness

As mentioned above, brightness and contrast are interrelated. Basically, the brightness is the relative amount of light from the screen.

In one system, the brightness is controlled by the adjustment of bias on the grid of the C-R tube, which in turn controls the beam current. The bias on the C-R tube grid is adjusted to the desired value. Then the video signal is applied to the C-R tube cathode, driving it alternately more and less positive with respect to this value. If the brightness control is adjusted for too low a negative bias, then the video signal may drive the C-R tube cathode negative with respect to the control grid and cause distortion of the picture. Full contrast capabilities of the receiver are then not realized and the contrast control must be adjusted downward to compensate.

Thus, the circles in the center of the test pattern must be used to adjust both brightness and contrast, before the contrast is considered to be improper. How these adjustments are made is explained in Chapter 6.

### 5-5. Linearity

If the current through the deflection coils of the C-R tube is not a true saw-tooth, the speed of the C-R tube beam spot across the screen is not uniform. The beam spot then does not move across the screen in step with the beam in the transmitter camera, with the result that the picture becomes distorted. Where the beam moves too fast, the picture becomes pulled apart, and where it moves too slowly, the picture becomes squeezed together. This condition is known as *nonlinearity* and may occur in either the horizontal or the vertical direction.

Nonlinearity would be indicated on the test pattern of Fig. 5-1 by a tendency of the circles to become egg-shaped. Either the circular sections in the center or the larger black circle can be used for this indication. Examples of nonlinearity are given in Chapter 6.

### 5-6. Focus

The focus of the picture depends on how nearly the electrons in the C-R tube beam are made to converge to a single point on the screen. Focus influences the over-all sharpness of the picture or pattern. It has been previously pointed out that the focus can be checked by noting how well the horizontal deflection lines stand out upon close examination of the screen when there is either a plain raster or a complete picture present. Even when a pattern is present, this is still the best final determination of focus, because a fuzzy picture may be caused by poor resolution or improper response in the video i-f and video amplifiers rather than poor focus. However, even if there is trouble in the video i-f and video amplifiers, the horizontal lines should stand out clearly if proper focus is available.

Thus the portion of the vertical wedges nearest the center are an auxiliary but not a final check for focus. It must be remembered that improper horizontal resolution can also give an indication of blurring of the spokes of the center portion of the vertical wedges.

### 5-7. Interlace

When the picture information is transmitted from the TV station, the first, third, fifth, etc. horizontal lines are transmitted first; then the second, fourth, sixth, etc. lines are filled in. The receiver must keep in step accordingly. This is known as *interlace.* Trouble in the receiver's sync section, or improper adjustment of certain of the controls, may cause improper interlace. The horizontal wedges of the test pattern of Fig. 5-1 are used to indicate the degree of interlace. The ordinary effect of improper interlace is that successive horizontal lines are not quite in phase with each other, causing general over-all fuzziness. In the inside (near the center) portions of the horizontal wedges, the spokes of these wedges become narrow and close together. The width of the spokes and the spacing between them approaches line width, so imperfections of interlace interfere with the distinctness with which the lines are distinguished from each other. The result is a sort of blending of the lines in a moving circular pattern of white and black, called a *moiré* effect. This is how the test pattern indicates poor interlace. How far out along the wedge this effect is noticed is an indication of the degree of imperfection. A certain amount of this moiré effect is present in all receivers in the first inch or so of pattern (on a 16-inch picture), but if it extends, for example, half-way out along the wedge, interlace can be considered unsatisfactory.

### 5-8. Resolution

Resolution is the degree of perfection with which small variations from light to dark and vice versa are reproduced on the screen. It is measured by the number of lines of equal width and spacing which can be distinguished from each other across the picture. The degree of distinguishing horizontal lines is called *vertical resolution* and the degree of distinguishing vertical lines is called *horizontal resolution.*

The degree of vertical and horizontal resolution obtainable depends on the response characteristics of the video path of the receiver. The sharpness of fine detail depends on high-frequency video-signal response. The quality of reproduction of the broad black portions of the picture depends on the low-frequency response.

The spokes in the wedges of the test pattern can be used to indicate the resolution. The vertical wedges are used to indicate the degree of horizontal resolution and the horizontal wedges for vertical resolution. The relative resolution is indicated by how far in toward the center the spokes are distinguishable from each other. To be sure we are checking resolution, we should first adjust for focus by noting the sharpness of the horizontal deflection lines. Resolution can be distinguished from interlace indications because poor resolution causes a general blurring effect, whereas poor interlace causes a moiré effect.

### 5-9. Use of Bar and Cross-hatch Generators

We have mentioned before that in many localities the extension of programs through most of the day has limited the amount of time during which test patterns are provided by TV stations. Thus, when the technician is to make his observations and adjustments, there may be no test pattern available. In that case, most of the same indications can be obtained by use of a cross-hatch pattern generator.

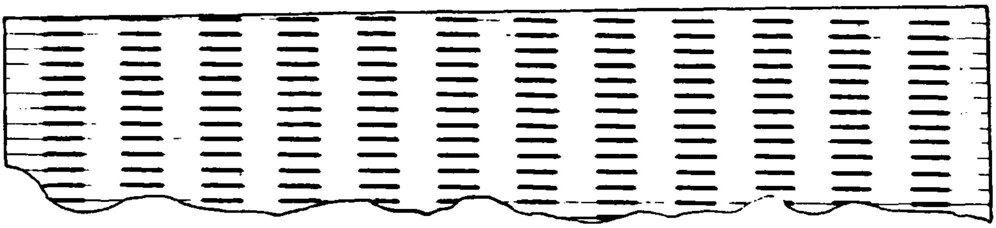
This generator should be capable of producing a signal with a carrier frequency equal to the video i-f with amplitude modulation of the carrier by two signals. One of the modulation signals should be a low frequency of about 1 to 2 kc; the other modulation signal should be a relatively high frequency, about 100 to 200 kc. These modulation signals should also be available alone and direct, without the carrier.

If the modulated carrier is injected into the mixer of the receiver, it is amplified by the video i-f amplifier and demodulated by the video second detector. If the modulation signals are used directly, they can be injected into the output circuit of the video detector. In either case, the two modulation signals are amplified by the video amplifier and applied to the grid of the C-R tube.

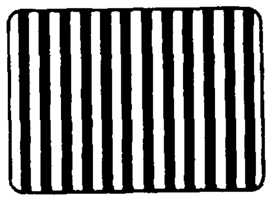
The high-frequency modulation signal causes alternate light and dark areas across each horizontal line; these light and dark spaces combine in the different horizontal lines and form a *bar pattern,* as shown in Fig. 5-2. The number of bars across the raster is about equal to the ratio between the horizontal deflection frequency (15,750 cps) and the higher modulation frequency (100-200 kc).

The lower frequency is low enough so that it takes several horizontal sweep lines for one of the modulation frequency cycles. This means that alternate *sets* of horizontal lines are blanked out and bright, forming horizontal bars across the picture, as illustrated in Fig. 5-3.

Now, with both modulation signals present together in the video amplifier, both horizontal and vertical bars are produced at the same

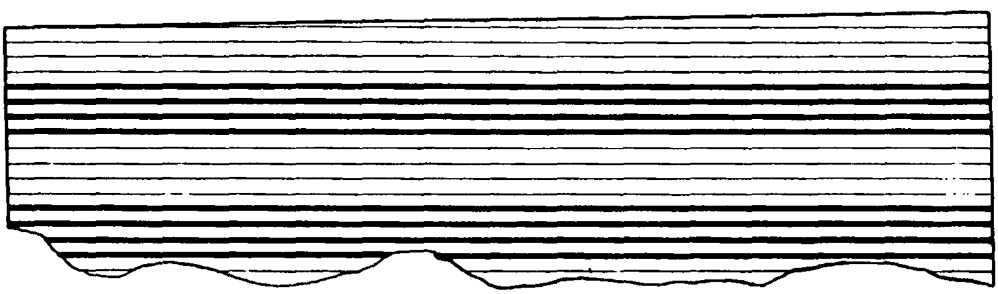


(A)



(B)

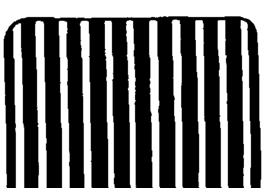
Fig. 5-2. How vertical bars are formed by a video signal considerably higher than the horizontal deflection frequency.

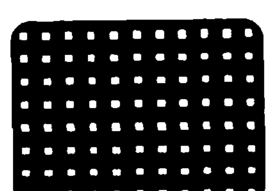


(A)

(B)

Fig. 5-3. How horizontal bars are formed by a video frequency appreciably lower than the horizontal deflection frequency.





(A) (B) (C)

Fig. 5-4. (A) Vertical-bar pattern, (B) horizontal-bar pattern, and (C) cross-hatch pattern.

time and we have what is referred to as a *cross-hatch* pattern. Typical horizontal-bar, vertical-bar, and cross-hatch patterns are shown in Fig 5-4.

Contrast and brightness are adjusted with this pattern in the same way as with the test pattern; i.e., for greatest contrast between whites and blacks (lines and spaces) and for sharpness of lines. The cross-hatch pattern is particularly suitable for checking the linearity. For example, if there is horizontal nonlinearity, the vertical bars of the pattern, instead of being equally spaced, will be farther apart on one side of the pattern and closer together on the other. If there is vertical nonlinearity, the spacing of the horizontal bars will vary from the top to the bottom of the pattern.

Resolution and interlace can be roughly checked by observing the sharpness of the edges of the bars in the pattern, which is also a guide in adjusting focus.

## 5-10. Don't Expect Perfection

As we all know, nothing in this world is perfect, and certainly TV receivers are less perfect than a lot of other things. It should be understood that the indications described above are relative. A certain amount of deviations from the ideal can be tolerated in most of the factors, without interference with practical use. For example, a slight nonlinearity detectable as a tendency toward egg-shaped circles on the test pattern will never be noticed in the reception of program material. There is also a definite limit to the degree of resolution and interlace which can be expected of the average production-line receiver chassis. The technician will learn by experience just what degree of perfection will be worth while, and will thus avoid hours of unnecessary effort to obtain slight improvements which would not be noticed by the customer.

By this we do not mean that one should cut corners and not do the best job possible. But it should be remembered that this job consists in providing entertainment and information for the customer for the lowest price, and not in meeting any strictly technical specifications which do not enhance or increase the customer's appreciation of the picture. The technician must use his judgment in striking the balance.

When the preliminary examination and investigation of the complaint has been completed, the need for simple adjustment of controls may be indicated. The possibility that a control adjustment may be the solution should be checked first, since this is a simple operation and may save time and expense. For this reason, our next chapter discusses the various controls of the TV receiver and how they are handled.

## *Chapter 6*

# CONTROLS AND THEIR ADJUSTMENT

### 6-1. The Place of Controls in Troubleshooting

There are so many factors involved in the production of a picture in a TV receiver that it is difficult to keep voltages, currents, frequencies, etc. sufficiently constant over long periods of use to prevent a tendency toward improper reception. The electrical constants of the circuits are bound to vary under conditions of varying temperature, humidity, and dust. For this reason, TV manufacturers build into their receivers certain controls by which adjustments can be made to correct these varying conditions as the receiver ages.

Many times a service call involves only a slight adjustment of these controls. It is important to investigate this possibility early in the service call, so that unnecessary operations are avoided. For this reason, we consider in this chapter what each control is, and how and why it must be adjusted.

### 6-2. Location of Controls

The various controls of the TV receiver, together with the section to which each is most closely related, are shown in the block diagram of Fig. 6-1. As we consider each control individually, the reader may wish to refer to this figure to place the over-all position of the control in the complete circuit.

The channel selector, fine-tuning, and contrast controls are always mounted on the front of the receiver chassis, since they must be frequently adjusted during the tuning of stations. This is also true of the volume control, used for adjustment of sound level. Sometimes included on the front of the receiver, but not always, are the horizontal and vertical hold, focus, and brightness controls.

Horizontal and vertical hold controls on the front of the receiver are usually fine adjustments. Ordinarily, other horizontal and vertical hold controls, with a wider range for coarse adjustment, are located on the rear of the receiver. It is expected that only the service technician

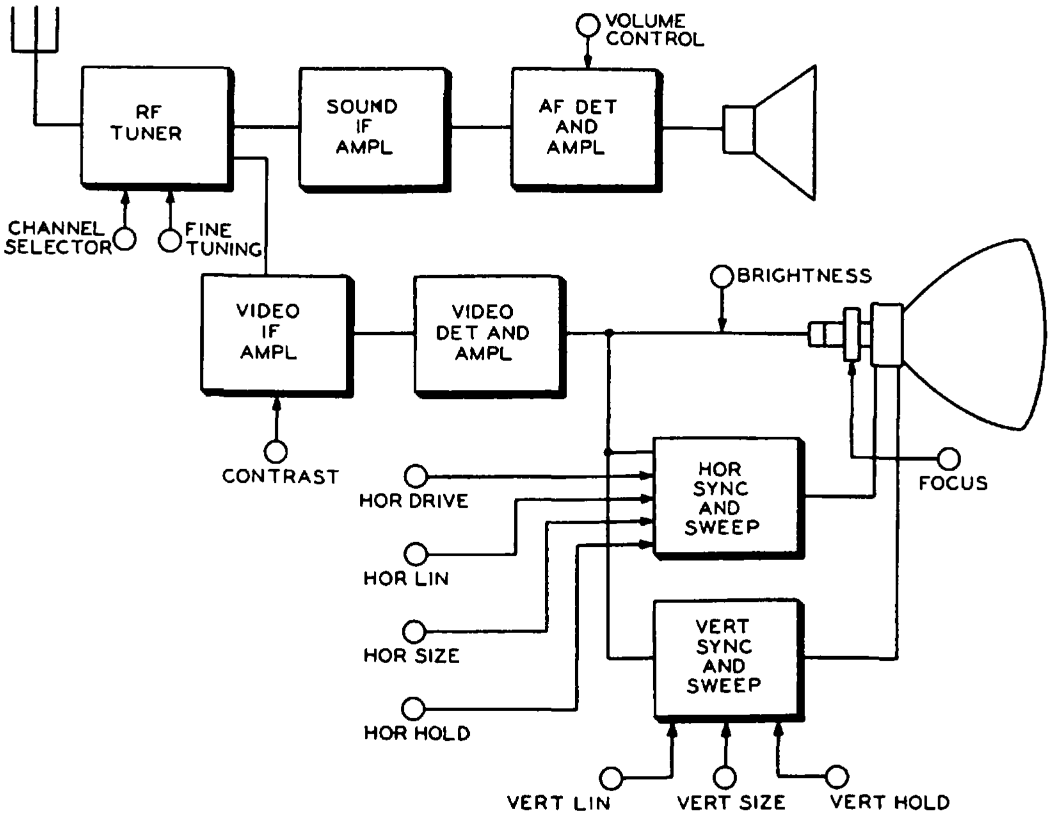



Fig. 6-1. Various controls of a TV receiver and the related sections of the receiver.

will make adjustments to the controls on the rear of the chassis, while those on the front are so placed for convenience of the receiver owner in tuning from one station to another, and to compensate for ordinary changes in temperature, fluctuations in line voltage, etc. In a few cases the technician may need to instruct the receiver owner in the proper method of adjustment of the front controls, since many customers have owned receivers for years without knowing how to tune them properly.

A word of caution at this point is necessary. Many set owners try to adjust the rear apron controls either haphazardly or by following the instructions in a "home fix-it" book. The technician should not show any irritation if otherwise unnecessary calls result from these attempts – after all, the set belongs to the customer, not to the technician. Furthermore, insinuations that the customer is a dope (even if he is) will result in a definite slump in call-backs.

Let us now consider the principle of operation and method of adjustment of each control in the receiver, from the standpoint of the service technician.

## 6-3. Channel Selector and Fine-Tuning Control

The channel selector may be either of two types. First, and most commonly, it may be the step-switch arrangement. A multisection switch connects the proper tuned circuits into the front end for the channel selected. The physical arrangement inside the receiver chassis may be either the *turret* type, in which the coils rotate into position, or the *fixed-coil* type, in which leads from the separate coils and capacitors are connected into the circuit by means of the switch contacts. In either case, the step-switch arrangement involves separate resonant circuits for each channel for the r-f amplifier, mixer, and oscillator. Hence, there is a separate set of alignment adjustments in the tuner for each channel.

In the other tuner arrangement, *continuous* tuning is provided. In other words, the channel selector is similar to the tuning mechanism of an ordinary radio receiver. Here, one set of alignment adjustments is used to provide tracking over the range of the tuner.

The fine-tuning control is ordinarily required only in the step-switch arrangement. In the continuous tuner, the tuning knob is also the fine-tuning control. For the step-switch arrangement, the resonant circuits are prealigned at the factory. The fine-tuning control is simply a low-capacitance, low-range, variable capacitor connected across the resonant circuit of the oscillator. Sometimes, the control is connected to an iron-dust core to vary the inductance of the oscillator tuned circuit. In either case, the fine-tuning control varies the frequency of the oscillator within small limits, so that picture and sound for each channel can be tuned for best reception and variations due to temperature and so forth can be compensated for.

The adjustment of these controls is primarily a matter for the receiver owner. However, the technician should check their operations, since they may indicate other troubles.

For one thing, the channel selector switch may have deteriorated or be out of adjustment so that good contact is not made on all channels. This is usually a result of dust or corrosion due to humidity or fumes (such as coal gas) or misuse and rough handling. Sometimes, removal of the switch (with the complete tuner) and thorough cleaning and gentle pressing together of loose contact points will do the job; in other cases, the tuner or the switch may have to be replaced.

One common trouble, quite easily remedied, is aging of the oscillator and other circuits so that the fine-tuning range does not include the proper frequency for best reception. The fine-tuning knob will not quite bring in the best sound and picture. Many late-model tuners provide oscillator trimmer adjustments accessible from the front panel of the receiver, so that the chassis does not have to be removed. A long, thin alignment tool is usually needed since the adjusting screws are frequently deep inside. In most tuners, the detent mechanism is such that only the proper adjustment screw for the channel is accessible when the switch is set for that channel.

When the oscillator trimmer for a channel is adjusted, the fine-tuning control is first adjusted to the center of its range. Then the trimmer is adjusted so that proper reception will be available at the center of the fine-tuning range. Then, slight subsequent variations of oscillator frequency are not likely to go outside the fine-tuning range again unless there is something else wrong with the tuner.

In some receivers the trimmer adjustments are available *under* the front of the cabinet. In others it may be necessary to remove the chassis from the cabinet to make the adjustments.

As in most instances, the proper service literature is of great help. With this available, the technician will have diagrams of where all the proper adjustments are located and be able to go immediately to the required ones.

## 6-4. Contrast Control

The contrast control is frequently an adjustment of the gain of the receiver. In older models the contrast control was frequently found in the video i-f amplifier sections. However, in modern receivers it is nearly always located in the video amplifier. The reason for this change is probably that the video i-f amplifier stages are now always controlled

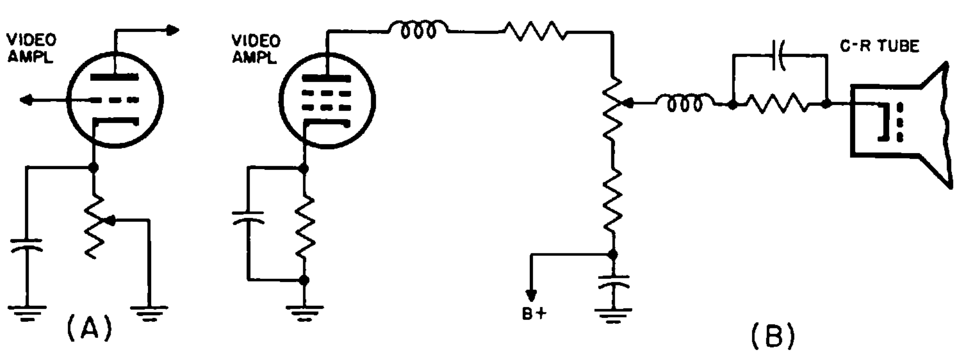



Fig. 6-2. Two commonly-used methods of contrast control. (A) By variation of cathode resistance, and (B) by a plate circuit potentiometer connection.

automatically by AGC (automatic gain control) so contrast adjustment is just a matter of "picking off" as much or as little of the final video signal as desired for application to the picture-tube grid.

Typical contrast control arrangements are shown in Fig. 6-2. The gain of the video amplifier is controlled either by variation of cathode bias or by an output potentiometer connection.

Since the contrast control is one of the basic controls on the front of the receiver chassis and is usually quite familiar to the customer, there is little the technician can do as far as additional adjustment is concerned. But he should be particularly interested in the effect of its adjustment on any trouble the receiver may have.

## 6-5. Brightness Control

The brightness control adjusts the cathode-to-control grid voltage relationship of the picture tube, thus controlling the intensity of the electron beam and the over-all brightness of the raster on the screen. The control may be placed in the circuit in either of two ways: (1) it may control the bias on the cathode, in which case the video information from the video amplifier is injected at the control grid, or (2) it may adjust the bias on the control grid, in which case the video is supplied to the cathode (Fig. 6-3 shows a typical arrangement). The brightness control determines the static negative voltage on the control grid of the picture tube, and the video output of the video amplifier is directly coupled to the cathode. The —135-volt and +125-volt supplies

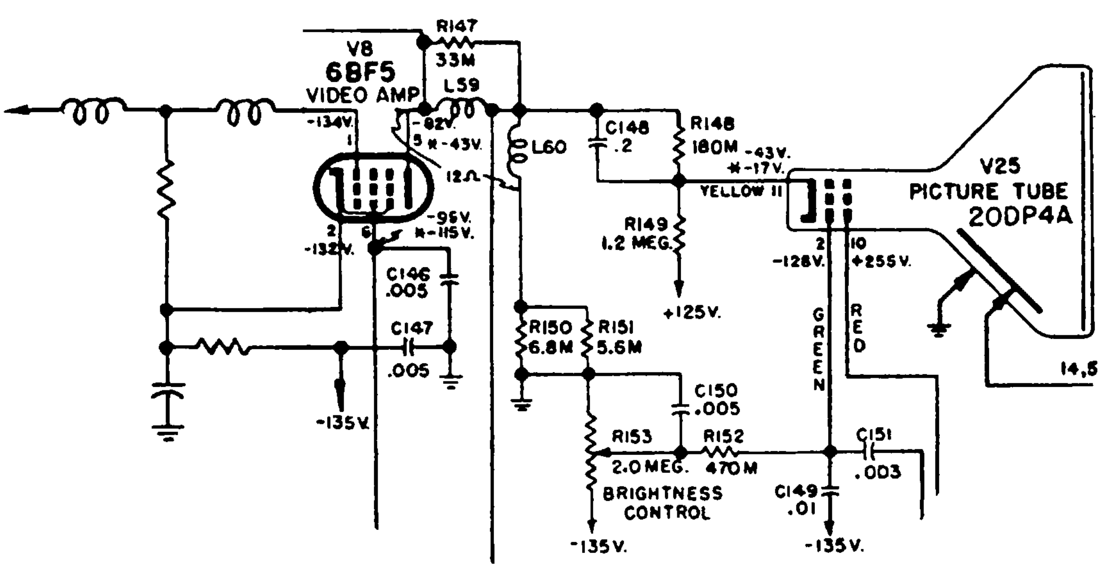



Fig. 6-3. Typical coupling circuit between video amplifier and picture tube, showing location of brightness control.

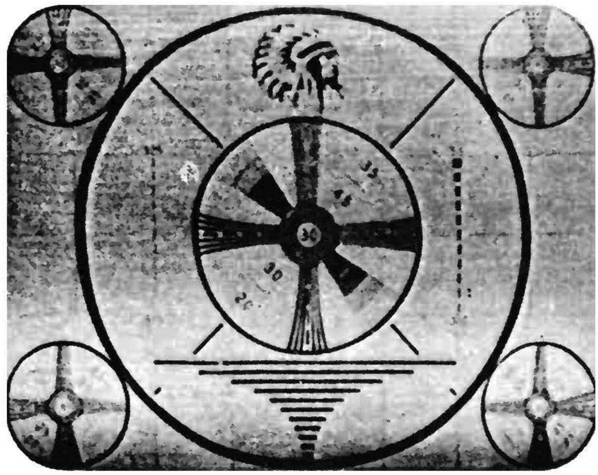


Fig. 6-4. How the horizontal retrace lines during the vertical retrace period become visible when the brightness control is too high or the contrast too low, or both.

*Courtesy: G.E.*

are so connected that the electrodes, including the plate, of the video amplifier operate at potentials negative with respect to ground. The cathode of the picture tube, therefore, is at a slight negative voltage, and the control grid is at a potential from 0 to —135 volts, depending on the setting of the brightness control.

One common error is that of adjusting the brightness control to too advanced a position; this produces a high illumination on the screen but reduces the bias so much that the video signal cannot swing far without driving the cathode negative with respect to the grid and resulting in distortion. The brightness control should therefore be adjusted for the lowest setting consistent with comfortable viewing of the picture. Then the optimum video signal, as determined by the contrast control, can be applied to the C-R tube without distortion.

When the balance between the brightness and contrast control settings is not correct, the horizontal lines of the vertical retrace appear in the picture as shown in Fig. 6-4, indicating that there is too little bias on the picture-tube grid (brightness control too far advanced). The blanking pulses are not driving the cathode positive enough with respect to the control grid to cut off the electron beam, and are appearing on the screen.

Like the contrast control, the adjustment of the brightness control is more or less a routine tuning procedure, although the brightness adjustment in some receivers is found on the rear of the chassis instead of at the front.

### 6-6. Focus Control

Methods of controlling focus have undergone a series of changes in recent years. Because receivers representative of any of the stages in these changes may be encountered, let us review the history involved.

The earliest TV receivers largely employed *electrostatic* focus. That is, the degree to which the electrons converged to a point on the screen was controlled by the d-c voltage applied to an additional anode, called the *focusing anode.* In these early receivers, the focusing voltage was high, and represented an appreciable percentage of the potential applied to the high-voltage anode. Focusing voltage was obtained from a voltage divider consisting of a number of resistors across the high-voltage supply. A variable resistor, which had to be carefully insulated, was used as a focus control.

Then electromagnetic focusing came into general use. A coil of wire was placed around the neck of the picture tube at the proper place and a direct current from the low-voltage power supply passed through

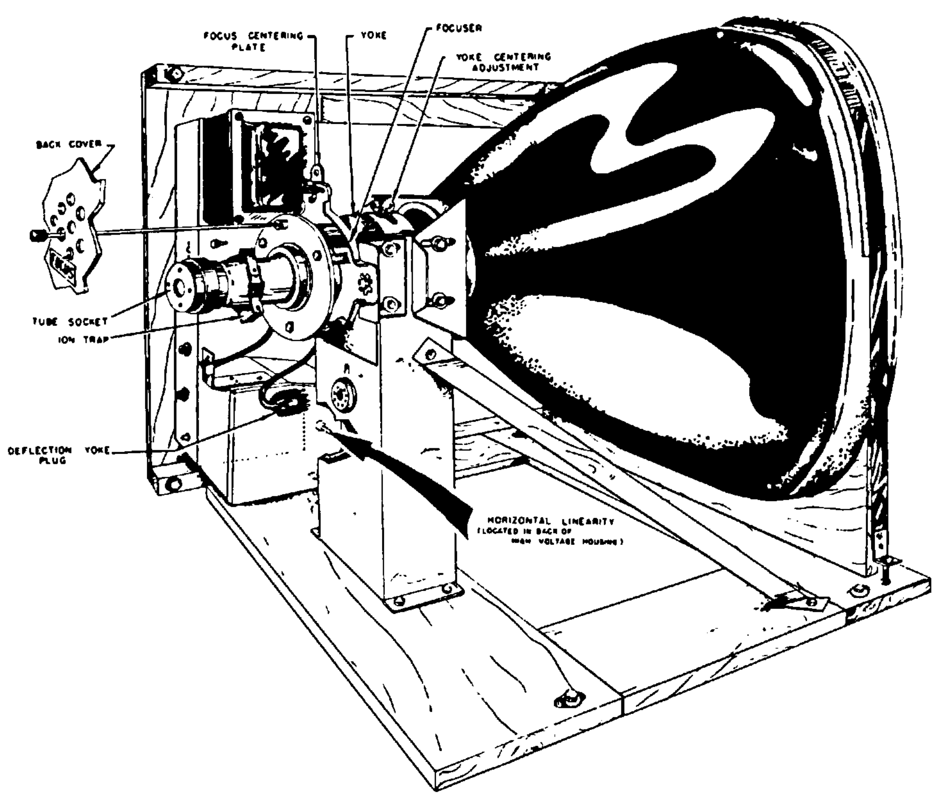



Fig. 6-5. Typical focus adjustment assembly on neck of picture tube.
*Courtesy: Fada*

it. The magnetic field set up by the coil acting as an electromagnet causes the electrons in the beam to converge. Focus is adjusted in these receivers by variation of current through the focusing coil. This variation is effected by connecting a variable resistor across the focusing coil, thus by-passing more or less current around it.

The development of powerful, dependable permanent magnets opened the way to the use of a permanent magnet as the focusing agency, thus eliminating the need for bleeding current from the low-voltage power supply. The strength and position of the permanent magnet along the neck of the tube is varied mechanically to obtain focus adjustment. Many receivers using this principle are now in use. A typical focus adjustment assembly of this type is shown in Fig. 6-5. The magnetic field strength is varied by a magnetic shunt that is moved forward and backward by means of a screw which is coupled by means of an extension to the back of the receiver chassis, or back of the cabinet.

The need for conservation of some of the strategic materials used in permanent magnets led to the general abandonment of the permanent magnet focusing arrangement on the newer receivers. Instead, the old electrostatic method was revived. However, the need for high voltage on the focusing anode was eliminated by the design of new electrostatic-focus picture tubes whose focusing anode requires only the relatively low voltage which can be supplied by the receiver's low-voltage power supply. A great many receivers of this type are now in use.

Finally, a new type of picture tube, called the *Selfocus* tube, has been developed. In this tube the beam is automatically focused at all times with zero voltage on the focusing anode, and no adjustment is required. Thus, on receivers using the Selfocus tube, there is no focus adjustment, which means one less adjustment for the technician to consider.

The method of adjustment of focus has been mentioned previously. A typical example of a poorly focused picture is shown in Fig. 6-6. About the easiest and most dependable method of focus adjustment, with either a plain raster or a received picture, is to observe the sharpness of the horizontal deflection lines. For proper focus, these horizontal lines should be sharp and clearly distinguishable when viewed from quite close. If the focus control does not provide proper focus even though adjusted over its entire range, there must be trouble in the focus circuit or in the positioning of the permanent magnet. It should also be remembered that undue variation of the high voltage on the main anode of the tube can also make it difficult to get good focus, even though the focus circuit itself is satisfactory.

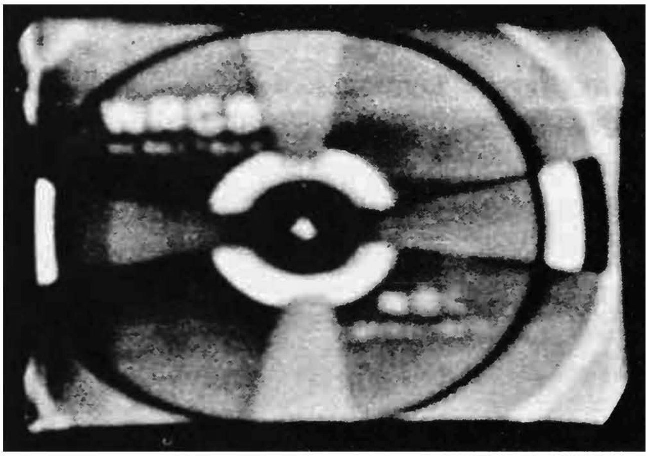


Fig. 6-6. Example of a picture which is not properly focused.

*Courtesy: G.E.*

### 6-7. Horizontal Hold

The horizontal hold control adjusts the free-running frequency of the horizontal oscillator so that it will remain locked in synchronism with the received sync pulses from the TV station. Sometimes there is only one horizontal hold control, located on the rear of the chassis. More often, however, there are two horizontal hold controls: a fine adjustment on the front and a coarse adjustment on the rear. Small variations in sync, due to variations in strength of different stations and to temperature changes, can be compensated by the viewer, by adjustment of the front control.

Several examples of the appearance of the screen when there is loss of horizontal sync are shown in Chapter 9. The technician should satisfy himself that such a condition is not due to temporary difficulties at the transmitting station. The way to check this is, of course, to turn the channel selector to other stations and see if the condition is general. It should then be noted whether the horizontal hold control (if there is one) on the front of the receiver can be adjusted to eliminate the trouble and provide sync. If this control must be turned near one end of its range to provide sync, then the coarse horizontal hold control in the rear of the chassis should be adjusted. When this is done, set the front control to the middle of its range. Then adjust the rear control until sync is obtained. There will then be adjustment room on each side of the center position of the front-panel control to take care of small variations due to temperature changes and so forth.

When the adjustment for horizontal sync has been made, watch the picture for a while to determine whether the sync is stable. If the hold control is adjusted for a free-running frequency near the proper value, the sync system of the receiver should lock the horizontal oscillator into synchronism with the received signal. If the hold control finds a frequency that even momentarily syncs the receiver to the signal, then the hold control circuit is functioning properly. If the sync then has a tendency not to hold, there must be trouble in the sync section or in the video signal path, and the sync pulses are not providing effective control over the horizontal oscillator frequency.

In adjustment of the horizontal hold and other controls at the rear of the chassis, a suitable mirror is very handy. Most receivers are so deep that the screen cannot be viewed while a rear adjustment is being made. By means of a mirror with a handle, the technician can watch the screen through its reflection in the mirror while making the adjustment.

### 6-8. Vertical Hold

Vertical hold problems are similar to those of horizontal hold. Loss of vertical sync produces a picture that either rolls slowly up or down, or jumps rapidly and shows the edges of several frames at the same time. Examples of loss of vertical sync are shown in Chapter 9.

The procedure for adjustment is the same as for the horizontal hold discussed above. Try the front control, if any, first. Then, if satisfactory adjustment cannot be made, make adjustment of the coarse vertical hold control at the back of the chassis.

### 6-9. Failure of Hold Controls To Provide Sync

In the foregoing sections it has been assumed that the adjustment of the hold controls finally produces the required sync. This is sometimes not the case. If hold control adjustment does not produce sync, then it is probably necessary to pull the chassis out of the cabinet and check the deflection oscillator involved, and also the sync circuits. Check the horizontal AFC circuits carefully. Cases in which control adjustments are not sufficient to remedy the trouble are discussed further later.

### 6-10. Linearity Controls

The purpose of the linearity control for either vertical or horizontal sweep is to adjust the deflection voltage waveform so that the active sweep is linear; that is, plots as a straight line. Linearity means that the beam spot on the C-R tube moves across the picture from left to right horizontally and from top to bottom vertically, at a uniform speed. Only when this condition applies can the picture maintain its proper proportions. If there is not linearity, parts of the picture appear to be squeezed

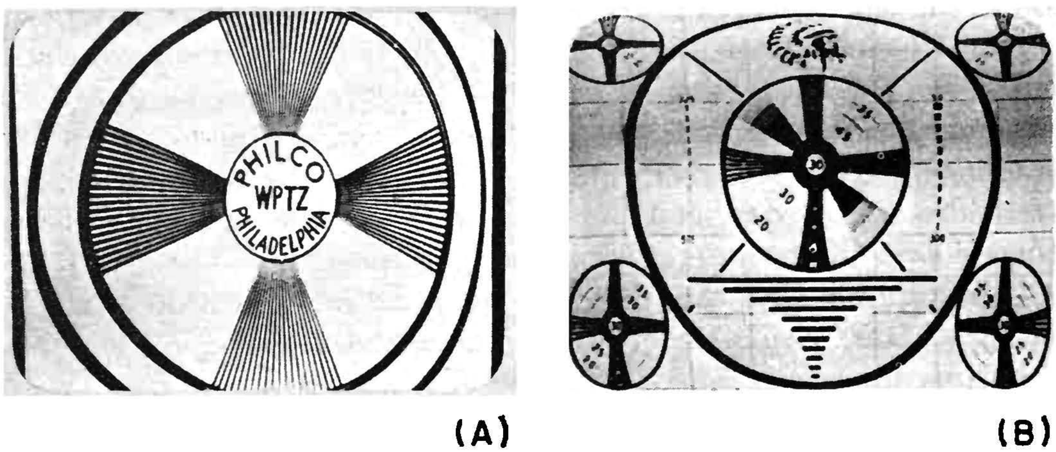



Fig. 6-7. (A) Horizontal nonlinearity. (B) Vertical nonlinearity.

(A) Courtesy: Philco
(B) Courtesy: G.E.

together and other parts pulled apart. Examples of horizontal and vertical nonlinearity are shown in Fig. 6-7.

Typical horizontal linearity control arrangements are shown in Fig. 6-8. In the one at (A), the waveform of the deflection signal is adjusted by adjustment of the bias on the horizontal output amplifier by variation of the cathode resistance. The other, more common method, shown at (B), is the adjustment of the series inductance in a feedback circuit in the horizontal output amplifier. Some of the output signal is fed back to the input, with its phase varied according to the amount of inductance in the linearity control. This allows an adjustment for just the proper amount of feedback to provide linearity of waveform.

As has been previously mentioned, linearity can be checked by observation of a test pattern from a TV station or by use of a cross-hatch generator. The latter instrument can be easily coupled to the mixer tube, or to the video detector, without removal of the chassis from the cabinet. In Fig. 5-4 we showed the bar and cross-hatch patterns obtained when

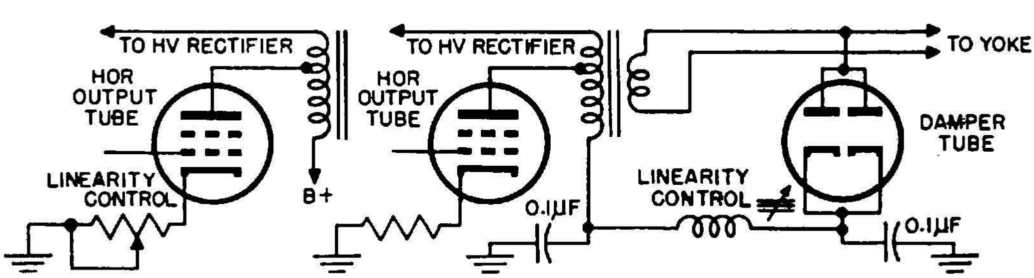
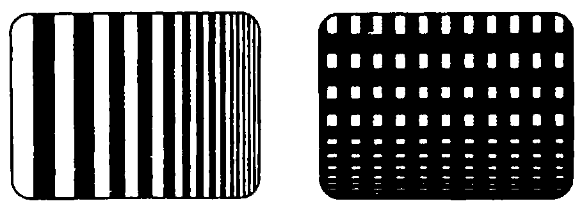



Fig. 6-8. Typical linearity control circuits.

vertical and horizontal linearity are proper. Figure 6-9 shows how nonlinearity in the horizontal and vertical directions shows up with bar and cross-hatch generators.

When it becomes obvious that there is nonlinearity, try adjusting the linearity control involved (horizontal or vertical, depending on whether there is horizontal or vertical nonlinearity). Here again, the mirror comes in handy. It may be found that the linearity control affects both the hold and size controls for the same direction. We must then jockey back and forth among these three controls until we obtain correct linearity consistent with proper size and sync. If such a condition is not obtainable, or requires that the controls be radically changed, there must be more trouble than just control adjustment. Therefore, other measures, starting with tube checking, should be taken. (Tube checking is discussed in Chapter 7.)



(A) (B)

Fig. 6-9. Nonlinearity indications with bar and cross-hatch generators. (A) Horizontal nonlinearity with bar generator, and (B) vertical nonlinearity with cross-hatch generator.

## 6-11. Size Controls

Size controls are provided to allow adjustment of the intensity of the deflection signal output, and thus the width and height of the picture.

Horizontal size (width) is ordinarily controlled by adjustment of a variable inductance connected across part of the secondary winding of the horizontal output transformer. This is shown in Fig. 6-10. Vertical size (height) is controlled by adjustment of plate current to the vertical oscillator by means of a series variable resistor, or by a *volume control* arrangement in the vertical output amplifier grid circuit, as shown in Fig. 6-11.

If the picture seems small, it is well to check for low line voltage before adjusting the size controls. Low line voltage is usually accompanied by lack of normal brightness as well as by insufficient picture size. Low line voltage also affects the centering of the picture in some cases, with the width or height reduced more on one side than on the other.

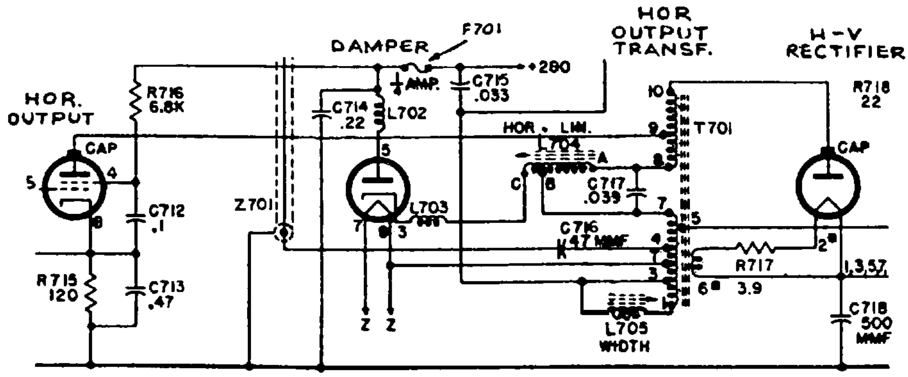


Fig. 6-10. Typical width control circuit.

*Courtesy: Hoffman*

If the line voltage proves to be low, try to determine whether this condition is temporary or more or less steady. If the latter, then some kind of voltage regulator is in order, rather than adjustment of the size and centering.

When the size controls are adjusted, the final raster should extend only a short distance beyond the edges of the mask. Sometimes there is a tendency to increase size far beyond the mask, to make the part of the picture appear much larger. However, this is not recommended since important parts of the picture may be obscured. On most screens, 16-inch and larger, the raster should extend about 1/4 to 1/2 inch beyond the

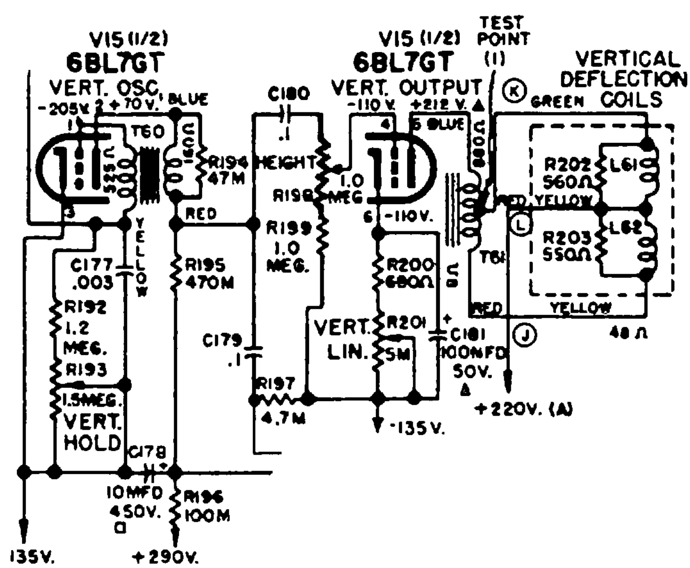


Fig. 6-11. One circuit arrangement for controlling height of the picture.

*Courtesy: Sylvania*


(A) (B) (C)

Fig. 6-12. (A) Improper centering, picture to right. (B) Improper centering, picture low. (C) Picture tilted.

(A) (B) *Courtesy:* RCA
(C) *Courtesy:* G.E.

mask. This extension ordinarily is adequate to take care of day-to-day variations due to line voltage, temperature, etc.

## 6-12. Centering and Other Mechanical Adjustments

If the raster is off-center or tilted, as shown in Fig. 6-12, adjustment must be made of the deflection yoke on the neck of the picture tube. The yoke is usually mounted on a bracket in such a way that its position can be varied by moving mounting screws along slots provided for the purpose. The details of this adjustment should be checked in the service data for the receiver.

It should also be remembered that not all cases of poor centering are due to yoke misadjustment. A few other possible causes are:

1. Shorts or other trouble in low-voltage power supply
2. Troubles in the video i-f amplifier or detector
3. Troubles in the AGC circuit
4. Deflection output transformer troubles

If adjustment of the yoke does not correct the situation, these possibilities should be checked in later testing.

Cases of low brightness may be traced to improper orientation of the ion trap magnet. This device, mounted around the neck of the picture tube well down toward the base, must be adjusted for maximum brightness of the signal. Two motions are involved: first, the magnet is rotated *around* the neck of the tube; and second, it is moved *along* the neck. The greatest brightness resulting from all combinations of positions from both motions is the proper setting.

Other types of picture tube require a somewhat different adjustment of this magnet. Hence, it is well to consult a tube manual or other manufacturer's data for the proper procedure. In any event, improper setting of the magnet with power applied to the picture tube causes a decrease in tube life. (If, upon examination of the set, no ion trap

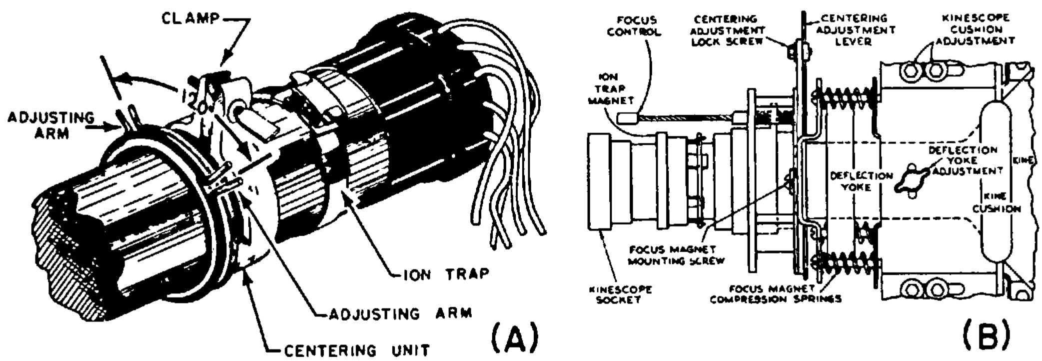



**Fig. 6-13. Yoke and other adjustments on the neck of the picture tube.**
*(A) Courtesy: Emerson*
*(B) Courtesy: RCA*

magnet is found, consult a tube manual – some types of kinescopes do not require this component.)

If the ion trap magnet has been improperly adjusted for some time, an *ion spot* may develop on the picture-tube screen. This is a brownish area in the center of the screen, appearing when the raster is present. The ion spot also produces small spots of light in the center of the screen where the ions are bombarding the screen. Through these characteristic symptoms, improper ion trap magnet adjustment can sometimes be noted immediately when the technician first examines the receiver.

The focus adjustment is frequently also part of the picture-tube neck assembly. Its adjustment has been previously explained in Chapter 5.

Figure 6-13 shows a typical assembly of the yoke and associated mechanical adjustments on the neck of the picture tube. Of course, there is no set or fixed arrangement for different receivers, and the details for each receiver must be individually investigated, preferably in the manufacturer's service data.

*Chapter 7*

# TUBES AND TUBE CHECKING

## 7-1. Prevalence of Tube Troubles

There is no doubt that many of the troubles encountered in TV receivers are traceable to tube failure. Various estimates as to the percentage of troubles resulting from this cause range from 50 to 90 percent. Tube trouble is about the easiest to remedy, by replacement with a new tube. In some cases, however, tube failure results from another fault, so the technician must be alert; he will frequently find it advisable to make routine circuit checks before replacing tubes.

In any event, the service technician concerned with TV receivers will meet more instances of tube failure than of any other kind of trouble. He must therefore know how to determine the faulty one in the shortest time, and be ready to replace any kind of tube.

## 7-2. When To Make Tube Checks

Because tube troubles are so prevalent, it might be thought that all the tubes in a defective receiver should be checked right away. True, this is one way to find tube troubles, but it is generally not the fastest way. There are so many tubes in a TV receiver, some of which cannot be involved in the trouble being analyzed, that it is unnecessarily time-consuming to check all.

Accordingly, it is always best to localize the trouble to one or more circuit sections before starting to check the tubes. Because of the many indications provided by the raster, picture, and sound, it is almost always possible to make preliminary estimates as to which sections of the circuit *could* contain the trouble. It is seldom that the trouble cannot be localized to the circuits of three or four tubes, or less. This will be illustrated by examples later in this chapter.

The time to start tube checks is after the preliminary checks have been made and the evidence gathered. By that time, if there are any obvious, quickly remedied troubles, (such as loose antenna connections, lack of power, a cold or unlighted tube which is obviously burned out, etc.) they will have been discovered. If not, then there will be enough evidence at hand to narrow the checks to the several tubes in the suspected section.

## 7-3. Localizing Trouble for Tube Checks

Trouble-localizing for the purpose of tube checks is similar to any trouble-localizing, except that one has in mind the tubes involved in a particular circuit. For example, if there is no vertical deflection, then the vertical oscillator and vertical amplifier tubes are involved. The trouble may be the failure of these tubes, or it may be in the circuit. But we make our tube check first, before checking the circuit, because tube replacement is the easiest and quickest check.

In order to make our tube checks, we must go through the following steps:

1. Determine the tube layout and kind of circuit in the receiver
2. Combine all evidence available and localize the trouble to one section
3. By replacement of each tube in the suspected section, determine which, if any, are bad

## 7-4. Determining Tube Layout

The locations of the various tubes in a receiver can be determined by examination of the receiver chassis. But this is usually a tedious job, and it is easy to run into errors. It is much better to obtain the tube layout from service data. A layout is usually pasted in the receiver cabinet, or somewhere on the chassis; but this chart ordinarily gives only the tube types and locations, and not their functions.

On the other hand, manufacturers and publishers of service data provide diagrams giving not only locations and types, but also the functions of the tubes. With this diagram at hand, the technician can proceed almost immediately to any particular tube or section of the receiver and quickly make any trial replacements. Examples of useful tube layout diagrams are given in Fig. 7-1.

If such a diagram cannot be obtained, indirect methods of determining the layout must be used. For example, the tuner section must be at the front, to make the channel selector and fine-tuning control accessible. It may be either at the left or right side, and this can be determined by following the antenna lead from the back of the receiver chassis to the tuner. The tuner is ordinarily a separate unit, on its own chassis, which can be removed from the main chassis when necessary.

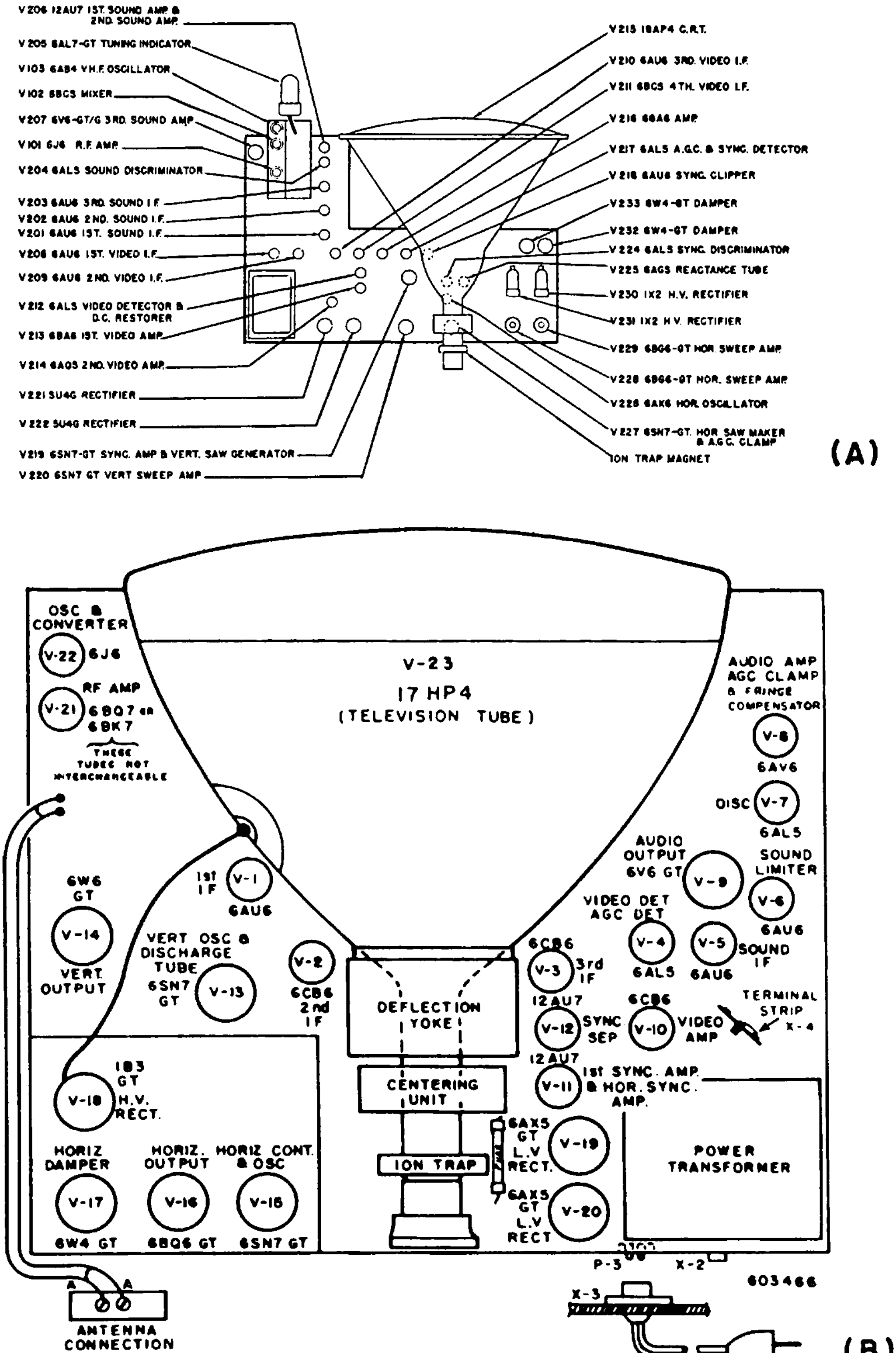



Fig. 7-1. Typical tube layout diagrams.

*(A) Courtesy: DuMont*
*(B) Courtesy: Emerson*

The i-f amplifier stages must be located near the tuner unit, and usually follow along in the order in which they occur functionally in the receiver circuit. Frequently, the sound i-f section can be distinguished from the video i-f section by locating the sound detector, which is either a duodiode such as the 6AL5, a combination diode and amplifier like the 6T8, or a 6BN6 gated-beam detector. Most of the receivers now are of the intercarrier type, so the sound i-f amplifier stages will probably be separated from the tuner, branching off at the video detector or video amplifier. Since the video i-f amplifier stages must still be near the tuner, it is then easy to distinguish between the sound and video i-f sections.

The horizontal output, damper, and high-voltage rectifier tubes are almost always enclosed in a metal case or shield, and are thus easily located. However, the vertical and horizontal oscillator tubes are frequently of the same type, and some difficulty may be experienced in distinguishing between them. If the receiver contains a power transformer and the tube heaters are all in parallel, the horizontal and vertical oscillator tubes can be distinguished from each other by pulling out the tubes which are thought to have these functions. Removal of the vertical oscillator tube stops vertical deflection and leaves only a horizontal line on the screen, instead of a complete raster. Removal of the horizontal oscillator tube cuts off excitation to the high-voltage power supply, thus removing high voltage from the picture-tube anode and producing a dark screen.[1]

Although the functions and locations of most of the tubes can be determined by such observations and tests, there will be many instances when there is not enough evidence to determine what all the tubes are.

It should be noted also that tests in which tubes are pulled from the socket are of no use with *transformerless* receivers, in which the tube heaters are connected in series, since the removal of any tube opens the heater circuit of a whole group of tubes. If the proper service data are not available, determination of the functions and locations of the tubes requires much wire-tracing and study of the chassis, both above and below the chassis. The importance of layout diagrams is thus obvious.

### 7-5. Types of Tubes Found in TV Receivers

The functions and locations of the tubes in a TV receiver can be spotted much more quickly if the technician is thoroughly familiar with

[1] In extremely rare cases, a receiver with an r-f high-voltage power supply may be encountered. In that event, removal of the horizontal oscillator tube will not affect high voltage, but will disable horizontal deflection, leaving a vertical line in the middle of the screen.

the types of tubes usually encountered and what each is used for in different receivers. Therefore, to aid the reader in learning or in reviewing the various types of tubes, Table 7-1 shows what tube types are used in standard, commercial TV receivers for each functional purpose. If the information in this table is kept in mind, the job of spotting tube types and locations in a receiver is greatly simplified. It is suggested that the reader study the table carefully and thus save much time and trouble in service work.

Table 7-2 lists the most frequent functions of each tube type. This classification is useful in determining the function of any given tube type in a receiver, or at least several *possible* functions. In other words, Tables 7-1 and 7-2 can be used with other evidence to determine quickly the functions of all the tubes in the receiver. Although this method is not a substitute for manufacturers' tube layout and function diagrams, it is very helpful when these are not available.

Obviously, the tables are not guaranteed to be absolutely complete, and they will certainly need revision as new tube types appear. However, they cover, by and large, a good majority of all the types used in generally encountered receivers. They were derived from a large number of typical receivers in use today.

## 7-6. Checking the Tubes

For servicing radio receivers, tube-checking instruments have always been useful. However, these instruments cannot be depended upon to find all the possible defects in all the tubes in TV receivers. There is only one completely dependable method of TV receiver tube checking, and that is replacement of each suspected tube with an other known to be good. Various factors, such as small interelectrode capacitance changes, heater-to-cathode leakage, etc., can seriously affect operation in certain TV receiver circuits, but do not show up on a regular tube checker.

Therefore, instead of a tube checker, the technician maintains a large stock of replacement tubes. Table 7-2 covers nearly all possible cases. However, some of these types are less often encountered, and the technician may find that a somewhat smaller list will cover over 90 percent of all jobs and be sufficient for field trips. The types marked with an asterisk are those of which two or more should be stocked because of the frequency with which they are found in TV receivers or because of their susceptibility to failure. For these reasons, it is likely that more than one will be needed during one inventory period. The recommended list has been proved by actual experience in the field to be the minimum needed to prevent extra trips back to the shop for tubes. At least several of each type, and more of those with an asterisk, should be kept in the shop.

In checking the tubes, it should be kept in mind that the tube itself, although it has failed, may not be the *basic* cause of trouble. The tube may have failed because of the failure of some other component in the same or in a related circuit. Observation of the receiver by the technician may reveal these other component troubles. However, since the cases in which the tube *is* the basic trouble greatly out-number those in which related components are at fault, circuit checks are seldom made before tube replacement unless there is definite evidence of other trouble. The reason for this is that tubes can be changed from the top of the chassis,

## TABLE 7-1

### TV Receiver Tubes, Functional Listing

*RF Amplifiers*

| *Triode grounded-grid* | *Dual-triode cascode* | *Pentode grounded-cathode* |
|---|---|---|
| 6AB4 | 6BQ7 (A) | 6AG5 |
| 6J6 | 6BK7 | 6AK5 |
| | 6BZ7 | 6AU6 |
| | | 6BC5 |
| | | 6BH6 |
| | | 6BJ6 |
| | | 6CB6 |

*Mixers and Oscillators*

| *Separate mixer tube* | *Separate oscillator tube* | *Dual-triode mixer-oscillator* | *Combination triode oscillator and pentode mixer* |
|---|---|---|---|
| 6AG5 | 6C4 | 6J6 | 6U8 |
| 6AK5 | 6J6 | 7F8 | 6X8 |
| | | 12AT7 | |
| | | 12AV7 | |
| | | 12AZ7 | |

*Video IF Amplifiers*

| | | |
|---|---|---|
| 6AG5 | 6BA6 | 6CB6 |
| 6AU6 | 6BC5 | 6U8 (pentode section) |

*Video Second Detector*

| | | |
|---|---|---|
| 1N34 | | 6AL5 (1 diode) |
| 1N60 | 1N64 | 12AU7 (1 triode section) |

without removing it, whereas complete circuit checks ordinarily require access to the wiring side of the chassis. If the replacement tube does not hold up, then of course the circuits must be carefully checked.

An exception to the high incidence of tube failure is found in the low-voltage rectifier and high-voltage rectifier circuits. Here, tube failure is no more frequent than circuit failure, especially burn-out of filter capacitors. In the case of the high-voltage rectifier, failure is often due to leakage, breakdown of insulation, etc. When a rectifier tube has failed, one simple circuit check is definitely desirable before the tube is replaced. That check is a resistance measurement between B+ and ground. Such a test will show capacitor burn-out and excessive leakage. These faults must be remedied before a new tube is tried.

## Table 7-1 (Continued)

*Video Amplifier*

| | | |
|---|---|---|
| 6AC7 | 6AG7 | 7C5 |
| 6AH6 | 6CB6 | 12AT7 |
| 6AQ5 | 6X8 (pentode section) | 12AU7 |
| 6AU6 | 6K6-GT | 12BY7 |

*Sound IF Amplifiers*

| | |
|---|---|
| 6AU6 | 6SH7 (limiter) |
| 6BA6 | 6X8 (triode section) |

*Sound Detectors*

| | |
|---|---|
| 6AL5 | |
| 6AQ7-GT (diode section) | 6S8 (diodes) |
| 6BN6 | 6T8 (diodes) |

*Sync Separators, Amplifiers, and Clippers*

| | | |
|---|---|---|
| 6AU6 | 6SN7-GT | 12AU7 |
| 6BE6 | 6U8 | 12AX7-GT |
| 6C4 | 7F7 | 12BH7 |
| 6SH7 | 7N7 | 12BZ7 |
| 6SK7 | 12AT7 | 12SN7-GT |
| 6SL7-GT | | |

*Horizontal Oscillators and Discharge Amplifiers*

| | |
|---|---|
| 6K6-GT | 12AU7 |
| 6SN7-GT | 12BH7 |
| 7N7 | 12SN7-GT |

*Horizontal Output Amplifiers*

| | | |
|---|---|---|
| 6AQ5 | 6BG6-GT | 19BG6-G |
| 6AU5-GT | 6BK6-GT | 25BQ6-GT |
| 6AV5-GT | 6CD6-G | 50B5 |

## TABLE 7-1 (Continued)

*AF Amplifiers*

| *Voltage Amplifiers* | *Power Amplifiers* |
|---|---|
| 6AT6 (triode section) | 6AQ5 |
| 6AV6 (triode section) | 6AS5 |
| 6C4 | 6BK5 |
| 6SN7-GT | 6K6-GT |
| 6SQ7 (GT) | 6L6 (-G, -GT) |
| 6S8 (triode section) | 6V6-GT |
| 6T8 (triode section) | 6W6-GT |
| | 6Y6-G |
| | 25L6-GT |

*Damper Tubes*

| | | |
|---|---|---|
| 5V4-G | 6W4-GT | 25W4-GT |
| 6AS7-G | 6V3 | |
| 6AX4-GT | 12AX4-GT | |

*Vertical Oscillators*

| | | |
|---|---|---|
| 6BF6 | 6SL7-GT | 12BH7 |
| 6BL7-GT | 6SN7-GT | 12SN7-GT |
| 6C4 | 6U8 | |
| 6J5-GT | 7N7 | |

*Vertical Output Amplifiers*

| | | |
|---|---|---|
| 6AU5 | 6K6-GT | 6W6-GT |
| 6AV5 | 6S4 | 12AU7 |
| 6BL7-GT | 6V6-GT | 12BH7 |

*Automatic Gain Control*

| | |
|---|---|
| 6AL5 | 6SN7-GT |
| 6AU6 | 12AX7-GT |

*Horizontal AFC*

| | |
|---|---|
| 6AC7 | 6SN7-GT |
| 6AL5 | 12AU7 |
| 6CB6 | 12SN7-GT |

*High-Voltage Rectifiers*

| | |
|---|---|
| 1AX2 | 1B3-GT (8016) |
| 1X2 (A) | 5642 |

*Low-Voltage Rectifiers*

| | | |
|---|---|---|
| 5U4-G | 6X5 | Selenium types |
| 5V4-G | 7Z4 | |
| 5Y3-GT | 25Z6 | |

# TABLE 7-2

## Functions of Tubes Found In TV Receivers

(*Desirable to have two or more spares. Listed by tube type.)

*1B3-GT (8016)—High-voltage rectifier
1N34—Video detector (crystal rectifier)
*1N60—Video detector (crystal rectifier)
*1N64—Video detector (crystal rectifier)
*1X2 (A)—High-voltage rectifier
*5U4-G—Low-voltage rectifier
*5V4-G—Damper; low-voltage rectifier
*5Y3-GT—Low-voltage rectifier
*6AB4—Grounded-grid RF amplifier
6AC7—Video amplifier; horizontal AFC
*6AG5—Grounded-cathode RF amplifier
Separate mixer
Video IF amplifier
6AG7—Video amplifier
6AH6—Video amplifier
6AK5—Grounded-cathode RF amplifier
Separate mixer
*6AL5—Video detector; AGC
Horizontal AFC; sound detector
*6AQ5—Video amplifier
Horizontal output amplifier
6AQ7-GT—Sound detector
AF amplifier
6AS7-GT—Damper
6AT6—AF amplifier
6AU5—Vertical output amplifier
Horizontal output amplifier
*6AU6—Grounded-cathode RF amplifier
Video IF amplifier
Video amplifier
AGC
Sound IF amplifier
Sync section
6AV5—Vertical output amplifier
Horizontal output amplifier
6AV6—AF amplifier
*6AX4-GT—Damper
*6BA6—Video IF amplifier
Sound IF amplifier
6BC5—Grounded-cathode RF amplifier
Video IF amplifier
6BE6—Sync section
6BF6—Vertical oscillator
6BG6-G—Horizontal output amplifier
6BH6—Grounded-cathode RF amplifier
6BJ6—Grounded-cathode RF amplifier
6BK5—AF output amplifier
*6BK7—Cascode RF amplifier
6BL7-GT—Vertical oscillator
Vertical output amplifier
6BN6—Gated-beam sound detector
*6BQ6-GT—Horizontal output amplifier
6BQ7—Cascode RF amplifier
6BZ7—Cascode RF amplifier
6C4—Separate local oscillator
Vertical oscillator
AF amplifier
Sync section
*6CB6—Grounded-cathode RF amplifier
Video IF amplifier
Video amplifier
Horizontal AFC
6CD6-G—Horizontal output amplifier
6J5-GT—Vertical oscillator
*6J6—Grounded-grid RF amplifier
Local oscillator
Mixer-oscillator
*6K6 (-GT)—Video amplifier
Vertical output amplifier
AF output amplifier
Horizontal oscillator
Horizontal discharge amplifier
6L6 (-G, -GT)—AF output amplifier
*6S4—Vertical output amplifier
6S8—Sound detector
AF amplifier
6SH7—Sound IF amplifier (limiter)
Sync section
6SK7—Sync section
*6SL7-GT—Vertical oscillator
Sync section
*6SN7-GT—Vertical oscillator
AGC
Horizontal AFC
AF voltage amplifier

## Table 7-2 (Continued)

*6SN7-GT— (Continued)
Sync section
Horizontal oscillator or discharge amplifier
6SQ7-GT—AF amplifier
6T8—Sound detector
AF amplifier
6U8—Oscillator-mixer
Video IF amplifier
Vertical oscillator
Sync section
*6V3—Damper
6V6-GT—Vertical output amplifier
AF output amplifier
*6W4-GT—Damper
6W6-GT—Vertical output amplifier
AF output amplifier
6X5—Low-voltage rectifier
6X8—Oscillator-mixer
Video amplifier
Sound IF amplifier
6Y6-G—AF output amplifier
7C5—Video amplifier
7F7—Sync section
7F8—Mixer-oscillator
7N7—Vertical oscillator
Sync section
Horizontal oscillator and discharge amplifier
7Z4—Low-voltage rectifier
*12AT7—Mixer-oscillator
Video amplifier
Sync separator and clipper
12AV7—Mixer-oscillator
12AZ7—Mixer-oscillator
*12AU7—Video detector
Video amplifier
Vertical output amplifier
Horizontal AFC
Sync section
Horizontal oscillator and discharge amplifier
12AX4-GT—Damper
12AX7-GT—AGC
Sync section
12BH7—Vertical oscillator
Vertical output amplifier
Sync section
Horizontal oscillator and discharge amplifier
12BY7—Video amplifier
*12SN7-GT—Vertical oscillator
Horizontal AFC
Sync section
Horizontal oscillator and amplifier
19BG6-G—Horizontal output amplifier
25BQ6-GT—Horizontal output amplifier
25L6-GT—AF output amplifier
25W4-GT—Damper
25Z6—Low-voltage rectifier
50B5—Horizontal output amplifier
5642—High-voltage rectifier

## Chapter 8

# THE DEAD RECEIVER

*After all preliminary tests* and observations have been made and defective tubes replaced, a receiver that still fails to function will fall into one of the following categories: dead receiver, picture or raster distortion, sound troubles, or a combination of the latter two. Tube tests have already been discussed because they apply in all three of these cases, but they do not, of course, necessarily precede the classification of the receiver into one of these categories. In fact, they more often follow it. In this chapter we consider the first of the three main symptoms – the dead receiver.

### 8-1. What Is a Dead Receiver?

A dead receiver is one with no light of any kind on the picture-tube screen and no sound from the loudspeaker, even though the power is apparently turned on. Such indications on the screen as a single line, dim raster, etc. are actually some form of pattern; they are therefore discussed in Chapter 9.

We do allow, however, for one indication in our dead receiver. The receiver will still be referred to as *dead,* even though the heaters are lit. In fact, in the case of a dead receiver, the condition of the heaters is one of the first considerations in gathering evidence.

### 8-2. General Considerations

Let us consider the nature of the dead receiver symptom. The first thing to consider is lack of power, either at the power-line plug or in the receiver power supplies. Careful examination of the block diagrams shown in Chapter 2 reveals that there is no failure of any one section in the receiver, except for the low-voltage supply or its a-c power supply, which can cause a completely dead receiver. For example, failure of the antenna system or the tuner section will cause loss of signal but will not affect the raster, which is produced by the deflection of the cathode-ray tube beam spot upon the screen. The sweep sections which cause this deflection are separate from the tuner portion. If the high-voltage power supply fails, the screen goes dark, but sound is still received. If the horizontal sweep section goes dead, both deflection and high voltage are lost, but the sound signal is still received. Thus, we can continue through all the sections and show that only the failure of the low-voltage power supply can cause a completely dead receiver. This, of course, narrows our search considerably.

## 8-3. Classifying Trouble by Heater Operation

If the receiver is dead, one of the first things to check is whether the heaters are lighted. Since most TV receivers contain only a few metal tubes, this observation is not difficult. After power has been on for a while, the operation of metal tube heaters can be detected by placing the hand on the metal envelope. If the envelope is warm, the heater must be operating.

There are three possibilities:

1. All the heaters are dead
2. Some of the heaters are dead, the others lighted
3. All the heaters are operating normally.

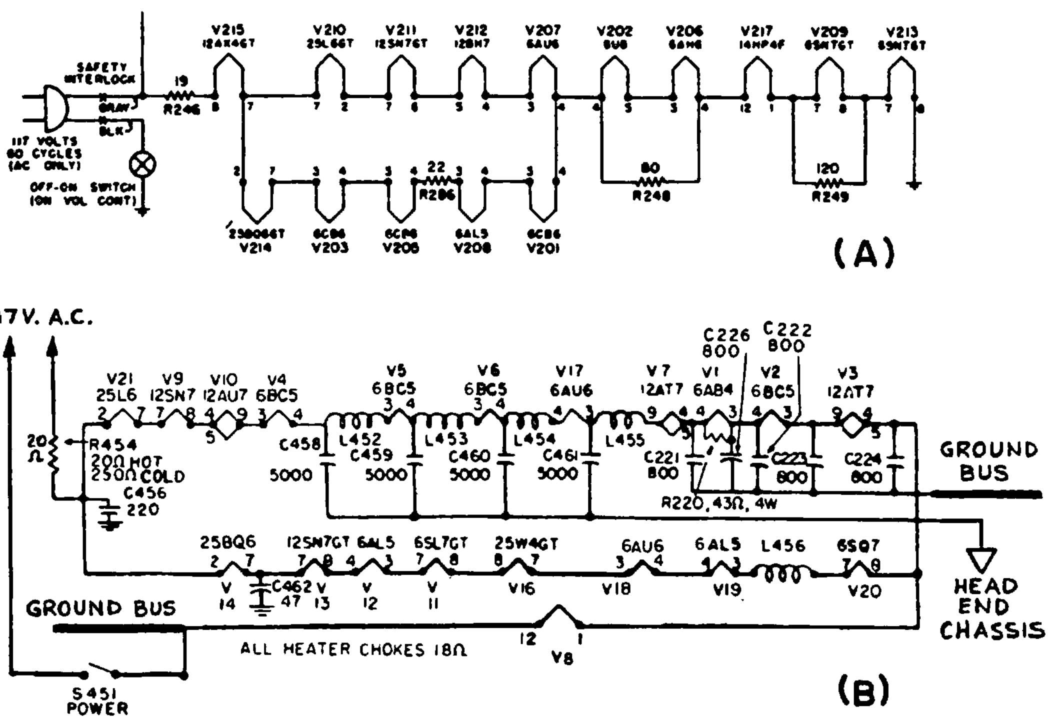



Fig. 8-1. Examples of series-heater circuits used in transformerless TV receivers.

*(A) Courtesy: Motorola*
*(B) Courtesy: G.E.*

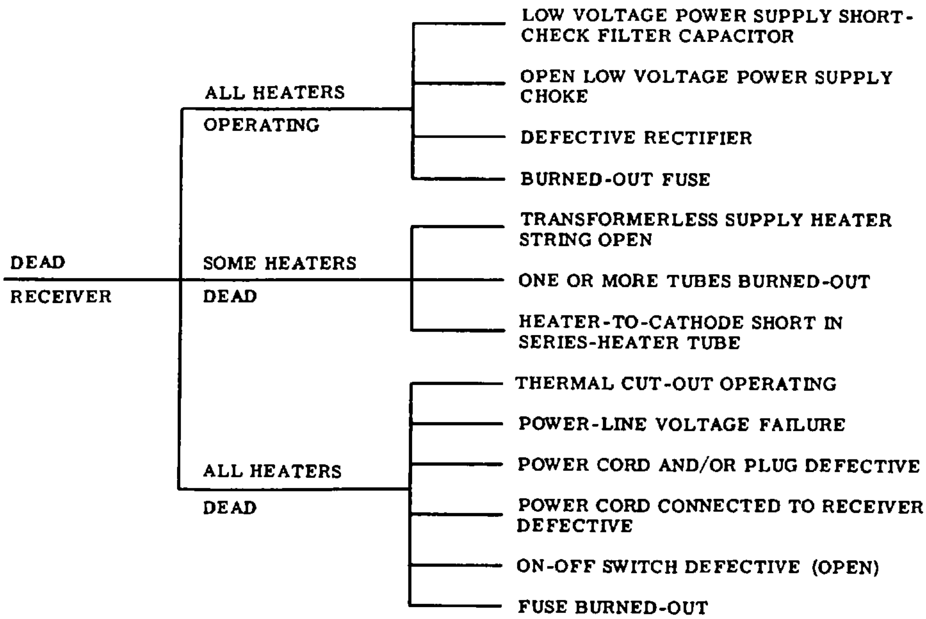



Fig. 8-2. Chart showing the most likely possibilities of trouble location in a dead receiver, and how they may be separated according to whether the heaters are operating.

Classification into one of these three categories should be easy as soon as the cover is removed from the back of the cabinet and power is applied to the receiver through a power-line jumper plugged into the interlock. If the circuit diagram of the receiver is at hand, check the heater circuit. If some of the heaters only are lighted, note whether all the dead heaters are in series. This will occur, of course, only in transformerless receivers, in which the heaters are connected in parallel groups, each group containing a number of heaters in series. Examples of such arrangements are shown in Fig. 8-1. Note that if a single heater should burn out, all the heaters in its series group would lose power.

The initial breakdown of the dead receiver into the three main possibilities is shown in Fig. 8-2, along with the follow-up possibilities. We shall now consider each one of these possibilities separately.

## 8-4. All Heaters Operating

As soon as we see heaters operating, we know that there must be a-c power available to the receiver, because this is what supplies the heaters with their voltage.

If the receiver has a power transformer, it is almost certain that the power transformer is all right, since the heater voltages are obtained from a secondary winding of the power transformer. Occasionally, the high-voltage secondary winding of the power transformer may be defective and the filament windings normal, but this is very unusual.

In transformerless receivers, the operation of all the heaters shows that the circuit from the a-c power lines into the receiver and into the series strings of heaters is not defective.

In either case, a dead receiver with all heaters lighted narrows down to a defect in the low-voltage plate power supply. Lack of plate voltage is disabling all other sections of the receiver, making it dead. The rectifier should be checked for poor emission or open circuit. The B+ line should be checked for short circuit. The filter choke and any dropping resistors should be checked for opens. Sometimes, there is a fuse in the plate voltage supply line, which can burn out without affecting the heater supply.

## 8-5. Some Heaters Operating

The first possibilities with some heaters operating are those which involve series-heater circuits found in transformerless receivers. The best possibility is that a heater in one of the series heater strings has burned out and disabled the remaining heaters in the same string. This possibility is strengthened if it is found from the schematic diagram that the heaters which are dead correspond with the tubes in one of the series strings. In the transformerless receiver, the heaters must always go out only in strings, never one at a time, since the failure of one tube breaks the heater circuit to the others.

If only one or two of the heaters in a series string are dead but some of the others glow *overbrightly,* a cathode-heater short in one of the tubes is indicated. Since one side of the power line is connected to both B— and one end of the heater strings, a cathode-heater short can shunt one or more heaters out of the circuit, at the same time placing an excessive voltage on the other heaters in the same string, as shown in

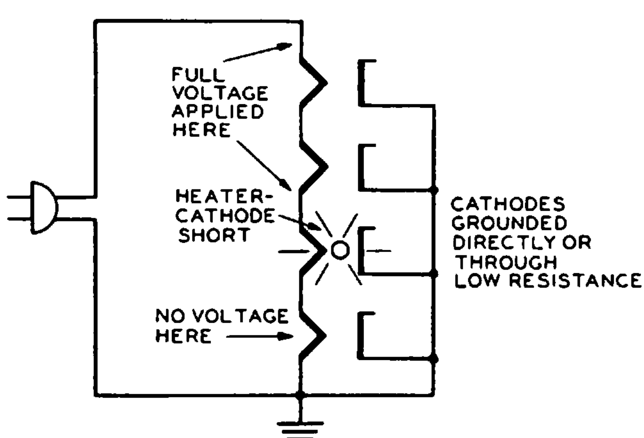



Fig. 8-3. How a heater-cathode short circuit can cause some heaters to glow overbrightly and others to be dead.

Fig. 8-3. When such is the case, the tubes which have been overloaded should be checked by replacement, to determine whether the overload has caused them damage.

In receivers using a power transformer, it is seldom that more than one tube heater opens at the same time. Tubes ordinarily burn out individually, and since each is individually connected across the heater supply, the open affects only the one tube. However, the possibility of more than one heater failing at the same time should be considered and checked, even if it is a rare possibility.

### 8-6. No Heaters Operating

If none of the heaters are operating, the first thing to check is the power-line voltage at the socket. Trace it from there down through the power cord by making a-c voltage checks at the power receptacle and at the point where the power cord connects inside the receiver under the chassis. If there is no power at the power receptacle, the trouble is in the house wiring, or perhaps a switch is off in the circuit to the receiver. The customer, of course, should be consulted about this.

If there is power at the receptacle but none at the connection to the receiver, then the connection of the power cord to the a-c plug has come loose, the plug does not make proper contact with the receptacle, or the conductors in the power line have opened.

If there is power at the connection to the receiver, check the voltage across the primary of the power transformer. There may be a fuse which has opened. Turn the on-off switch, which is usually mounted on the volume control, to "on" and measure the voltage on the receiver side of the switch. Sometimes these switches fail to make proper contact in "on" position.

If voltage is present across the primary of the power transformer, check the secondary filament winding and both sides of the high-voltage winding for voltage output. If there is no voltage from the secondary windings, the transformer has failed.

If there is voltage from the secondary windings, then the filament circuits themselves must be checked to see what is preventing the tube heaters from operating. Obviously, the trouble must be an open in the heater lead at some point before the heater current divides into branches or to individual tubes, so that it affects all the heaters. If there are signs of overheating at the transformer or along some of the heater wiring, then there may be a short in the heater circuit, thus preventing heater operation. If this is true, there should be a clear indication in a smell of burning and evidence of smoke. Needless to say, as soon as such a condition is discovered, the receiver should be turned off immediately and the circuit checked with an ohmmeter. Usually, visual observation will reveal such trouble.

### 8-7. Summary of Dead Receiver Considerations

We have seen that whenever a receiver is completely dead, both on the screen and from the loudspeaker, the only section of the receiver circuit which could contain the cause is the power section. We define the power section as that section starting at the power receptacle, following through the power cord, through any fuses, through the on-off switch, and through the power transformer if there is one. It also includes the rectifier, power supply filter, and the main B+ lead before it branches off to the different sections, plus all the heater wiring. The trouble can be somewhat localized as explained above by noting whether all heaters are operating, some operating, or whether they are all dead.

The dead receiver is one of the easiest problems to handle, especially in the simplicity of the deductions involved. Next we proceed to the type of receiver which has some indication, either of raster alone or picture also.

## Chapter 9

# INTERPRETING RASTER OR PICTURE DISTORTION

### 9-1. Importance of Screen Indications

The old saying that "One picture is worth ten thousand words" is nowhere better exemplified than in the screen of a defective TV receiver. There are scores of combinations of screen raster and picture patterns, each of which tell their own story about the probable location of trouble. In fact, when some sort of distorted pattern is present on the screen, the experienced technician can almost always localize trouble to a particular section at a glance.

There are so many types of trouble indications found on C-R tube screens that space would not permit our consideration of each individually here. Nor should that be necessary. The important thing is the *method* of observation and reasoning which leads to the conclusion about the trouble location. If the technician is thoroughly familiar with the nature of the TV receiver and the trouble indications of its various sections (explained in Chapter 2), and can follow just a few of the cases in this chapter, he should be well prepared to apply the same reasoning to *all* cases. Although the technician can often save valuable time by calling upon experience gained from individual cases, he will find his greatest ally in his ability to reason out a given case, using his general knowledge of TV and his particular knowledge of the receiver itself.

Accordingly, although we try to give as many of the possible trouble cases involving distorted raster or picture in this chapter, the reader should remember that the emphasis belongs on the *basic reasoning* behind each case, rather than on the individual case.

### 9-2. Cases in Which There Is No Raster

The simplest case of screen trouble, that in which the screen is completely dark, has been partly considered in Chapter 8, when we discussed the dead receiver. Now let us consider the possibilities when the screen is dead but there is sound present.

*Screen dark but sound normal.* The fact that sound is being received satisfactorily shows that the low-voltage power supply is operat-

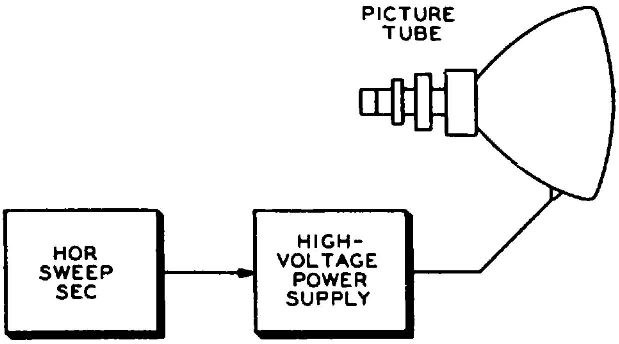



Fig. 9-1. If screen is dark and low voltage is normal (sound reception is satisfactory), the trouble area reduces to that shown by this block diagram.

ing properly. Possibilities then reduce to the picture tube and the high-voltage power supply, as illustrated in Fig. 9-1. Since picture-tube failure is far less frequent than other types of failure, it is well to check the high-voltage power supply first. This can be done with a high-voltage probe on a vacuum-tube voltmeter, but this instrument is not necessary for a qualitative check (to see if there is high voltage), which we can do very quickly and easily by means of a screw driver with a dry, well-insulated (preferably plastic) handle. Hold the tool well back along the handle and touch the blade to the cap of the high-voltage rectifier tube. If there is high voltage up to that point, it should be possible to draw an arc about ¼- to ½-inch long. If there is voltage, then check the high-voltage rectifier output, which is one of the filament terminals under the high-voltage rectifier socket. If there is high voltage at the picture-tube anode, check the C-R tube cathode circuit, and see if the C-R tube heater is operating. If these are satisfactory, check the ion-trap magnet and the other adjustments on the picture-tube neck. If no trouble is apparent there, it is time to measure the potentials at the socket of the picture tube. If these are normal, start to suspect the picture tube. Substitution of a tube known to be good is the safest test.

If our screw driver test shows that there is no voltage at the cap of the high-voltage rectifier tube, turn off the receiver and short the high-voltage filter capacitors to ground momentarily to ensure that they are discharged. Remove the clip from the cap of the high-voltage rectifier, turn on the receiver, and again check for voltage on the clip with the same test. If removal of the clip from the cap restores high voltage at the clip, a short circuit or excessive loading from that point on is indicated. Try removing the anode lead from the picture tube, replace the clip on the high-voltage rectifier cap and see if high voltage is restored on the cap of the tube. (Make certain that the rectifier is turned off when making these mechanical adjustments – even though no high voltage was measured, disturbing the dress of the leads may suddenly restore it.) If high voltage is now present on the cap of the rectifier, there is probably trouble in the picture tube. If high voltage is still absent, then turn off the receiver, discharge the high-voltage capacitors, and check for a short circuit or leakage between the high-voltage lead and ground; use a high-ohm scale for this measurement. If there is negligible leakage, try replacing the high-voltage rectifier tube. If there is a short circuit or excessive leakage (less than several megohms between the lead and ground), check the high-voltage filter capacitors. Also check the picture-tube anode lead for poor insulation. Frequently the insulation on these leads will deteriorate with time and either short or overload the high-voltage power supply. As was stated in Chapter 3, it is well to carry several spare anode leads on service trips.

If there is still no high voltage on the clip after it has been removed from the rectifier cap, then start checking back through the horizontal output transformer and into the horizontal oscillator and amplifier circuits.

This is the best time to check all the tubes in the horizontal sweep section. First replace the horizontal output amplifier tube. If this does not restore operation, try replacing the horizontal oscillator and discharge tubes (if separate). If tube replacement does not reveal the trouble, then measure the plate and screen voltages, checking the values against the voltage chart or schematic diagram labels of the manufacturer's service data.

Instead of voltage readings, some will prefer to trace the horizontal deflection signal with an oscilloscope. The lead from the vertical amplifier of the scope is first applied to the horizontal oscillator output circuit. If a signal is present, as indicated by vertical deflection, adjust the oscilloscope sweep frequency until it synchronizes with the deflection frequency and the waveform is shown on the screen. If desired, this waveform can be checked against the manufacturer's waveform specifications. (However, the test here need be only qualitative, and for the *presence* of the signal rather than for its waveform or voltage.) If the oscillator output signal is present, the oscilloscope vertical lead is then moved to the succeeding stage, and successively through the horizontal deflection section until the point at which the deflection signal stops is found. The trouble is then localized to that stage in the signal path.

*Single horizontal line across the screen.* This symptom means that the C-R tube beam is constrained to move only along one horizontal line because there is no vertical sweep current present in the vertical deflection coils. The basic appearance of the symptom is shown in Fig. 9-2. The sound operates normally, and the low-voltage and high-voltage power supplies must be satisfactory since there is light on the screen. This definitely narrows the trouble area to the vertical sweep section (from the vertical oscillator through the vertical deflection coil). Since there are only two or three tubes in this section, it is well to try replacing these immediately; in a large number of cases, one of the tubes will be found to be defective. If the tubes are all right, then test the vertical output transformer, a frequent offender. Check both windings of the latter (or in some cases, all three) for continuity, shorts between windings, and shorts to ground. Failure of the vertical output transformer is found often enough to warrant carrying at least one replacement on field trips.

As in the case of horizontal deflection signal failure, the oscilloscope is convenient for tracing trouble in the vertical section. The same approach applies, except that here we start with the vertical oscillator section and proceed through the remainder of the vertical section.

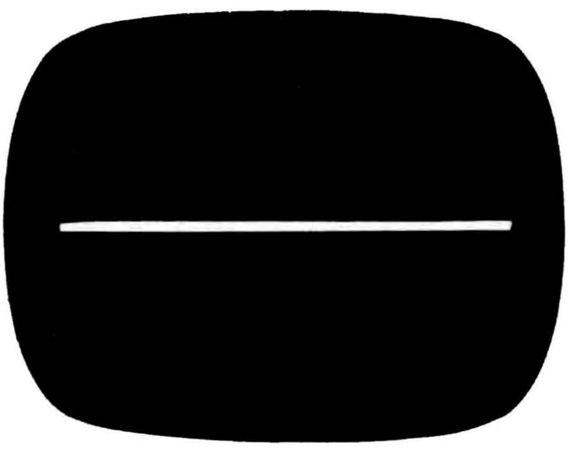


Fig. 9-2. Type of pattern indicating no vertical sweep.

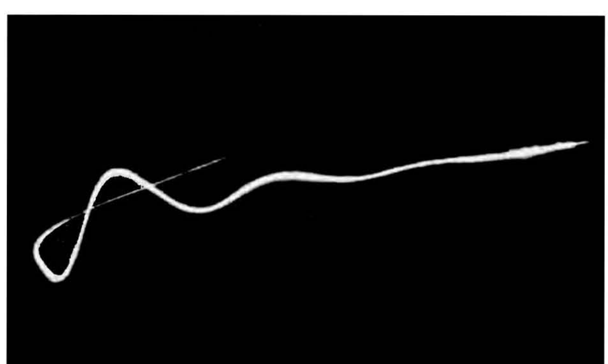


Fig. 9-3. Another case of loss of vertical deflection.
Courtesy: G.E.

*Wavy horizontal line.* This type of pattern is illustrated in Fig. 9-3. Again, the basic trouble is the loss of vertical deflection. Here, however, some horizontal deflection signal is present in the vertical deflection coils, as indicated by the waves in the line. This condition may result from an open circuit at the ground end of the vertical deflection coil, with some horizontal signal being induced from the horizontal deflection coils and a high-frequency transient present. The same indication is also possible if some trouble in the vertical section cuts off vertical signal and couples some horizontal signal into the vertical section.

Another common trouble-maker in the vertical section is the blocking oscillator transformer. Resistance tests should be made on this component in addition to voltage checks with power on. Blocking oscillator transformers for replacements should also be carried in the field kit when on service trips, as explained in Chapter 3.

After the transformers and the tubes have been checked, and the trouble is still not evident, circuit voltages should be measured, and other conventional step-by-step elimination measures should be followed to isolate the offending component or components. Resistance measurements and individual component checks in the vertical section are also in order, and conventional radio troubleshooting should be pursued until the faulty component is found.

*Single vertical line.* The basic trouble indicated by a single vertical line is loss of horizontal sweep. This symptom is rarely encountered because, in the great majority of receivers, loss of the horizontal deflection signal also disables the high-voltage power supply and the screen goes completely dark. In certain receivers the only trouble which would cause only a vertical line to appear on the picture-tube screen, as illus-

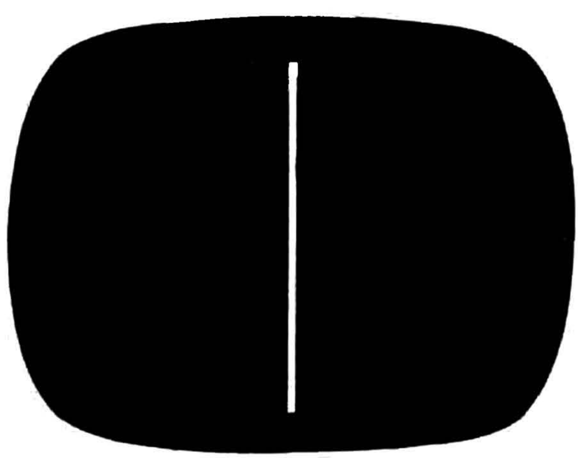


Fig. 9-4. Pattern when there is no horizontal sweep but with high voltage still present.

trated in Fig. 9-4, is an open in the horizontal deflection coil circuit of the yoke.

*Single point of light in center of screen.* The basic indication is loss of both vertical and horizontal deflection. The same reasoning applies as in the case of the vertical line, but this case is even more rare, since it is very unlikely that the horizontal deflection coil circuit and some part of the vertical deflection section would fail at the same time.

### 9-3. Raster but No Picture

The raster is the rectangle of light on the picture-tube screen. It is formed by the simultaneous sweep of the beam spot horizontally and vertically, at the proper speed and in proper sequence. A typical normal raster is shown in Fig. 9-5.

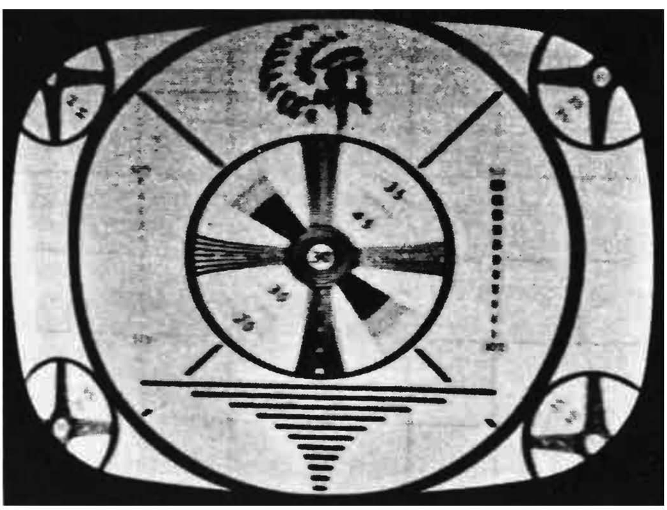


Fig. 9-5. A normal raster.

A raster should be present even when there is no received signal. The raster must be formed properly, and be undistorted, before a picture can be received satisfactorily. It has been previously pointed out how the linearity, focus, and size can all be checked with a raster present, even if there is no picture. It should be noted that distortions of the raster alone have nothing to do with the signal paths of the receiver, so that raster distortion trouble without a picture present can be localized to the deflection circuits, high-voltage supply, damping circuit, or mechanical adjustments on the neck of the picture tube.

If the raster is normal and there is sound reception but no picture, we can narrow the trouble area considerably. The indication is that those sections which carry the video signal are not presenting the signal to the grid of the picture tube. However, since the sound is normal, the sections in which both sound and picture signals are handled are eliminated. The remaining trouble possibilities are in an area depending upon whether the receiver is an intercarrier or split-sound type, and where the sound signal is separated from the picture signal. The various possi-

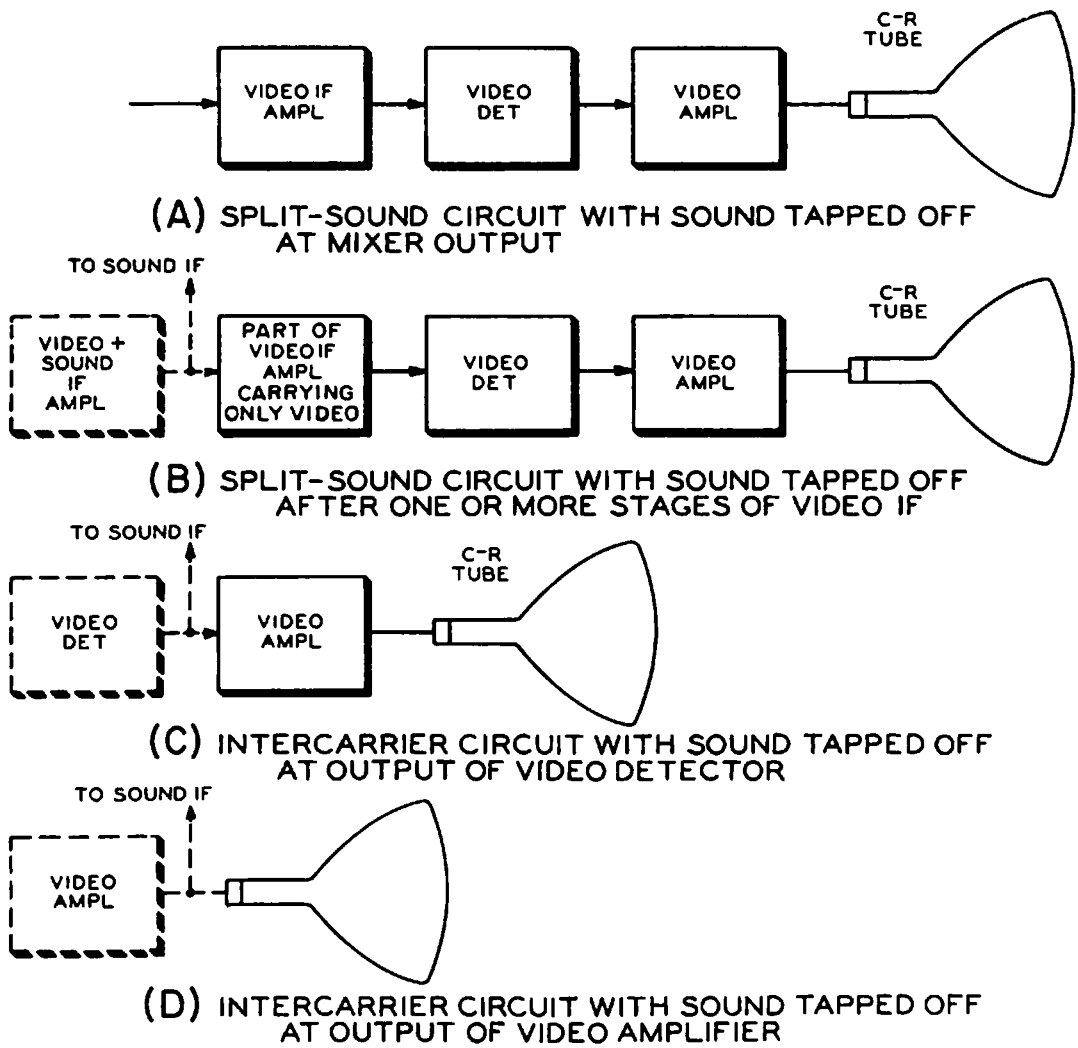



Fig. 9-6. Possible trouble areas for different circuit arrangements when the symptom is raster and sound but no picture.

bilities have been discussed in Chapter 2. From the diagrams and explanations in that chapter, the trouble areas in different case will be seen to be as in Fig. 9-6. This illustration clearly shows how important it is to know the type of circuit one is dealing with, in order to trace trouble. In split-sound receivers part or all of the video i-f amplifier, the video

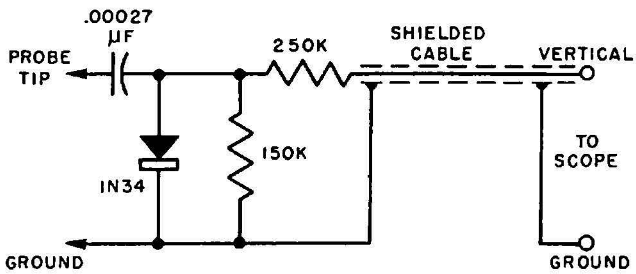



Fig. 9-7. Typical crystal probe cricuit suitable for use with an oscilloscope to trace video signals in the i-f section.

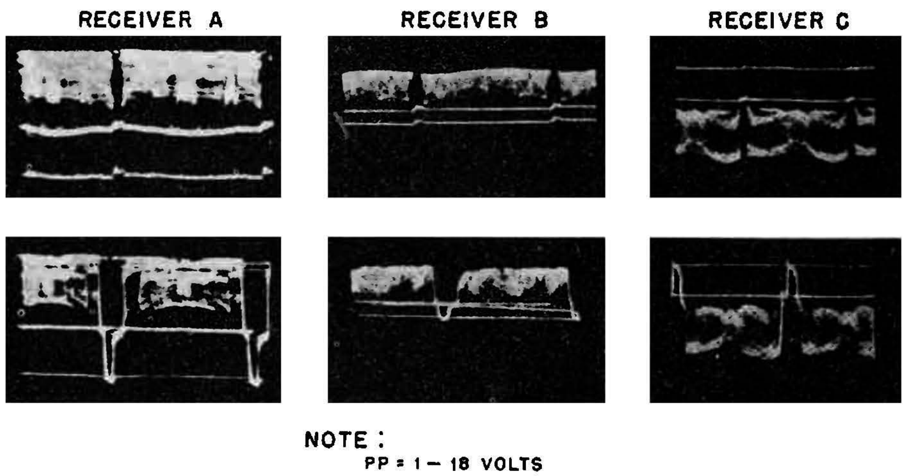



Fig. 9-8. Typical oscilloscope waveforms produced by the video signal, when tracing for a no-signal condition.

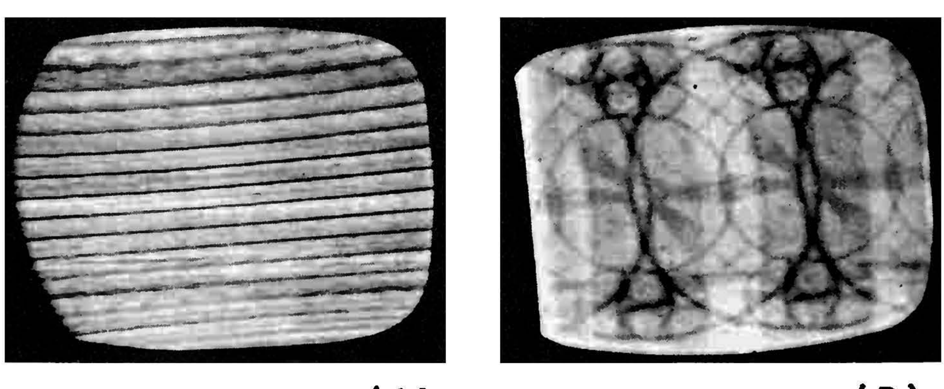



Fig. 9-9. Types of patterns which result from failure of the horizontal sweep to synchronize.

detector, the video amplifier, and the picture tube are in the possible trouble area for the raster-but-no-picture symptom. On the other hand, for intercarrier receivers, in which the sound i-f signal is tapped off after the video amplifier, the satisfactory reception of sound eliminates all but the connection between the video amplifier and the C-R tube and the C-R tube itself.

When the possible trouble area has been determined in accordance with the type of receiver circuit, the video signal can be traced with an oscilloscope. For tracing in video i-f amplifier stages, a detector probe must be used with the scope to detect the video signal. A typical probe circuit suitable for such observations is shown in Fig. 9-7. By application of this probe to signal points in the video i-f amplifier, signal tracing can be accomplished, although in the earlier stages there may not be sufficient sensitivity in the vertical amplifier of the oscilloscope to make the signal visible. From the video detector output circuit to the C-R tube grid, no detector probe is necessary, and the vertical input lead, suitably isolated, is used direct. Typical signal waveforms as traced in this manner are shown in Fig. 9-8.

When the trouble area for the particular type of receiver has been determined according to the type of receiver circuit, the tubes in this area can be checked by replacement. If this does not reveal the trouble source, then voltage checks and other conventional troubleshooting measures previously considered should be applied to that area.

## 9-4. Sync Troubles

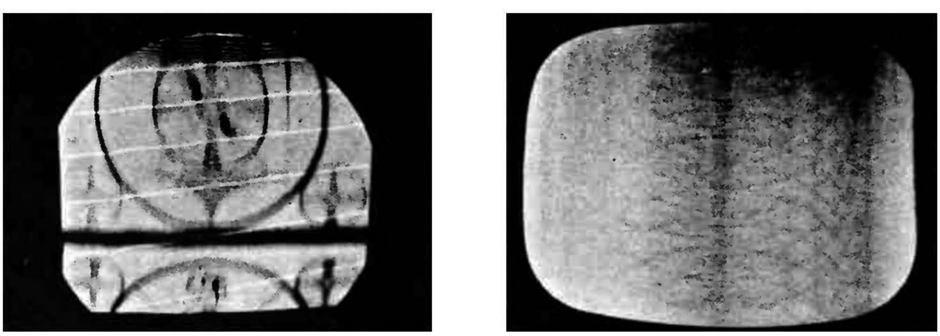
Now suppose the raster is satisfactory and video is being received, but the picture will not stay in sync. The lack of sync can be in either the vertical direction, the horizontal, or both.

*No horizontal sync.* Different kinds of patterns which may result from the failure of the picture to synchronize in the horizontal direction are shown in Fig. 9-9. The first thing to do, of course, is to try adjustment of controls, as explained in Chapter 6. We will assume here that these adjustments have been tried, but without success.

As explained in Chapter 6, we should determine whether the controls can be adjusted so that the picture synchronizes, even for a moment. If sync is never obtained for any adjustment of the controls, the free-running frequency of the oscillator is too far from the desired value, and the horizontal oscillator circuit should be checked. If the picture will sync for a moment or for a short time, but is unstable and tends to drift out again, it is more than likely that the trouble is in the sync section, including sync separators and clippers, or in the horizontal AFC circuit. The latter may include the horizontal output transformer. Video amplifier trouble could also cause this effect if there is improper bias, a defective tube, or a defective coupling capacitor. When the picture momentarily synchronizes, the quality of the picture should, if possible, be noted because, if it is distorted, there is a strong possibility that the sync trouble arises in the video amplifier section.

As in previous cases, the tubes in the affected sections should be checked, one by one, by replacement. If tube trouble is not found, check plate and screen voltages and make other conventional tests. The trouble area is now so small that the guilty component should soon be uncovered.

*No vertical sync.* Loss of vertical sync is illustrated in Fig. 9-10. The procedure for correcting this trouble is the same as for horizontal sync trouble, except that now there is no AFC circuit to worry about. First check the controls and see if sync can be obtained even momentarily. If it can, but is unstable, look for sync or video amplifier trouble; if not, check the operation of the vertical oscillator.



(A) (B)

Fig. 9-10. Examples of loss of vertical sync.

*No vertical or horizontal sync.* Loss of both vertical and horizontal sync results in a jumbled picture that may be hard to perceive and analyze. However, adjustment of the hold controls may help to spot it. An example of this condition is shown in Fig. 9-11. Since is is unlikely that there would be trouble in both the horizontal and the vertical oscillators or amplifiers at the same time, the trouble is likely to be in the video amplifier or the sync separators.

*Improper interlace*: This condition is indicated by the close examination of the horizontal sweep lines in a well-focused picture. In a normal

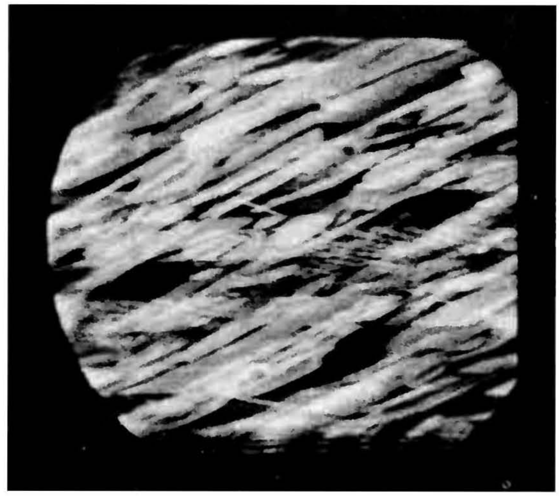
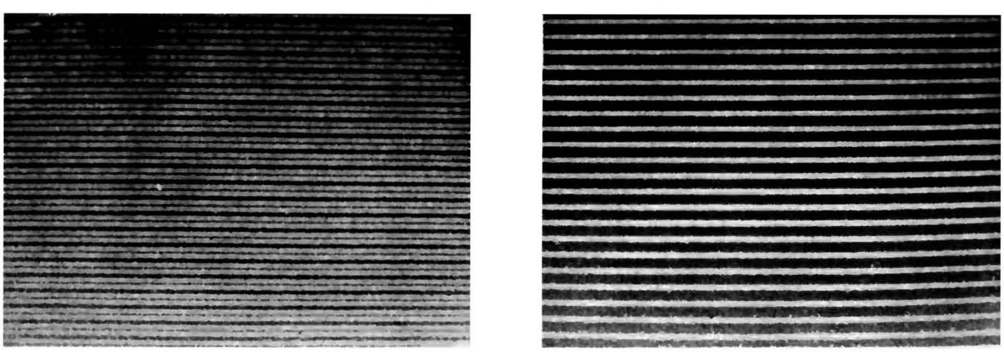


Fig. 9-11. Loss of both vertical and horizontal sync.

picture, with proper interlace, the sweep lines are equally spaced. In a picture indicating interlace trouble, the lines become "paired" as illustrated in Fig. 9-12 (A). If failure of interlace is complete, the paired lines will merge, and the picture is noticeably broken up into light and dark lines, even at normal viewing distance, as illustrated in Fig. 9-12 (B). Improper interlace may result from a faulty vertical sweep amplifier tube. Trouble in the video amplifier output circuit or in the sync amplifier and sync separator may also produce this effect. One likely source is the vertical integrator, which fails to integrate the sync pulses into clean, well-defined pulses for operating the vertical sync circuits.



(A) (B)

Fig. 9-12. Close examination of the horizontal sweep lines of a TV picture indicates whether there is poor interlace. (A) shows how lines pair when there is partial loss of interlace, while (B) shows how the lines merge when the loss of interlace is complete.

## 9-5. Nonlinearity

If adjustment of controls fails to eliminate the trouble, the tubes in the section involved should be checked one by one. In other words, for vertical nonlinearity, check the vertical deflection section; and for horizontal nonlinearity, check the horizontal deflection section. If tubes do not prove to be the trouble, then check for leaky or shorted coupling or by-pass capacitors and open or changed-value resistors.

### 9-6. Deflection Circuit Transients

Transients in the deflection circuit cause fold-over of the side of the picture, as shown in Fig. 9-13. This trouble results from the generation of a high-frequency transient wave in the yoke deflection coil and its associated circuit. Since the damper circuit is designed to eliminate this effect, it is there that we look for the trouble. Check for a poor damper tube or defective circuit components connected to it.

Fig. 9-13. Typical case of picture fold-over resulting from transients in the horizontal sweep section.

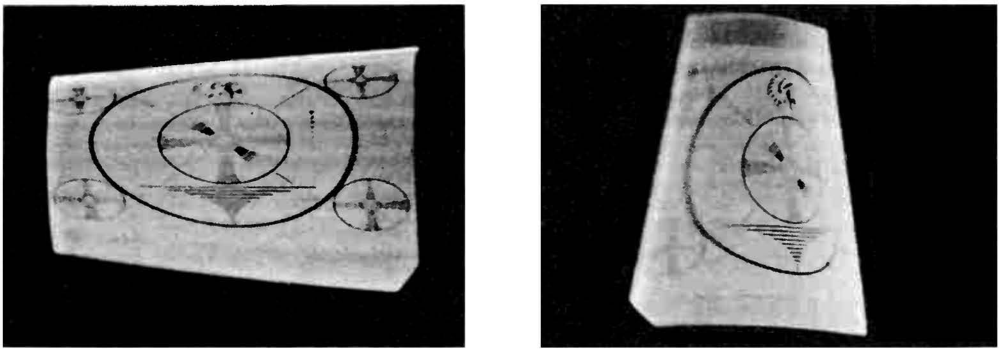
### 9-7. Keystoning

Keystoning (wedge-shaped raster) may occur either vertically or horizontally, as shown in Fig. 9-14 (A) and (B). It is caused by some defect in the deflection coils, frequently a short circuit. Pattern (A) results from vertical deflection coil trouble and pattern (B) from horizontal deflection coil trouble.

### 9-8. Picture Blooming

*Blooming* describes a condition in which the size of the picture becomes much greater than normal, extending quite far beyond the edges of the mask. It is usually accompanied by poor brightness and lack of focus. Figure 9-15 is an example.

The cause of picture blooming is usually found in the low- or high-voltage power supply. The change of voltages on the picture tube changes

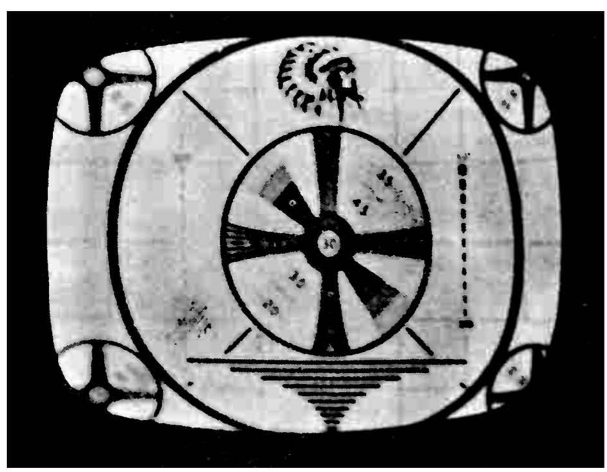


(A) (B)

Fig. 9-14. Examples of keystoning (wedge-shaped raster).

the deflection, the focus, and the brightness. Check carefully for defective filter capacitors in the low- and high-voltage power supplies. An increase in the value of the high-voltage filter resistor will also produce this effect.

Fig. 9-15. Example of picture blooming.



## 9-9. Interference

There are many ways in which interference can affect TV reception. Probably the most common interference is that illustrated in Fig. 9-16. This type is due to an unwanted r-f signal entering the front end of the receiver. The interfering signal may be from a transmitting station, such as a police radio transmitter or a radio amateur, or it may be from another TV receiver. The interference also may appear as in Fig. 9-17; if the interfering carrier is modulated or unstable, the interference pattern may move back and forth. Such interference may also originate inside the receiver itself.

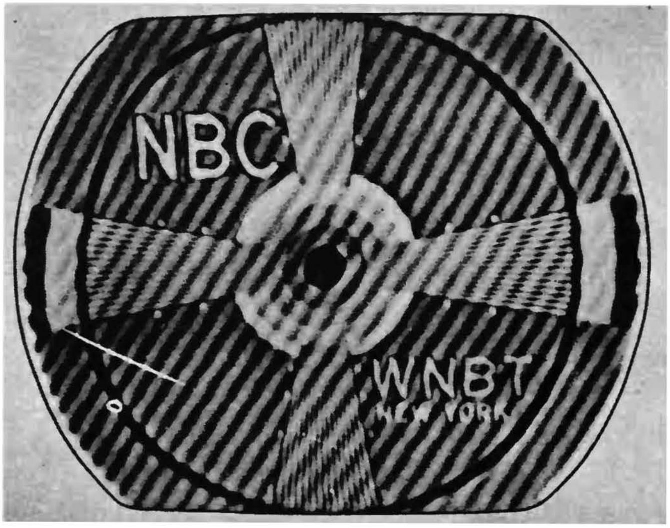



Fig. 9-16. Typical r-f interference pattern.
Courtesy: RCA

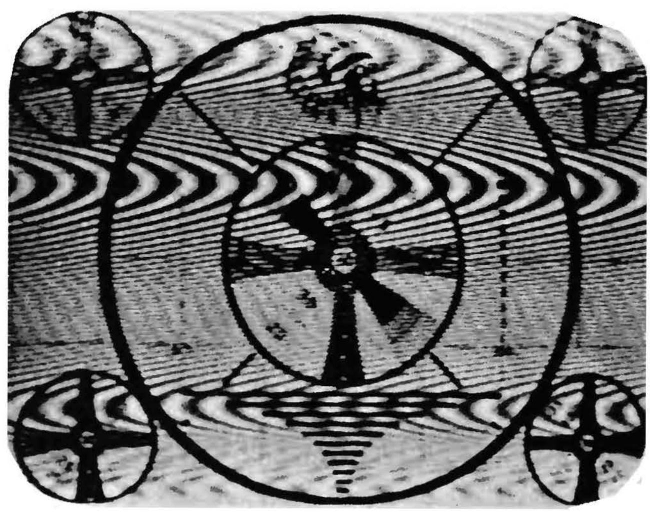


Fig. 9-17. Another type of interference arising from r-f interference.
Courtesy: G.E.

When the interference originates outside the receiver, it is necessary to determine its frequency as the first step toward eliminating it. If the interference is at a frequency that falls within the band of the channel to which the receiver is tuned, nothing can be done to eliminate it since eliminating the interference would also blank out the signal. On the other hand, the interference may be at a frequency different from those covered by the received TV channel, but a harmonic is generated in the receiver circuits and falls within the received pass band. In other cases, the interfering signal is close enough in frequency, and strong enough, to pass into the front end in sufficient strength to overload the receiver and prevent reception of the desired TV station, even though the interfering station frequency is not nominally within the desired channel.

If tne interference is being generated as a harmonic in the receiver circuits, then a high-pass filter will usually help. A typical high-pass filter is illustrated in Fig. 9-18, and units like it are generally available. To illustrate its use let us consider an example. Suppose a TV receiver is set to receive a station on channel 3, which covers the band 60-66 mc. Then assume that there is a transmitting station close by operating on 31 mc. The second harmonic of this signal is 62 mc, and is thus received along with the desired station signal, with which it interferes. If the second harmonic signal is generated at the receiver, by applying such a strong signal to it that the r-f stage is overloaded and distortion produced, then the high-pass filter is applied to the receiver to remove the trouble. This is illustrated in Fig. 9-19. The high-pass filter attenuates (exhibits a very high impedance to) all signals below a certain cut-off frequency, the cut-off frequency for most models designed for TV reception being from 40 to 50 mc. Let us assume that the cut-off of our filter is 45 mc. Then the filter keeps out of the receiver all signals below 45 mc,

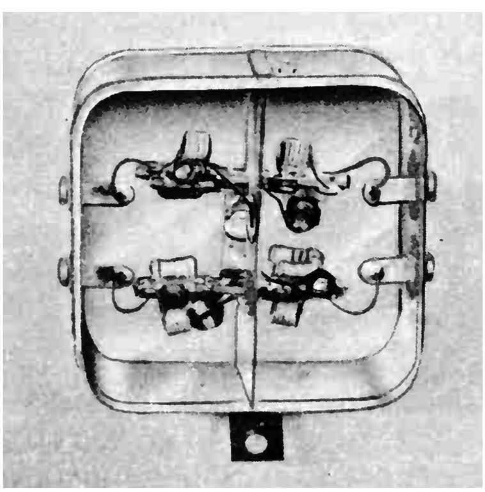


Fig. 9-18. Typical high-pass filter for connection in the antenna lead of a TV receiver to reduce certain kinds of interference.

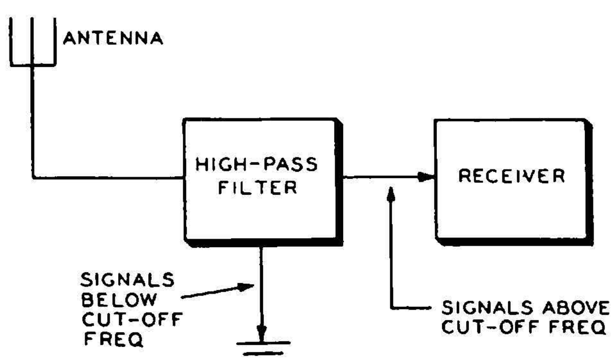



Fig. 9-19. Block diagram illustrating the action of a high-pass filter in removing interference from signals of frequencies below the cut-off value.

but passes normally all signals having frequencies higher than 45 mc. Thus our interfering signal at 31 mc is filtered out and the desired TV station signal at 60 to 66 mc passes normally into the receiver. Since the strong 31-mc signal is thus kept out of the front end, the latter is not overloaded, and the second harmonic is not generated.

However, if the interference is derived from a second harmonic signal being radiated from the transmitting station itself, it cannot be removed at the receiver except possibly by orientation or relocation of the antenna. In this case, the interfering signal (second harmonic at 62 mc) arrives at the receiver as a 62-mc signal; thus any effort to filter it out at the receiver also tends to filter out the received signal. However, if the interfering station and the desired TV station are located in different directions from the receiver, careful orientation of the receiving antenna may help some. Otherwise, relief can be obtained only by measures taken at the station that is causing the inteference.

Another way in which interference can be caused is by *image* response of the TV receiver. Consider, for example, a TV receiver with a 45-mc intermediate frequency in the vicinity of a strong interfering signal at 145 mc. From the theory of images, we know that interference can be caused by a frequency equal to the desired frequency plus twice the intermediate frequency (plus because the oscillator frequency is higher than the signal frequency). In this case, the receiver is tuned to channel 2, for which the video carrier frequency is 55.25 mc. To find the image interference frequency we add twice the intermediate frequency to 55.25, i.e., 55.25 plus $(2 \times 45)$ equals 145.25 mc. Thus, a station putting out a strong signal at, or near, 145.25 mc may cause image interference. However, both the front end and the i-f amplifier sections of the TV receiver are designed for a pass band at least 4 mc broad, and the edges of the pass band are often not too sharp. For this reason, any frequency within a range of several megacycles either way from 145.25 mc can cause serious interference if the interfering signal is strong enough and if the TV receiver front end has a broad pass band and is not well shielded. Note that the interference in this case is entirely the fault of the TV receiver, since the transmitter causing the interference is operating on its proper, assigned frequency.

Image interference indicates that better shielding, better filtering, or both are required in the front end of the receiver. Considerable differences will be noted in different models of receivers as to their susceptiblity to this kind of interference. In several cases, the author has noted that one receiver model will suffer sufficient interference to make a channel unreceivable, while another model in the same location under the same conditions will not show a trace of interference. As his experience increases, the technician will develop a knowledge of which receivers are most susceptible.

However, if a service job involves this kind of interference, the customer already has the offending receiver, and the technician must try to eliminate it (or perhaps sell the customer a better shielded and filtered receiver). If the interfering station operates only on one frequency, or within a small range of frequencies, a wavetrap with a parallel-resonant circuit in each leg of the receiver's antenna lead is about the best bet. In most ordinary cases, this trap can be connected at the antenna terminals of the receiver; but in severe cases, it may be necessary to connect it at the point where the antenna lead connects to the tuner itself. Each resonant circuit should, of course, be tuned to the interfering station frequency.

In cases of blanket interference, the same kind of trap is in order. For example, an amateur radio station located nearby, operating on 50 mc (amateur band 50-54 mc), may overload the front end and, in severe cases, completely disable the receiver on channel 2. A wavetrap tuned to the 50-mc frequency will usually eliminate this trouble. Most commercially available high-pass filters do not have a cut-off frequency high enough to eliminate 50-mc signals, so are not useful in this respect.

The management and staff of radio transmitting stations are usually quite anxious to do anything possible to remove interference, even when the fault lies in the receiver. It is therefore suggested that the technician consult them in difficult interference problems.

Most forms of interference of external source enter the TV receiver through the antenna leads; that is why we have discussed traps and high-pass filters. However, occasionally interference will enter through the power line. In this case, a line filter will be helpful; in some cases, both a line filter and a trap or high-pass filter in the antenna leads may be necessary. Suitable line filters usually are available from parts dealers.

Another form of interference is caused by the ignition systems of automobiles, and is referred to as *ignition noise.* The spark plugs of a gasoline engine act as small spark transmitters, radiating pulses of r-f energy, which are picked up by the TV receiver. This interference is not nearly the problem it used to be when the pulses of ignition noise would interfere with the horizontal sync system and cause the whole picture to lose sync. Horizontal AFC, which locks the horizontal oscillator into the *average* frequency of the received sync pulses rather than to the individual pulses, has minimized the effect of ignition noise in modern receivers. However, when the receiver is located near a busy highway, vertical sync may be affected and there may be a tearing effect in the picture, or jagged horizontal lines. In other cases there may be thin streaks across the picture, as shown in Fig. 9-20. About all that can be done is to attempt to orient the antenna so as to discriminate against the ignition noise as much as possible without losing too much signal. In some cases, the use of coaxial cable for antenna lead-in, with the shield grounded, reduces noise pick-up. Then, of course, the higher the antenna, the farther it will be from the source of the noise and the less it will pick up. The shielded lead-in prevents ignition noise from being picked up along the lead-in wire.

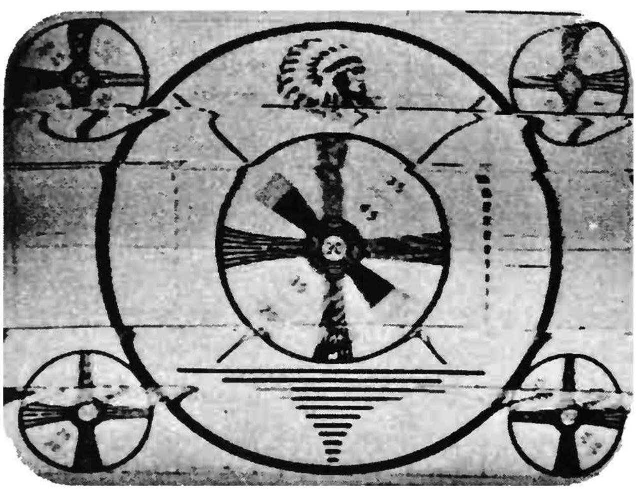
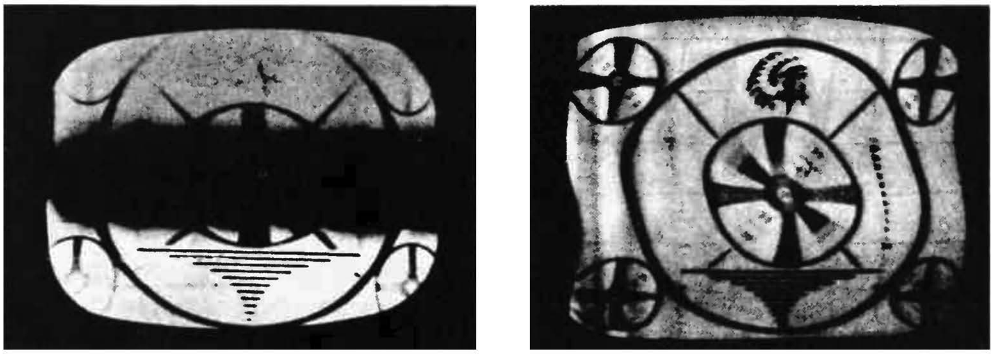


Fig. 9-20. Streaks of interference caused by auto ignition and similar sources.

*Courtesy: G.E.*

## 9-10. Hum

Sometimes, defects in the receiver will cause 60-cps or 120-cps hum to be picked up and amplified in the video, sound, or deflection circuits. Two examples of the effect of hum on the picture are given in Fig. 9-21. At (A) is shown the picture that results when hum in the video section is excessive. This hum may be picked up in the video amplifier or may originate in the sound i-f or detector sections and be amplified. The alternations of the hum voltage cause the C-R tube grid to swing positive and negative; when it swings negative, the screen becomes dark. Since this happens once each cycle, one black bar appears on the screen as shown.



(A) (B)

Fig. 9-21. Patterns resulting from hum troubles. (A) The hum is in the video signal, producing an effect similar to that produced by a bar generator. (B) Hum is modulating the horizontal deflection voltage, producing waving effect on sides of raster.

Typical causes for such a condition are defects in the filter circuit of the low-voltage power supply, improper by-pass capacitors, or heater-cathode leakage in the tubes. If the receiver has parallel-heater connections, removal of tubes starting with the video amplifier and working backwards will usually reveal the trouble section.

Figure 9-21 (B) shows what happens when the hum is modulating the horizontal deflection voltage. The deflection-voltage amplitude varies with the hum voltage and causes the wavy effect shown. The causes are similar, but trouble is more likely to be found in, or directly connected with, the horizontal deflection circuit.

## 9-11. Weak Signal

A weak signal is characterized by indistinctness, lack of contrast, and the presence of "snow" in the picture, as shown in Fig. 9-22. The

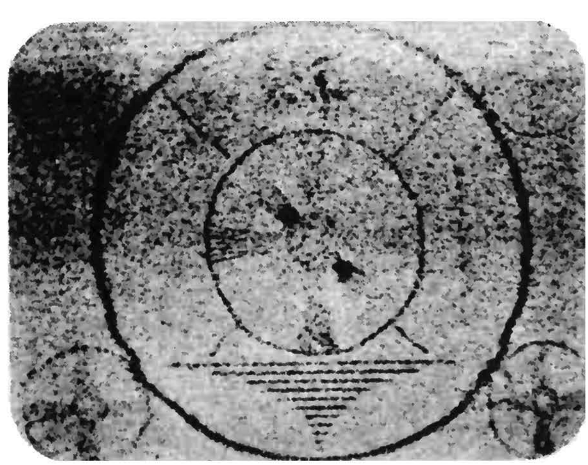


Fig. 9-22. Typical weak-signal pattern.

*Courtesy: G.E.*

snow is a large number of small specks of light spread across the screen, and is due to the presence of a relatively large amount of random noise (rush). A stronger signal would ordinarily override and suppress this noise.

If the sound is also weak, or is accompanied by excessive random noise, it is apparent that the trouble must be in, or directly related to, those sections of the receiving system through which both sound and video signals must pass. These include the antenna, the antenna lead-in and connections, the front end (tuner), and whatever other sections there are between the tuner and the point in the circuit at which the sound and video signals separate. Chapter 2 contains a discussion regarding this point for the various types of receivers.

If the picture is weak but the sound is normal, then the trouble must be in, or directly related to, only those sections through which the video signals pass. In intercarrier receivers, these sections include only that portion of the circuit from the video amplifier input or output circuit up to and including the picture tube. In split-sound receivers, the sections involved start at the input of the video i-f amplifier or one or two stages later, and continue through the video i-f amplifier, the video detector, the video amplifier, and the picture tube.

In determining whether the sound is "normal," it should be kept in mind that the sound is receivable long after the picture has been attenuated to the level at which it is no longer visible. For example, in fringe areas it is often true that sound can be received satisfactorily, while the picture is not visible, or is too weak to be viewed comfortably. The point of this is that rather good reception of sound is not always a good indication that sound reception is normal. With some experience, the technician can detect, by the signal-to-noise ratio and the range of adjustment on the fine-tuning control over which the sound signal "kills" the rush (random noise), whether the sound signal is being normally received at the location involved.

If both the sound and the picture are weak, one of the first things to check is the antenna system. If a field strength meter is available at the location, the signal strength at the receiver end of the antenna lead-in can be measured. If the strength of the signal giving trouble is less than 500 $\mu$v, it is likely to appear weak. For good reception, a minimum of 1,000 or 2,000 $\mu$v should be present at the receiver input terminals.

For a complete test, relative signal strength of all the stations operating in the area should be noted. Then the relative strengths with which these stations are received on the receiver's C-R tube screen should be noted. If the relative strengths are not the same in reception as they are for field strength measurement, then there may be misalignment trouble in the receiver.

If reception of all channels is weak, and the readings on the field strength meter indicate that the strengths are low at the receiver end of the antenna lead-in, then the fault is in the antenna system. Of course, the decision as to whether either reception or field strengths are low depends on the technician's knowledge of the location and what signal strength must be expected with a given antenna system.

If the installation is not a relatively new one (within six months), it should not be immediately concluded that the antenna is of wrong design, not high enough, etc. Rather, the customer should be questioned about how long he has had the weak signal trouble and whether reception was at one time much better. If reception has been better, it is very likely that the trouble is in antenna *deterioration.* Although aluminum is a reasonably weather-resistant metal, it does form oxide coatings after many months of exposure. This oxide is a poor conductor and interferes with the interception and transfer of a good signal to the receiver. Often, although the elements of the antenna are aluminum, the screws and some of the other hardware may be iron, which rusts badly after a few months of exposure.

In addition to the antenna, the lead-in wire may also deteriorate sufficiently to cause a weak-signal condition. Certain types of 300-ohm ribbon, employing transparent or semitransparent plastic, are especially subject to harm from sunlight, which causes the plastic to break down chemically and develop a number of cracks; this weakens the line physically and causes excessive leakage due to moisture. Such a line should be replaced by heavy-duty 300-ohm ribbon with dark-brown insulation.

In some areas, the lead-in line may be affected by the atmosphere. Many cases have been observed in which soot gathers on the outside surface, causing severe leakage, especially in the higher frequency channels. Moisture from rain is absorbed by this soot, making the conditions worse. Such a line must be thoroughly cleaned with a damp wiping cloth at regular intervals. If the line has deteriorated seriously, it should be replaced. Besides soot, corrosive gases and vapors also can cause lead-in line trouble that shows up as a weak signal.

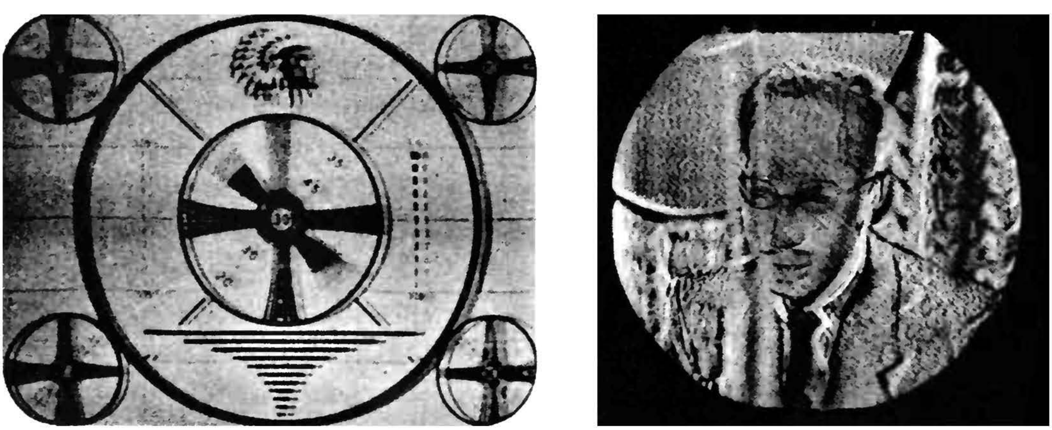
In a few cases, a weak signal from the antenna system may be due simply to a poorly oriented antenna, insufficient height, etc. In some cases, reception may have been satisfactory at one time, but the antenna has been disoriented by windstorms, accidents, etc.

If the weak signal trouble is not in the antenna system, then the field strength readings will show a good signal at the receiver end of the lead-in. If the weakness of signal seems to be general, and not just on one channel, try replacing one tube at a time in the front end. Start with the r-f amplifier, then the mixer, then the oscillator, if separate. Remember that the alignment adjustments for each stage may have to be "touched up" each time a tube is changed, in order for the test to be conclusive. If the front-end tubes seem to be normal and if their replacement does not eliminate the weak signal trouble, then proceed with checks of video i-f amplifier tubes.

One way to localize weak-signal troubles to a certain extent is to note whether there is much random noise present. Random noise (rush) primarily originates in the front portion of the receiver. If there is a good deal of random noise present, such as is shown in Fig. 9-22, then it is likely that the trouble is in the front end. On the other hand, if the signal is simply flat and weak, without much snow, the trouble is more likely in the latter portion of the video i-f amplifier, the video detector, or the video amplifier, rather than in the front end.

## 9-12. Ghosts

The term *ghosts* is applied to repetitions of the picture on the screen, these repetitions being somewhat delayed in phase as compared with the main signal. Figure 9-23 shows typical examples of ghosts. Besides the main reproduction of the pattern, there is an additional reproduc-



(A) (B)

Fig. 9-23. Examples of ghosts.

*(A) Courtesy: G.E.*

tion, called a "ghost," slightly to the right. The ghost results from the reception of the signal twice, the second reception being a moment later than the first.

Most cases of ghosts are caused by the reception of reflected signals in addition to those received over a direct path from the station. Such a situation arises where there is a mountain, large building, or other large object located to one side of the direct path between the transmitter and the receiving location. The ghost signal travels first to this object, is reflected from it, and then arrives at the receiving antenna a microsecond or so after the direct signal from the transmitter to the receiver.

Ghosts often are a result of the character of the terrain and development of the surrounding area, and thus nothing basic can be done to eliminate them. However, an antenna which is reasonably directive can usually be oriented so as to minimize ghosts in a given location. Antenna height is another means of minimizing ghosts; the higher the antenna, the less susceptibility to this trouble.

Ghosts sometimes result from troubles within the receiver itself. For example, if one or more stages in the video signal path tend to be unstable, and the response curve develops a peak (or high spot), ghosts and a negative picture may result, as shown in Fig. 9-23 (B). In this case, check for faulty tubes, by-pass capacitors in the video i-f amplifier, and decoupling networks. Also check the alignment of the video i-f amplifier stages. Sometimes misalignment of stagger-tuned circuits becomes such that two of the circuits resonate at nearly the same frequency, thus peaking the response curve at that frequency. If the receiver's contrast control is located in the video i-f amplifier, its adjustment may vary the severity of the ghosts.

## Chapter 10

# SOUND TROUBLES

In *previous chapters,* we have emphasized the indications on the picture-tube screen, and assumed in most cases that the sound was operating satisfactorily. In this chapter we consider the types of troubles we are likely to meet which primarily affect sound reception.

### 10-1. The Sound Path

In order to troubleshoot in cases of sound troubles, we should keep clearly in mind the *path* through which the sound signals must pass in order to be properly reproduced. The complete sound paths for (A) split-sound and (B) intercarrier receivers are shown in Fig. 10-1. In the split-sound type, the sound signal is intercepted with the video signal by the antenna and applied to the tuner. It appears at the output of the tuner as a sound i-f signal 4.5 mc lower in frequency than the video i-f signal, which also appears at that point. In some receivers the sound i-f signal is separated at this point and fed to the sound i-f amplifier, as indicated by the solid line in the illustration. In other split-sound receivers, the sound i-f signal is amplified together with the video i-f signal in one or two stages of the video i-f amplifier before being separated, as indicated by the dashed line. The sound i-f signal is then applied to the sound i-f amplifier, demodulated in the sound detector, and the resulting a-f signal is amplified in the a-f amplifier and fed to the loudspeaker.

Now consider the intercarrier circuit shown at (B) of Fig. 10-1. The action of the antenna and front end is the same as in Fig. 10-1 (A). However, the whole video i-f amplifier is designed to amplify both the sound i-f and the video i-f signals and applies both of them to the video detector. In the video detector they mix (heterodyne) to produce a third signal, which has a carrier frequency of 4.5 mc, the difference between the carrier frequencies of the two i-f signals. The 4.5-mc carrier is frequency-modulated by the audio signal and, in addition, is amplitude-

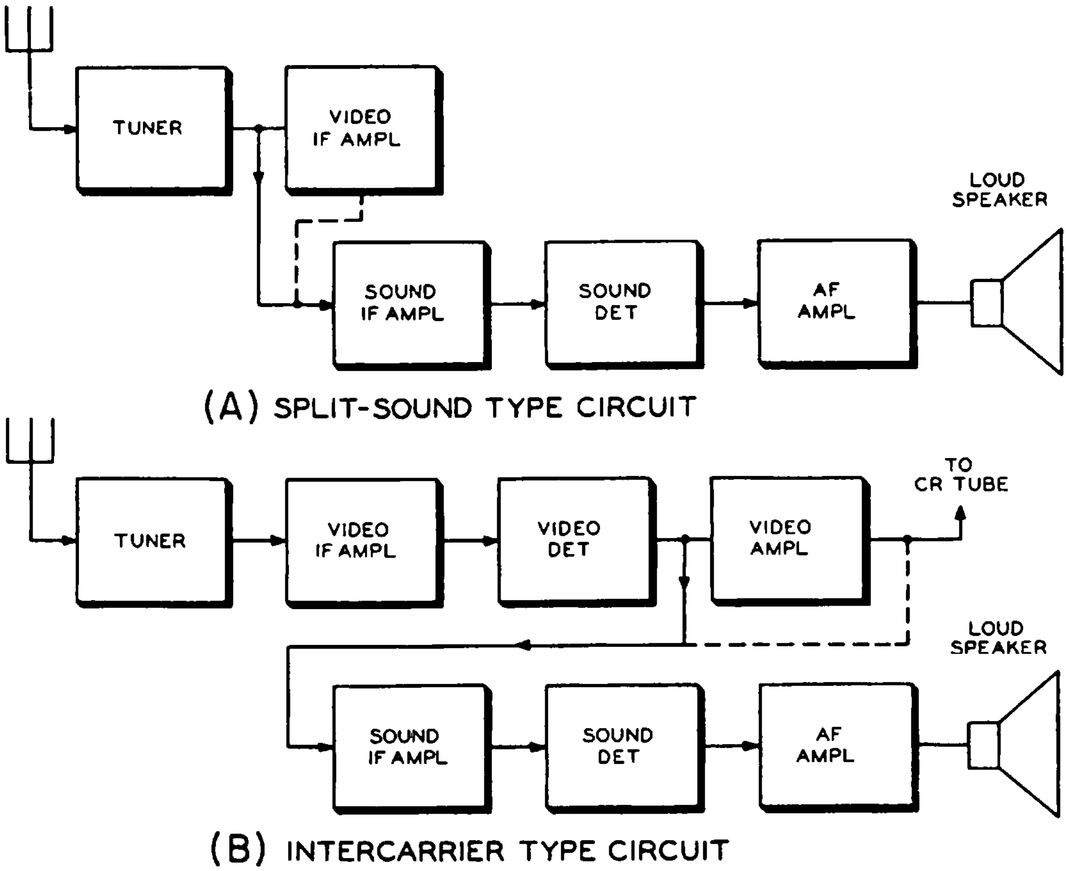



Fig. 10-1. Complete sound signal paths for (A) split-sound type and (B) intercarrier type TV receivers.

modulated to some extent by the video signal. The a.m. is removed by the limiting action of the succeeding sound stage. The i-f sound signal of 4.5 mc is amplified in the sound i-f amplifier and demodulated in the sound detector. The resulting a-f signal is then amplified in the a-f amplifier and applied to the loudspeaker.

## 10-2. Sound Paths when the Picture Is Normal

We have considered the path of the sound signals through the two main types of receiver circuits. For sound troubles in general, the source may be anywhere in this over-all path. However, sound troubles frequently occur when there is no trouble with the picture. When this is the case, we can eliminate from our trouble area the portion of the sound path shared with the video signal. If the picture is received satisfactorily, then those portions of the sound path which also carry picture signals can be assumed to be operating properly.

By eliminating the sections in which both signals are handled, we reduce our sound trouble area for each type of receiver to that shown in Fig. 10-2. In both cases, the tuner section can be eliminated, since it must operate properly for either sound or picture to be received. In the split-sound type (A) we can also eliminate any video i-f amplifier stages which carry sound i-f signals also, since they must be working properly to produce a good picture. So, in (A) we have only the sound i-f amplifier, sound detector, a-f amplifier, and loudspeaker in the trouble area for sound trouble and good picture.

In the intercarrier case we can eliminate, besides the tuner, the video i-f amplifier, video detector, and video amplifier stages which carry both sound and picture signals. We thus have left the 4.5-mc sound i-f amplifier, the sound detector, the a-f amplifier, and the loudspeaker. It is interesting to note that, when there is trouble with the sound but picture reception is normal, the trouble area for either type of receiver is the same, except that in the split-sound receiver we are dealing with a high-frequency i-f signal, while in the intercarrier type we have a 4.5-mc signal. In either case we can concentrate on a sound i-f amplifier and detector, an a-f amplifier, and a loudspeaker.

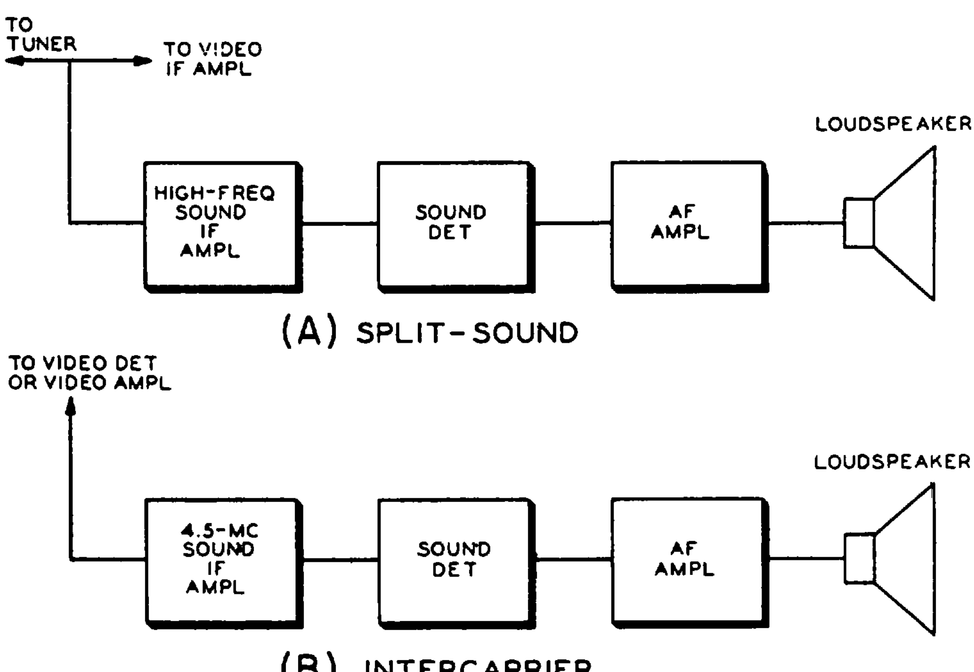



Fig. 10-2. Shows resulting limited sound signal paths after sections which share sound and picture signals have been removed. These are appropriate trouble areas for cases in which the picture is good but the sound reception is not satisfactory.

The above reasoning is 99 percent true. However, we must recognize the possibility of rare exceptions to some of the assumptions we have made. For example, it is almost always true that a video i-f amplifier designed to carry sound signals also, must pass sound properly if it passes picture. But there is always a slight possibility that the response of the video i-f amplifier has changed so that the sound signal is not passed properly, although the picture signal is. This is not considered in ordinary troubleshooting, since it is extremely rare, but should be kept in mind for any persistent cases, when the ordinary conclusions do not seem to hold valid.

Let us now consider a few of the most common types of sound troubles, and how they can be most easily remedied in the customer's home.

## 10-3. Loudspeaker Dead, Picture Normal

In this case, we have determined that there is no sound at all from the loudspeaker. However, it is well to double-check and see whether there is evidence of a weak hum or slight random noise emanating from the speaker when the ear is pressed close to it.

Complete silence is most likely to arise from troubles nearest to the loudspeaker, so that is the best point at which to start. The easiest first test is to place the finger on the grid contact of the a-f output amplifier or the first a-f amplifier tube, and see whether there is a strong hum or noise from the loudspeaker. If there is a response from the output tube, but not from the first a-f amplifier stage, then the trouble is probably in the first a-f stage. If there is no response from either, be sure you have listened carefully when the output grid was touched, because the response is not usually so loud from this stage since there is less amplification. If there is definitely no response from either stage with this test, then the likelihood is that the trouble is in the output stage.

A test of the loudspeaker is then in order. Most of the late-model receivers employ PM loudspeakers. It is very easy to test these, especially if a replacement speaker is carried on service trips. The two leads to the speaker usually fit into two small tip jacks, and these leads can be removed and connected to clips on the test speaker. The output transformer is ordinarily mounted on the receiver chassis, and the leads to the speaker can be connected directly to the voice-coil leads of a PM speaker. If an electrodynamic speaker is used, provision must be made for connection of the field, in addition to the voice-coil leads.

If the grid tests fail to indicate trouble in the a-f amplifier section, that is, if there is ample loudspeaker response when the grids are touched with the finger, then we must look farther back into the circuit. The remaining tubes that might be involved are the sound detector and the audio i-f amplifiers. In most receivers this amounts to a maximum of three tubes for intercarrier types and four tubes for the split-sound receivers. This is a small enough number to warrant tube tests by replacement at this point. Try replacing each tube, from the a-f section back through the detector and the i-f amplifiers.

If the tube check does not reveal the trouble, then signal injection tracing is in order. Usually, it is not practicable to carry a signal generator on service trips although it may not be too difficult to keep one in the truck, so that if this situation arises, a quick stage-by-stage check can be made. However, a pair of headphones makes a good instrument for signal tracing the a-f section in the field. In the shop a signal tracer, vacuum-tube voltmeter, or oscilloscope should be available for the purpose.

The method of signal injection is, of course, the standard one for any radio receiver and the details of it are beyond the scope of this book. Briefly, we simply feed a signal of sound intermediate frequency into the grid of the last sound i-f stage. If there is an output, we move back to the next-to-last sound i-f stage grid, etc. Although the sound section is designated to receive FM, an amplitude-modulated signal will also work for this test. For intercarrier receivers, the frequency should be 4.5 mc; for split-sound receivers the frequency should be that specified for the sound i-f in the service data.

## 10-4. No Sound on Some Channels, Picture Normal

This symptom can be corrected by oscillator frequency adjustment. The picture reception will remain satisfactory over a much wider range of adjustment of local-oscillator frequency than will the sound. Thus, if the fine-tuning control must be adjusted to one extreme of its range to obtain a picture and the sound for the channel is still not received, then the oscillator trimmer for that channel must be readjusted. Frequently, these trimmers are accessible from the front of the receiver, as illustrated by the diagram of Fig. 10-3. When the front escutcheon is removed, holes for the alignment tool to be inserted are revealed. There is usually some mechanical arrangement which prevents the adjustment of any channel except the one for which the selector switch is set.

To adjust a given channel, set the selector for that channel. Then adjust the fine-tuning control to the middle of its range and insert the alignment tool. Adjust the trimmer until proper sound reception results. With proper reception occurring in the middle of the fine-tuning control range, there is room to allow for oscillator drift either way. The same procedure is repeated for each channel that requires adjustment.

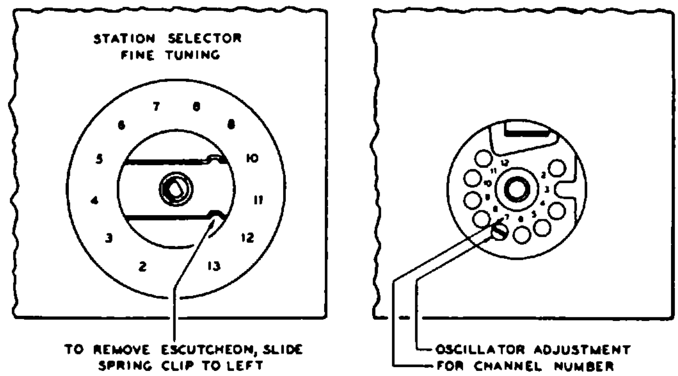



Fig. 10-3. Typical front-panel adjustment locations for adjusting oscillator trimmers to restore sound reception on channels for which the oscillator has drifted.

*Courtesy: RCA*

If there is sufficient range to the oscillator trimmer, there may be two points at which reception of sound is possible. However, only one will give proper picture reception, so the picture must also be noted while the adjustments are being made.

Of course, the above procedure is appropriate only for receivers with channel selector switches. Receivers that have continuous-coverage tuners do not suffer from this trouble, since the oscillator is continuously adjustable in frequency by the main tuning dial.

## 10-5. Sound Distorted and Weak when Picture Is Adjusted for Best Reception

This condition may be caused by misalignment of the discriminator. The adjustment of the discriminator (or ratio detector) is quite critical and must be in harmony with the peak response of the sound i-f amplifier. The tuned circuits in the discriminator may drift, that is, change their resonant frequencies over a period of time, and thus become misaligned. If the variation is considerable, the strongest signal from the sound i-f amplifier may be obtained at a frequency different from that at which the discriminator is peaked, and distortion result. The situation is more critical in intercarrier receivers, because adjustments in the exact value of the sound intermediate frequency cannot be made as in the split-sound receivers. In intercarrier receivers, the sound intermediate frequency is determined by the frequency difference between the received sound and video carriers, and these are rigidly controlled at the transmitting station. Thus, the sound intermediate frequency remains at exactly 4.5 mc regardless of receiver adjustments. If the discriminator adjustments drift, the only remedy is in the readjustment of that circuit, since the sound intermediate frequency cannot be adjusted by fine tuning as in split-sound receivers.

### 10-6. Intercarrier Buzz

In intercarrier receivers the sound i-f signal of 4.5 mc is the result of the mixing of the high-frequency sound and video i-f signals at the video detector. The sound modulation is kept predominant in the 4.5-mc i-f signal by keeping the relative amplitude of the sound carrier in the high-frequency sound i-f section small as compared to the video i-f carrier amplitude.

However, suppose the amplitude modulation of the video carrier reaches or exceeds 100 percent. Then the video carrier actually goes to zero amplitude on modulation peaks. Since the modulation of the video signal is negative (maximum values of video signal correspond to minimum values of carrier), the momentary zero values of the video carrier occur during the sync pulses, which are the peaks of modulation. When the video carrier is thus interrupted, the 4.5-mc beat signal must also be interrupted. Since the sync pulses occur at the rate of 60 cps and 15,750 cps, the interruptions are actually a heavy pulse modulation of the 4.5-mc sound i-f carrier. Both the ear and the receiver a-f section have a very limited response at 15,750 cps, so the main effect of this modulation is a loud 60-cps buzz in the loudspeaker output. This is frequently referred to as *intercarrier buzz.*

As has just been explained, intercarrier buzz can be caused by overmodulation of the received station's video carrier. Thus, when it is heard, it is well to note whether the buzz is heard on other stations, and whether it varies with change of programs. If it is present on all stations, and most of the time, then the trouble, of course, must be in the receiver.

A number of troubles, especially in the video amplifier and video detector, can result in the same effect as overmodulation of the video carrier or interruption of the 4.5-mc i-f carrier. Therefore, when intercarrier buzz is encountered, check the video detector and video amplifier tubes, and all the tubes in the sound i-f, detector, and a-f amplifier sections. Check the video detector, video amplifier, sound i-f amplifier, and sound detector circuits carefully. Check the adjustment of the discriminator, or ratio detector, and make sure that the coils or tuned circuits in this section are not shorted or defective. Look also for peaking circuit trouble or defective coupling capacitors.

### 10-7. Weak Sound, Picture Normal

When the sound reception is weak, it is well to note whether *random noise* is present. Random noise is a background rush, or hiss, present when the gain of a receiver is high and there is no received signal or only a weak received signal. For weak signals, or no signals, it is quite normal to have a fairly strong random noise present when the contrast and volume controls are well advanced. The noise is the result of molecular action in resistances (thermal noise) and random electron flow variations in the electron streams of vacuum tubes (shot effect). Since these voltage variations are minute, they become audible only when there is a number of tubes and amplifier stages present. Most of the random noise originates in the front end of the TV receiver, although some is also derived from later stages.

Now, suppose the weak sound reception is experienced with some random noise present. It can then be expected that the sound section is operating back several stages from the loudspeaker, and probably back to the sound take-off point, at which the sound i-f signal is separated from the video i-f signal.

Another quick check is obtained by manipulation of the volume control. If the weak sound is *not* affected by the volume control, then the sound signal may be by-passing the control or perhaps the whole first a-f amplifier circuit. If the cause is an open volume control, there may be a hum or squeal present because of improper grid circuit conditions in the first a-f amplifier grid circuit.

Weak sound, of course, can also be caused by improper alignment of the sound i-f amplifier or detector sections, or by the sound i-f trap which is used to separate the sound i-f signal from the video i-f signal.

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