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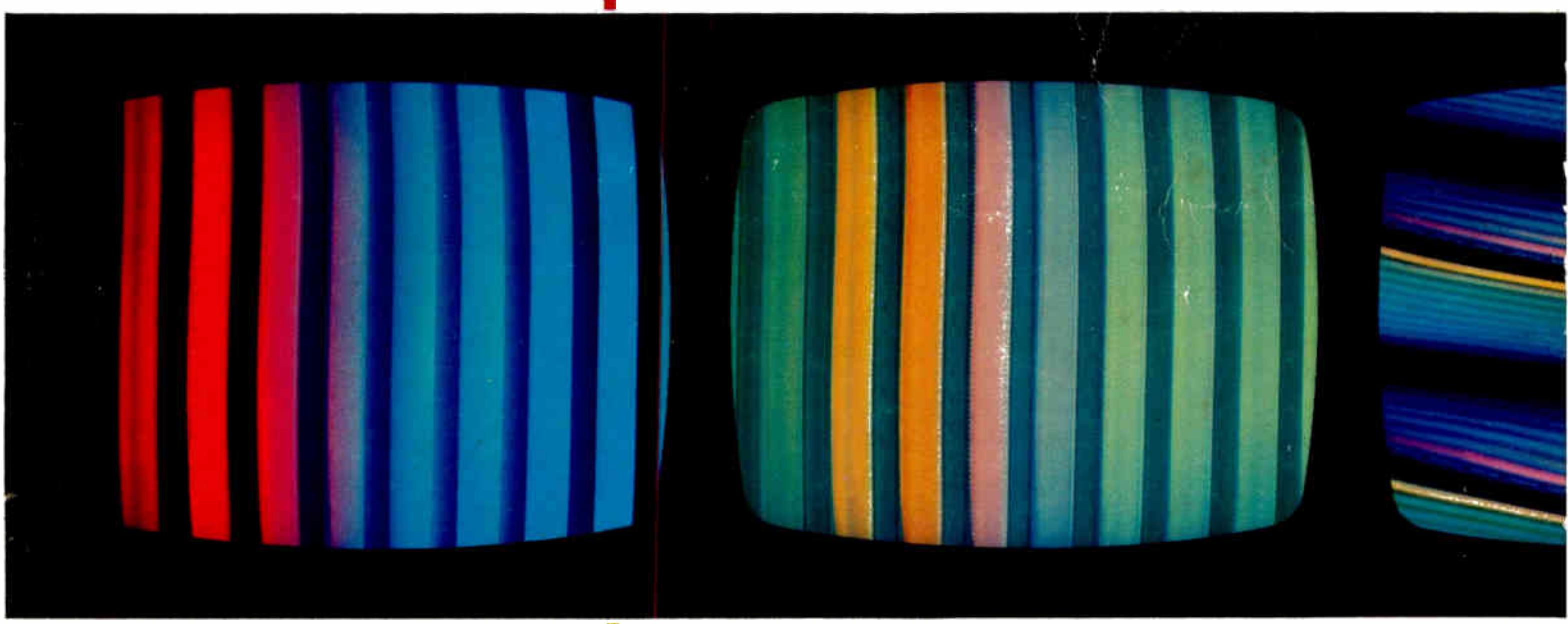
COLOR-TV Servicing Guide

by Robert G. Middleton

ARRANGED BY TROUBLE SYMPTOMS



A practical single-volume source on color-TV servicing procedures. Includes color photos of trouble symptoms.

COLOR-TV
Servicing Guide

Arranged by Trouble Symptoms

ROBERT G. MIDDLETON

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Preface

Technicians who have had experience in troubleshooting only black-and-white receivers may believe that color circuits are formidably complex. However, this is not true; there is nothing really novel or exotic about the chroma circuitry in a color-television receiver. There are merely a few more sections to contend with. As always, the initial clues come chiefly from symptoms indicated in the picture on the screen or in the sound output. The symptoms shown in the picture indicate defects in both the black-and-white and chroma portions of the video signal. Once the color-television technician has analyzed these symptoms, he usually directs his attention to specific sections of the receiver. Hence, this servicing guide has been organized so that it will be useful as a quick reference to a particular part of the receiver when any given set of symptoms is encountered.

The book is functionally divided according to sections in the color-television receiver, and further subdivided according to symptoms. Most of the possible causes are listed for each symptom. Color photographs are presented whenever clarity of explanation is enhanced by their use. When a photograph is impractical, a descriptive explanation of the screen symptom is provided. Considerable effort was made to select only those troubles most frequently encountered in the field.

It is a basic tenet that if the service performed is to be accurate, the troubleshooting equipment must be more accurate than the circuits that are tested. Hence, the first chapter in this book includes a discussion of various types of color-test equipment, and the last chapter explains in detail how to test and troubleshoot color-bar generators.

ROBERT G. MIDDLETON

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Chapter 1

General Troubleshooting Procedures

The troubles with which we are familiar in maintenance and repair of black-and-white television receivers are also encountered in color receivers. This fact is based on the fundamental design of a color receiver. Fig. 1-1 depicts how a color receiver employs conventional black-and-white circuitry, plus chroma circuitry. Color receivers are *compatible,* which means that either color programs or black-and-white programs can be received without any adjustment of controls. During black-and-white reception, the chroma section in Fig. 1-1 is turned off by an electronic switch called a *color killer*. It is evident that service problems may involve only the black-and-white section of the receiver. On the other hand, other service problems may involve only the chroma section. Some types of defects cause trouble symptoms during either black-and-white or color reception.

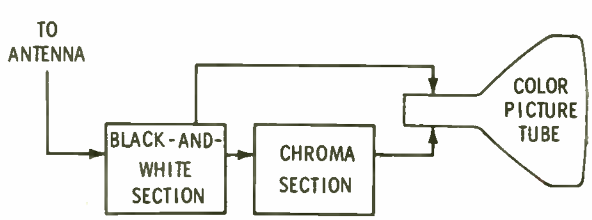


Fig. 1-1. Two main sections of a color receiver.

FUNCTIONAL TROUBLE SYMPTOMS

Some trouble symptoms have a functional basis, while others do not. For example, a program occasionally has non-standard sync, which causes the picture to tear or roll. The symptom, of course, has nothing to do with receiver function. If you switch to another channel, the picture locks in normally. Again, a program occasionally has distorted colors that cannot be corrected by adjustment of the receiver controls. This difficulty is most commonly present during the programming of certain types of color movie film. Again, this symptom has nothing to do with the receiver function. If you switch to a color program on another channel, normal colors are displayed.

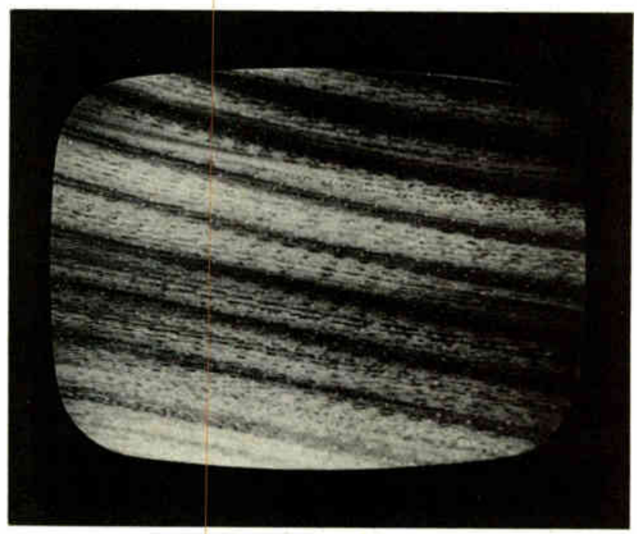


Fig. 1-2. Loss of horizontal sync during the reception of a black-and-white picture.

During black-and-white reception, loss of horizontal sync appears as shown in Fig. 1-2. In the majority of cases, this symptom has a functional basis which is confirmed by observing reception on more than one channel. The approach to this service problem is measurement of d-c voltages, adjustment of maintenance controls, and analysis of scope waveforms. The technician's approach to this symptom should be exactly the same in the case of a color receiver.

On the other hand, black-and-white sync is often retained during *loss of color sync*, as exemplified in Fig. 1-3. In other words, the color portion of the picture breaks up into rainbows. This is usually a functional trouble symptom, although it can be due to technical difficulties at the transmitter. The reception on another channel should be checked to verify the symptom. If another color program is not available at the time, a color-bar generator can be used as a cross-check. The photo in Fig. 1-3 shows a keyed-rainbow pattern on a receiver that has lost color sync. Since this is a functional trouble symptom, the pertinent circuits in the chroma section of the color-television receiver should be checked.

Another basic example of color picture analysis is shown in Fig. 1-4; the picture symptom results from loss of horizontal sync during color reception. The picture is broken up into diagonal strips, as in Fig. 1-2. But in addition, the color portion is also broken up into rainbows. The beginner might suppose that trouble is present in the chroma section of the receiver. However, this is not true. It is impossible for a receiver to maintain color sync when the horizontal sync is lost. In other words, color sync is a *sub-function* of the horizontal-sync lock. The photo in Fig. 1-4 was made with the use of a keyed-rainbow generator. With this brief introduction, let us consider some of the chief features of various color-signal generators.

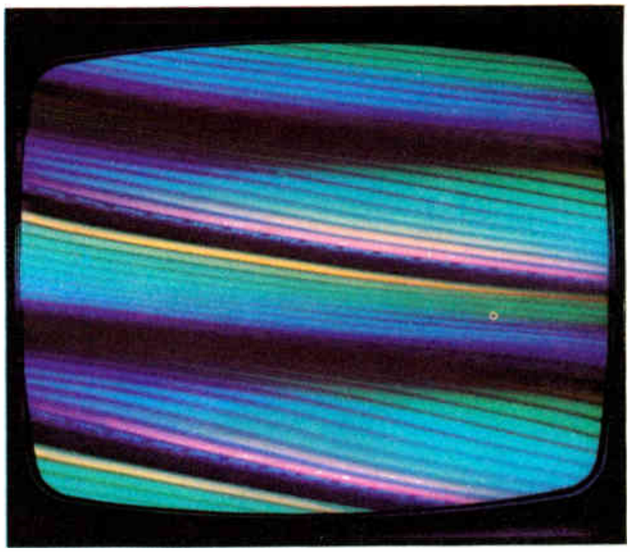


Fig. 1-4. Loss of both black-and-white and color sync.

COLOR TEST PATTERNS

Most of us are familiar with test-pattern generators that provide black-and-white test patterns, such as the one illustrated in Fig. 1-5. A generator test pattern is preferred to program material in service work for several reasons. First, a generator test pattern is steady,

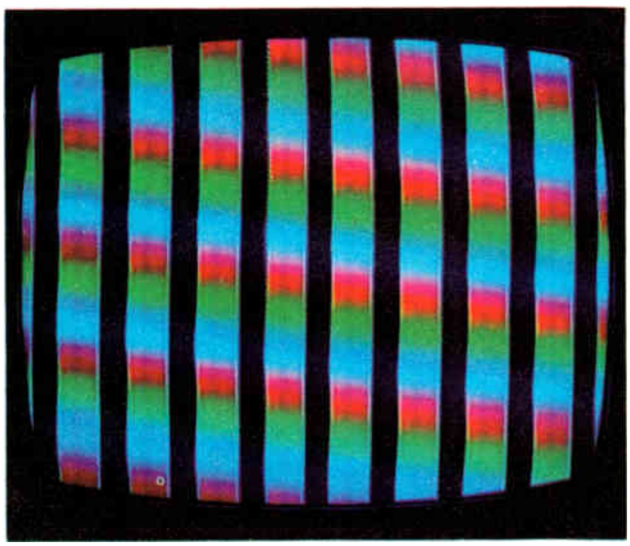


Fig. 1-3. Loss of color sync.

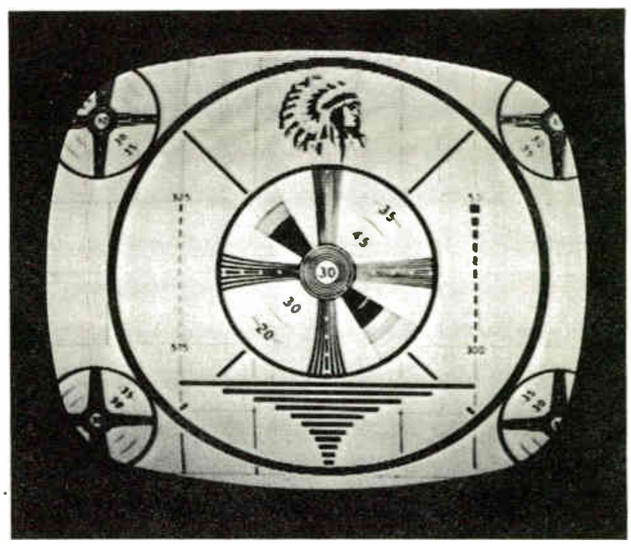


Fig. 1-5. Black-and-white test pattern.

permitting a better evaluation of a trouble symptom. Second, the basic information needed to properly evaluate a symptom is provided in a test pattern, but this information is often missing in a broadcast signal. Third, the signal level from a test-pattern generator is under direct control. These same basic advantages are available when a color test-pattern generator is used.

The color-television technician should employ some type of color-signal generator in troubleshooting procedures. Most color-signal generators provide both chroma and black-and-white signal outputs that may or may not be separately available. Fig. 1-6 shows an *unkeyed-rainbow* color test pattern. This is about the simplest color test pattern possible, and it provides a chroma signal only. The one simpler type of pattern consists of a single bar at burst phase and is not useful for troubleshooting procedures. Hence, the burst-phase single-bar pattern will be disregarded for present purposes.

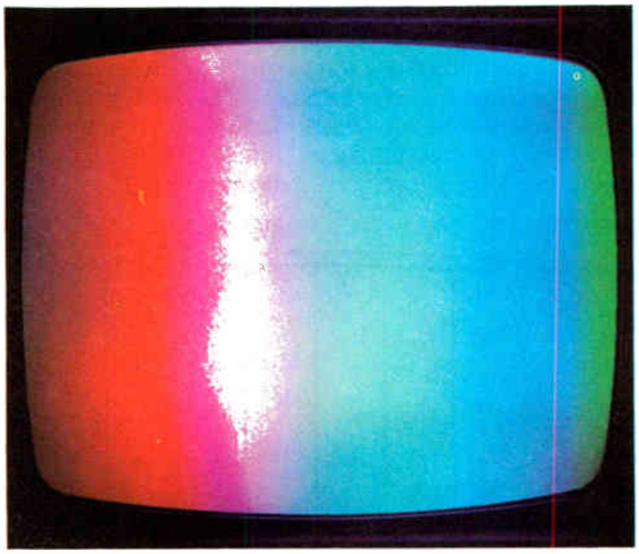


Fig. 1-6. Unkeyed-rainbow color pattern.

A great deal of information concerning receiver circuit action can be obtained from an unkeyed-rainbow signal; but, on the other hand, color-picture analysis is more complete when a more elaborate signal is used. For example, it is necessary to have more "know how" and to make supplementary tests in many situations if you are using an unkeyed-rainbow pattern. For this reason, the unkeyed-rainbow signals are supplied chiefly by installation-type instruments. Bench-type generators specifically designed for troubleshooting work provide some form of black-and-white signal along with the chroma signal.

Keyed-Rainbow Generators

The basic colors provided by a *keyed-rainbow* type of color-signal generator are very much the same as those provided by the unkeyed generator. However, the display is divided into 10 alternate chroma bars and black bars, as illustrated in Fig. 1-7. The spectrum of the chroma signal is not continuous. Each chroma bar has a characteristic hue; that is, each chroma bar is associated with a certain *chroma phase*. The phase identification provided by the keyed pattern greatly facilitates analysis of chroma circuit problems.

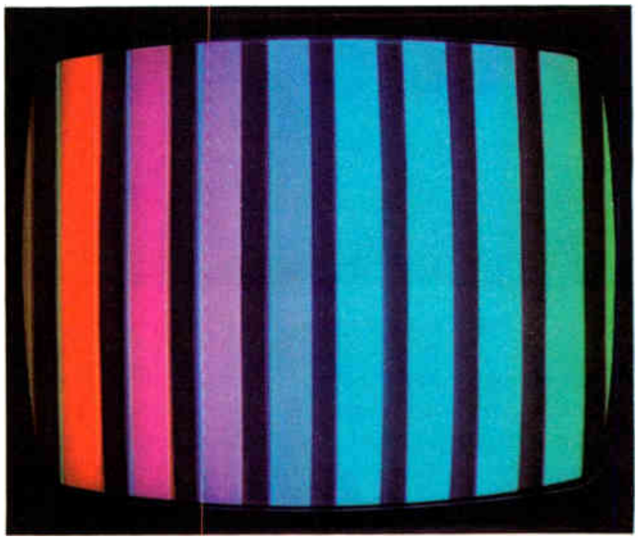


Fig. 1-7. Keyed-rainbow color pattern.

Color fit is one example of circuit analysis that is possible with a keyed-rainbow generator. Notice that each chroma bar is flanked by defining lines. These lines may be comparatively dim unless the contrast control is advanced, it is important to recognize their presence. These vertical lines show whether "color fit" is correct or incorrect. Thus, Fig. 1-8 shows an example of poor color fit—the vertical lines do *not* flank the chroma bars as they normally should. Poor color fit results from various circuit defects, such as misalignment, defective components in the chroma section, or a defective delay line.

With this brief introduction to color pattern analysis, let us return to the basic characteristics of color test patterns. Rainbow colors in all cases are not "true" colors, as defined by NTSC standards. In other words, rainbow generators do not provide a *complete* color signal. We shall find that this lack results in colors which are more or less desaturated, or which lack "true" brightness. Some of the colors in a rainbow spectrum are less saturated than others; some rainbow colors depart more from normal brightness than others. In addition, some of the "standard" hues, such as yellow, are absent.

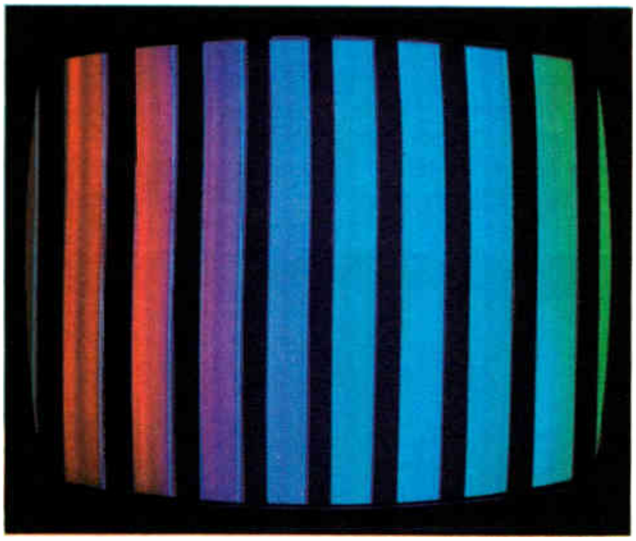


Fig. 1-8. An example of poor color fit.

These facts might be overrated by the beginner. Actually, a color-television technician often reports that he can do just as good a job with a keyed-rainbow signal as he can with a more elaborate NTSC color-bar generator. The basic requirement is that the technician must understand his particular generator and its applications. Whether a keyed-rainbow generator is more difficult to use in trouble analysis than an NTSC generator is a controversial point, and much depends (as in all areas of service work) on personal preferences.

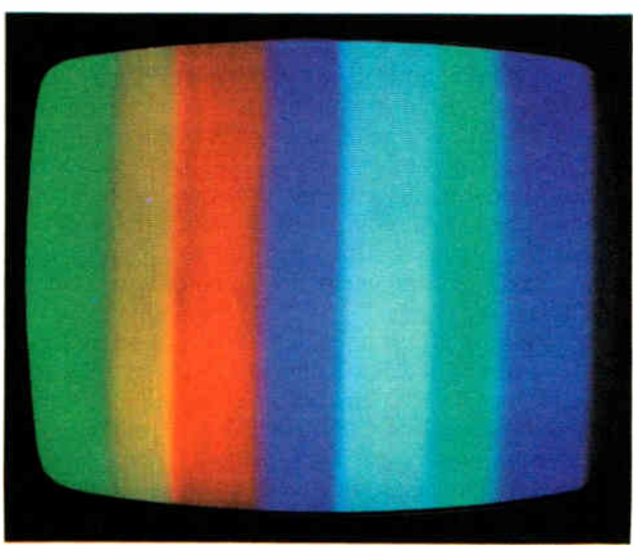


Fig. 1-9. An NTSC color test pattern.

NTSC Signal Generators

The test pattern provided by some of the NTSC-type color-signal generators provides a choice of single color bars or a multibar pattern. Others provide single bars only or a multibar pattern only. Practically all NTSC generators provide primary and complementary colors: these are red, green, blue, yellow, cyan, and magenta. Various rainbow hues may also be provided as single bars or pairs of bars. Fig. 1-9 illustrates an NTSC multibar pattern, having a sequence of primary and complementary colors, including a white bar that is useful in troubleshooting procedures and generator maintenance.

All colors are fully saturated and are displayed at normal brightness in an NTSC color-bar pattern. The sequence of color bars from an NTSC generator is arbitrary. For example, another NTSC color-bar generator provides a single blue bar depicted in Fig. 1-10. In this respect, NTSC color-bar patterns appear to be superficially different. However, varying bar sequences have no bearing on the utility of the NTSC signal. On the other hand, the sequence of chroma bars in a keyed-rainbow signal (Fig. 1-11) is always the same. This order of chroma bars is established by the basic operating principle of a rainbow generator.

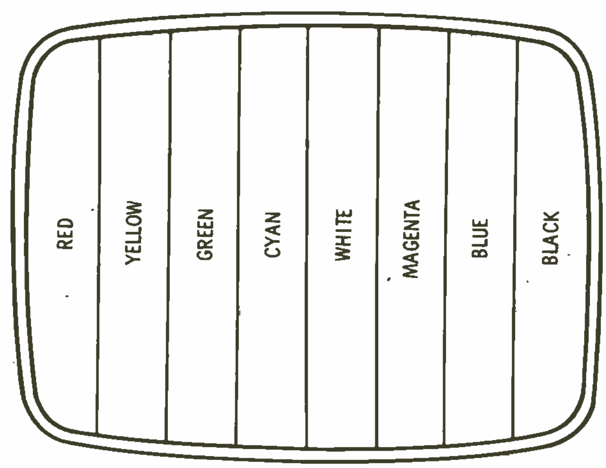


Fig. 1-10. One sequence of hues that is generated by a color-bar generator.

A multibar NTSC generator alone is insufficient to troubleshoot a color-television receiver. Various chroma-circuit tests require the use of *color-difference* signals. Accordingly, all NTSC generators also supply chroma signals, such as R−Y, B−Y, G−Y, G−Y/90°, I, and Q. Such chroma signals may be

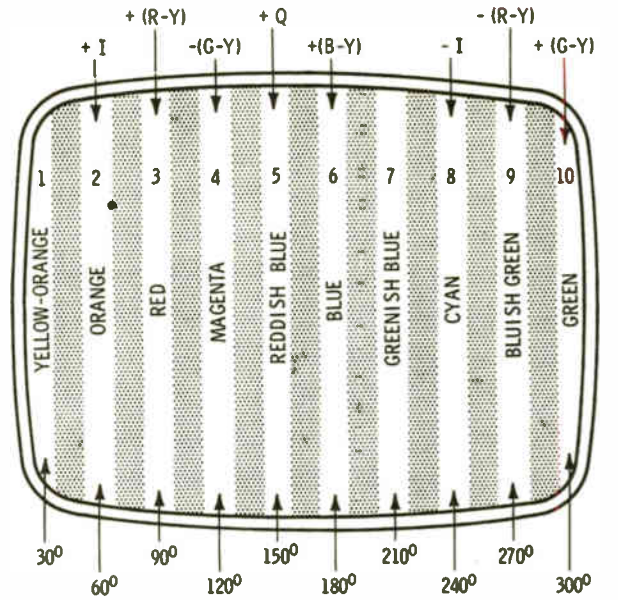


Fig. 1-11. Identification of the colors produced by a keyed-rainbow generator.

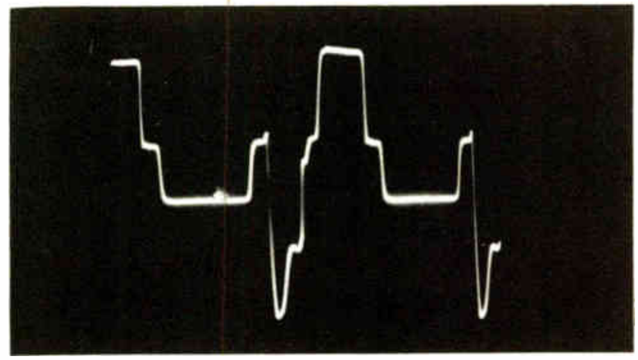


Fig. 1-13. B—Y and R—Y signals at the output of the bandpass amplifier.

available singly or in pairs. For example, Fig. 1-12 shows a pair of B—Y and R—Y chroma bars. Note that one chroma bar is considerably wider than the other. This facilitates identification in scope patterns. Fig. 1-13 shows how B—Y and R—Y bar signals appear in a chroma waveform.

NTSC generators which provide single color bars may present a color field that is split by a vertical black bar, or the single color bar may be displayed at the center of the screen (Fig. 1-14). These are merely differences of detail in display which do not affect the utility of the generator. You will also find single-bar generators of the *partial-NTSC type* in which the signal is provided at NTSC phase, but without the standard brightness component. In such cases, the brightness of the color bar is incorrect unless the receiver's brightness control is suitably adjusted for the particular color. Thus, the partial-NTSC generator is an instrument which is intermediate to the keyed-rainbow generator and the complete NTSC generator.

Basic Applications

To introduce the utility of color-bar signals, the following general applications for the color-bar generator are briefly noted:

1. To determine whether the receiver under test will reproduce color signals from an r-f input.

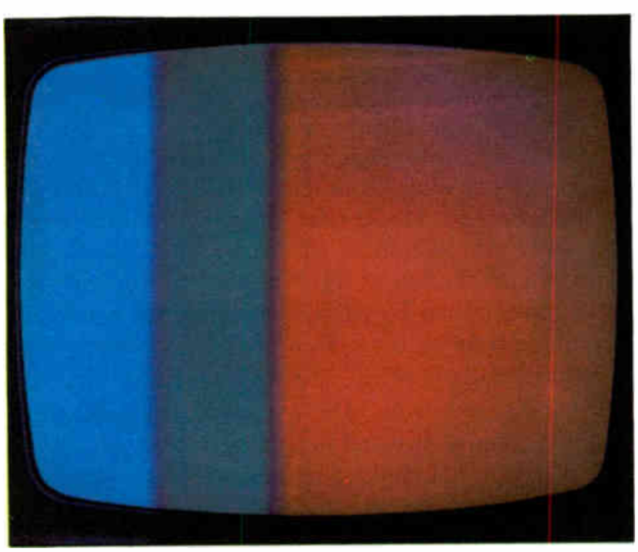


Fig. 1-12. B—Y and R—Y displayed on a color screen.

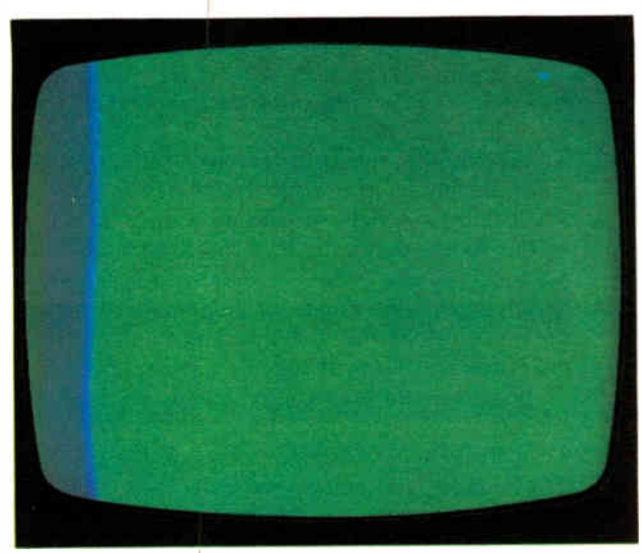


Fig. 1-14. Single-bar pattern produced by some generators.

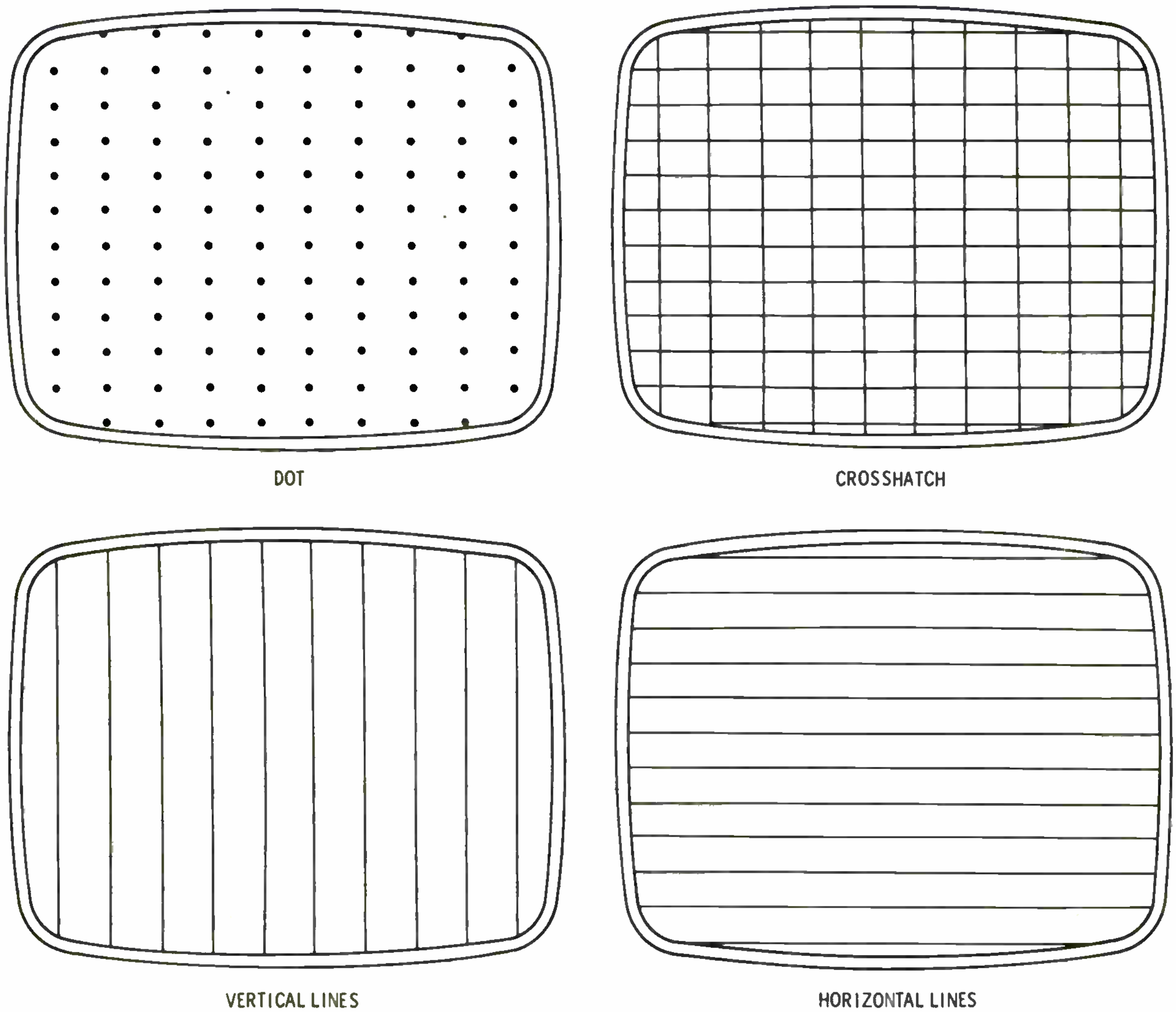


Fig. 1-15. Test patterns that are used during convergence procedures.

2. To determine whether the receiver will reproduce color signals from a video-frequency input.
3. To localize faults by providing a chroma signal in the receiver circuits that can be traced with a scope.
4. To show up distortions in color-pattern reproduction and permit the interpretation of these distortions in terms of specific circuit defects.
5. To help evaluate and analyze defective color-sync action.
6. To permit accurate adjustment of the chroma demodulator and matrix phases.
7. To help check the gain of each chroma section, and the relative amplitudes of signal voltages at each grid of the color picture tube.

In addition, color signal generators of the analyzer type provide modulated outputs which can be injected at any i-f stage. The carrier frequency is tunable to accommodate differences in receiver i-f design. The chroma amplitude in analyzer-type generators, as well as in conventional keyed-rainbow generators, is often adjustable from zero to twice normal amplitude. The burst amplitude is often individually adjustable in the NTSC-type generator. These features provide additional flexibility in analysis of defective color-sync action. A normally-operating color receiver will hold color-sync lock when the signal level is reduced to the point where the bars are barely visible on the picture-tube screen.

Many color signal generators also include some type of sound signal, chiefly as an aid in tuning the receiver properly (setting the fine-tuning control). However, a sound signal also serves as a useful check of trap action. If a 920-kc beat appears on the screen, the cause should be investigated. It might be that the fine-tuning control is slightly misadjusted or that a color-subcarrier trap is misaligned. Hence, this check supplements visual-alignment procedures in a color receiver.

Supplementary Generator Features

Some color-signal generators provide a color-gun interrupter switch. This switch operates through a plug-and-socket adapter for the color picture tube and speeds up checks of red, green, and blue color fields. Instead of a plug-and-socket adapter, some generators provide special clip leads for connection to the picture-tube grid terminals. Again, pin-jack connections are sometimes provided for convenient scope connections to the picture-tube grids to make chroma waveform checks. A window viewer is still another feature provided as a part of some generators. The viewer is a series of illuminated plastic windows for use as a convenient guide to correct reproduction of basic hues.

BLACK-AND-WHITE TEST PATTERNS FOR CONVERGENCE PROCEDURES

Convergence of a color-picture tube requires the use of special black-and-white test patterns (typical displays are seen in Fig. 1-15). Since the latest convergence procedures call for the use of both dot and line patterns, many generators offer a choice of horizontal-line, vertical-line, crosshatch, or dot displays. Simplified generators provide only dots or lines. The edges of the dots or lines change abruptly from black to white, because a sharp transistion helps to reveal any color fringing caused by misconvergence. Most technicians feel that a small dot size or thin lines also show up convergence errors to better advantage.

However, dots should not be so small that they are difficult to see clearly. Typical generators provide dots from less than ⅛ inch to about $\frac{3}{16}$ inch across. A few generators have provision for varying the dot size. Note that dot, crosshatch, and line generators are also useful to check linearity adjustments. Basically, these instruments are specialized pulse generators that utilize triggered-blocking oscillators or multivibrators to form the pulses. However, a few are designed as flying-spot scanners that employ a phototube and produce the pulses from a slide transparency.

Shading bars are also produced by some generators; this is a coarse crosshatch pattern formed by wide lines. The background of the pattern is black; the lines correspond to a 50% gray level; the crossovers of the vertical and horizontal lines correspond to white. Technicians find this type of test pattern useful in adjusting the gray scale in which the biases on individual guns in the color picture tube are adjusted so that minimum color tinting is visible in the grays and whites of a black-and-white picture.

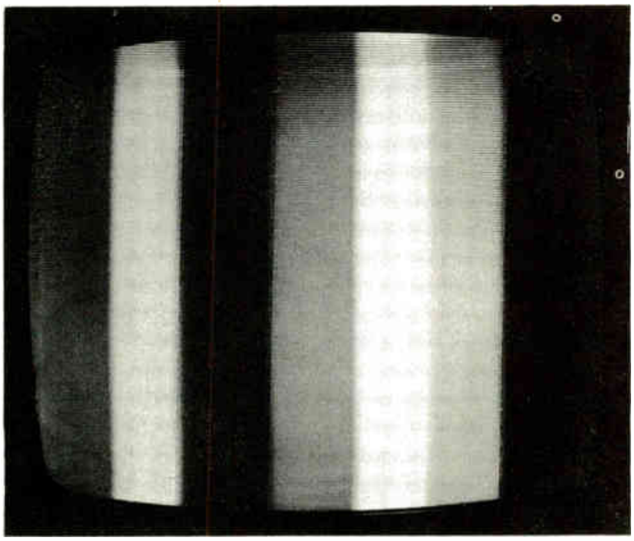


Fig. 1-16. Black-and-white portion of the signal from an NTSC color-bar generator.

It is much more practical to use a shading-bar signal instead of a television-station signal, because the generator pattern is stationary on the picture-tube screen. Technicians often find it distracting to analyze tinting in a continually changing picture. Note that an NTSC color-bar generator can be operated as a shading-bar generator by turning off the chroma signal. The remaining Y signal displays vertical bars in various shades of gray, as illustrated in Fig. 1-16. In case any bars show visible color tinting, the d-c voltages at the color-picture tube are adjusted as required.

COLOR-TELEVISION BLOCK DIAGRAM

Color-television receivers in present use have two dozen tubes or more and contain as many as 11 semiconductor diodes. All color receivers perform essentially the same function. The general plan of a color-television receiver is seen in Fig. 1-17. You will recognize some of the sections which are the same as in black-and-white receivers. Other sections are used only in color receivers. Some of the "black-and-white" sections, such as the tuner and i-f blocks carry both black-and-white and chroma signals. Thus, defects in the circuitry of these stages can cause trouble symptoms during either black-and-white or color reception.

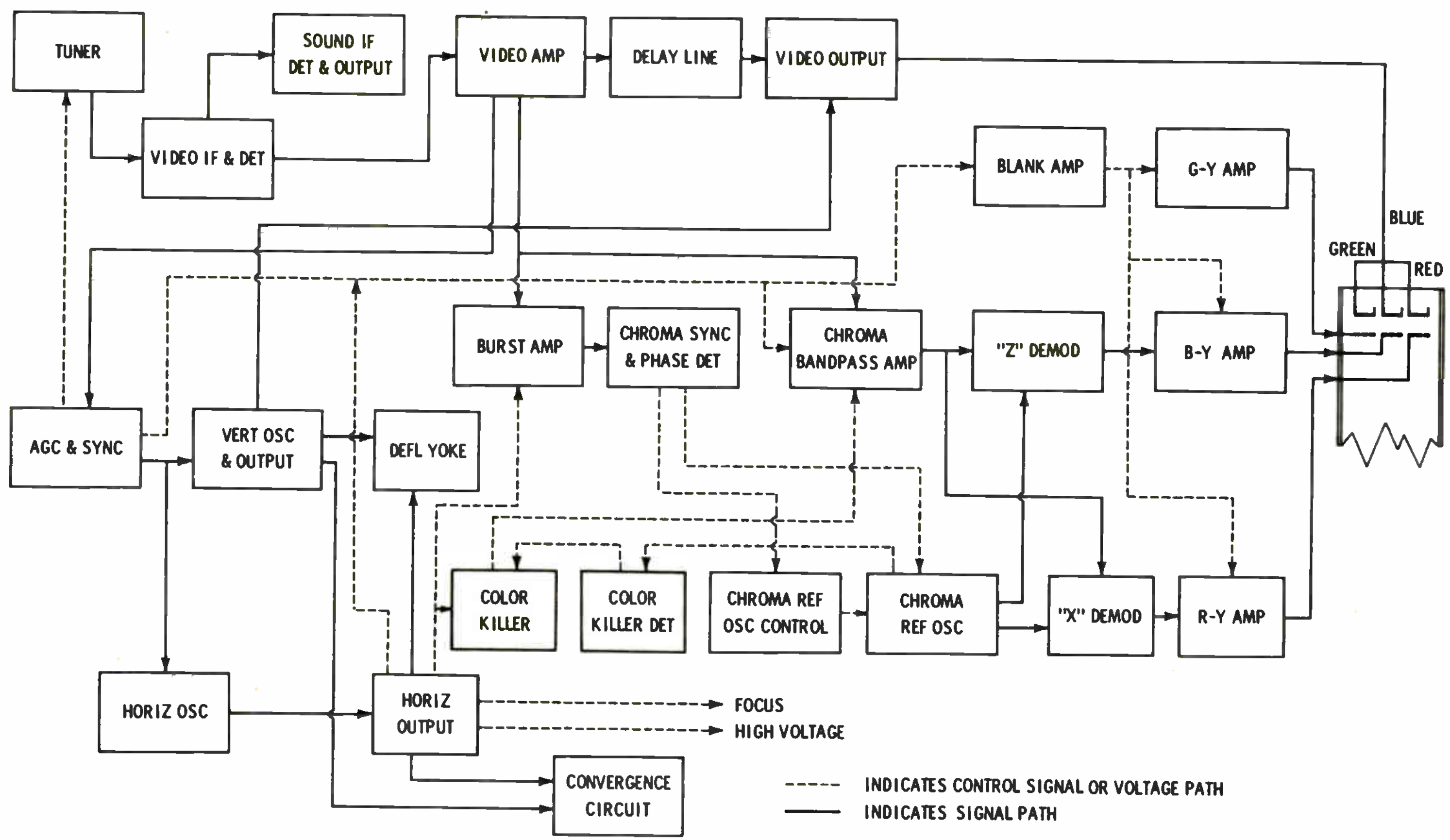


Fig. 1-17. Block diagram of a color-television receiver.

Defects in the video-output section affect black-and-white reproduction only. On the other hand, circuit faults in the chroma bandpass amplifier affect color reproduction only. The incorrect operation of the convergence circuit will impair picture quality of both black-and-white and color reception. There are some types of defects in the G−Y amplifier, for example, which cause trouble symptoms in color reception only —but there are other types of defects in a G−Y amplifier that also cause trouble symptoms during black-and-white reception. Hence, it is not always possible to pinpoint a given trouble symptom to a "chroma" section, or to a "black-and-white" section. Progressive tests must often be made to isolate the defective section and finally locate the defective component(s).

This book is primarily concerned with servicing of chroma symptoms and troubles. It is assumed that the reader is familiar with troubleshooting black-and-white receivers. However, due to combined functions of some receiver sections, and interaction between black-and-white and chroma sections, your servicing of chroma troubles will often involve the "black-and-white" circuitry. Note also that certain minor defects which would ordinarily be disregarded in black-and-white reception become serious defects in color reception—for example, i-f amplifier alignment must be correct for the reception of color, but a poorly aligned i-f strip will provide acceptable black-and-white pictures.

APPROACH TO SERVICE PROBLEMS

Set owners are usually cooperative in stating what they think is wrong with the receiver, and they *can* provide useful information concerning whether the initial trouble symptom has changed, whether its onset was sudden or gradual, and whether the symptom is intermittent. Such descriptions, in laymen's terms will provide a hint as to the circuit section that is defective. After you have listened to the set owner's explanation, turn the receiver on and carefully note any additional symptoms, such as burning odors, arcing noises, or overload hum from the power transformer.

Notice whether warm-up time is abnormally slow, and at what point during warm-up the momentary "rustling" due to high voltage is heard. It a picture appears, no matter how weak, distorted, snowy, or color-streaked, make a careful picture analysis to help in preliminary isolation of the defective circuit section. Note whether sound is present, absent, weak, or distorted. If a color broadcast is not available, follow up your analysis with a color test pattern from a portable color-signal generator. Make a tentative decision concerning whether the symptoms point to a defect in the black-and-white circuitry, or in the chroma section.

After completing the picture and sound analysis, make a systematic check of the operating controls. Setup and maintenance controls which should have been changed should also be checked, particularly if the symptoms indicate that misadjustment could be causing the difficulty. Technicians can obtain considerable information from a check of various controls, even when the trouble stems from a defective component. A thorough understanding of the normal response when each control is varied is necessary if the difficulty is to be localized in these tests. Abnormal responses, inadequate range, or lack of response in a certain control indicate a particular receiver section in which the trouble exists.

When all pertinent data have been observed, tubes in the suspected section or sections should be checked first. Fuses should also be checked at this time, if you have reason to suspect them. Tubes can be checked with a tube tester, or by substitution with known good tubes. When tubes are checked by substitution, lay them aside in an orderly manner so that they can be returned to their original sockets if they are not defective. It is good practice to substitute tubes in sequence, and to leave all new tubes in the chassis until the trouble is located or until the defective tube or tubes are found. This precaution insures that you will not be misled by two or more defective tubes.

Since so many tube types are in present use, and because of the number of new tube types appearing in late-model receivers, you may tackle a chassis for which you do not have a substitute tube, or, you may not be able to check a new tube type in your tube tester. In such a case, observe whether another tube of this type is used in the chassis; interchange the two tubes and if the trouble symptom changes, it indicates that one of the tubes is defective. Finally, if this procedure fails to disclose the trouble symptom, the receiver should be removed to the shop where equipment is available for making more extensive tests and repairs.

When a color picture tube falls under suspicion, most technicians measure the various electrode voltages. This immediately eliminates the possibility of circuit trouble simulating a picture-tube defect. A high-voltage d-c probe must be used with the vom or vtvm to measure the accelerating and focus voltages. A more complete checkout requires the application of a color test signal, and resulting waveform checks at the cathodes and control grids—however, this is usually a bench procedure. Color picture-tube testers will indicate whether the tube is definitely bad.

Installation of a new color-picture tube is a four-step procedure, which is followed by purity and convergence adjustments. Briefly, the procedure is as follows:

1. Removal of the chassis, and removal of the color picture tube.
2. Removal of components from the tube.
3. Placement of components on the new tube.
4. Installation of the new tube, and replacement of the chassis.

Components must be properly located on the neck of the tube, or you will be unable to obtain proper purity and convergence. Check the service data—do not assume that the original placement is necessarily correct for the new tube.

TEST EQUIPMENT FOR COLOR SERVICE

Certain basic color test equipment has already been noted in the discussion on test patterns. Additional instruments are, of course, required for most troubleshooting jobs. All available test equipment is worth while, though it may not be essential. "Workhorse" instruments should be obtained first, and others acquired to meet specific job demands, or work-load increases. Understandably, all the test instruments used in black-and-white receiver servicing are basic for servicing of color receivers. The following list is representative of the instruments that should be acquired before professional color servicing is attempted.

1. A vtvm and/or vom, with high-voltage probe. (vtvm is preferable).
2. Tube tester (preferably of the mutual-conductance type).
3. Wide-band oscilloscope that has a flat response through 3.58 mc and a low-capacity probe.
4. An a-m/f-m signal generator or two separate generators with a video-frequency sweep output.
5. Marker generator, if the f-m generator is a separate unit.
6. Absorption-marker box, if it is needed for use with the video-frequency sweep output.
7. White-dot and/or crosshatch generator.
8. Color signal generator (may be combined with dot-crosshatch generator).
9. Assortment of universal cables used to interconnect chassis, picture tubes, and yoke assemblies.
10. A degaussing coil is essential. Also a color picture-tube test jig is very useful.

Your preliminary approach is very important. Obviously, circuit defects must be accurately analyzed if a vast amount of time is not to be wasted in trial-and-error procedures or replacement of unnecessary parts. Technicians who are well experienced in black-and-white receiver servicing have developed preliminary approaches which are readily adaptable to color servicing. From beginning to end, benchwork employs the basic instruments listed above. Electrical measurements and circuit analysis are the keys to efficiency at the bench.

If you have the basic color-television test instruments, most receivers can be serviced without undue difficulty. The essential considerations concerning any test instrument are that it must be accurate, and you must know how to use it properly. Hence, it is advisable to add new color-television test equipment to your shop only when you are sure that you know how to use it in your troubleshooting procedures. This requires study as well as experience. A professional technician is a person whose studies are never finished. Not only is color television a wide-ranging technology, it is a continually evolving technology.

SCHEMATIC AND SERVICE DATA

It is essential to have a schematic diagram and complete service data for a color receiver before bench troubleshooting procedures are started. You must analyze the trouble symptoms with respect to the receiver circuitry, measure d-c voltages and resistances, observe waveforms and peak-to-peak voltages, refer to maintenance procedures, and occasionally realign one or more of the signal circuits. Hence, schematics and service data are as essential as test instruments.

Chapter 2

Chroma Troubles in Black-and-White Sections

Because the chroma and black-and-white signals are amplified together in the r-f and i-f sections of a color receiver, various circuit troubles which produce defective black-and-white reproduction also affect color reproduction. In this chapter, we are concerned primarily with r-f tuner, i-f amplifier, and video-amplifier troubles that cause poor or no color reception. Suitable tests are described that localize color-picture symptoms either to the r-f tuner, i-f amplifier, or video amplifier. Common symptoms include:

1. Complete absence of both black-and-white and color pictures, no sound, no snow, but with raster normal.
2. Hum bar(s) in both black-and-white and color pictures, poor sync, possibly accompanied by distorted sound.
3. Intermittent reception that affects color pictures.
4. Color picture and sound normal, but black-and-white picture absent.
5. Neither color nor black-and-white picture, prominent snow and confetti in raster, loud rushing noise from the speaker.
6. Fine-tuning control must be set to one point for acceptable color pictures, but to another point for acceptable black-and-white and/or sound reproduction.
7. Color picture is satisfactory, but sync lock is unstable.
8. Weak color and black-and-white pictures, prominent confetti, often with loss of color sync. Sound may be weak and noisy.
9. Color picture badly distorted; black-and-white picture partly or completely negative; sync action unstable.
10. Color and black-and-white picture-pulling, with partial or complete loss of color sync.
11. Ghosts or ringing in color picture and black-and-white picture which persists when test is made with color-bar generator.
12. Poor color "fit."
13. Weak or no color reproduction; smeared black-and-white picture.

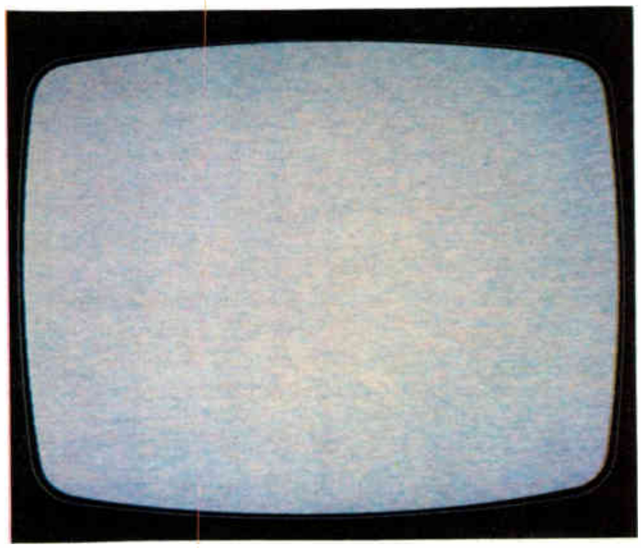


Fig. 2-1. Confetti caused by a defective tuner.

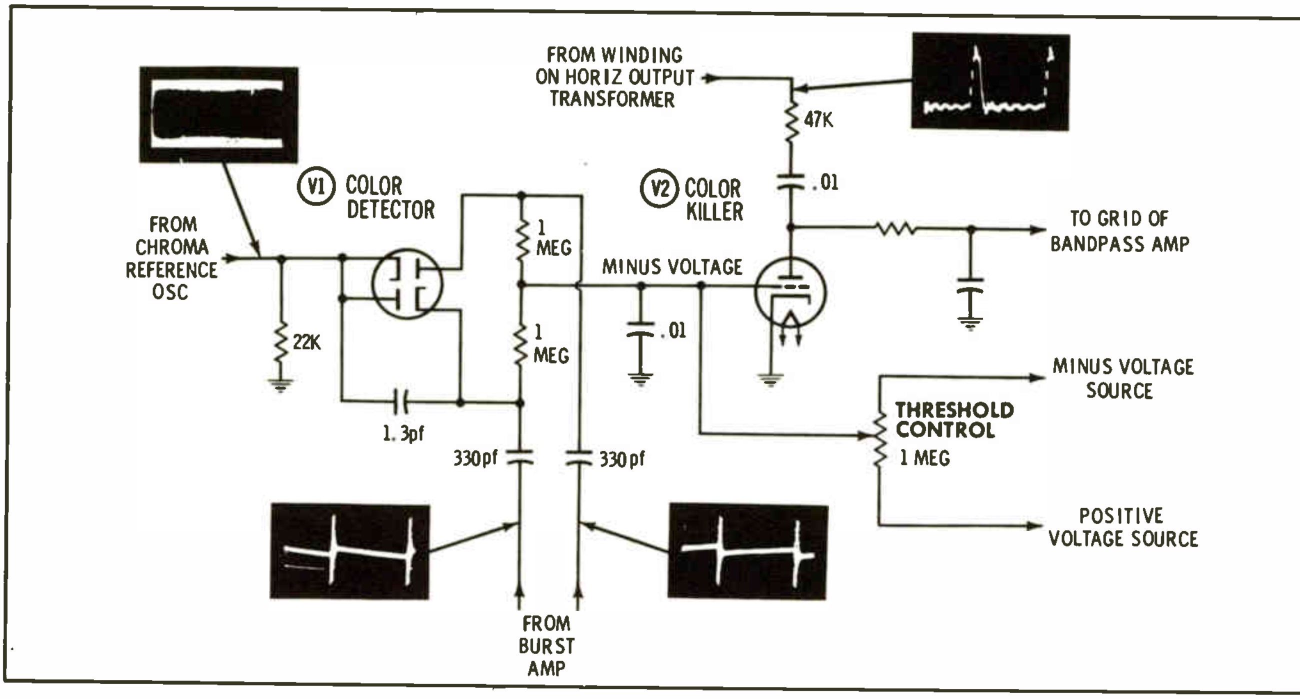


Fig. 2-2. Color detector and color-killer circuits.

CONFETTI PATTERNS

Confetti is colored snow. When the r-f stage is seriously defective, you can expect to see more or less confetti in the raster, as illustrated in Fig. 2-1. In this example, the confetti is being modulated by 60-cycle hum voltage from the defective tuner. Note that if you turn the color-killer control to minimum, the chroma section is cut off, and you then see ordinary snow instead of confetti in the raster. Ordinary snow is caused by noise voltages which pass through the video-output stage (sometimes called the Y amplifier) to the cathodes of the color picture tube. On the other hand, confetti is produced by noise voltages which pass through the chroma bandpass amplifier and the chroma circuitry to the grids of the color picture tube.

The color killer in a color receiver controls the bias to the bandpass amplifier, as shown in Fig. 2-2. The color killer is a form of electronic switch that turns the bandpass amplifier "on" only when a 3.58-mc color burst is being received. An exception to this occurs when the r-f amplifier is weak and the contrast on the receiver is turned up. Colored snow will appear on the screen as a result of 3.58-mc components of the noise causing the chroma-bandpass amplifier to turn on. Noise is generated by the mixer and amplified by the increased gain of the i-f stages operating with nearly zero bias.

BLACK-AND-WHITE VERSUS COLOR REPRODUCTION

R-f tuner gain can be adequate for marginal black-and-white reception, but it is inadequate for acceptable color reproduction. For example, Fig. 2-3 shows a peaked response curve for an r-f tuner. This misalignment is such that the picture carrier falls on top of the curve, and the color subcarrier falls down considerably on the side of the curve. Under these conditions, a black-and-white picture is reproduced at higher gain than the color component. Although fine detail is re-

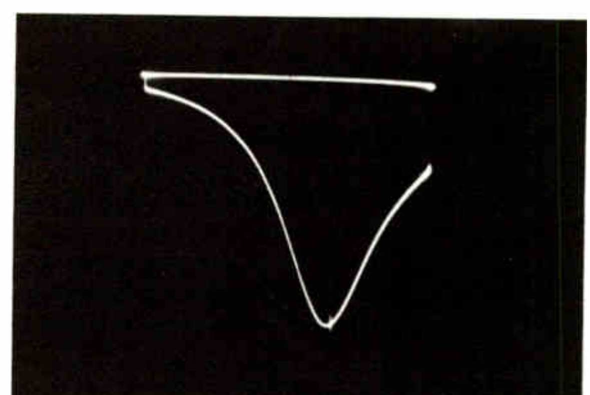


Fig. 2-3. A peaked r-f response curve.

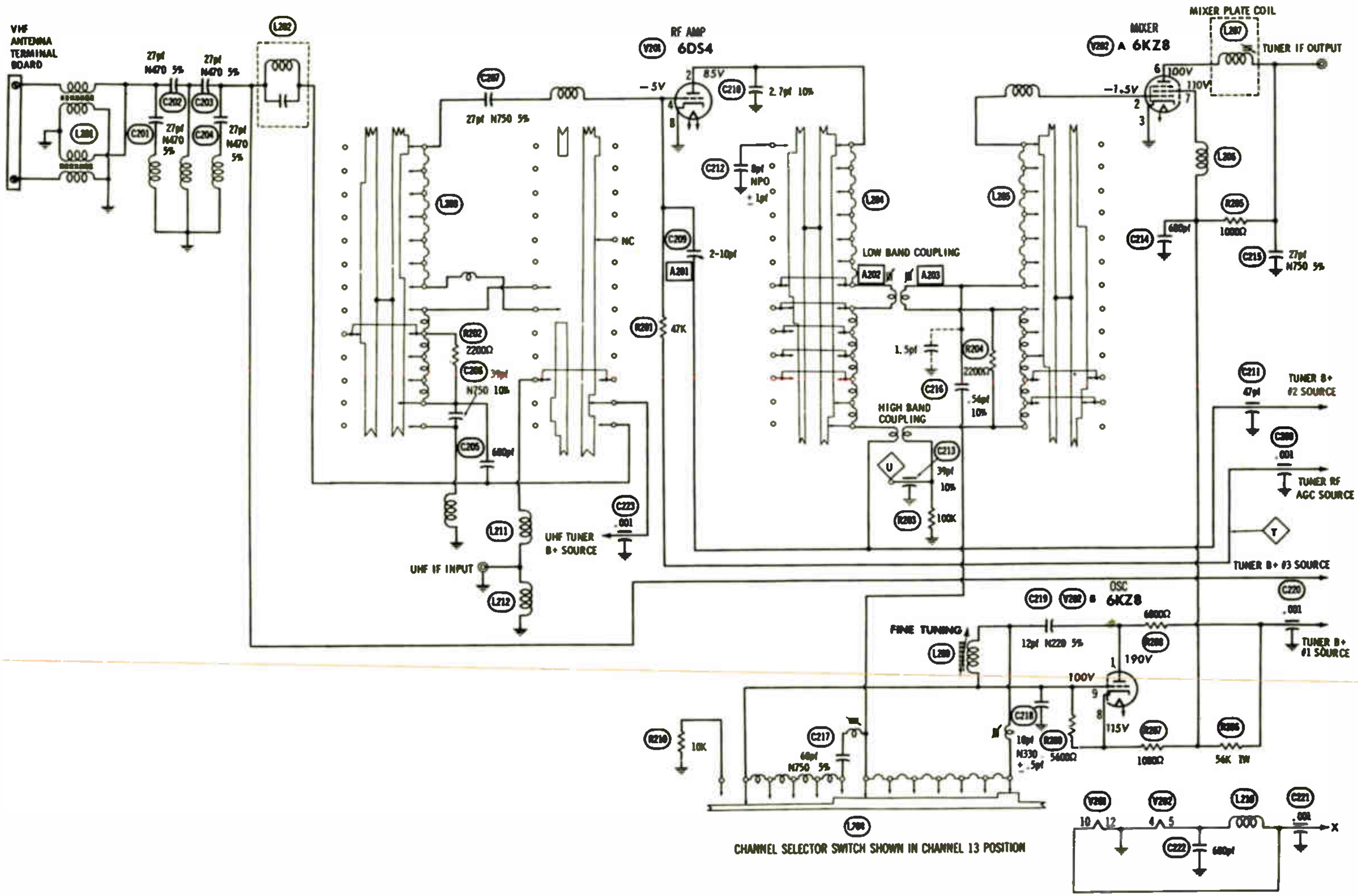


Fig. 2-4. Tuner used in a color receiver.

duced in the black-and-white picture, reception remains tolerable. On the other hand, color will be reproduced with pale and washed-out hues unless the incoming signal is comparatively strong. Weak signals in this case will produce a low-contrast black-and-white picture with no visible color.

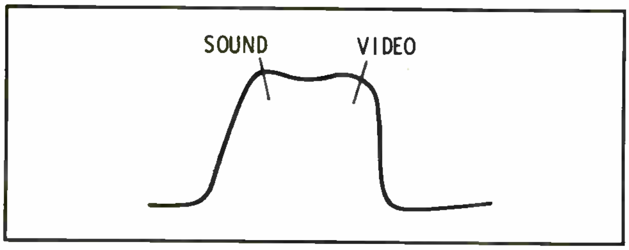


Fig. 2-5. Alignment curve for a color-television tuner.

From the foregoing example, it is apparent that good alignment is essential for color reception. All color-television manufacturers specify that the r-f tuner should be aligned so that both the picture and sound carriers appear on top of a flat (or double-humped) r-f response curve. Your receiver service data is an essential guide in this regard. Fig. 2-4 shows a typical r-f tuner configuration for a color receiver. Note that the alignment curve shown in Fig. 2-5 is relatively flat between the video and the sound carriers. One of the chief requirements for good color reception is that the tuner must provide flat (or double-humped) response curves on all channels.

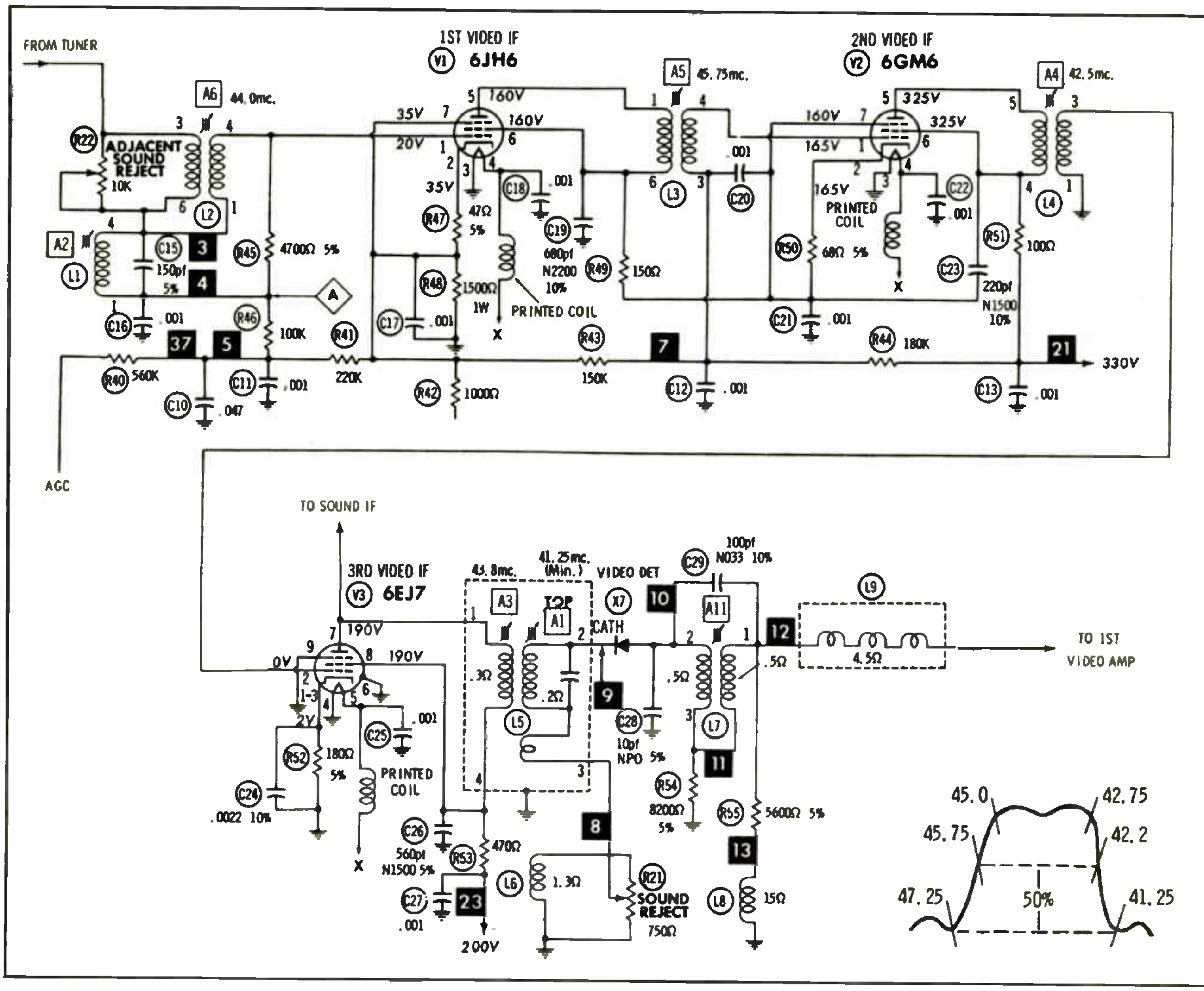


Fig. 2-6. An i-f amplifier used in a number of color-television receivers.

Preliminary Considerations

Picture analysis will sometimes pinpoint color-reception trouble to the r-f tuner section. In most cases, however, you will need to make some localization tests. It is not always possible to distinguish between r-f trouble and i-f trouble by picture analysis. Confetti and snow are chief clues in preliminary analysis. If you observe a large amount of confetti and/or snow in the raster, the r-f tuner logically falls under suspicion. It is assumed that all tubes in the signal circuits have been tested or replaced. Trouble localization is facilitated by careful observation of operating-control response. The action of the fine-tuning control and contrast control can be particularly significant.

Remember that occasionally an r-f tuner is fused, and this possibility must not be overlooked on a home call. Otherwise, a job which requires only replacement of an r-f tuner tube and fuse could be dubbed a bench problem. Even if the schematic diagram does not indicate an r-f tuner fuse, it is advisable to look for one. When an r-f tuner has been previously serviced for burned-out resistors (caused by a shorted tube), technicians sometimes insert a small fuse in the B+ line to the tuner in order to prevent the same resistors from burning out again.

Localization Tests

In case tube or fuse replacement and adjustment of maintenance controls do not restore normal color reproduction, the chassis must be pulled for bench servicing. At the bench, you will often need a quick test to localize circuit defects to the r-f tuner, i-f amplifier, video detector, or video amplifier. As in the case of black-and-white receivers, the agc line(s) may be clamped to eliminate a particular section from suspicion. A color-television analyzer can be used to inject color test-pattern signals at the input to the video amplifier, at the input of the video detector, at the grid of each i-f tube in turn, and at the antenna-input terminals.

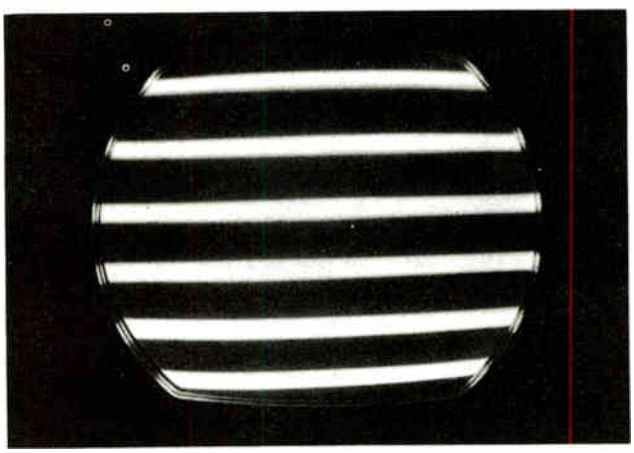


Fig. 2-7. Screen pattern obtained by injecting a modulated signal into the grid of the first i-f stage.

A sweep generator and scope are very useful for localizing chroma defects in the black-and-white sections of the receiver. Look for badly distorted response curves, low gain, and instability. How is normal gain evaluated? This can only be done on the basis of practical experience. In case of doubt, run response curves on a color receiver which is in good operating condition. Carefully note control settings on both generator and scope. Also, make it standard bench practice to use the value of agc override voltage specified in the receiver service data in all tests.

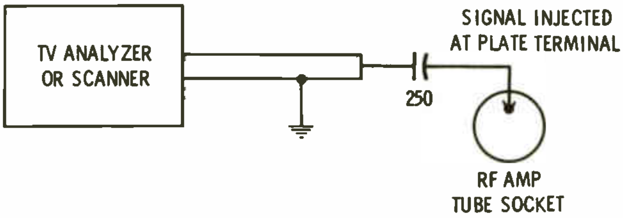
COMMON TROUBLE SYMPTOMS AND CAUSES

1. No Black-and-White or Color Picture; Normal Raster, No Snow, No Sound

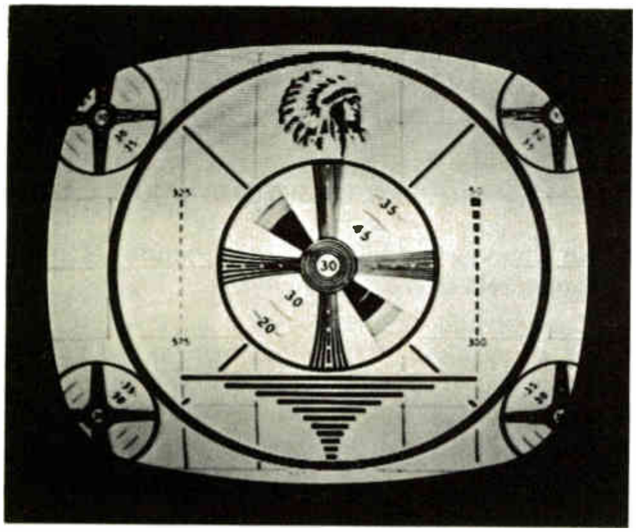
Most symptoms are caused by a single defect, and this assumption can be made in a preliminary analysis. The chief clue in this group of symptoms is "no snow." This means that the mixer stage, or an i-f stage ahead of the sound-takeoff point is dead. Let us review the possible defects:

a. Defective oscillator-mixer or i-f amplifier tube. In Fig. 2-4, V202 would be suspected. In Fig. 2-6, V1, V2, or V3 would be suspected.
b. Circuit defect in mixer or i-f stage prior to the sound-takeoff point.
c. Excessive agc bias voltage.
d. Oscillation in an i-f stage.
e. Defective tube socket in the mixer or an i-f stage ahead of sound takeoff point.
f. Failure of B+ or heater supply voltage.

Note that when the mixer stage is dead, there may be a very small amount of snow and/or confetti in the raster, especially at very low values of agc clamp voltage. Experience with various color receivers is the best guide in evaluating very low snow and confetti levels. If you do not have a color-television analyzer, a rough test can be made with an ordinary signal generator to aid in distinguishing between an r-f tuner trouble and an i-f amplifier trouble. Apply modulated i-f output to the grid of the first i-f tube, as depicted in Fig. 2-7. If modulation bars are displayed at normal contrast on the picture-tube screen, you can conclude that the i-f amplifier is working. Of course, you must know your signal generator, and apply the correct signal level to produce normal contrast.



(A) Injecting a signal at the r-f tube socket.



(B) The test pattern on the screen.

Fig. 2-8. Television test pattern.

After a defect is localized to a section or stage, the next step is to isolate the defective component. Start by making a series of d-c voltage measurements, unless specific clues make this step unnecessary. The *exact* voltage values specified on the receiver service data will usually not be indicated. On the other hand, readings outside of ±20% tolerance should be regarded with definite suspicion. Also, make sure that test conditions are correct; here are a few typical specifications:

a. The d-c voltages noted on the schematic are nominal values measured with a vtvm.
b. All receiver controls are set for normal operation; no signal is applied.
c. All d-c voltages are measured with respect to the common ground.
d. Line voltage is maintained at 117 volts.

When d-c voltage measurements do not suffice, switch off the power to the receiver and check circuit resistances. Tables of nominal resistance readings given in the receiver service data are very helpful, because there are often branch paths present. Certain defects, such as open coupling capacitors, cannot be pinpointed by either resistance or d-c voltage measurements. However, a modulated i-f signal from an analyzer or signal generator can be applied to the input and then to the output terminals of a suspected capacitor for a definitive test.

A simple verification test for a suspected mixer stage can be made by unplugging the r-f amplifier tube and injecting a modulated i-f signal into the plate terminal of the socket. Note that you can also unplug the mixer tube and inject a modulated i-f signal into the plate terminal of the mixer socket. This test helps to narrow down a defect to the input or output circuit of the mixer stage. A signal from a television scanner injected into the socket of a normally operating receiver as shown in Fig. 2-8A. A test pattern such as the one in Fig. 2-8B should be displayed on the screen.

2. Hum Bars in Black-and-White and Color Pictures; Poor Sync

Hum bars are caused by entry of 60-cycle or 120-cycle voltage into the signal circuits. Black-and-white hum bars show that the point of entry is in a black-and-white section. Note that small hum voltages usually produce *picture-pulling,* and the black-and-white hum bars may have very low contrast. Fig. 2-9 illustrates a typical example of hum introduced at the r-f tuner. Possible sources of these symptoms are:

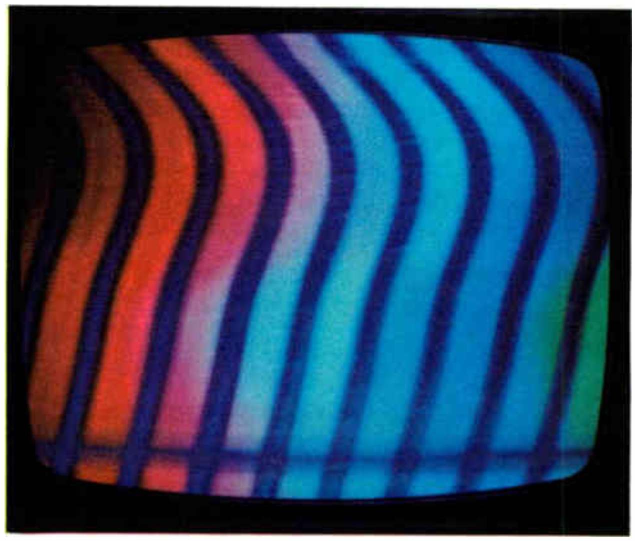


Fig. 2-9. Hum voltage in the tuner.

a. Heater-cathode leakage in an r-f or i-f tube or in the circuit of Fig. 2-10. The hum could occur in any of the video-amplifier tubes.

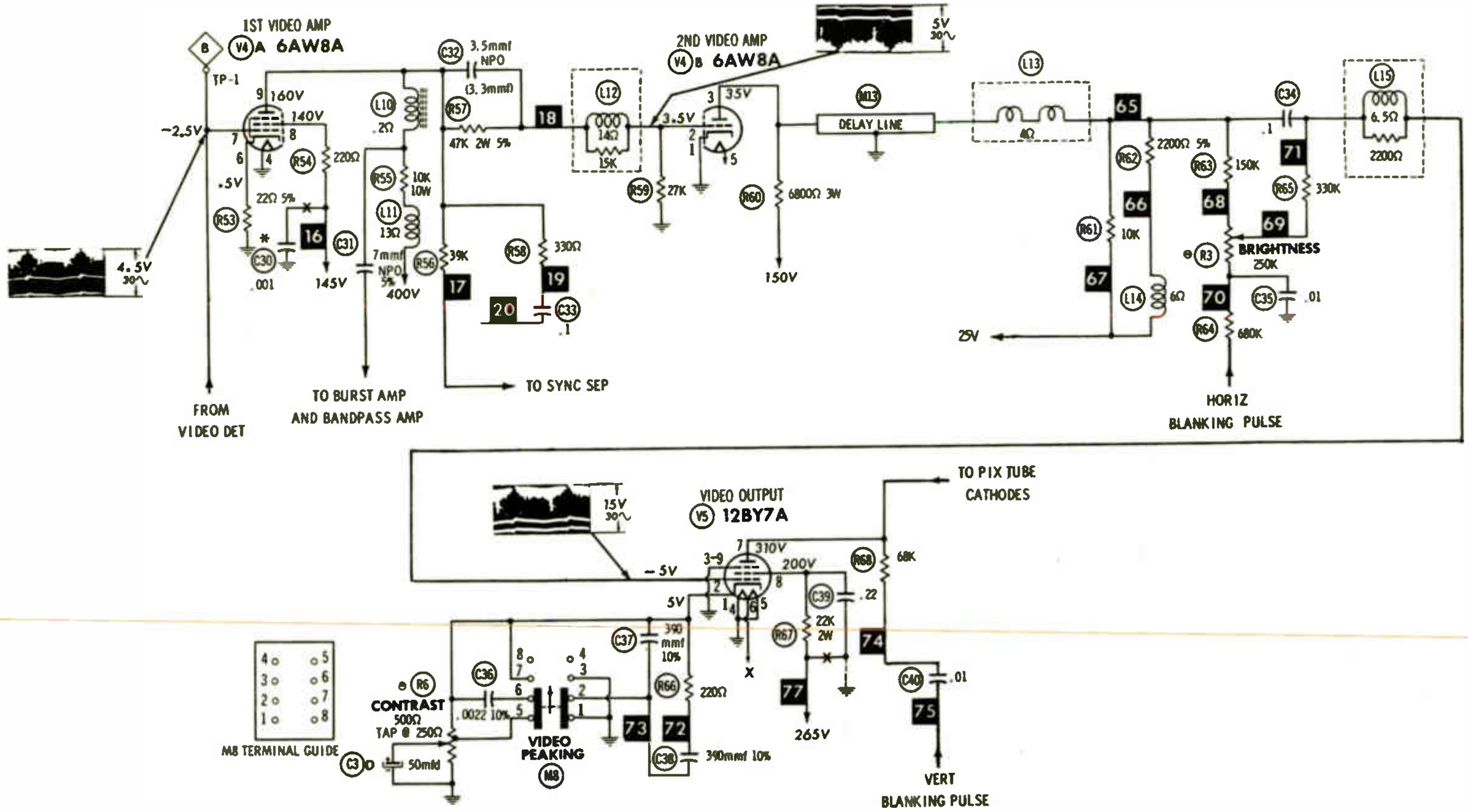


Fig. 2-10. Circuit of a video amplifier used in a color-television receiver.

b. Corrosion or leakage between heater terminals and other socket terminals.
c. Leakage between conductors on printed-circuit boards.
d. A-c ripple voltage in the agc supply (can be checked by agc clamping).
e. Excessive ripple in the B+ voltage; (check with scope).
f. Lack of decoupling from vertical-output section (check with scope).
g. External interference (check by using a color test-pattern generator).

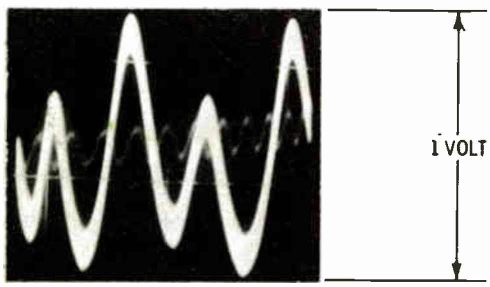


Fig. 2-11. Approximate amount of ripple on the B+ line.

Maximum tolerable ripple voltage in the B+ supply is specified in the service data for the color receiver. For example, a peak-to-peak amplitude of 1 volt is generally permissible. An example of the ripple on a B+ supply is shown in Fig. 2-11. When you are concerned only with the amplitude of an a-c voltage, and do not need waveform data, a vtvm can be used instead of a scope. Note that the characteristics of a ripple waveform will sometimes provide a clue concerning the source of the trouble. For example, if the ripple waveform "writhes" when the picture is rolled, a decoupling capacitor in the vertical-output section is probably defective.

3. Intermittent Reception

Intermittent reception is one of the most vexing problems the technician can encounter. Unless only color reproduction is affected by the intermittent, the trouble will be found somewhere in the black-and-white sections. Possible causes are:

a. Intermittent tube; replace all suspected tubes with known good tubes.
b. Corroded tube sockets; defective switch contacts. Move the tubes in sockets. Rock suspected switches back-and-forth.
c. Intermittent capacitor, resistor, or coil. Tap suspected components. Heat pigtails with a soldering gun.
d. Cold solder joint, break in printed-circuit conductor. Flex the wires at suspected break. Inspect printed circuit boards under a magnifying glass.
e. Defective heater choke. Check for heater voltage at each end of the choke.
f. Erratic agc voltage. Clamp the agc line for a definitive test.

It is sometimes helpful to turn the receiver off and on several times to initiate the intermittent trouble. Also try raising and lowering the line voltage and changing the signal-input level. While the defective operation is occurring, analyze the picture for confetti, snow, or other key symptoms. For example, a herringbone pattern might be present in the raster, which points to the possibility of i-f oscillation. When confetti and snow are prominent, it is possible that the local oscillator has stopped. A substitute local-oscillator signal can be injected as shown in Fig. 2-12. The marker generator performs the same function as the local oscillator and will produce a picture on the screen if the local oscillator is at fault.

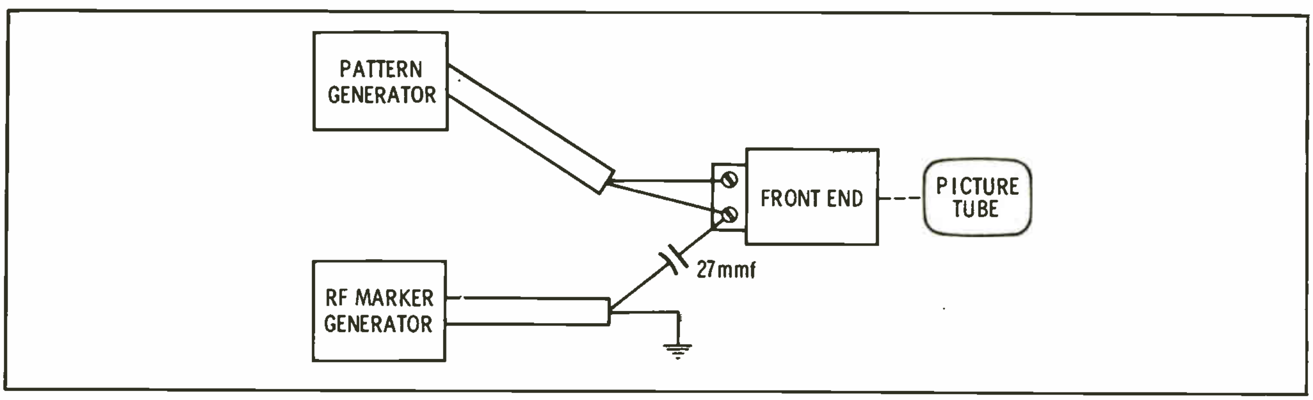


Fig. 2-12. Substitute for a defective local oscillator will produce a signal on the screen.

4. Color Picture and Sound Normal, Black-and-White Picture Absent

This group of symptoms indicates that the trouble is located in the circuits following the chroma-takeoff point. For example, in Fig. 2-10 the defect would be found in circuits beyond L10. Except for the delay line, this circuitry is basically the same as in a black-and-white receiver. The first step should be to measure d-c voltages and resistances and compare them with those listed on a schematic. An audio-frequency signal can be injected at the grid of the second video and audio output stages to help localize the trouble. The construction of a delay line is seen in Fig. 2-13. The fine wires seldom break but are often damaged by tools and soldering irons. An open may occur at the junction of a lead, or the solder point may be defective. An ohmmeter will usually indicate whether the winding is open, or perhaps shorted to ground.

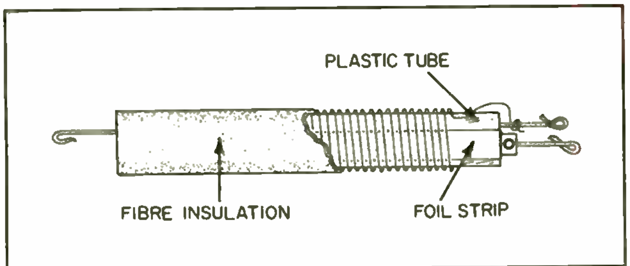


Fig. 2-13. Construction of a delay line in a color receiver.

5. No Color or Black-and-White Picture; Prominent Snow and/or Confetti; Loud Rushing Noise From Speaker

This group of symptoms throws immediate suspicion on the r-f tuner. The defect should be located ahead of the mixer tube. Possible causes are:

a. Short circuit. For example, C210 in Fig. 2-4 could be shorted. Try injecting a modulated i-f signal at the plate of the r-f amplifier. Also, C205 or C209 in Fig. 2-5 might be shorted. Make a voltage test.
b. Short-circuited switch. Look for solder splashes, bare lead touching the switch frame, or "whiskers" from stranded-wire leads.
c. Dead local oscillator. Use a signal generator to substitute for the local-oscillator signal, as shown in Fig. 2-12.
d. Excessive agc voltage to r-f tuner only. Check by applying clamp bias.

When a defect is definitely localized to the r-f tuner; some technicians undertake to make a repair, others simply send the tuner to a repair depot. The choice is a matter of personal preference. Most color-television tuners are quite compact and may be difficult to service with conventional service equipment. Special jigs are often required.

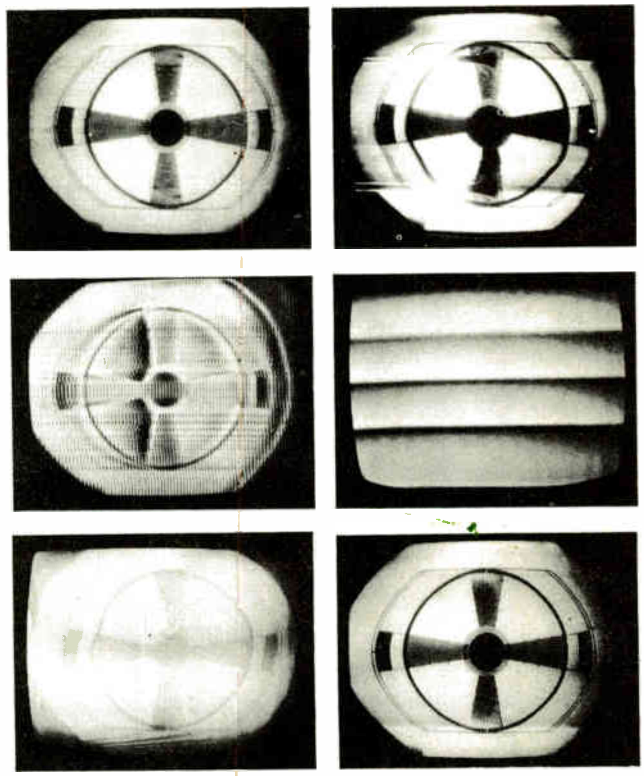


Fig. 2-14. Six symptoms of i-f regeneration trouble.

6. Fine-Tuning Control Must Be Adjusted to Different Points For Best Color and for Best Black-and-White Pictures

This trouble is usually associated with abnormal response curves. Separation of color and black-and-white pictures is often accompanied also by separation of picture and sound. Possible causes are:

a. Misalignment of mixer or i-f amplifier stages. This cause usually results from attempted alignment without the use of an accurate sweep and marker generator.
b. Regeneration in an i-f stage (explained below).
c. Strong standing waves on the lead-in; check by applying a signal from a color signal generator.
d. Technical difficulties at the television transmitter; check by switching to another channel.
e. Strong external interference. Check by switching to another channel, or use a color-generator signal.

A quick test that identifies i-f regeneration 99 times out of 100 can be performed as follows: Apply the output from a test-pattern generator to the receiver, and watch the picture-tube screen as the r-f signal is changed from a high level, such as 100,000 microvolts to a very low level. If the trouble is due to i-f regeneration, the picture will change greatly; examples are illustrated in Fig. 2-14. The most rapid changes occur at low input signal levels. Below a minimum input level, the i-f amplifier often breaks into oscillation. Weak oscillation causes herring-bone patterns. On the other hand, strong oscillation causes a clear raster with no snow or confetti. A vtvm connected across the video-detector load resistor will read from 10 to 30 d-c volts when the i-f amplifier is oscillating.

Here are some useful procedures:

a. A highly regenerative stage can usually be located by touching your finger to the grid of each i-f tube in turn. The screen indication changes greatly when you touch a regenerative grid.

b. An i-f stage often becomes regenerative because of misalignment in which the grid and plate circuits are peaked to the same frequency.

c. When an i-f strip cannot be aligned properly and stabilized, look for open decoupling or bypass capacitors.

d. If the delay capacitor (filter capacitor) is open in an agc line, feedback can occur and cause i-f regeneration. The clue to this trouble is noted by the disappearance of regeneration when override agc bias is applied.

When a regenerative i-f response curve is displayed on the scope screen, its chief characteristics are narrow-bandwidth, peaked sharply at one frequency, and instability. As the sweep-signal level is varied, the response curve changes shape. This symptom is aggravated at low values of agc override bias. In case you have peaked each i-f stage at the frequency specified in the receiver service data and instability persists, start looking for an open screen-bypass, screen-decoupling, or plate-decoupling capacitor and decoupling resistors that are off value.

7. Color Picture Satisfactory; Sync Lock Unstable

This difficulty has the same source in a color receiver as in black-and-white receivers. The trouble will usually be in the horizontal-afc section. If the picture does not lock solidly in vertical sync, the vertical integrator should be the prime suspect. An oscilloscope should be used to localize the trouble. This should be followed by a check for defective capacitors, off-value resistors, or faulty semiconductor diodes in the sync section. The procedure should be the same as that used to troubleshoot a black-and-white television receiver.

8. Weak Color and Black-and-White Pictures, Prominent Confetti, Color Sync May Be Lost, and Sound Weak and Noisy

When contrast is low and snow or confetti is prominent for both color and black-and-white pictures, the trouble will frequently be found ahead of the mixer stage. The most likely cause is a dead or weak r-f stage. If the r-f amplifier tube is good, it is likely that B+ or screen voltage is low or zero. Make d-c voltage measurements at the outset. Quite often, a shorted r-f amplifier tube has burned out a dropping resistor, such as R211 in Fig. 2-4. For this reason, some technicians fuse the B+ line to the r-f tuner.

However, in case the supply voltages to the r-f amplifier tube are normal, you may find that the tuner agc line is supplying excessive negative voltage to the tube. If such is the case, attention should be directed to the agc section. Other high-probability causes for these symptoms are open capacitors, such as C202 or C203 in Fig. 2-4. Also, be on the alert for damaged baluns, such as L201; lightning that strikes in the vicinity of a television antenna may burn open the balun winding.

A defective switch in the r-f tuner may be the culprit. Investigate the possibility of poor socket contacts, particularly in older receivers that have had the tubes changed many times. Solder splashes on r-f coils can cause shorted turns with resulting misalignment and poor signal transfer. In general, use the same approach that is employed in troubleshooting contrast in a black-and-white receiver.

9. Color Picture Badly Distorted; Black-and-White Picture Partly or Completely Negative; Sync Action Unstable

Two basic causes must be considered when this group of symptoms occurs. The most likely one is agc trouble. Clamping the agc line will confirm or clear this possibility. The other cause is due to i-f regeneration, as explained under topic No. 6. However, you will occasionally find that what appears to be agc trouble is caused by a gassy tube, or by a leaky coupling capacitor that permits B+ voltage to bleed into the grid circuit of a tube. Measurements of bias voltage at the grid of each tube in the signal circuits will pinpoint this difficulty.

10. Color and Black-and-White Picture Pulling; Partial or Complete Loss of Color Sync

The preceding discussion has explained how color sync becomes unstable or completely lost when the color pulls; the color burst is not keyed into the burst amplifier; and the subcarrier oscillator drifts off-frequency. The basic trouble in this case will be found in the horizontal afc section or one of the branch circuits. The troubleshooting procedures are exactly the same as in the case of a black-and-white receiver.

11. Ghosts or Ringing in Color and Black-and-White Picture

The possibility of multipath ghosts is easily checked by applying a signal from a color-pattern generator. If the symptom persists, look for the cause in the black-and-white signal sections—the clue here is that the black-and-white and color picture are both affected. Regeneration in the i-f amplifiers can produce picture symptoms of this kind. The ringing or ghost patterns are usually tunable, and change considerably with variations of the fine-tuning control. Suspect misalignment or an open bypass capacitor when i-f regeneration is present. However, a shorted bypass capacitor will sometimes cause the same symptoms. In a typical case history, a shorted screen bypass capacitor caused subnormal screen and plate voltages on the first i-f tube. When the capacitor was replaced, the ghosts disappeared.

Incorrect peaking-coil inductances in the video-detector circuit or video-amplifier circuit can also cause "repeats" or circuit ghosts. When this difficulty occurs, it is usually due to an incorrect replacement. Check the coil against the service data for correct coil specifications. This is a more important consideration in color receiver servicing than in black-and-white servicing, inasmuch as set-owners are more critical of color reception.

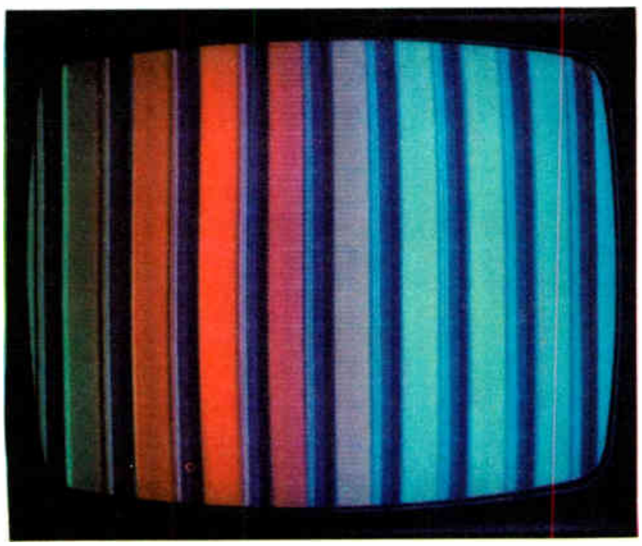


Fig. 2-15. Result of a broken antenna lead.

An example of a color symptom that persisted when a color-bar generator was connected to the receiver. The problem appeared to be in the antenna but when a color-bar generator was connected to the receiver, the pattern shown in Fig. 2-15 appeared on the screen. In this case, one side of the antenna lead had broken at the tuner. This resulted in ghosts, ringing and improper hues. The black-and-white picture in this instance was tolerable but the shift in color during a color telecast made viewing impossible.

12. Poor Color Fit

When color areas are displaced from corresponding black-and-white areas in the picture, the color fit is considered poor. The cause is usually pinpointed to incorrect alignment, either in the black-and-white or the chroma signal sections. Therefore, make systematic alignment checks when this symptom is encountered. There is a small possibility that a defective delay line (Fig. 2-13) is at fault. In case of doubt, a substitution test is advisable. Always check alignment first. Remember that poor alignment may itself be a symptom, and the i-f regeneration might be present. Therefore, check the stability of the i-f response curve at both low and high values of agc override bias before the chassis leaves the bench.

13. Weak or No Color Reproduction; Smeared Black-and-White Picture

This difficulty can be caused by misalignment. In addition, there is the possibility of trouble in the video-detector or video-amplifier sections. For example, a load resistor which has increased in value causes smearing and reduces response at the chroma signal frequencies. Open capacitors are also common culprits. For example, if C34 in Fig. 2-10 becomes open, the black-and-white picture is badly smeared, while color reproduction is unaffected. The same symptom applies if C32 or L15 opens, the black-and-white picture becomes smeared. Thus, picture analysis serves to provide a general localization of the circuit trouble.

Consider the result if such defects occur ahead of the chroma-takeoff point. In such instances, both the chroma signal and the black-and-white signal become smeared. Contrast is not greatly affected in many cases, because the low-frequency components of the signals are not seriously attenuated. On the other hand, high-frequency components are attenuated and shifted in phase. It is phase shift which causes smearing.

Chapter 3

Color-Killer and Automatic-Chroma-Control Troubles

The color killer and automatic chroma control (acc) sections have a general family relationship. Both of them control the gain of the chroma system. However, a color-killer is essentially an on-off electronic switch, while an acc circuit operates as a chroma-agc system. The color killer turns off the chroma system when the receiver is tuned to a black-and-white broadcast. The acc section maintains essentially constant output from the chroma system when the receiver is tuned to a color-television broadcast. Acc is used in many receivers to supplement agc, because the color subcarrier is 3.58 mc removed from the picture carrier. Hence, propagation conditions can cause independent changes in the amplitude of the color subcarrier.

The following list notes several basic symptoms of color-killer trouble:

1. Spurious color interference in black-and-white pictures.
2. Black-and-white pictures normal; no color pictures reproduced.
3. Color pictures reproduced only when receiving a strong color-television signal.
4. Intermittent color picture; black-and-white component normal.

Fig. 3-1 shows a block diagram for the chroma-control system of a color receiver. The video detector feeds a signal, such as illustrated in Fig. 3-2, to the chroma amplifier or to the chroma-bandpass amplifier. This video signal produces a black-and-white picture, but it also contains high-frequency components and appreciable noise voltages. If these voltages happen to have frequencies in the vicinity of 3.58 mc, you can see that they will enter tuned circuits in the chroma system, and thereby produce annoying color flashes and interference in the black-and-white picture. Hence, the color killer operates to cut off the bandpass amplifier when a black-and-white video signal is being received.

How is this done? The color killer circuit produces a negative bias voltage unless a *color burst* is present in the video signal. Observe the difference between Figs. 3-2 and 3-3. In Fig. 3-3, a 3.58-mc chroma signal is present with the black-and-white signal. The color burst appears on the back porch of the horizontal sync pulse. The color burst feeds into the color-detector circuit as in Fig. 3-1. If a color burst is present, the color detector changes the bias at the color killer, which in turn changes the bias on the chroma bandpass amplifier. This bias control voltage, from the color killer in Fig. 3-1, is applied to the grid of the bandpass amplifier. The bandpass amplifier is turned on.

Gating or keying pulses from the horizontal-output transformer are applied to the burst amplifier and to the chroma-bandpass amplifier. The gating pulse turns on the burst amplifier permitting the 3.58-mc burst to be amplified. The pulse turns off the chroma-bandpass amplifier during the burst time and prevents the burst from reaching the demodulators.

The color detector compares the 3.58-mc burst with a 3.58-mc signal from the reference oscillator. When both are present, a signal is developed which biases the color killer and causes it to turn on the chroma-band-

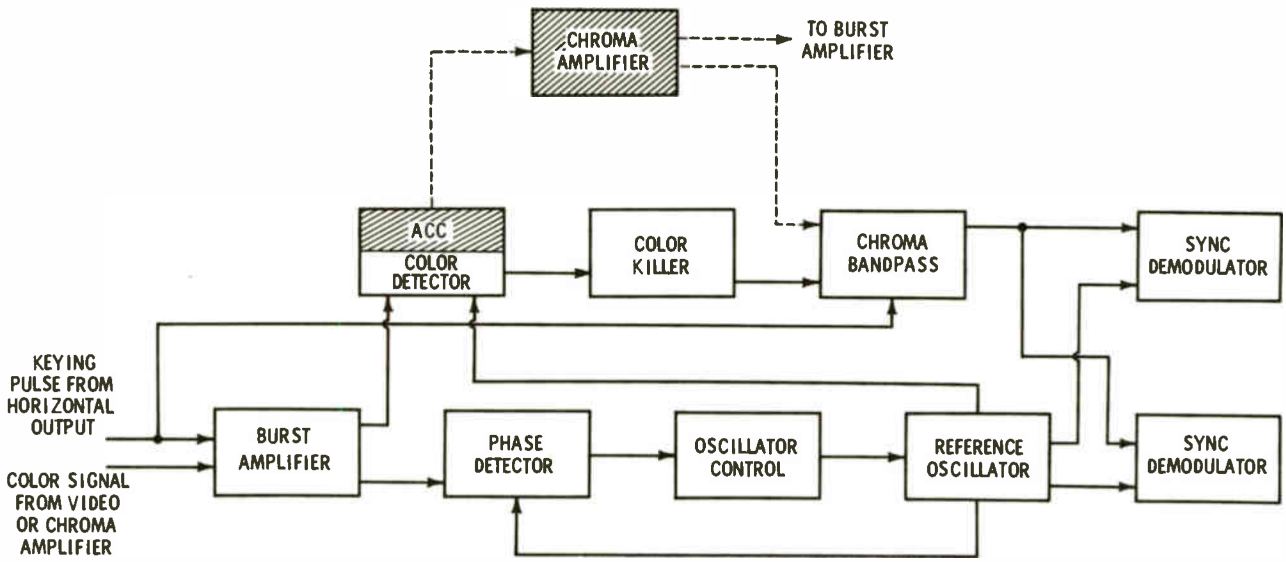


Fig. 3-1. Chroma-control system for a color receiver.

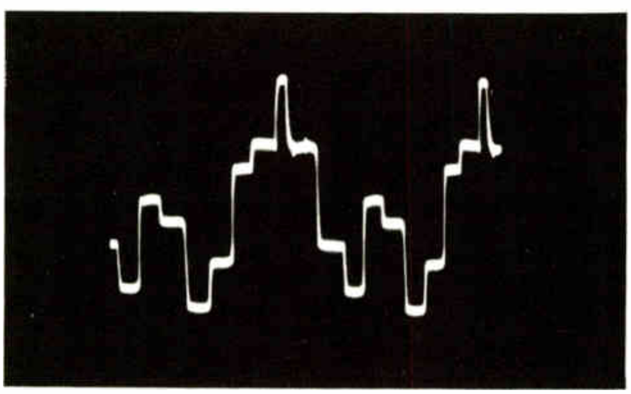


Fig. 3-2. The black-and-white portion of a color-bar signal.

pass amplifier. The time constant of the bias circuits is such that the bandpass amplifier will remain on during the intervals between bursts.

A *killer threshold* control is provided in the grid circuit of the color killer (see Fig. 3-4). This control is set high enough to reject the prevailing noise voltages, but low enough to pass the color-burst signal during a color broadcast. The color-killer circuit is similar to an ordinary keyed-agc circuit. V17 is keyed into conduction by a pulse from the flyback system. The plate of V17, in turn, develops a negative voltage. By adjusting the killer-threshold control R5, you can eliminate any random color from the black-and-white pictures. When a color burst is present, the signal bias on the grid of V17 decreases the amount of negative voltage developed at the plate, and permits the bandpass

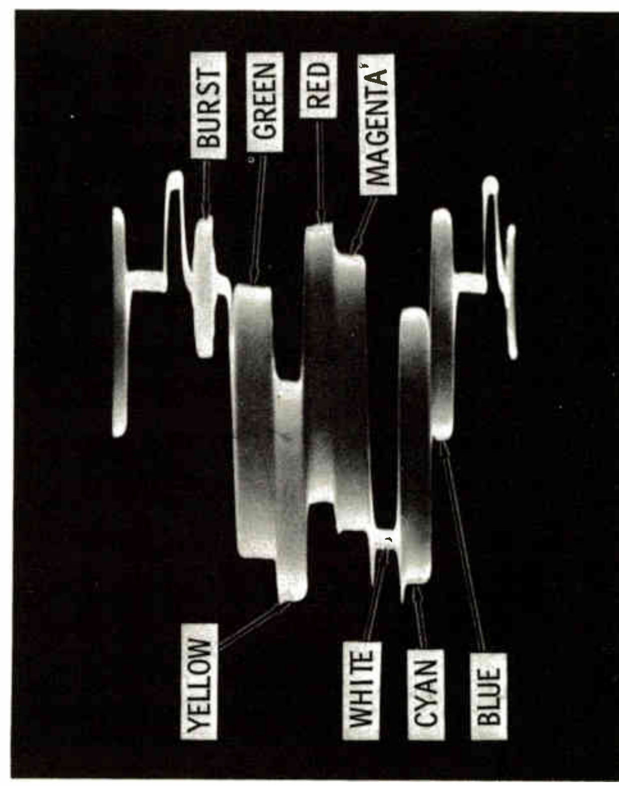


Fig. 3-3. The color signal from a color-bar generator.

amplifier to turn on. Note that in this schematic, the pulse detector and the color detector employ one tube (V19).

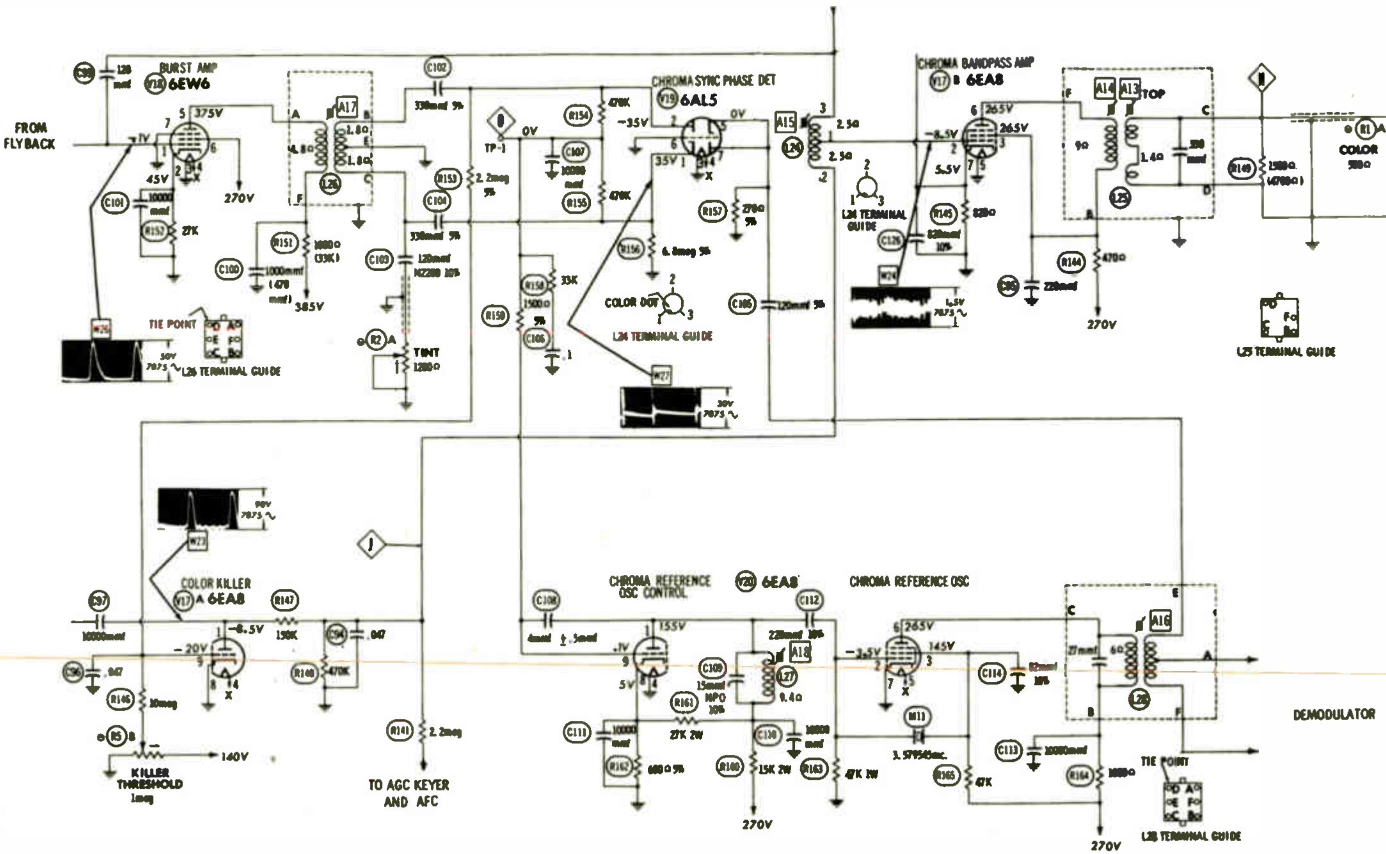
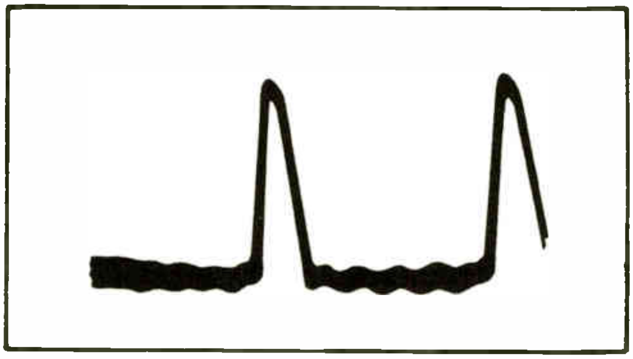
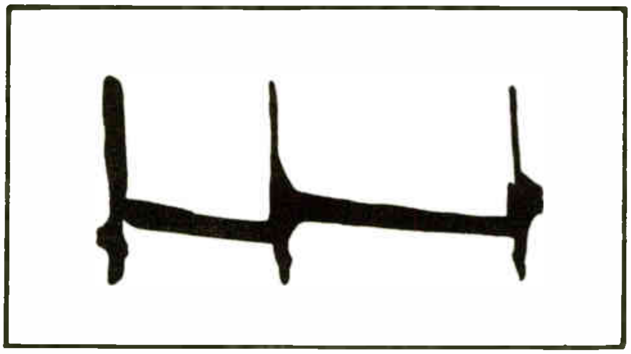


Fig. 3-4. Example of the color section of a color receiver.



(A) Keying pulse at plate of color killer.



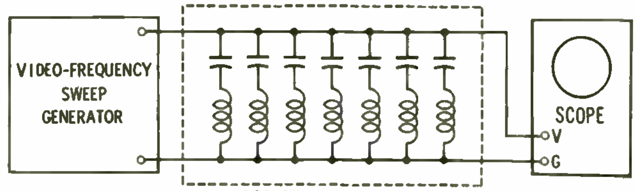
(B) Color burst at pin 1 of the phase detector.

Fig. 3-5. Waveforms at color killer and phase detector.

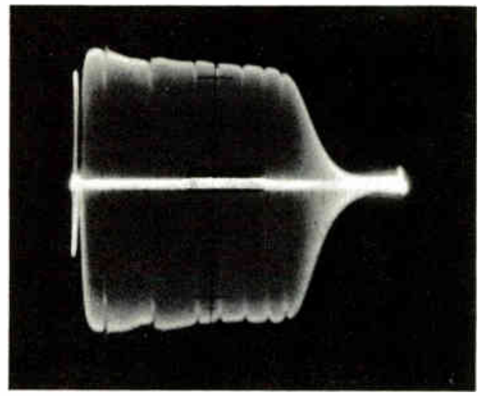
GENERAL TROUBLESHOOTING PROCEDURE

When troubleshooting a color receiver for "killer" trouble, first test or replace the tubes. Unless some definite clues are noted, the best approach is to use a scope and low-capacitance probe to check whether the color control signal and keying pulse are arriving at the color-killer stage. Fig. 3-5 shows typical waveforms that should be present at the color detector and at the plate of the color killer. It is good practice to use a low-capacity probe in chroma-circuit tests to avoid circuit disturbance and waveform distortion. The scope must have wideband response to display 3.58-mc waveforms, such as shown in Fig. 3-3 and 3-5(B). In addition, the scope should be calibrated, to check whether the waveform voltages are within reasonable tolerance —usually within 20% of those shown on the schematic.

Waveform checks often pinpoint a defective component directly, such as an open capacitor or an open coil winding. On the other hand, oscilloscope tests must often be followed by d-c voltage and/or resistance measurements. There is very little difference between troubleshooting chroma circuitry and troubleshooting black-and-white circuitry. Color television seems quite different because of the types of signal that must be



(A) Setup for frequency test.



(B) Typical response on a 5-mc oscilloscope.

Fig. 3-6. Test for frequency response of oscilloscope.

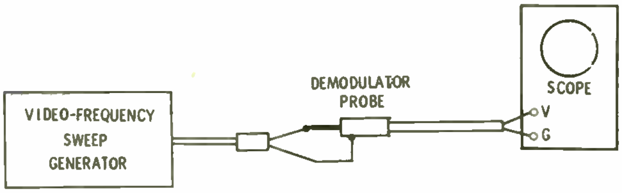
observed, but the same techniques are employed in both types of receiver.

Signal Generators and Oscilloscopes for Chroma Troubleshooting

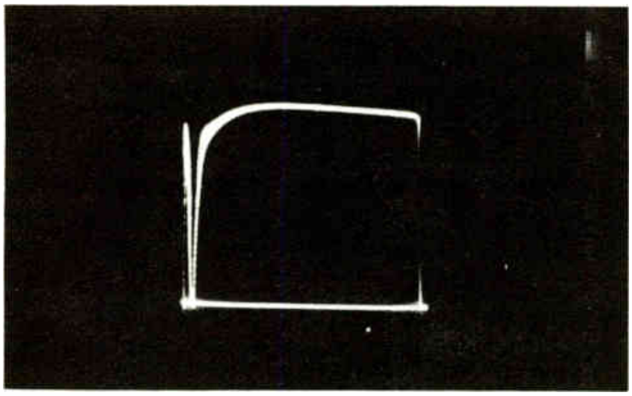
The signal generators and oscilloscopes used to analyze the chroma section of a color receiver must be calibrated for reasonable accuracy.

The best guide to use for adjusting any color-signal generator is a *good* wide-band scope. *Good* is emphasized, because some wideband scopes are only "useful" at 3.58 mc. This will cause the color burst (and chroma signals) to be attenuated by an unknown amount, and peak-to-peak indications at 3.58 mc will be misleading. In case of doubt, check your scope with a video-sweep generator and absorption-marker box as depicted in Fig. 3-6. The frequency response should not be down more than 10% at 3.58 mc.

It is just as essential that your video-frequency sweep generator have a flat output. A quick and easy check can be made with a demodulator probe and any scope, as depicted in Fig. 3-7. You do *not* need a wide-band scope for this particular test, because the demodulator probe has an output which approximates a 60-cycle square wave. The foregoing are the basic cross-checks of your test equipment which can save you complete bafflement in troubleshooting chroma circuitry.



(A) Setup for flatness test.



(B) Acceptable response pattern. Relatively flat to 5 mc.

Fig. 3-7. Test for sweep-generator output.

COLOR-KILLER SYMPTOMS

1. Spurious Color Interference in Black-and-White Pictures

This type of interference appears in various forms. For example, when the receiver is tuned to a weak black-and-white station, confetti may be displayed. Or, when the receiver is tuned to a strong black-and-white station, narrow rainbows of color may "writhe" at the edges of sharply defined images. Again, as fabrics or other patterns are scanned, a shimmer of color may be superimposed. All of these symptoms throw initial suspicion upon the color killer. Possible causes of these difficulties are:

a. Killer threshold control set too low.
b. Shorted bypass capacitor, such as C97 in Fig. 3-4. (Drains off the bias.)
c. Open capacitor, such as C97 in Fig. 3-4. (Stops the keying pulse.)
d. Shorted capacitor, such as C94 in Fig. 3-4. (Drains off the bias.)
e. Burned resistor, such as R147 in Fig. 3-4. (Blocks the bias voltage.)
f. Defective bandpass transformer, such as L24 in Fig. 3-4. (Prevents development of killer bias.)

In other words, circuit defects which prevent the generation of killer bias or which prevent the killer plate current from reaching the grid of the chroma-bandpass amplifier are responsible for spurious color interference in black-and-white pictures.

2. Black-and-White Pictures Normal; No Color Pictures Reproduced

This symptom can be caused by trouble in more than one section. When it is due to defective color-killer action, the possible causes are:

a. Killer threshold control set too high.
b. Defective burst-amplifier transformer L26 in Fig. 3-4.
c. Open capacitor C102 or C99 in Fig. 3-4. (Prevents input waveform from reaching V19.)
d. Open resistor R153 in Fig. 3-4.
e. Low or zero plate and/or screen voltage on V18 in Fig. 3-4. (Check C100.)

To briefly summarize, this symptom, when due to color-killer trouble, results from failure of the color burst to reach the chroma sync-phase detector, or from a defect which prevents the d-c output from the detector from arriving at the grid of the color killer. Scope checks are very useful in this situation. The output waveform from the burst amplifier was shown in Fig. 3-5(B). On the other hand, the input waveform to the burst amplifier consists of the keying pulse (Fig. 3-5A) and the complete color signal (Fig. 3-3).

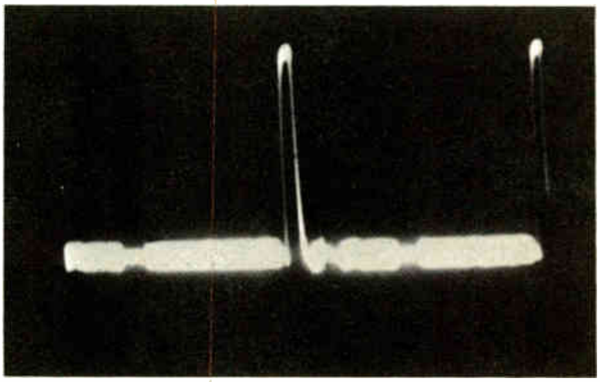


Fig. 3-8. Chroma-level control set too low.

Note that when a capacitor is open, the 3.58-mc waveform may not be completely blocked. Stray capacitance often permits a slight transfer of waveform voltage; however, the greatly attenuated signal is unable to cause the color-killer circuit to operate normally. When making tests with a color-generator signal, be sure that it is set for normal chroma output. For

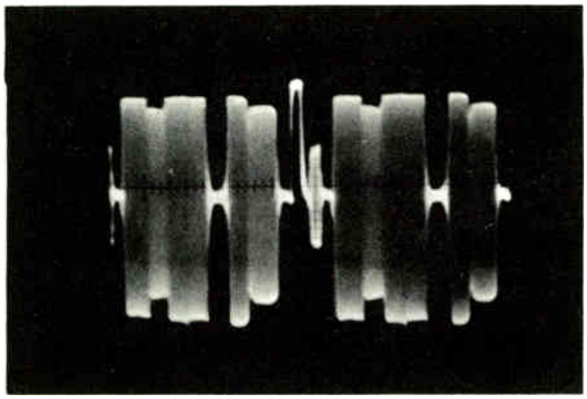


Fig. 3-9. Burst-amplitude control set too low.

example, Fig. 3-8 shows the burst and chroma signals at an unusable level, because the generator is incorrectly adjusted. Also, the chroma-level control could be set at a suitable level, but the burst-amplitude control might be set too low, as shown in Fig. 3-9. The burst amplitude should be adjusted to have the same peak voltage as the horizontal sync pulse.

3. Color Pictures Displayed Only When Tuned to a Strong Color-Television Broadcast

This is a variation of the symptom previously discussed. It is caused by defects which impair but do not completely disable the color-killer function. Possible causes of impaired functioning are:

a. Killer threshold set too low.

b. Misaligned burst-amplifier transformer (L26 in Fig. 3-4).

c. Low plate and/or screen voltage on burst-amplifier tube.

d. Cathode bias resistor greatly increased in value (R15 in Fig. 3-4).

e. Killer grid resistance increased in value (R146 in Fig. 3-4).

The burst-amplifier transformer should be peak-aligned at 3.58 mc. It has a narrow-band response, and hence the slug adjustment is comparatively critical. A crystal-calibrated marker generator is necessary to make an accurate frequency check. The peaking adjustment is customarily made on the basis of vtvm indication. A vtvm is connected through a 0.5-meg isolating resistor to pin 1 of V19 in Fig. 3-4. With a color-bar signal applied to the receiver, the slug in L26 is adjusted for maximum indication on the vtvm.

4. Intermittent Color Picture; Black-and-White Component Normal

When only the color component is intermittent, the trouble will be found in the chroma section of the receiver. A large area of the color system can fall under suspicion. If the intermittent is due to a defect in the color-killer circuitry, it will show up as an abnormal bias variation at the grid of the chroma bandpass amplifier. Hence, the first step is to monitor the bias voltage with a vtvm. Possible causes of intermittent operation in the color-killer section are:

a. Noisy and worn killer-threshold control (R5 in Fig. 3-4).

b. Defect in pulse winding on flyback transformer; monitor the pulse amplitude with a scope (use low-capacitance probe).

c. Intermittent capacitor (C102 or C99 in Fig. 3-4).

d. Intermittent resistor (R153 in Fig. 3-4).

e. Fluctuating plate and/or screen voltage on V18 in Fig. 3-4. C100 could be intermittent.

Observe the vtvm response as the killer-threshold control is slowly turned. If the bias at the grid of the bandpass amplifier (V17 in Fig. 3-4) does not change smoothly, replace the threshold control. If the keying pulse fluctuates in amplitude, and the defect is traced back to the flyback transformer, a transformer replacement will be required. Tap suspected capacitors and resistors, while watching the vtvm for sudden jumps. You can also heat the pigtails of suspected components with a soldering gun to detect a thermal intermittent. Microscopic breaks in printed-circuit conductors can also cause intermittents. Flex the board slightly to see whether a sudden change occurs in the meter indication. Sometimes a cold-soldered lead to a terminal on a printed-circuit board is the culprit. Press suspected leads from side to side, while watching the bias voltage indicated by the vtvm.

Chroma intermittents due to cold-soldered connections can occur in any chassis. For example, a burst-amplifier transformer was replaced in a hand-wired chassis, and all connections except one were soldered. Because there was considerable solder on the defective tie lug, a superficial inspection did not reveal that the lead was merely looped through the lug. The receiver operated normally in the shop, and was therefore delivered to the owner. However, a call-back was soon requested for intermittent-chroma reproduction. The recheck and analysis took a great deal of time, and before the unsoldered joint was finally discovered. A substantial loss was chalked up for this particular service job.

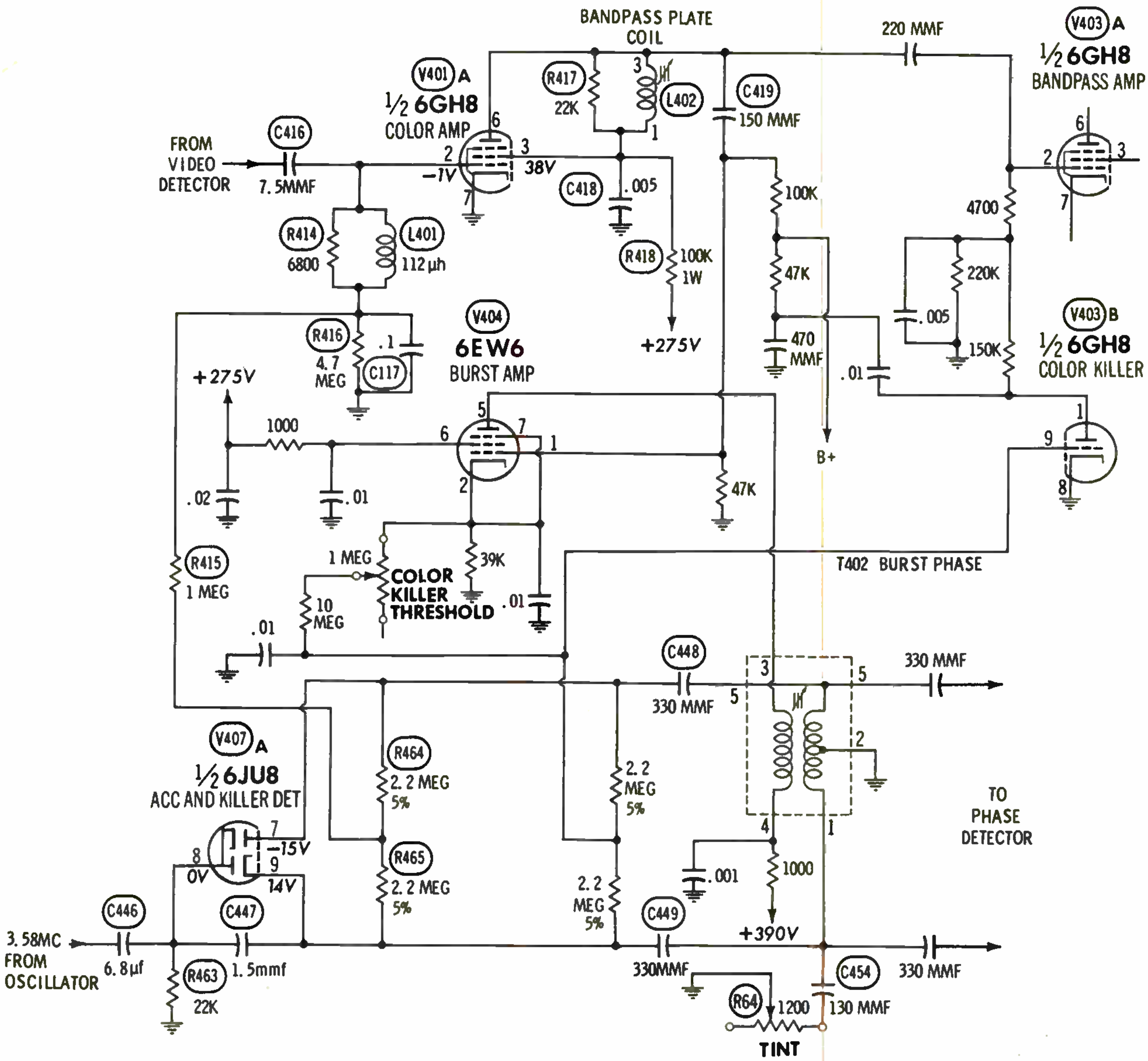


Fig. 3-10. Chroma-control circuitry.

AUTOMATIC-CHROMA-CONTROL SYMPTOMS

Fig. 3-10 shows the arrangement of an agc section which utilizes the same detector as the color killer. Let us analyze the operation of this circuit. The color burst is coupled from the plate of color amplifier V401A through capacitor C419 to the grid of burst amp V404. Output from the burst amplifier flows through the primary of T402 and induces the color-burst voltage in the secondary winding. Output from the secondary is coupled through C448 and C449 to the plate and cathode respectively of V407A. At the same time, a 3.58-mc signal from the 3.58-mc oscillator is applied to pins 1 and 8 of detector V407A. There are two basic conditions for operation of this circuit:

1. When no color burst is present in the received signal, the d-c voltage output at the junction of R464 and R465 is zero. Similarly, there is zero d-c voltage at the junction of R466 and R467.
2. On the other hand, if a color burst is present, the phase relations are such that a negative d-c voltage appears at both of these junctions.

The negative bias applied to the grid of color-killer V403B produces less bias on V403A, and turns the bandpass amplifier "on". The negative acc voltage, applied to grid of V401A, is not large enough to cut off the color amp, but it does reduce the gain of the stage. The exact value of the acc bias voltage depends on the amplitude of the color burst. In case the burst amplitude becomes less, the acc bias also becomes less. In turn, the gain of V401A increases. Thus, the output from the color amplifier is held essentially constant.

The following are several basic symptoms of acc trouble:

1. Color reproduction is abnormally intense and cannot be brought to normal by adjustment of the receiver's color-intensity control.
2. Color reproduction is weak and cannot be brought to normal by adjustment of the color-intensity control.
3. Color intensity drifts, requiring frequent re-setting of the color-intensity control.
4. Intermittent changes in color intensity.

1. Color Intensity Is Excessive

When color intensity is excessive, the gain of the color amplifier is abnormally high. An example of intense color is shown in Fig. 3-11. Excessive color is usually characterized by a loss of detail, smearing of color areas, possible blooming, and lack of color control. Possible causes of excessive color intensity in a receiver using the circuit in Fig. 3-10 are:

a. R464 increased in value.
b. C448 leaky.
c. C417 leaky or shorted.
d. C416 leaky or shorted.
e. R413 increased in value, or opened.

In addition to the foregoing component defects, equivalent trouble spots can occur in cold-soldered connections, dirty or intermittent socket terminals, breaks in printed-circuit conductors, and leakage between printed-circuit conductors. Remember that preliminary tests can be made by clamping the acc bias line. When so doing, it is often advisable to clamp the color-killer line also, this ensures that the bandpass amplifier (V403A in Fig. 3-10) remains in operation while you vary the acc voltage.

2. Color Reproduction Is Weak; Color-Intensity Control Lacks Range

This picture symptom is opposite to the symptom discussed above. It can be caused by defects other than acc trouble. If excessive acc bias voltage exists at the grid of the color-amplifier tube (V401A in Fig. 3-10), the trouble will be found in the acc section.

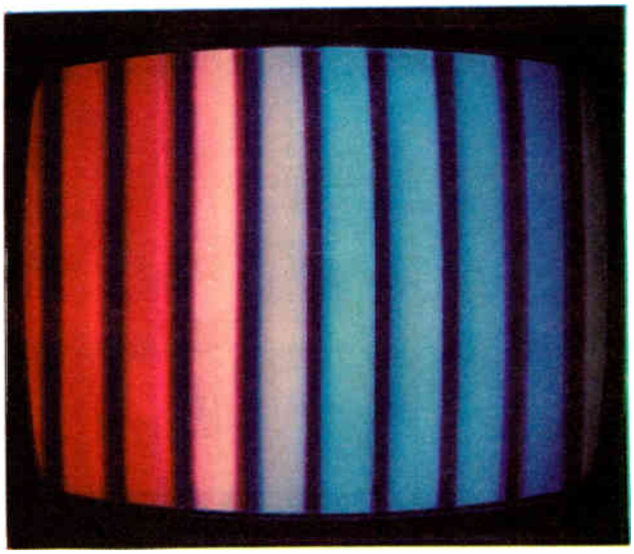
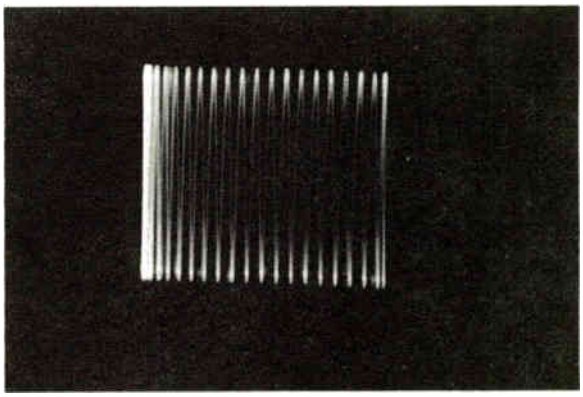
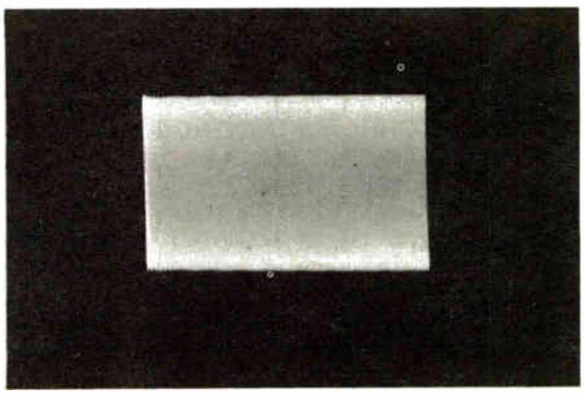


Fig. 3-11. Example of excessive color.



(A) Appearance on scope with fast sweep.



(B) Appearance on scope with slow sweep.

Fig. 3-12. Oscilloscope signal at acc detector.

Possible defects in the acc circuits of Fig. 3-10 that cause weak color are:

a. R465 increased in value, or open.
b. C449 leaky.
c. C416 open.
d. C447 leaky.
e. C448 leaky.

It is assumed that the acc detector (V407A in Fig. 3-10) has a steady and normal 3.58-mc voltage present at pin 8. Defects in C446 or R463 can cause this voltage to be abnormal or subnormal. Check the voltage with a calibrated wide-band scope and low-capacity probe. This is a sine-wave voltage, but you may not be able to see the individual cycles unless your scope has a fast horizontal sweep. Fig. 3-12A illustrates this point. However, only the amplitude of the injected voltage is of concern when troubleshooting the acc detector and therefore the signal shown in Fig. 3-12B is adequate to indicate the presence of the 3.58-mc signal.

3. Color Intensity Drifts, Requiring Frequent Resetting of the Color-Intensity Control

This trouble is caused by the same defects noted under (1) and (2). The only difference in this case, is that the defects are marginal instead of dominant. Resistance and capacitance tolerances rather than total component failure are often involved. Small amounts of capacitor leakage can be responsible. It is often easier to pinpoint a component which has failed completely, because the change in value is obvious when it is tested. On the other hand, if a 5% resistor (such as R464 in Fig. 3-10) is off-value by 10%, this defect could easily be missed in a superficial resistance test. Remember too that tolerances through the system are *cumulative*, and that a small off-tolerance value in one branch can be aggravated by an off-tolerance value in another branch. As receivers age, tolerances in several associated branches can impair system operation, and creates quite a troubleshooting problem.

4. Intermittent Changes in Color Intensity

This symptom can result from defects in more than one area of the chroma system. However, if you measure corresponding changes in acc bias voltage, it is logical to conclude that the trouble is in the acc system. The same component defects apply as noted previously. However, this symptom is caused by an intermittent component which changes value. The general troubleshooting procedures discussed previously for pinpointing intermittent components must be used in this situation.

Chapter 4

Color-Sync Troubles

Previous mention has been made of the fact that color sync is a separate function from black-and-white sync. Color sync is controlled by the stages shown in the block diagram in Fig. 4-1. The burst amplifier separates the color burst from the color signal by gating action. The burst amplifier also increases the amplitude of the burst signal. At the phase detector, the phase of the color burst is compared with the phase of the 3.58-mc oscillator signal from the reference oscillator. If the color burst gets out of step with the 3.58-mc oscillator, a d-c correction voltage is produced and fed to the oscillator control (reactance tube) which corrects the frequency of the 3.58-mc oscillator so that it is exactly in phase with the color burst.

Some of the more common trouble symptoms resulting from defects in the color-sync system are:

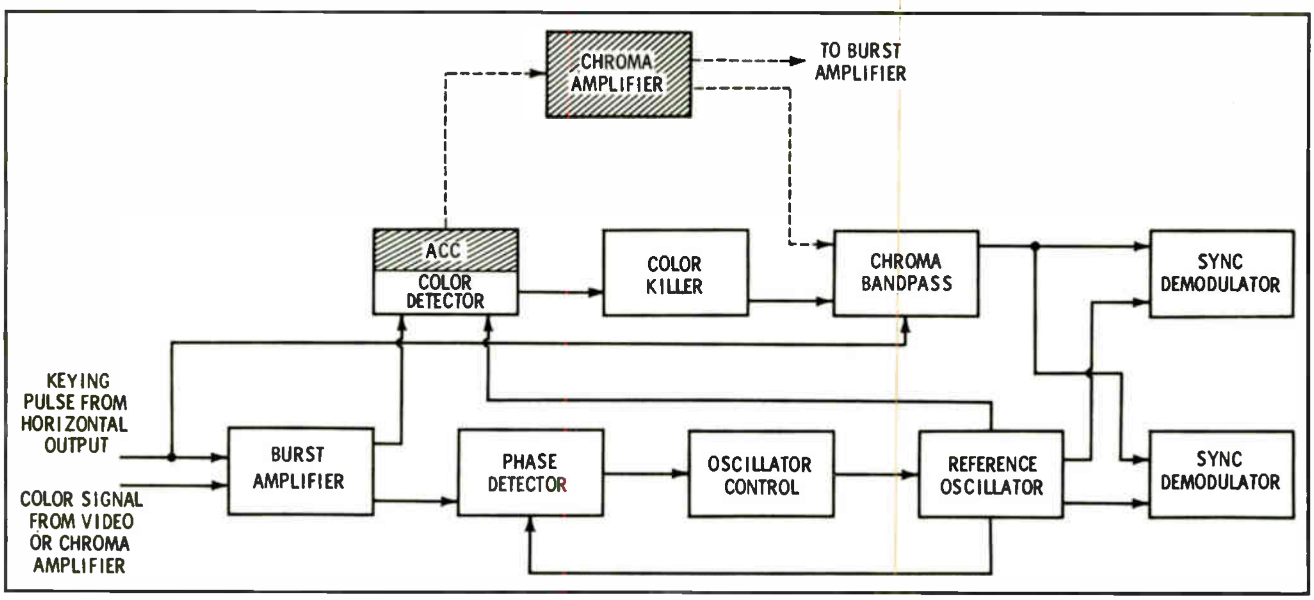


Fig. 4-1. Chroma circuits for a color receiver.

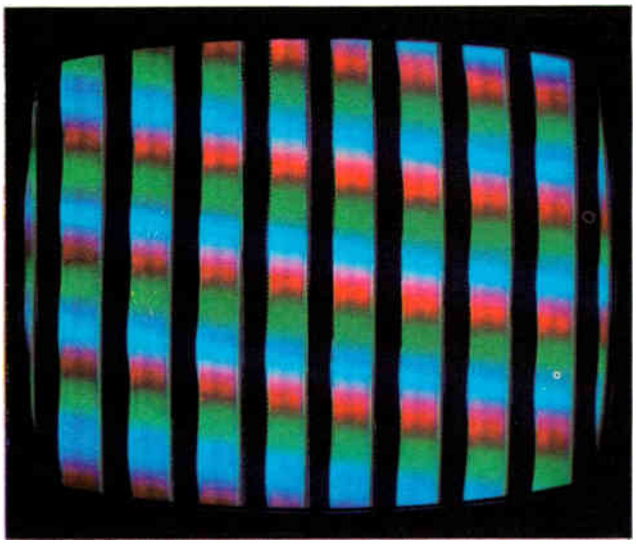


Fig. 4-2. Loss of color sync.

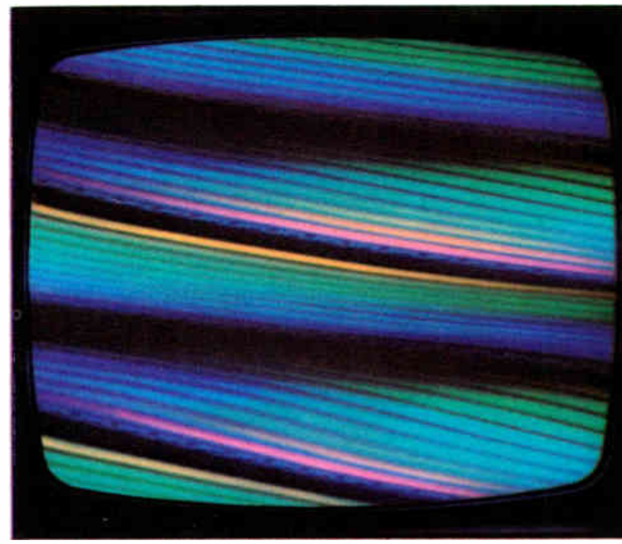


Fig. 4-3. Loss of black-and-white and color sync.

1. Loss of color sync, with black-and-white sync normal. An example is illustrated in Fig. 4-2.
2. Loss of both black-and-white and color sync. An example is illustrated in Fig. 4-3.
3. Fluctuating color sync. Color-sync lock is lost gradually, and then drifts back into lock.
4. Intermittent color sync.
5. Color sync normal when tuned to a strong signal, but color sync is absent when tuned to a weaker signal.

GENERAL DISCUSSION

With reference to Fig. 4-4, the reference oscillator is a form of tuned-plate tuned-grid crystal oscillator that operates at 3.58 mc. Its output is coupled through L30 and C120 to phase-detector tube V1. Note that the color-burst signal is coupled from the burst transformer through C117 and C118 to the phase detector. Comparison of the phases of these two 3.58-mc signals occurs in V1. In case the oscillator is slightly out of step with the burst signal, either a positive or a negative d-c correction voltage appears at the junction or R162 and R163. This correction voltage is d-c coupled through R183 to the grid of the chroma-reference control .

V2A is called an oscillator reactance control tube, or simply a reactance tube. The grid bias of the reactance tube is nominally zero, but it will become positive or negative when the oscillator signal tends either to lead or lag the burst signal. In turn, the plate current in V2A increases or decreases. The effect of this current charge is the same as if the capacitance across the grid circuit of the oscillator were changing. Hence, any bias variation on the grid of the reactance tube changes the frequency of the reference oscillator. In this manner, the crystal oscillator is kept locked to the color-burst phase.

Let us examine why phase lock is so important in the chroma system. If you apply a keyed-rainbow generator signal to a color receiver, the output from the bandpass amplifier appears on a scope screen, as shown in Fig. 4-5. Each of these chroma bars has the same voltage and the same frequency. The only difference between the various signals is in the phase. In other words, chroma phases correspond to specific colors on the picture-tube screen.

Now, refer to Fig. 4-6. Notice that the burst phase is identified as $-(B - Y)$. This would be a greenish-yellow color if it were to appear on the screen. The burst does not appear on the picture-tube screen during normal operation, because it is blanked out during retrace, along with the horizontal sync pulse. Hence, the first chroma-bar signal in Fig. 4-5 remains invisible. The remaining ten chroma signals produce the chroma colors indicated in Fig. 1-11. Observe that the third bar has the $R - Y$ phase depicted in Fig. 4-6. The sixth bar has the $B - Y$ phase.

Suppose that the burst phase in Fig. 4-6 were to change to the $R - Y$ position on the diagram. Obviously, all of the chroma bars will change phase the same amount, and the bars will then have different hues. It is for this reason that a color-sync system is essential; the subcarrier oscillator must be locked solidly in phase with the color burst. If color sync is lost, the colors "float" around in the picture in much the same manner that a black-and-white picture floats

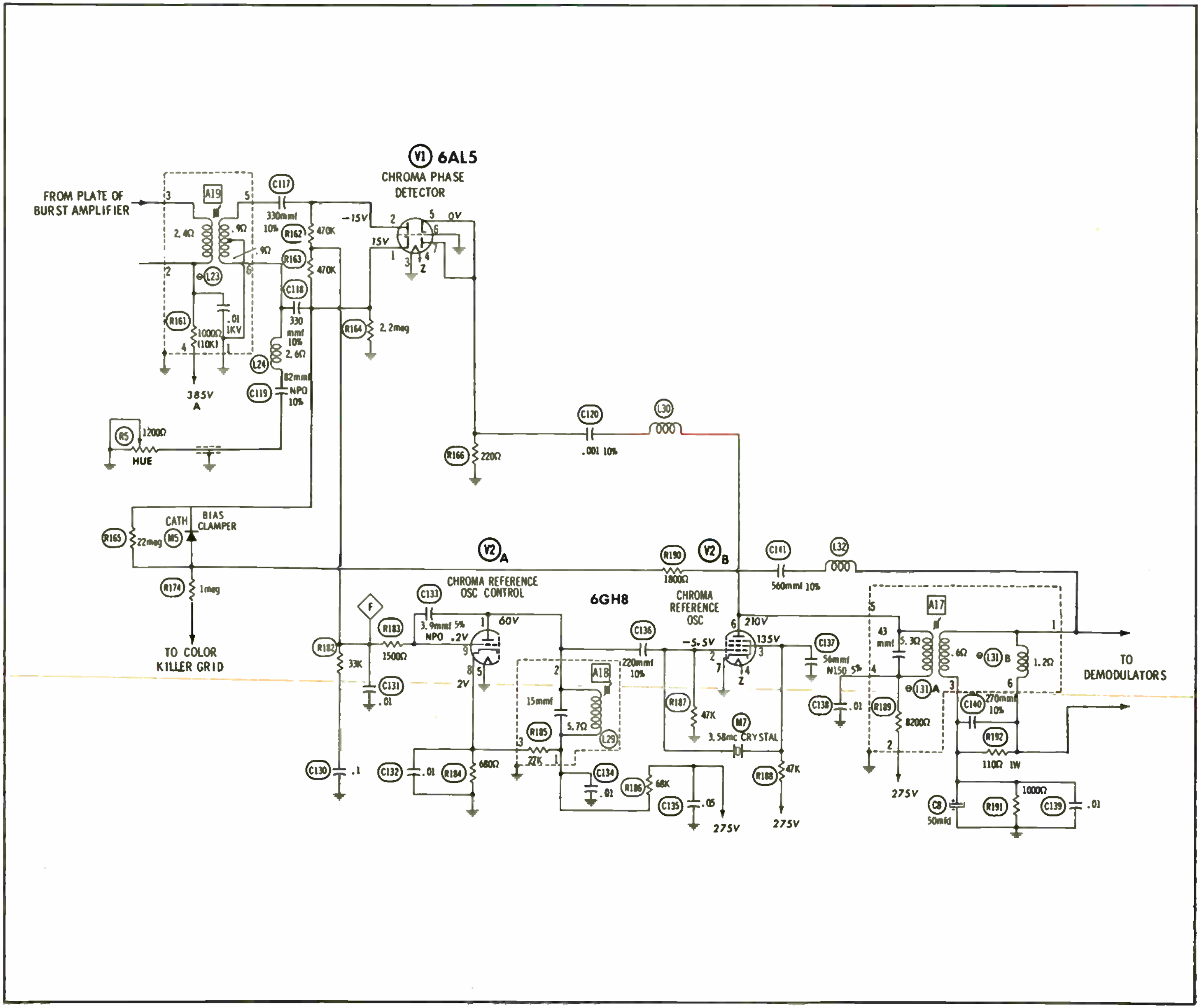


Fig. 4-4. Color-subcarrier control system.

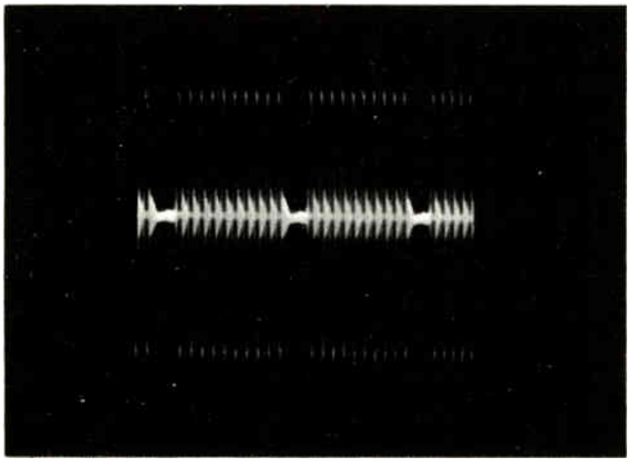


Fig. 4-5. Keyed-rainbow signal at the output of the chroma-bandpass amplifier.

horizontally when the horizontal-afc section is dead. When color sync is lost and the subcarrier oscillator operates considerably off-frequency, a large number of drifting "rainbows" will be observed on the picture-tube screen.

GENERAL TROUBLESHOOTING PROCEDURE

There are several preliminary steps that should be taken to isolate color-sync trouble while the receiver is still in the owner's home. Suspected tubes are tested or replaced as a matter of course. A suggested procedure for localizing color-sync trouble in logical order is as follows:

A. The fine-tuning control adjustment should be checked.
B. Observe operation on all active color channels, or apply signals from a color generator.
C. Make sure that the picture is framed correctly from left to right. Touch up the setting of the horizontal-hold control, if required. (DO NOT adjust the centering controls).
D. Make sure that the color-killer control is not set to the point at which color reproduction "kicks out."
E. Check the agc-level control for correct operation of the i-f amplifiers and front end.
F. Make sure that the noise-gate control is not set to an extreme position which affects proper agc action.

If the fine-tuning control is advanced too far, a 920-kc beat, and sound interference will appear in the picture. Excessive interference can upset the action of the phase detector and cause loss of color sync. On

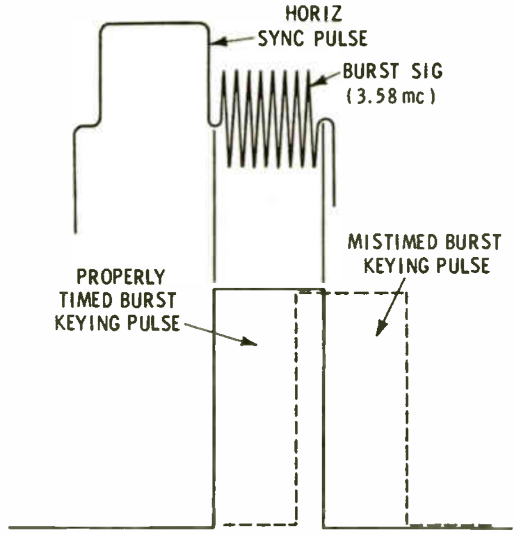


Fig. 4-6. Burst-keying pulses.

the other hand, if the fine-tuning control is not advanced far enough, the chroma signal falls too far down on the side of the i-f response curve. This weakens the color burst, and it cannot operate the phase detector normally. It is advisable to observe operation on more than one channel (or to use a color-signal generator), because technical difficulties at a color-television transmitter can simulate trouble in the receiver.

Recall that the burst amplifier is keyed. The burst-keying pulse must be in step with the color burst, as depicted in Fig. 4-6. Otherwise, the keying pulse "misses" the burst, and the burst signal is blocked from passage through the burst amplifier. Of course, this means that the phase detector receives no signal for comparison with the subcarrier-oscillator phase, and color sync is lost. Mistiming of the burst-keying pulse is caused by incorrect framing of the picture horizontally. Hence, the horizontal-hold control should be adjusted to center the picture horizontally. As you probably anticipate, there are various defects which can occur in the burst-keyer circuit which can also mistime or weaken the pulse.

If the color-killer control is set too close to the chroma "kickout" point, the operation of the chroma system will be marginal, or fluctuate "on" and "off." In turn, the color-sync section may "pull" or break color sync completely. Preliminary analysis can be made to best advantage with the color-killer control set to minimum. After the color-sync action is restored to normal, the killer control can then be set to a suitable position for the prevailing signal levels.

Remember also to check the setting of the agc-level control, because high settings cause the horizontal sync

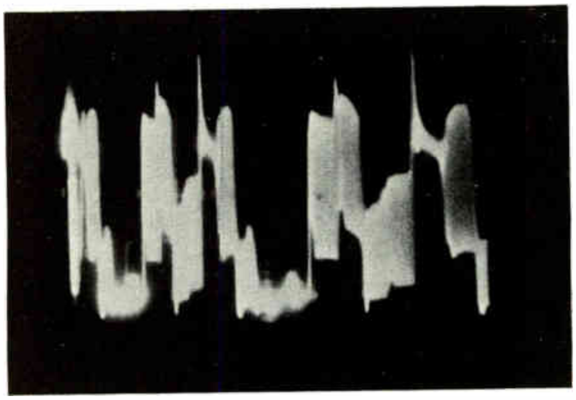


Fig. 4-7. Horizontal-sync pulse is clipped and the color burst is compressed.

pulse and color burst to be clipped or compressed, as seen in Fig. 4-7. On the other hand, low settings of the agc-level control will weaken the entire color signal. Although the color-intensity control may be turned abnormally high to obtain fair color contrast, the phase detector can still be operating with a weak-burst signal. This may cause the color-sync section to "pull" or break color-sync lock. Since the noise-gate control interacts with the agc-level control in many receivers, it is advisable to check this control setting.

COMMON SYMPTOMS

1. Loss of Color Sync, With Normal Black-and-White Sync

When this symptom is not caused by a bad tube and the receiver controls are properly set, it is logical to conclude that there is a defective component in the color-sync system. The possibility of low B+ voltage should be investigated at the outset. Remember that supply voltages are not necessarily correct in the chroma section just because they happen to be correct in the black-and-white section. Possible causes for loss of color sync are:

a. Subcarrier-oscillator V2B in Fig. 4-4 operating off-frequency. When the oscillating frequency is too far off, the reactance tube cannot bring the frequency back to 3.58 mc.
b. Defective component in the burst-amplifier stage.
c. Defective component in the phase-detector stage.
d. Defective component in the reactance-tube stage.

A quick and easy test that can be made to find out whether or not the subcarrier oscillator is off-frequency is to ground the grid of the reactance tube (point F at V2A in Fig. 4-4). This makes the oscillator free-running and eliminates any correction from the phase detector. Then, adjust the slug in the reactance coil (A18 in Fig. 4-4) to see whether the color bars can be made to change through the correct hues. Then:

A. If you can correct the oscillator for proper hues, the trouble is *not* in the oscillator or reactance stage.
B. If you cannot cause the oscillator to function at 3.58 mc, perform a complete alignment of the oscillator and control circuits; if the trouble persists, then check for a defective component in either the oscillator stage or the reactance-tube stage.

The most likely culprits are open or leaky capacitors. Make a systematic check of all of the capacitors in the oscillator circuit. A systematic check is necessary because it is practically impossible to tell which capacitor might be causing the oscillator to operate off-frequency. In case all the capacitors are good, resistors are the next suspects. A defective resistor can often be located by making d-c voltage measurements at the socket pins of the oscillator and control tubes. If you must dig deeper, proceed to check out the coils and transformers (L29 and L31 in Fig. 4-4) associated with these circuits. The best approach is a substitution test. Although it is quite unlikely, the quartz crystal could be defective. Again, the practical check is a substitution test.

Next, let us consider our approach in case the subcarrier oscillator can be controlled through 3.58 mc. In such case, we can suspect a defect in the burst-amplifier stage. The basic test is a check of the waveform at the plate of the burst amplifier. Use a wide-band scope and low-capacity probe. Then:

A. If a normal burst signal is displayed, the trouble is not in the burst-amplifier stage.
B. On the other hand, if the burst signal is subnormal or absent, there is a defect in the burst-amplifier stage. Check for signal at the input to the burst amplifier.

Inasmuch as color bars are displayed, but they are out of color sync, we do not anticipate trouble in the color amplifier. Start component checks at the input of the burst amplifier and progress systematically through the stage. The scope is an extremely useful signal-tracer. It will show where the burst signal or the keying pulse may be weakened or stopped. After the trouble has been localized to a particular circuit, d-c voltage and resistance measurements are made to assist in pinpointing the defective component. If a 3.58-mc coil or transformer is suspected of being defective, another unit should be substituted.

When preliminary tests show a normal burst signal at the plate of the burst-amplifier tube, the trouble area is narrowed down to the phase-detector stage (V1 in Fig. 4-4). The phase-detector load resistors (R162 and R163) have a 10% or closer tolerance rating, and in most receivers, they should be matched resistances. Hence, preliminary suspicion falls on these close-tolerance matched resistors. If these resistors are good, check coupling capacitors C117 and C118 for leakage. Use a scope and low-capacity probe to confirm that the 3.58-mc subcarrier signal is being injected into the phase detector. Weak or no injection voltage throws suspicion on C120. Loss of color sync also results from excessive leakage in C130 and C131.

2. Loss of Both Black-and-White and Color Sync

The loss of color sync necessarily accompanies loss of black-and-white sync, because the horizontal-keying pulse is not in proper time relation to the color burst. In this regard, loss of black-and-white sync has a tighter definition than for a black-and-white receiver. Even *moderate* impairment of black-and-white sync action in a color receiver, as during picture pulling or bending, causes the keying pulse to become mistimed (refer to Fig. 4-6) and causes loss of color sync. Consequently, any picture pulling or bending must be corrected before condemning the color-sync section. After the horizontal-afc difficulty is cleared, color-sync action will usually return to normal. But in the event that color sync is still unsatisfactory, attention must be turned to the color-sync circuits.

3. Fluctuating Color Sync; Color-Sync Lock Is Lost Gradually, and Then Drifts Back Into Lock

This symptom is quite puzzling when it is first encountered. There is no obvious reason why color sync should shift back and forth rhythmically, as if the hue control were being slowly rocked back and forth. The technical term for this symptom is *hunting*, and it can be compared to a slow motorboating in an audio system. When this occurs, suspicion should immediately fall on the anti-hunt network, comprised of C130, C131, R182, and R183 in Fig. 4-4. The color-sync system is a feedback loop, and the phase characteristic must not provide a positive feedback component, or low-frequency motorboating will occur. Defects in C130 and C131 are the usual trouble sources. However, resistors R182 and R183 can be off value and cause *hunting* to occur.

When the color-sync system is operating normally, a check with a wide-band scope and low-capacity probe will show no a-c voltage at the junction of R182 and R183. On the other hand, if color sync is completely lost, you will observe that an a-c waveform is

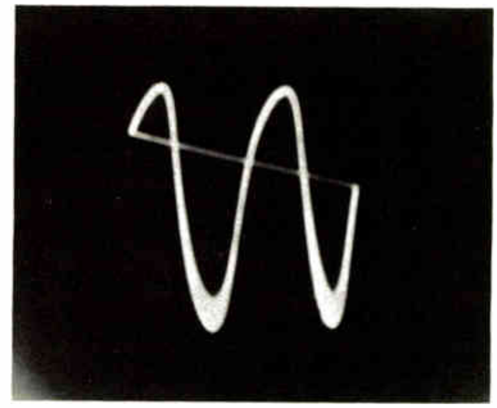


Fig. 4-8. Beat signal caused by the difference between the burst and the subcarrier signals.

present as shown in Fig. 4-8. This is a beat between the burst signal and the subcarrier oscillator signal. Now, if there is only a marginal defect in the anti-hunt network that produces fluctuating color sync, the a-c waveform will still be present, but it has a smaller amplitude and a comparatively low frequency. A d-c or low-frequency scope should be used to check circuits for low-frequency signals.

4. Intermittent Color Sync

Intermittent color sync is characterized by normal operation for a period of time, followed by a sudden loss of color sync. Eventually, normal operation resumes just as suddenly. From a previous discussion, it is evident that one of the components, noted under Loss of Sync (1 and 2), will be intermittently defective. Signal-tracing checks and d-c voltage measurements must be made systematically while the intermittent condition is present. Possible trouble areas include:

a. Subcarrier oscillator. An intermittent connection can cause the oscillator to jump suddenly to a frequency other than 3.58 mc.
b. Burst amplifier. An intermittent defect in this stage can suddenly weaken or kill the color burst.
c. Phase detector. Thermally caused intermittents in capacitors or resistors, or poor connection can cause the reactance tube to suddenly lose control of the oscillator.
d. Reactance tube. An intermittent condition in this stage can also cause loss of oscillator control.

Remember that tubes can be intermittent. It is good practice to replace tubes a second time, if preliminary tests do not turn up an intermittent component or connection. All components should be checked by moving the connections and the component. It sometimes helps to operate the receiver at elevated temperatures in order to cause an intermittent to show up.

5. Color Sync Is Normal When the Input Signal Is Strong, But Absent When the Input Signal Is Weak

There are several possible causes for this symptom. It is assumed that the color-killer control is properly adjusted, and that the agc level is correct. Some common causes for this type of color-sync trouble are:

a. Subcarrier oscillator is pulling. (Pulls out of lock when burst is weak).
b. Marginal defect in the burst-amplifier stage.
c. Off-tolerance component or slightly leaky capacitor in the burst-amplifier stage.
d. Keyer-pulse voltage is subnormal.
e. Marginal defect in phase-detector stage.
f. Off-tolerance component or leaky capacitor in the reactance-tube stage.

When the subcarrier oscillator is pulling, this means that its free-running frequency is a bit higher or lower than 3.58 mc. Check this possibility by grounding the grid of the reactance tube and observing whether the color-bar pattern can be tuned through the correct hues by adjustment of the slug in the reactance coil. In case of difficulty, check the B+ and screen voltages on the subcarrier-oscillator tube. A systematic check of components in both oscillator and reactance-tube stages must be made if you cannot adjust the operating frequency to 3.58 mc.

Marginal defects in the burst-amplifier stage show up as a subnormal burst signal at the output of the burst stages. Use a calibrated wide-band scope and low-capacity probe to measure the peak-to-peak voltage of the burst signal. Sometimes the trouble is not in the burst-amplifier stage itself, but in the keyer winding on the flyback transformer. Leakage from the winding to the core, for example, will attenuate the keyer pulse, and the burst-amplifier tube will not be driven into full conduction.

Supplementary service data for the receiver should also be checked in case preliminary tests do not turn up a defective component. Design changes are sometimes made by the manufacturer to obtain better color sync during reception of weak signals. When a particular trouble seems to have no solution, check the later information releases to find out if the circuit has been changed. Such an available design change can save hours of work and result in a properly operating receiver.

CONCLUSION

You will find different circuitry in different color receivers accomplishes the same functions that have been previously analyzed. For example, Fig. 4-9 shows a color-control system which appears superficially different from the one just discussed. Here, the stages are called chroma-sync amplifier, burst amplifier, color-killer, and chroma reference oscillator. The reference oscillator in this receiver is part of the chroma demodulator stage. The 3.58-mc oscillation and the chroma gating are both performed in a single operation.

A basic circuit variation which you will find in some color receivers is shown in Fig. 4-10. This is a crystal-ringing circuit, which is used instead of a free-running 3.58-mc oscillator. The crystal rings at 3.58 mc when a color-burst signal is applied to the input. If the color burst is absent, there is no output from the crystal ringing circuit. Then the crystal is shock-excited by the burst signal and in turn, a damped sine wave is generated. The damped sine wave slowly decays in amplitude between bursts, and therefore the output from the crystal-ringing circuit must be passed through a limiter. The limiter clips the ringing waveform so that the limiter output is a 3.58-mc wave of constant amplitude.

Neutralizing capacitor C2 in Fig. 4-10 balances out the stray capacitance of the crystal holder so that noise pulses are cancelled out and do not feed into the grid of V2. T1 is peak-aligned to 3.58 mc. L1 has the effect of tuning the quartz crystal over a small frequency range. Hence, the slug in L1 is adjusted to make the crystal ring at exactly 3.58 mc. Note C4 in the plate circuit of V2. Its function is to tune L2 either to the high side or low side of resonance, as required to produce the correct hues. The 3.58-mc output will either lead or lag the burst signal, depending on which side of resonance L2 might be operating. Maintenance adjustments are made by turning the slug in L2. C4 is an operating control used to set the correct hue on the color-receiver screen.

In theory, the color burst has a uniformly flat envelope, as depicted in Fig. 4-11A. Because burst-amplifier circuits have a somewhat limited bandwidth, the 3.58-mc voltage cannot rise to its maximum voltage at the instant that the burst enters the circuit. Similarly, it takes two or three cycles for the waveform to decay to zero. Ideal burst waveforms are not an absolute requirement for satisfactory color-sync action. As long as several cycles build up at maximum amplitude in the color-sync circuits, the receiver can lock in properly.

The color burst transmitted by a television station is not ideal. Similarly, you will find that the burst signal from a color-bar generator is not ideal. To make

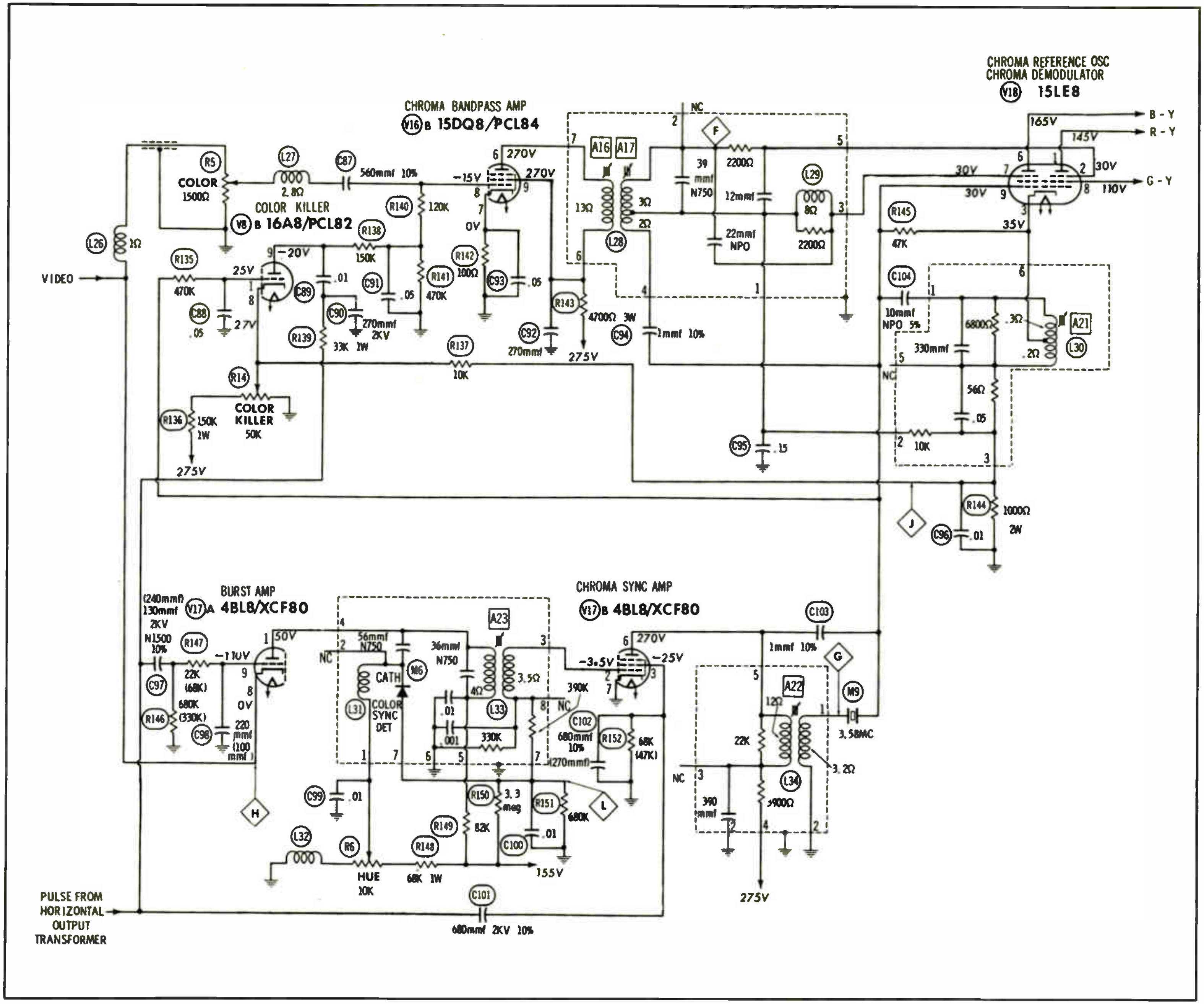


Fig. 4-9. Chroma-control system.

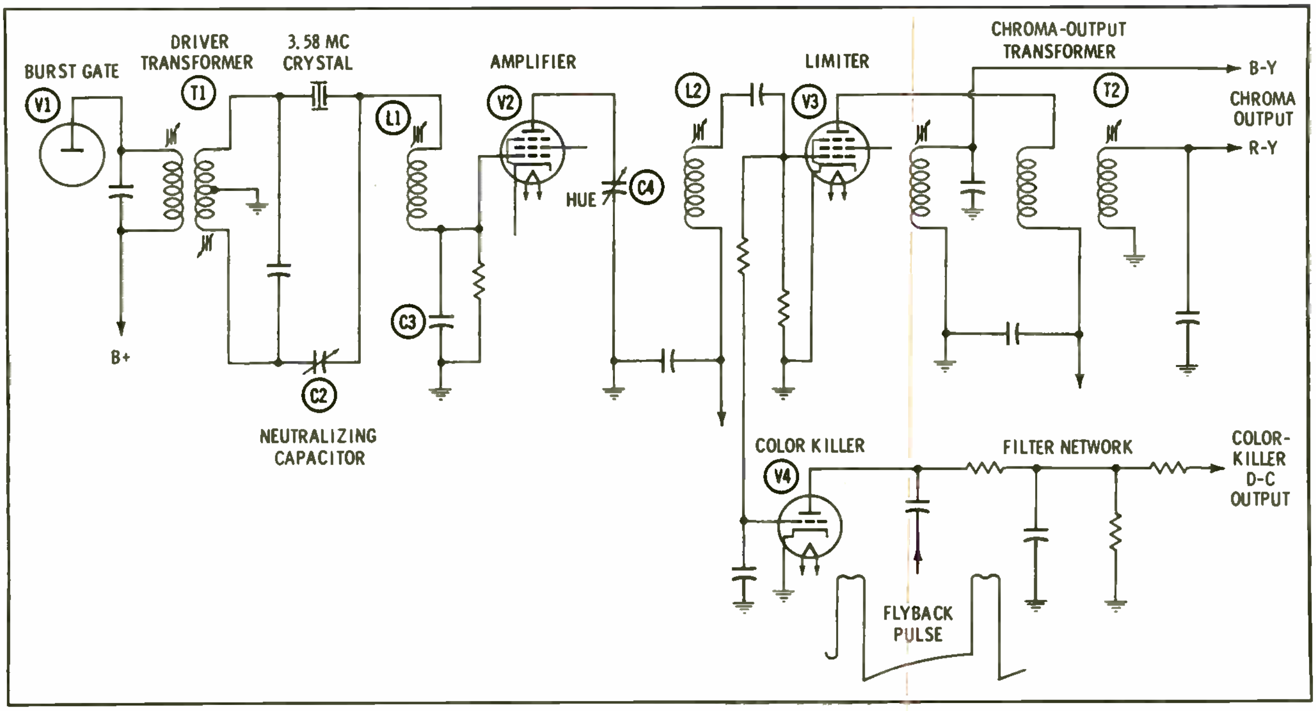
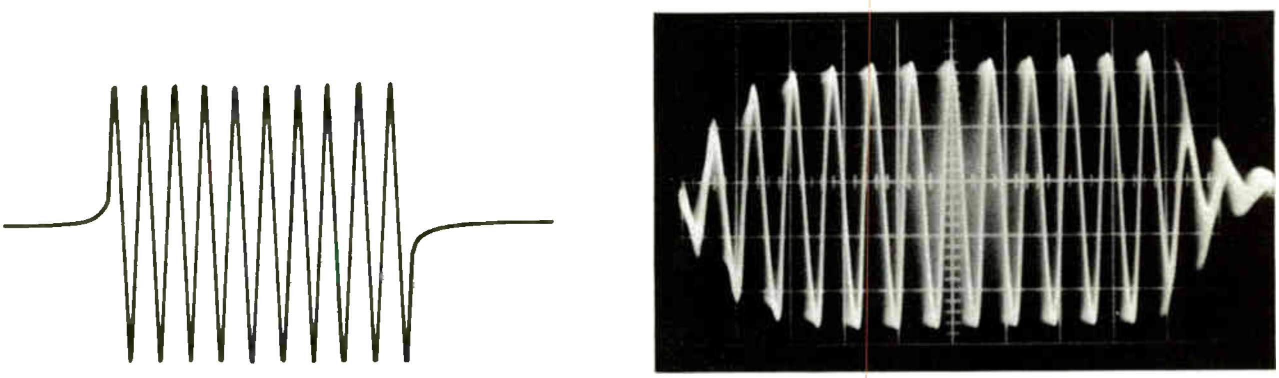


Fig. 4-10. Crystal-ringing oscillator.



(A) Ideal waveform.

(B) Practical waveform.

Fig. 4-11. Color-burst waveforms.

a check such as illustrated in Fig. 4-11B requires a scope with triggered sweep. The color burst cannot be expanded to full screen width with an ordinary service-type scope. You will find that it is comparatively difficult to stabilize a burst pattern on a scope screen. The best way to synchronize the pattern is to use the external-sync function of the scope, and feed in sync voltage from the subcarrier oscillator in the receiver. This method requires that your scope be able to pass a 3.58-mc frequency through its sync channel. Not all wide-band scopes meet this requirement.

Chapter 5

Chroma-Bandpass Amplifier Troubles

In principle, the chroma-bandpass amplifier is comparable to a video amplifier. However, its frequency response is different, and it amplifies the only chroma signal. Fig. 5-1 shows an arrangement in which the bandpass amplifier is driven by a color amplifier. Although the color amplifier is a part of the bandpass-amplifier section, the color amplifier has a comparatively broad frequency response, and it accomplishes only partial separation of the chroma signal from the black-and-white signal. The color amplifier also amplifies the signal for final separation by the bandpass amplifier. The chroma signal is broken down into two basic color signals by the demodulators. Finally, these color signals are processed into the three color-difference signals and applied to the picture-tube grids.

The difference between a black-and-white (Y) signal and a complete color signal is depicted in Fig. 5-2. The chroma signal is added to the Y signal to form the complete color signal. This completed color signal is present at the video detector. Both the Y signal and

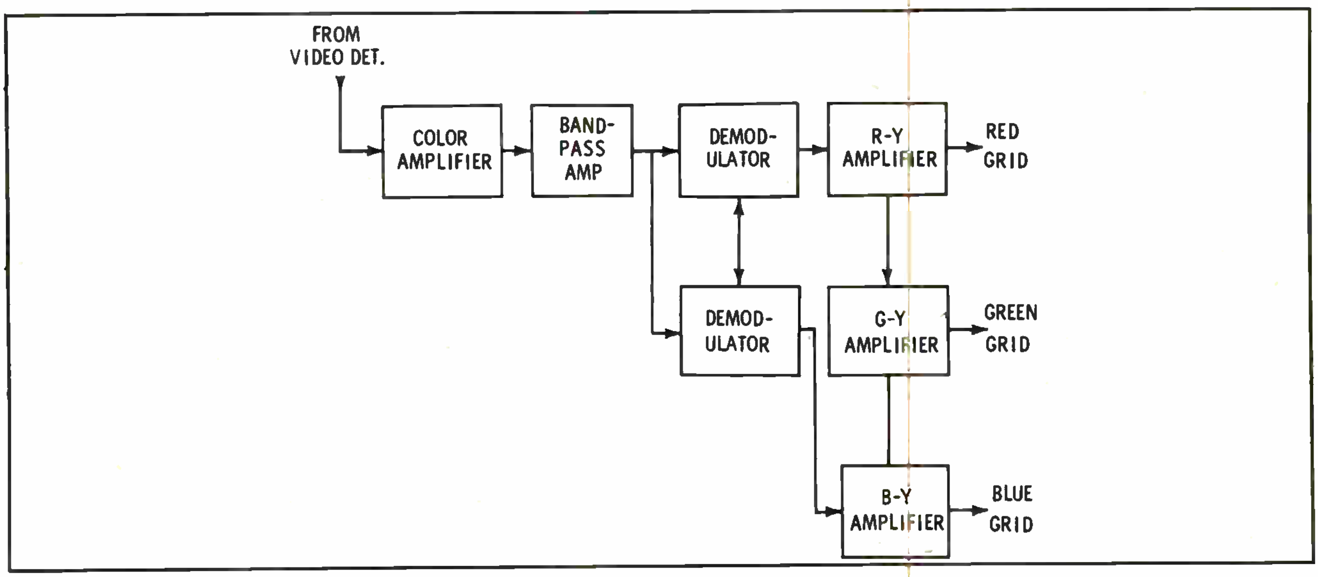
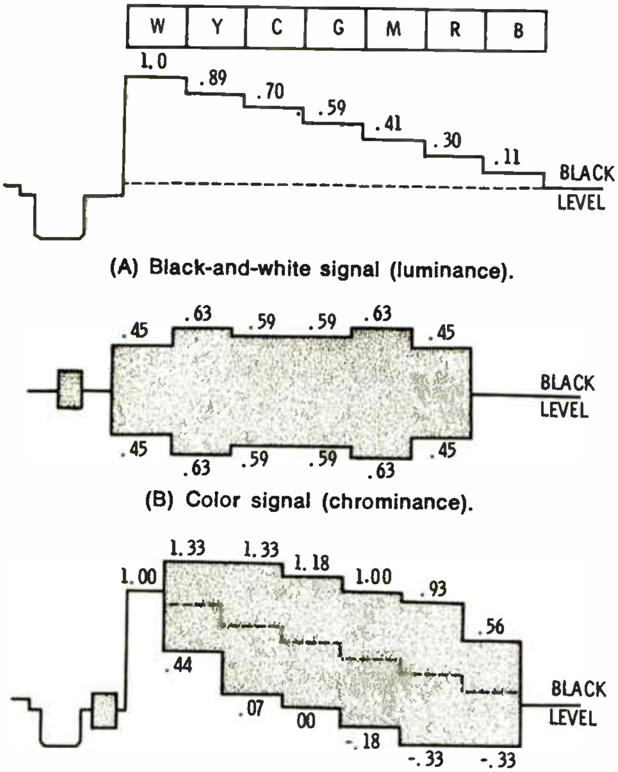


Fig. 5-1. Color section of a color receiver.



(A) Black-and-white signal (luminance).

(B) Color signal (chrominance).

(C) Color picture signal.

Fig. 5-2. Formation of the color signal.

the chroma signal are applied to the color-picture tube. However, the waveform from the detector (Fig. 5-2C) is separated into the luminance (A) and the chroma (B). The Y or luminance signal is fed to the cathodes of the color-picture tube, and the chroma signal is fed to bandpass amplifiers, demodulated, and then applied to the grids of the picture tube. Separation of the Y and chroma signals is accomplished by traps and tuned transformers.

The chroma signal shown in Fig. 5-2B is a phase-modulated frequency of 3.58 mc. The complete color signal is applied to the input of the video amplifier. A 3.58-mc trap at the output of the video amplifier stops the chroma signal, but it permits the Y signal to pass into the video-output stage, or Y amplifier. This circuit action is depicted in Fig. 5-3. The chroma bandpass amplifier is tuned to a center frequency of 3.58 mc; it passes only the chroma signal. The Y signal is almost completely rejected by the bandpass amplifier, because the chief components of a Y signal are comparatively low frequencies.

A frequency-response curve for one type of Y amplifier is shown in Fig. 5-4. It is evident that frequencies below 3.58 mc are passed, while the chroma signal is blocked. The frequency response for a chroma-bandpass amplifier is shown in Fig. 5-5. Notice that the 3.58-mc chroma signal is passed, while the comparatively low-frequency Y signal is blocked. Common

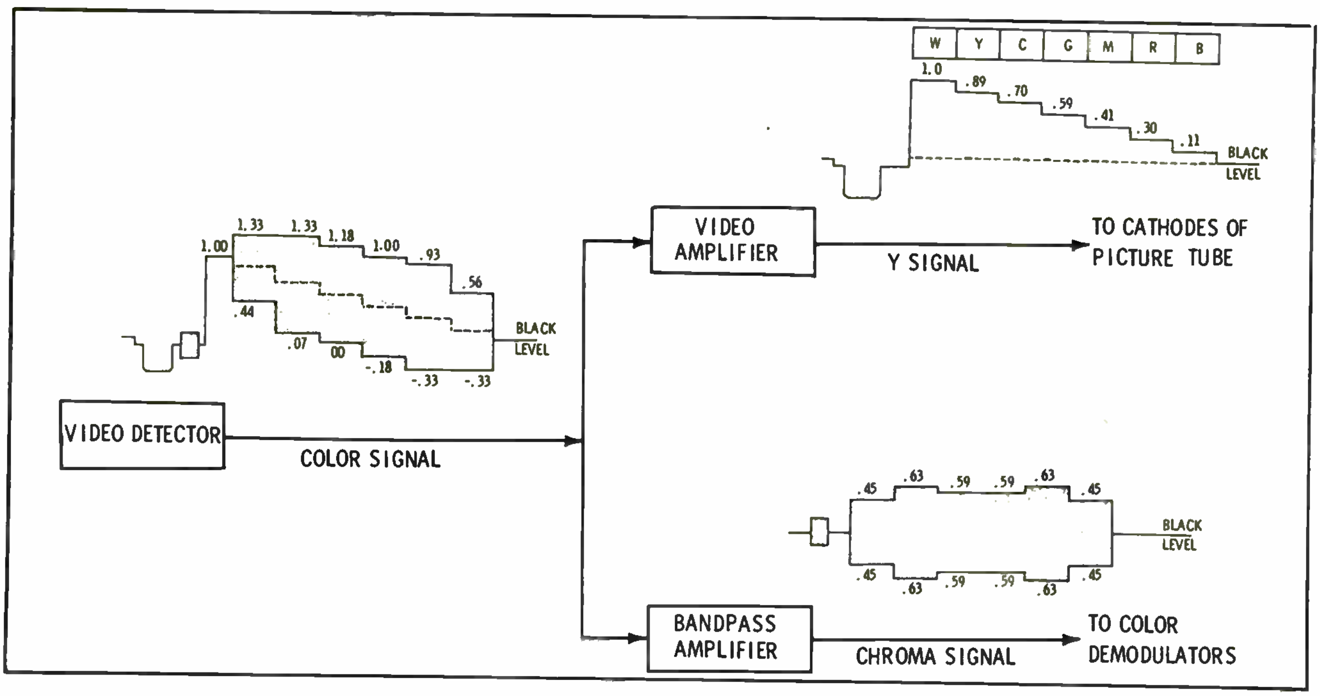


Fig. 5-3. Color signals in the color receiver.

trouble symptoms of color amplifiers and bandpass amplifiers are:

1. Weak or no color reproduction.
2. Smeared color bars (poor color fit).
3. Abnormally intense color reproduction, which cannot be corrected by adjustment of the color-intensity control.
4. Ringing (repeats) at leading and trailing edges of color bars.
5. Incorrect hues, which cannot be corrected by adjustment of the hue control.
6. Intermittent color reproduction.

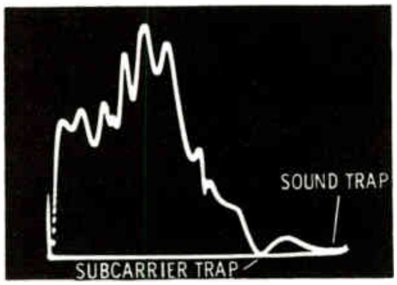


Fig. 5-4. Frequency-response curve for a Y amplifier.

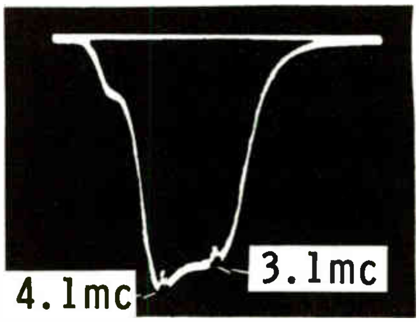


Fig. 5-5. Frequency-response curve for a bandpass amplifier.

GENERAL DISCUSSION

You will find circuit configurations of different color receivers utilized in this section. A common method of attenuating the Y signal is to employ a small coupling capacitor at the input of the chroma amplifier (50-mmf capacitor in Fig. 5-6). Subsequent separation of the chroma and Y signals is accomplished by the tuned circuits in the plate branch of the 6U8. When the slugs are adjusted correctly, a chroma response curve similar to the one shown in Fig. 5-5 is obtained. Note that the "notches" in the curve are not introduced by the chroma amplifier. These are frequency markers (absorption markers) produced by the sweep-alignment equipment.

The chroma amplifiers are sometimes called color i-f amplifiers (Fig. 5-7). Regardless of terminology, the function of this receiver section is always the same. There are several basic features that we should observe in Fig. 5-7. First, the gain of the chroma amplifiers, adjusted for normal reception, is not great. The signal at the grid of the first color i-f stage has an amplitude of 14.5 volts p-p. The signal at the plate of V20A has an amplitude of 20 volts p-p. The principal function of this stage is not to increase chroma signal voltage, but to process the signal and maintain a relatively constant level via acc action. The automatic-control bias on the grid of V20A is proportional to the burst amplitude.

Second, there is a reserve gain in the first stage. Note that the 20-volt p-p signal at the plate of V20A is normally reduced to 2 volts p-p at the grid of V27A in Fig. 5-7. This reduction is caused by the voltage-divider action of the color-intensity control. V27A provides a gain of about 4 times. In case the received signal is weak, the color-intensity control can be advanced to obtain the normal 9-volt p-p output at the plate of V27A.

Third, a blanking pulse is applied to the cathode of V27A from the cathode of V20B. This pulse blanks the color burst and prevents it from producing visible

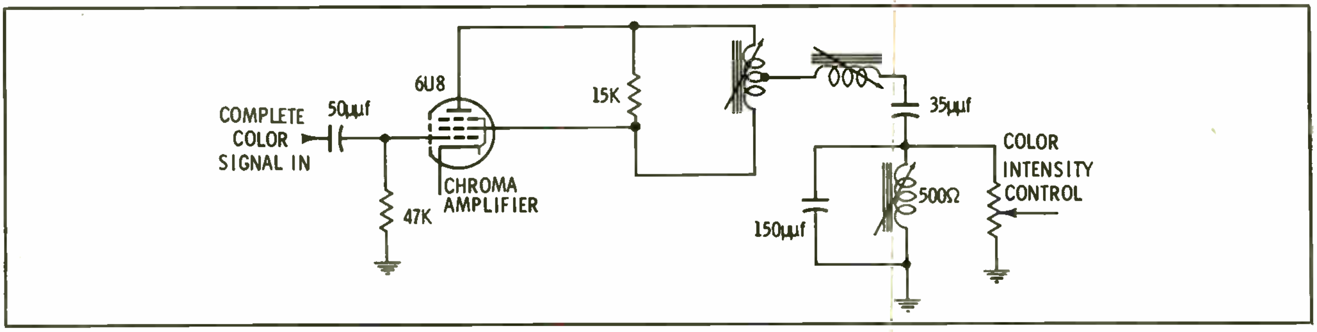


Fig. 5-6. Chroma amplifier.

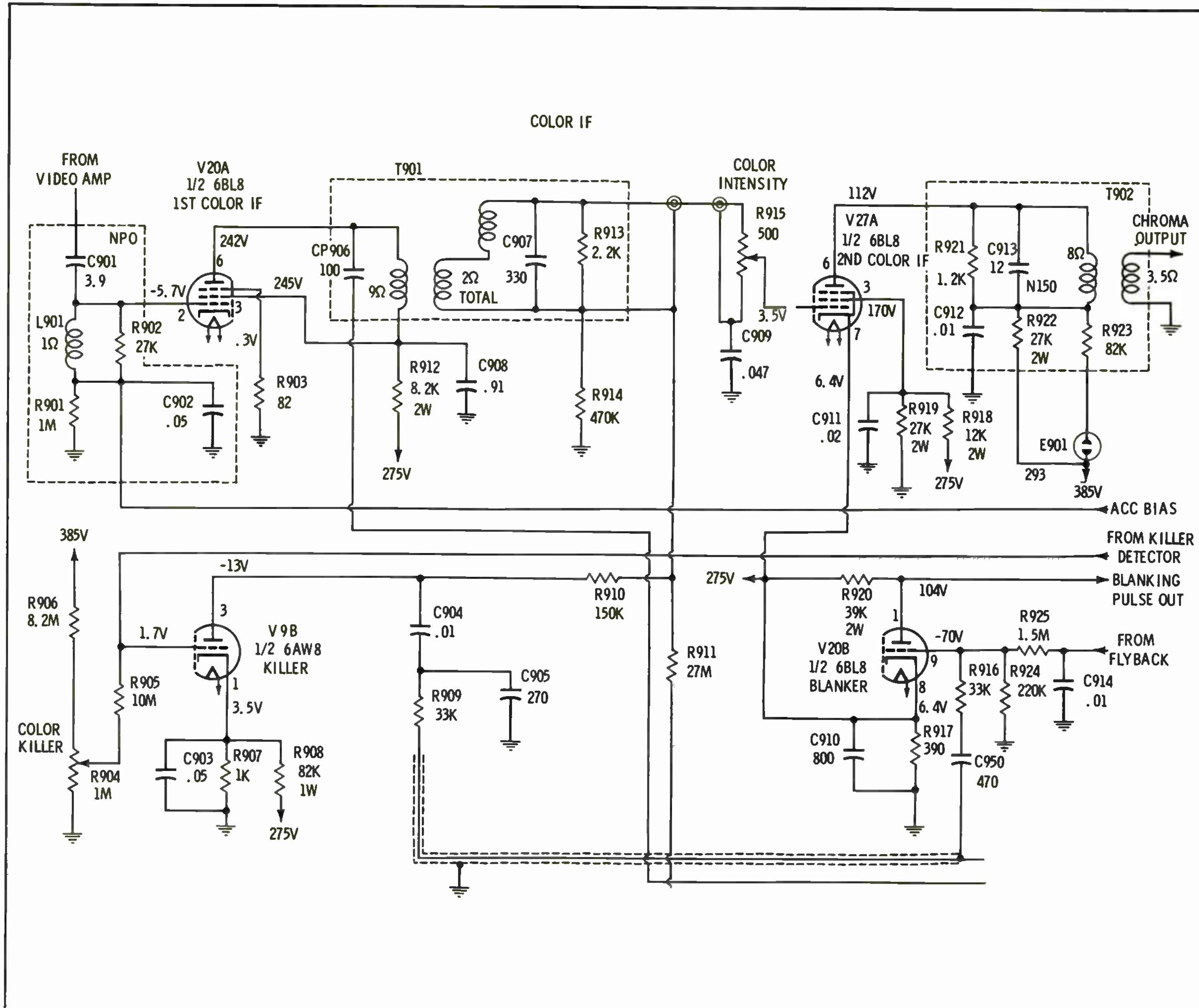


Fig. 5-7. Color i-f amplifiers.

color during retrace. Fourth, killer bias from V9B is fed to the grid of V27A.

Pulsing the cathode of V27A causes the chroma signal at the plate to ride on a sawtooth waveform. The sawtooth is incidental and has no functional significance. In other words, the chroma output from T902 in Fig. 5-7 consists of the chroma signal only. The sawtooth has been suppressed, because transformer T902 has a center frequency of 3.58-mc and cannot respond to the comparatively low frequencies that make up the sawtooth waveform. We see that a high-frequency tuned transformer can be compared in this respect with a small coupling capacitor, such as the 50-mmf capacitor in Fig. 5-6.

GENERAL TROUBLESHOOTING PROCEDURE

When troubleshooting a color amplifier or bandpass amplifier for weak or no color reproduction, it is advisable to trace the chroma signal through the circuits with a wide-band scope and low-capacity probe. This approach will show where the chroma signal is attenuated or stopped, and attention can be turned to the section which is defective. D-c voltage and resistance measurements will often pinpoint the faulty component. However, open capacitors must be localized either on the basis of waveform observations or by "bridging" with a good capacitor. Circuit tests of capacitors are generally not conclusive, and one end of the capacitor should be disconnected and tested with a capacitor checker.

A word of caution concerning alignment is in order here. Do *not* check the alignment of the chroma amplifier until all other trouble possibilities have been eliminated. You will find that misalignment is seldom the cause of trouble in this section, unless someone has misaligned the receiver. Of course, there are rare exceptions: for example, it is possible for a defect to occur in L901, T901, or T902 (Fig. 5-7) which throws the transformer out of alignment. Since such defects seldom occur, it is good practice to investigate all other components first.

COMMON SYMPTOMS

1. Weak or No Color Reproduction

This symptom can be caused by trouble in areas other than the chroma bandpass amplifier. For example, a poor antenna system can be responsible. Hence, confirm your diagnosis by applying a signal from a color generator to the receiver. Remember to check the fine-tuning control and the setting of the color-killer control. It is assumed, of course, that all tubes in the signal channel have been checked or replaced. If you find a normal waveform at the grid of the first chroma-amplifier tube (V20A in Fig. 5-7), the possibility of trouble in the black-and-white section of the receiver can be dismissed.

Possible causes of weak or no color reproduction are:

a. Excessive acc bias on the grid of the color-amplifier tube.
b. Poor contact of tube pins to socket terminals.
c. Low plate and/or screen voltages.
d. Excessive cathode bias.
e. Defective bypass or coupling capacitor.
f. Defective color-intensity control.
g. Defective color-killer control.

The possibility of trouble from the acc section is quickly confirmed by measuring the bias at the grid of the color amplifier (V20A in Fig. 5-7). In this example, the normal operating bias is −5.7 volts. You can clamp the acc bias line, if it seems desirable to check operation over the normal range. Trouble localized to the acc section was discussed in Chapter 3. To check for poor contact of tube pins, wiggle the tubes slightly in their sockets. If you must dig deeper, make a systematic check of plate and screen voltages. For example, leakage in C908 (Fig. 5-7) will reduce both plate and screen voltages on V20A. A similar trouble can be caused if R192 has increased in value.

If the plate and screen voltages are too high, measure the cathode bias. It is possible that the cathode resistor has increased in value. For example, if R903 in Fig. 5-7 becomes badly overheated (from a shorted tube), its resistance may be increased. Note that if R903 should be burned open, you will measure 275 volts at the plate of V20A, instead of 242 volts. The opposite trouble symptom is caused by a shorted cathode-bypass capacitor. For example, if C910 becomes shorted (Fig. 5-7), you will measure low plate and screen voltages at V27A. R917 is a common cathode resistor for V20B and V27A.

The contact in the color-intensity control can become erratic and "jumpy" after a long period of use. Also check for a defective color-killer control. While these are minor possibilities of trouble, they should not be overlooked.

2. Smeared Color Bars (Poor Color Fit)

This trouble symptom can be caused by poor alignment or regeneration in the i-f amplifier. However, if you observe a correct waveshape at the grid of the color-amplifier tube (V20A in Fig. 5-7), the i-f amplifier is cleared from suspicion. If the trouble is located in the chroma-amplifier system, it will show up in signal-tracing tests with a wide-band scope and low-capacity probe. The chroma waveform will be badly distorted in the circuit that is causing the smear.

Possible causes of color smear in the chroma-amplifier section are:

a. Gassy tubes.
b. Open screen-bypass capacitors.
c. Open plate-decoupling capacitors.
d. Open or leaky grid-decoupling capacitors.
e. Defective or seriously misaligned tuned circuits in the chroma section.

It is assumed, of course, that tubes have been carefully checked for gas, or replaced. Aside from tubes, the most common cause of smearing is an open capacitor. Two types of difficulty can result: The resonant frequency of the associated tuned circuit is shifted, which has the same effect as misalignment. An open screen-bypass will often permit a stage to become regenerative and the frequency-response cure develops a sharp and high peak.

Chroma smear is occasionally caused by a leaky grid-coupling capacitor. Leakage permits B+ voltage to bleed into the grid circuit, causing the chroma-amplifier tube to operate with excessive gain. Although the signal level can be brought to normal by a lower setting of the color-intensity control, the chroma waveform is distorted when the grid of the tube is driven positive. One of the distortion characteristics is smeared color bars. Resistors are much less likely to be responsible for this symptom. However, if the capacitors check good, don't overlook the possibility of a defective resistor that could cause subnormal bias, and consequent overlooking of the chroma amplifier. Defective resistors are often located in the acc section, and such symptoms were discussed in Chapter 3.

There remains a possibility of a defective or misaligned chroma transformer. With reference to Fig. 5-7, capacitor C907 or resistor R193 in the first-color i-f output transformer might be open. If the capacitor is open, the transformer cannot be brought into correct alignment. On the other hand, if resistor R193 is open, the frequency-response curve will be peaked and have insufficient bandwidth. The same type of trouble can apply to transformer T902. Detailed chroma alignment procedures should be followed if alignment is called for.

3. Abnormally Intense Color Reproduction, as Shown in Fig. 5-8

This symptom points to a chroma-amplifier stage that has excessive gain, or to a component defect that produces excessive chroma-signal output. Possible causes for this difficulty are:

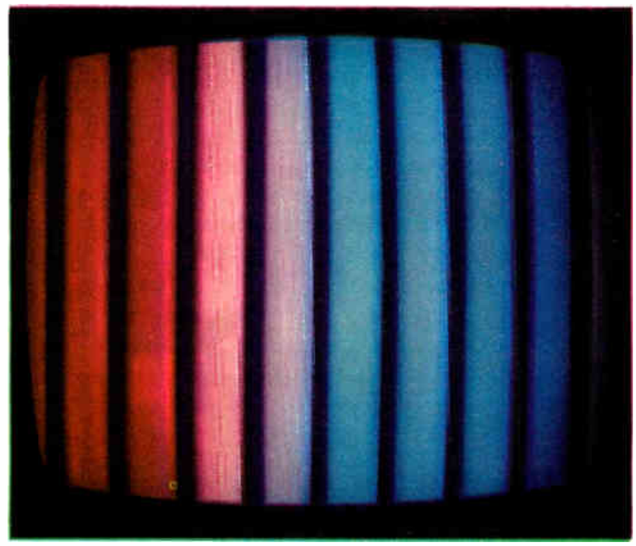


Fig. 5-8. Intense color on screen.

a. Subnormal grid bias on a chroma-amplifier tube.
b. Subnormal cathode bias.
c. Open color-intensity control, or open bypass capacitor.
d. Regeneration in the bandpass-amplifier stage.

The first step is to check the grid bias on the chroma-amplifier stages. The bias on V27A in Fig. 5-7 is the place most likely to start, because the color-intensity control does not affect its output. If you measure zero or low bias, check the color-killer stage. However, the bias voltage could be correct, and excessive output result from a defect in the color-intensity control circuit.

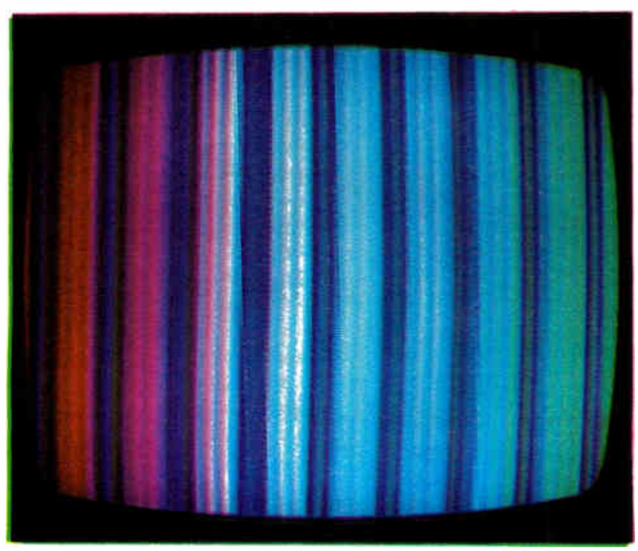


Fig. 5-9. Ringing at edges of color bars.

For example, if capacitor C909 is open, the grid-driving signal cannot be set to 2 volts p-p. A badly worn or open control can cause the same difficulty. Note that the normal cathode bias on V27A is 6.4 volts. If C910 is leaking badly or shorted, you will measure low or zero cathode bias.

Incorrect bias at the grid of V20A causes distortion of the chroma signal, but abnormally intense colors are not a direct clue; the color-intensity control will simply be set to a lower point to compensate for the increased gain of V20A. This trouble was explained under (2). Regeneration in the bandpass-amplifier stage can cause abnormally intense colors. An accompanying symptom is hue distortion. The prime suspect is an open capacitor, such as C911 in Fig. 5-7.

4. Ringing (Repeats) at Leading and Trailing Edges of Color Bars as Shown in Fig. 5-9

This symptom can be caused by defects in the i-f amplifier or in the chroma section. Note whether the ringing symptom appears also in the black-and-white picture. Misalignment or regeneration in the i-f amplifier affects both black-and-white and color reproduction. When ringing appears only in the color component, the chroma section falls under suspicion. The cause is invariably due to a sharply peaked response curve in the color-bandpass amplifier. A stage has either been seriously misaligned, or regeneration is present.

5. Incorrect Hues That Cannot Be Corrected by Adjustment of the Hue Control. An Example Is Shown in Fig. 5-10

This trouble symptom can point to trouble in more than one section of the receiver. A color-TV analyzer can be utilized to inject signals in the i-f amplifier at the input of the color amplifier and at the output of the bandpass amplifier. If you obtain correct hues when the signal is injected at the output of the bandpass amplifier, but observe incorrect hues when the signal is injected at the input of the chroma amplifier, the trouble is clearly in the chroma section.

When the symptom has been localized to the chroma section, the next step is to check the frequency response. In the majority of situations, you will find that correct response curves, as shown in the alignment instructions for the receiver, are not present. But in the comparatively few cases when response curves are normal, but hue distortion is present, check the acc line with a scope and low-capacity probe. It is possible that a defect in the acc section is feeding a spurious a-c voltage to the grid circuit of the color amplifier. A related situation is caused by a defect in the color-killer section in which a spurious a-c voltage is fed to the grid of the bandpass amplifier.

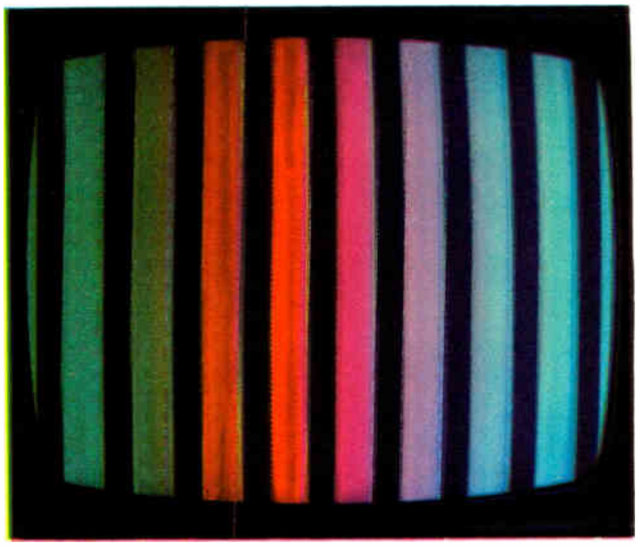


Fig. 5-10. Incorrect hues.

However, you will generally pinpoint the trouble to a defective capacitor in the chroma section, which either detunes a chroma transformer or causes regeneration. Do not attempt realignment, except as a final approach after all possibility of component defects has been eliminated. A difficult to locate trouble is poor grounding of coax cables or shield cans. For example, check the grounding of the coax cable to the color-intensity control in Fig. 5-7, and the grounding of shields over L901, T901, and T902.

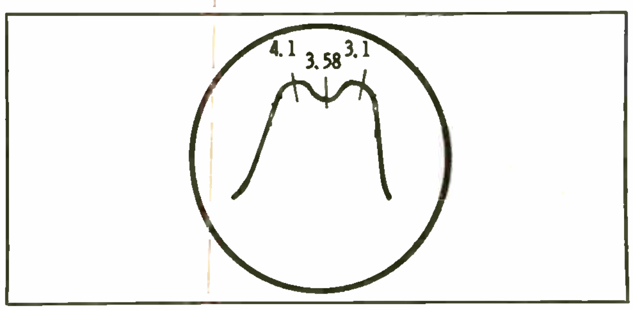


Fig. 5-11. Passband of a chroma amplifier.

Misalignment causes incorrect hues, because poor frequency response is accomplished by abnormal phase shift. Recall that the only difference between the 3.58-mc signals in a series of color bars is their relative phase. The chroma setcion of most receivers has a pass band from 3.1 to 4.1 mc similar to the one shown in Fig. 5-11. Unless this passband is reasonably flat, some of the chroma sidebands will undergo a relative phase

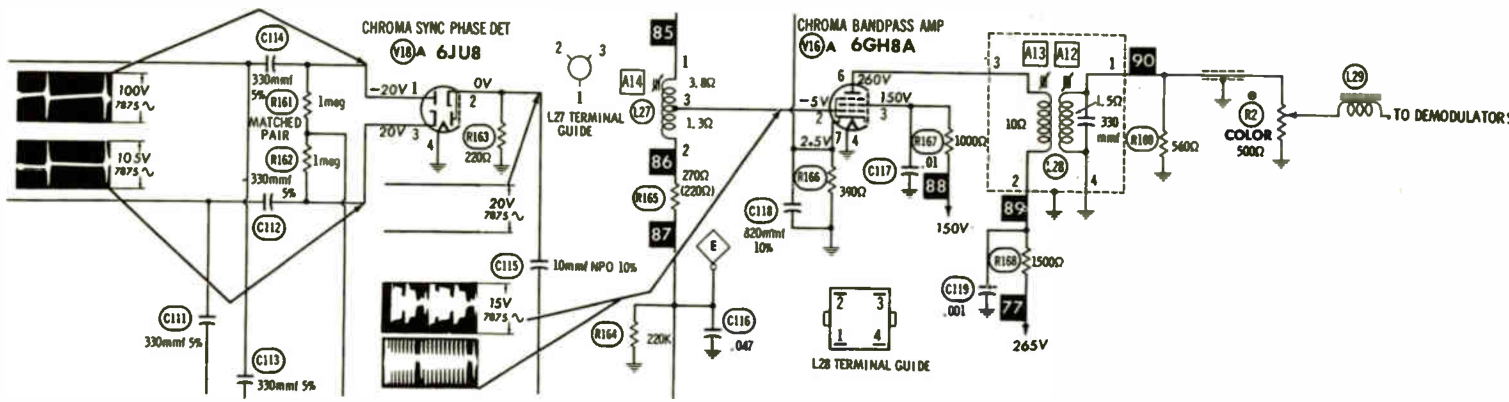


Fig. 5-12. Bandpass amplifier and phase detector.

shift. In turn, incorrect hues are reproduced in corresponding areas of the color picture. The curve shown in Fig. 5-11 has a dip in the center that illustrates the maximum that should be allowed. Most curves will be nearly flat across the top.

6. Intermittent Color Reception

Previous mention has been made of intermittent color reception due to defects in areas other than the chroma section. For example, you can clamp the acc line and the color-killer line to eliminate the possibility of intermittent trouble in these sections. Use a wide-band scope and low-capacity probe to monitor the signals in the chroma setcion. This is the most useful localization method. Possible causes of intermittent color reception due to chroma-sections troubles are:

a. Intermittent signal to grid of the color amplifier (V20A in Fig. 5-7).
b. Intermittent signal at plate of the color amplifier.
c. Intermittent signal to grid of the bandpass amplifier.
d. Intermittent signal at plate of the bandpass amplifier.

For example, if C901 in Fig. 5-7 opens intermittently, a scope check at pin 2 of V20A will show up this defect. Don't overlook the possibility of a tube socket having poor pin contact. There is also the possibility of a broken conductor on the printed circuit board. Suppose the input signal to the color amplifier remains normal during the intermittent interval. This clears the input circuit of the color amplifier from suspicion. Apply the low-capacity probe to the plate of the color amplifier, and proceed as before. If you have more than one scope available, monitor the chroma signal at more than one point in the network and speed up the localization procedure.

CONCLUSION

Let us review a tough-dog type of defect which could easily baffle the apprentice. Fig. 5-12 shows a simple bandpass-amplifier and phase-detector configution to R169, the picture symptom appears as illustrated in Fig. 5-13. The color pattern is distorted, has poor color fit, and displays chroma "ghosts." The beginner is likely to jump to the conclusion that there is a defect in the chroma phase detector. However, this conclusion would be incorrect, because the distorted colors are displayed vertically on the screen. If the trouble were actually in the phase-detector circuit, the color display would appear more or less "bent," as shown in Fig. 5-14.

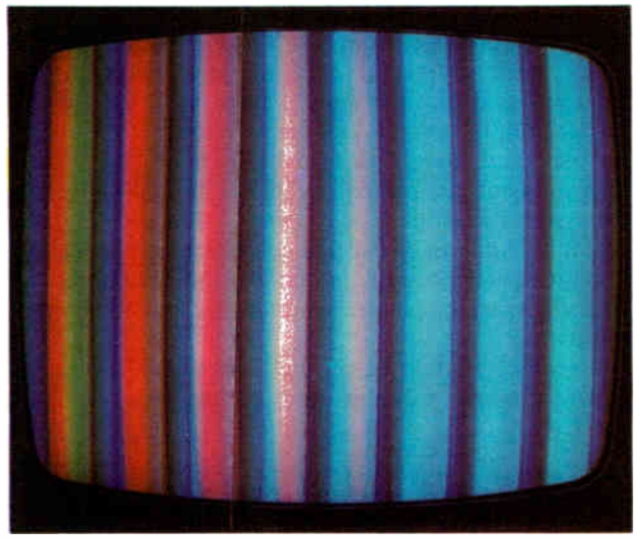


Fig. 5-13. Wrong hues, poor color fit and ghosts.

The technician should turn his attention to the bandpass-amplifier section in this case. Let us see what circuit action results from a poorly connected secondary winding in L28 (Fig. 5-11). Effectively, R169 is no longer shunted across the secondary. This makes the bandpass response much too narrow. We know that narrow-band response causes ringing, or "repeats" in the color pattern. Moreover, less circuit capacitance is now shunted across the secondary. This means that the transformer is badly detuned, as will appear on a sweep-frequency test. Detuning is serious enough that chroma sidebands are shifted considerably in phase. This phase shift causes hue distortion.

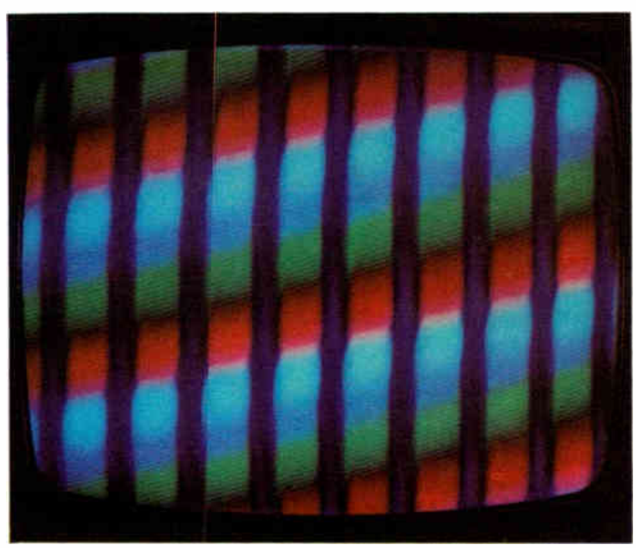


Fig. 5-14. Poor color sync.

Pinpointing of the trouble to the bandpass transformer also follows from a systematic check of waveforms with a wide-band scope and low-capacity probe. You will find that the input waveform to the stage is normal. On the other hand, the waveform at the output is weak and greatly distorted. Since all d-c voltage measurements are normal in this situation, the necessity for systematic scope tests is obvious. The poor connection to ground can be due to a cold-soldered connection, or a break in the conductor on the printed circuit board. In such cases, the picture symptom is likely to be intermittent.

Beginners should be on the alert to distinguish between chroma troubles and picture-tube troubles. Sometimes a color-picture tube becomes intermittent, and this trouble may be confused with circuit defects. In case of doubt, a scope test at the output of the chroma section will quickly show whether a circuit defect is present. Keep in mind that the purity may also fluctuate in a defective picture tube. Purity fluctuation causes color tinting on black-and-white reception, as well as incorrect hues during color reception. Hence, preliminary analysis of intermittent trouble should be cross-checked with a black-and-white signal. With color-television experience the technician will find that tough-dog color-television troubles are seldom as formidable as they first seem. Patient systematic analysis and good practices are acquired only by thoroughness.

Chapter 6

Chroma-Demodulator Troubles

A basic block diagram of the chroma-demodulation section is shown in Fig. 6-1. Note that the color picture tube basically has four signal inputs; the three cathodes that are used as one input, and the grids that are used as three inputs. When the cathodes are driven by a black-and-white video signal, a black-and-white picture appears on the picture-tube screen. On the other hand, if the red grid is driven, a red picture is displayed; if the green grid is driven, a green picture is displayed; and if the blue grid is driven, a blue picture is displayed. The chroma-signal output from the bandpass amplifier is separated into its red, green, and blue signal components. This function is performed by the color detectors usually referred to as the chroma demodulator.

A chroma demodulator is fundamentally a phase detector. The basic operation is depicted in Fig. 6-2. The detector has two signal inputs: one from the sub-

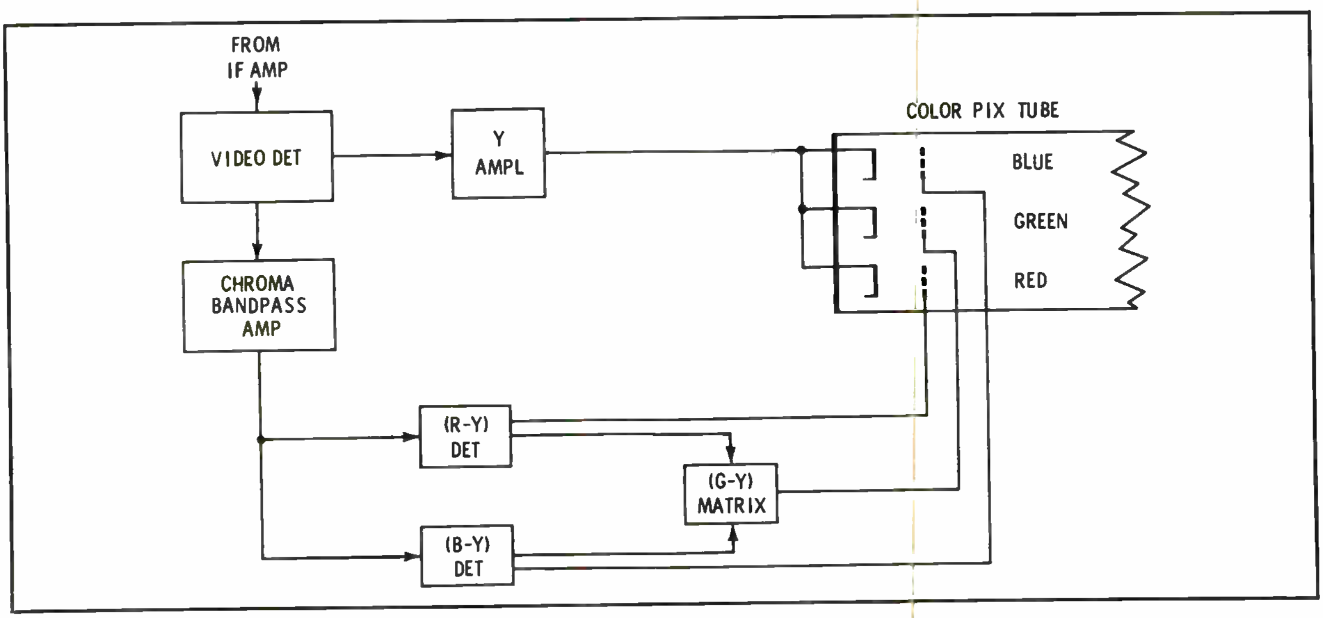


Fig. 6-1. Block diagram of chroma demodulator.

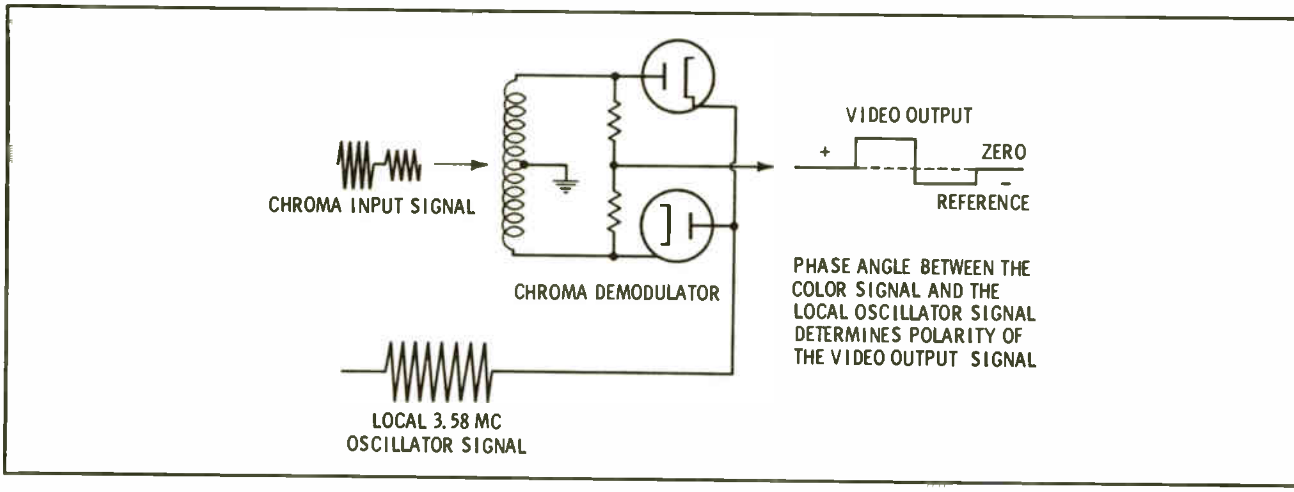


Fig. 6-2. A chroma-demodulation system.

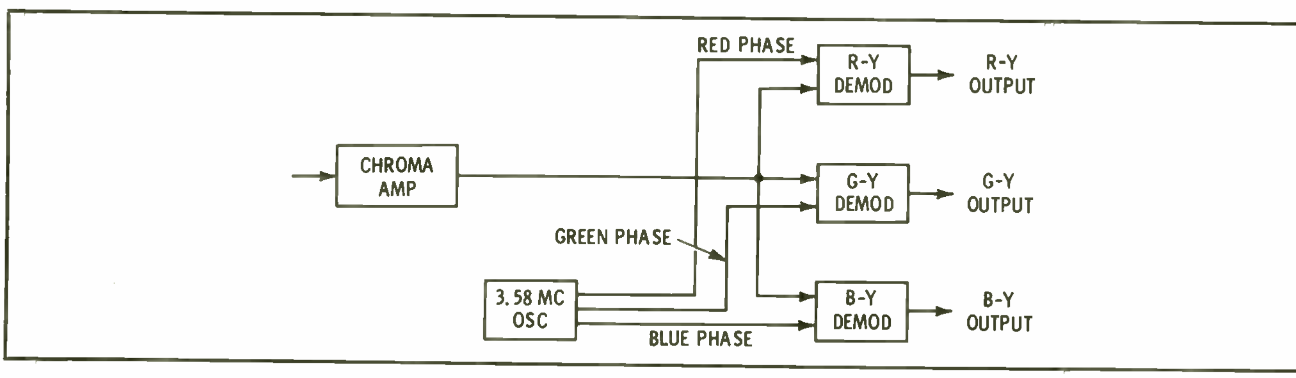


Fig. 6-3. Demodulator system that employs three demodulators.

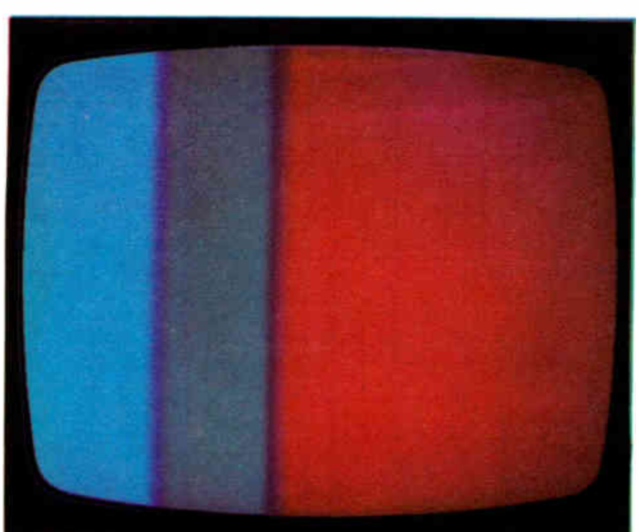
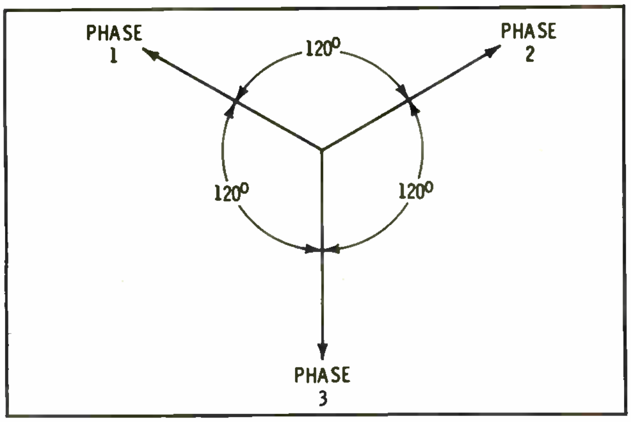


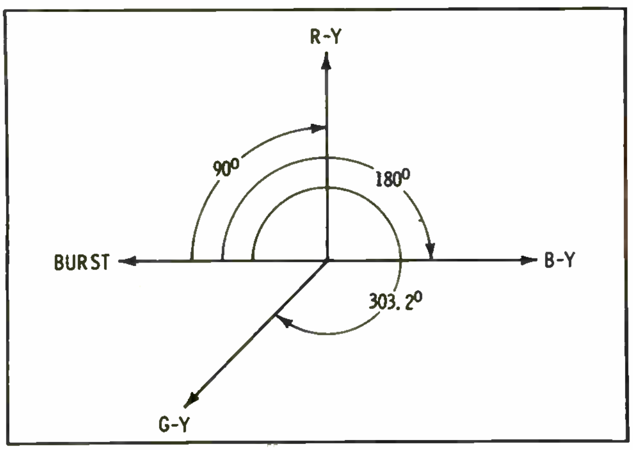
Fig. 6-4. B—Y and R—Y colors on screen.

carrier oscillator, the other from the bandpass amplifier. Output from the chroma demodulator may be either positive or negative, depending on the phase relation between the chroma input signal and the subcarrier signal. The amplitude of the output signal varies directly with the amplitude of the chroma input signal. Some color receivers have three chroma demodulators, as shown in Fig. 6-3. These systems demodulate all three color-difference signals for application to the picture-tube grids. However, most receivers have only two chroma demodulators and a matrix similar to that shown in Fig. 6-1. In either case, the end result is the same; R−Y, B−Y, and G−Y signals are produced for application to the grids of the color picture tube.

The appearance of R−Y and B−Y signals on the screen of the color picture tube is illustrated in Fig. 6-4. These colors are compared to a three-phase signal, such as depicted in Fig. 6-5A. However, there are certain distinctions. First, the voltages seen in Fig. 6-5A have a phase separation of 120°. This is the phase distribution that exists in a three-phase power



(A) 3-phase power line system.



(B) R—Y, B—Y, G—Y phases in relation to the color burst.

Fig. 6-5. Comparison of phase systems.

system. The R—Y, B—Y, and G—Y phases have a phase relation to the burst signal, as shown in Fig 6-5B. The characteristics of the NTSC system are such that the G—Y signal is really a specific mixture of the R—Y and B—Y signals. It is this fact that makes it possible to use a G—Y matrix in a color receiver.

A chroma demodulator is a phase-responsive detector having a high-frequency (3.58 mc) input, and low-frequency (0 to 0.5-mc) output. A chroma demodulator functions as an a-m detector as well as a phase detector. The troubles encountered in chroma-demodulator systems are generally associated with incorrect hues, or incorrect relative intensity of different hues. The following list notes common symptoms which will be analyzed in detail:

1. No color reproduction.
2. All hues incorrect.
3. One hue incorrect.
4. Hues correct, but relative intensities are incorrect.
5. One hue incorrect, accompanied by incorrect relative intensity.

GENERAL DISCUSSION

In practice, we find several different chroma-demodulation configurations utilized by various manufacturers. Fig. 6-1 and 6-3 illustrated two basic arrangements. The block diagram of Fig. 6-6 shows the X—Z demodulation system used in many color receivers. Unlike the arrangement in Fig. 6-1, the X—Z system operates at a phase angle of 63.9° instead of 90°. The X and Z demodulation phases are shown in Fig. 6-7.

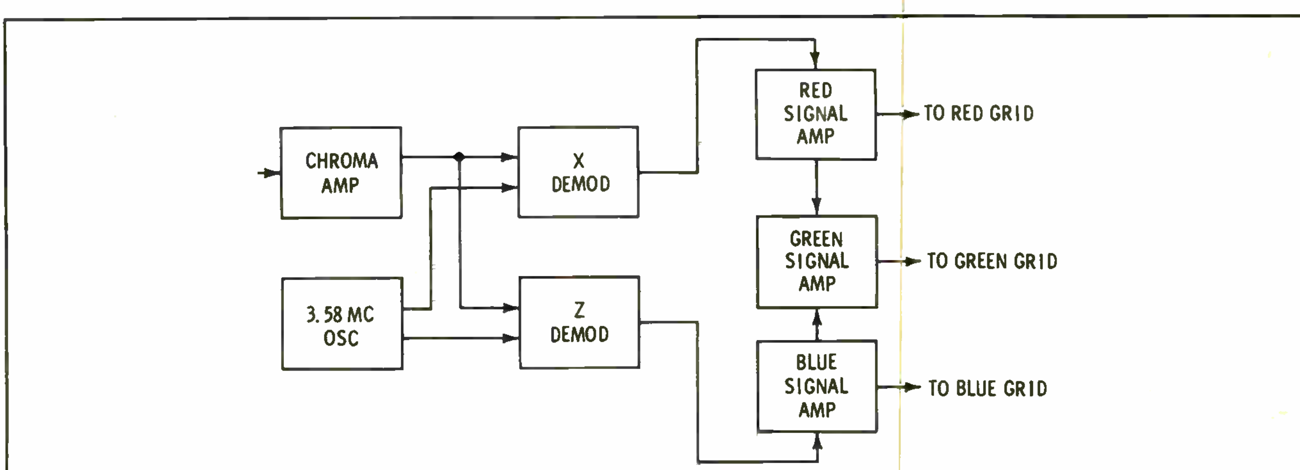


Fig. 6-6. The X and Z demodulation system.

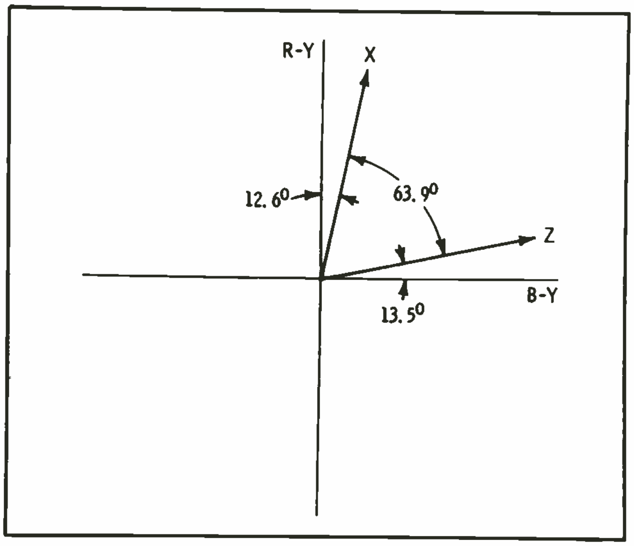


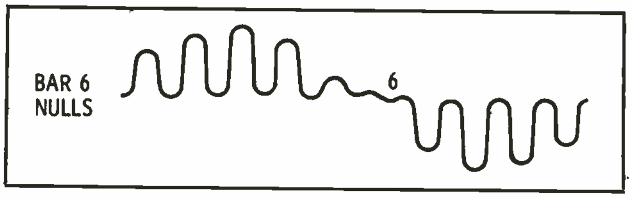
Fig. 6-7. Phases of the X and Z vectors.

Let us see why the X and Z configuration is not a 90°, or quadrature, type of demodulation system. Note in Fig. 6-6 that the green-signal amplifier is connected between the red- and blue-signal amplifiers. The green-signal amplifier operates as a matrix, and can be compared with the G−Y matrix in Fig. 6-1.

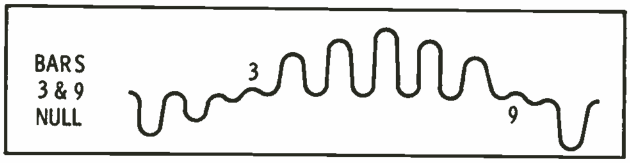
However, due to the interconnection between R−Y, and B−Y, and G−Y amplifiers in the X and Z system, there is a subtraction and addition of signals between the three amplifiers. This mixing, or matrixing, of signals follows the same rules as a mathematical formula in which the amplifiers and components become the determinents. The result produces a B−Y, G−Y, and R−Y signal. Note that the phase angle of 63.9° indicated in Fig. 6-7 may have a slightly different value in some receivers, depending on the type of matrix used to produce the final R−Y, B−Y, and G−Y signals.

Since R−Y and B−Y signals can be combined suitably (matrixed) to obtain a G−Y signal, it follows that the R−Y signal can be maxtrixed with a G−Y signal to obtain a B−Y signal. You may find an occasional receiver that uses a system similar to that shown in Fig. 6-1, but with the B−Y detector and G−Y matrix interchanged. This type of receiver demodulates R−Y and G−Y signals, and then matrixes the demodulated signal to form the B−Y signal. Nevertheless, the end result is the same: The three color signals fed to the color picture tube must be the same three R−Y, B−Y, and G−Y for any receiver.

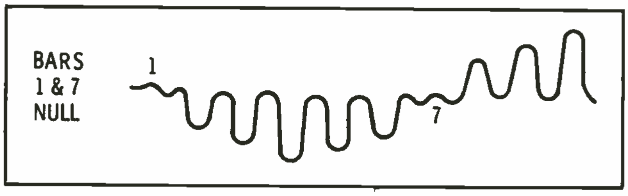
When a keyed-rainbow signal is applied to a normally operating color receiver, a scope employing a low-capacity probe will display typical pulse patterns, such



(A) Signal on the red grid.



(B) Signal on the green grid.



(C) Signal on the blue grid.

Fig. 6-8. Keyed-rainbow signal at the grids of the picture tube.

as those shown in Fig. 6-8, when the probe is applied to each grid of the color picture tube. When the probe is applied to the red grid, bar (pulse) No. 6 normally nulls (Fig. 6-8A). At the blue grid, bars 3 and 9 normally null (Fig. 6-8B). At the green grid, bars 1 and 7 normally null (Fig. 6-8C). If the hue (color-phasing) control is turned, all nulls will shift. Hence, this basic test must be made with the hue control adjusted correctly. The correct adjustment for the hue control can be established by observing these patterns. If the nulls do not fall at the indicated points, the trouble can be in the phase network at the input of the demodulator, the demodulator output circuits, or in the color-difference amplifiers.

An interesting color demodulator that uses only one tube to perform the functions of chroma demodulation, 3.58 oscillation, and difference-signal amplification is shown in Fig. 6-9. The 3.58-mc crystal rings when it is shock-excited by the color-burst, and this shock excitation maintains color-sync lock. The sub-carrier input is applied to the control grid of the tube. Chroma signals are fed to the suppressor grids. Demodulated R−Y and B−Y signals appear at the plates, and a G−Y signal appears at the screen grid. In spite of the difference in circuitry, outputs from the system are normally the same as shown in Fig. 6-8.

It is necessary that the chroma signals (Fig. 6-8) have correct amplitudes in addition to correct nulls. Comparative amplitudes for the three color-difference

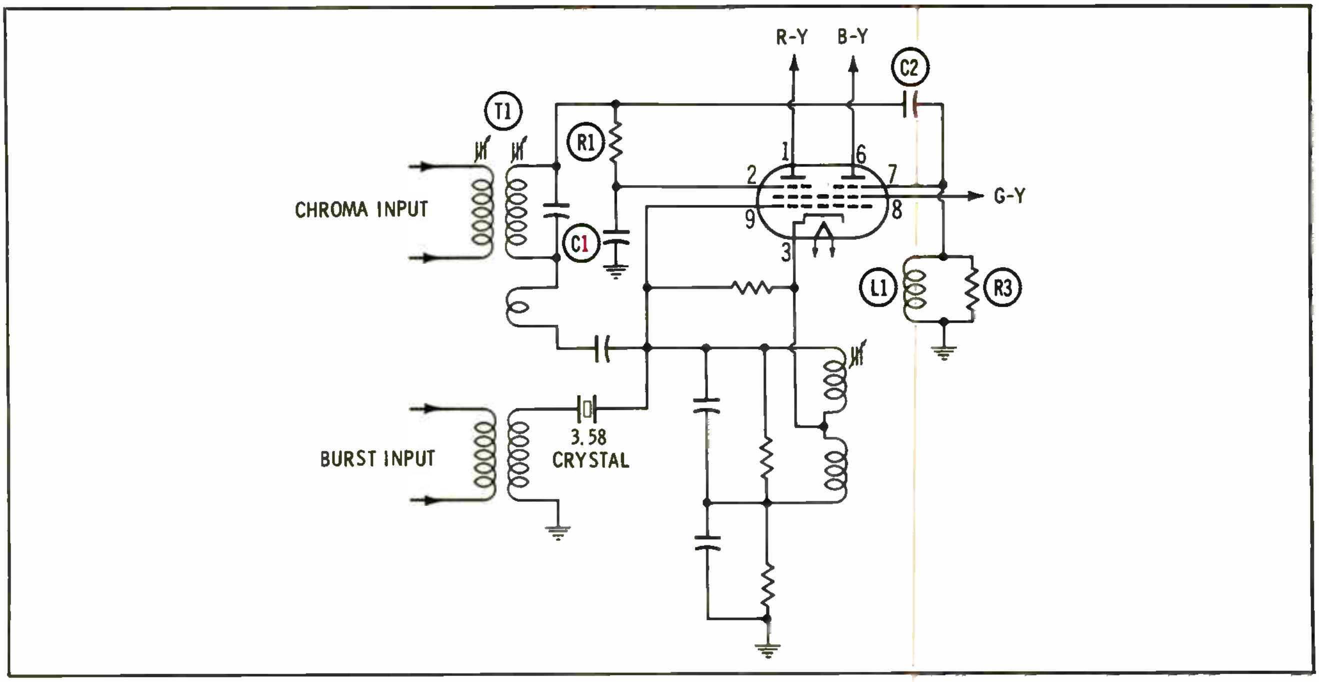


Fig. 6-9. Demodulator, oscillator, and difference-signal amplifier.

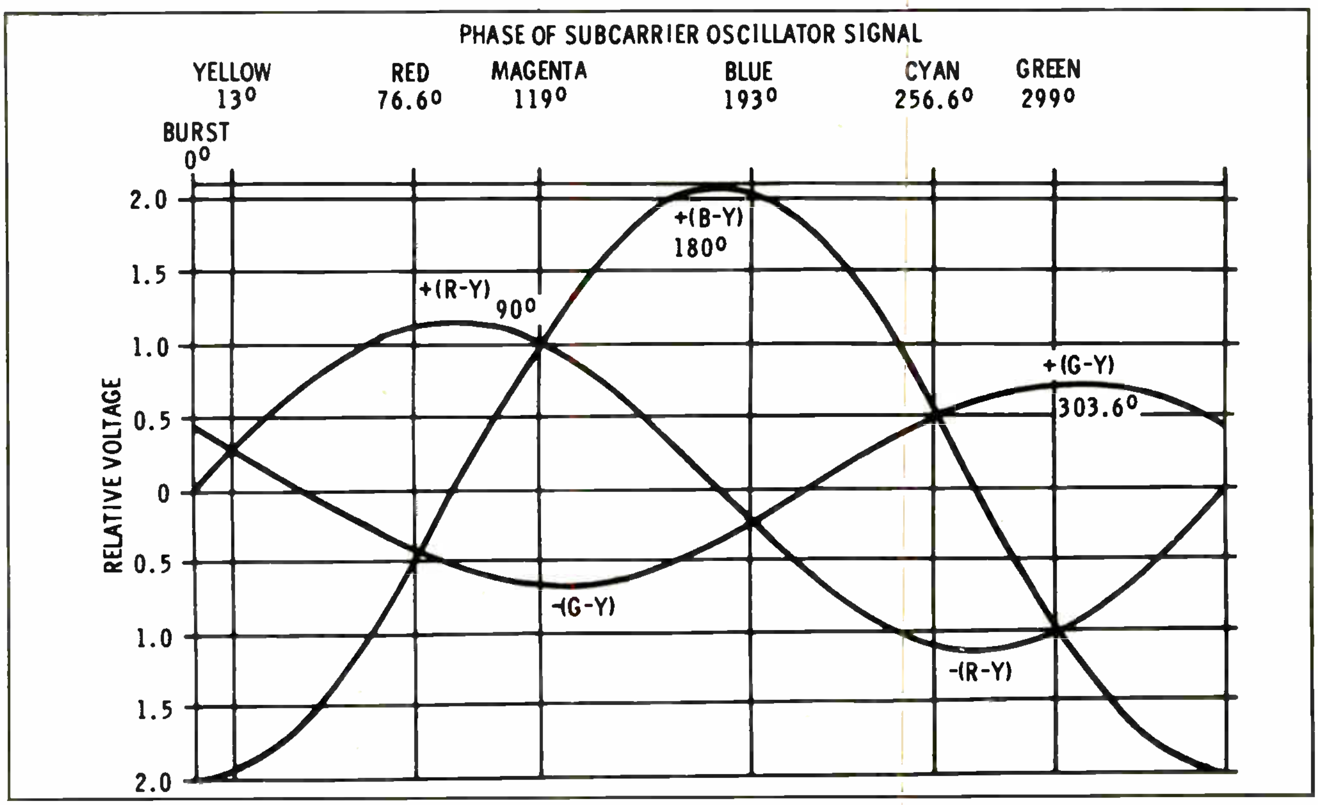


Fig. 6-10. Relation between the three color-difference signals.

signals are shown in Fig. 6-10. The B−Y output has the greatest amplitude, followed by R−Y and G−Y outputs. Although the proportions in Fig. 6-10 are typical, you will find some amplitude differences in the various types of color receivers. Hence, the receiver service data should be checked for the correct data on a particular receiver. Note that the waveforms depicted in Fig. 6-10 are obtained when the receiver is energized by an unkeyed-rainbow signal. When a keyed-rainbow signal is used, the waveforms are keyed into pulses, as in Fig. 6-8. The keying pulse does not affect the relative amplitudes of the signals for a given color.

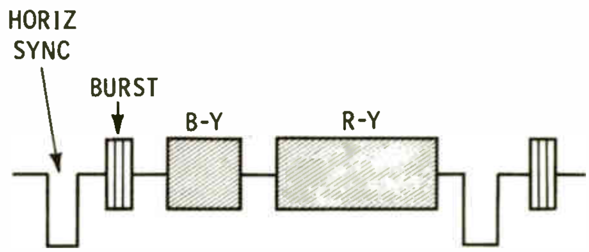
GENERAL TROUBLESHOOTING PROCEDURES

A color-television station signal is of little use in troubleshooting chroma-demodulator circuits. Either an NTSC color-bar generator, or a keyed-rainbow generator is required. When a circuit defect is present, the color program may not "look right." However, standardized chroma signals are not available in program material, and a color signal generator must be used to determine what is wrong in a signal path. Preliminary analysis can be made with an NTSC generator, using the R−Y and B−Y signals, as was illustrated in Fig. 6-4.

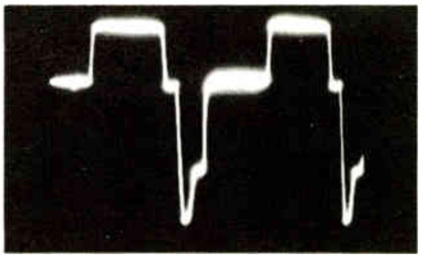
This method is illustrated in Fig. 6-11. In this example the B−Y bar is narrower than the R−Y bar. The difference in bar widths provides easy identification, as seen in the waveform photos. When the scope is connected via a low-capacity probe to the output of the R−Y demodulator, the B−Y bar will normally be nulled as shown in Fig. 6-11A. At the same time, maximum output is observed for the R−Y bar. If the R−Y demodulator is defective or the hue control is not set correctly, the B−Y will not null as it should and a B−Y output appears as in Fig. 6-11B.

Note that the B−Y bar nulls normally, as shown in Fig. 6-11A, only when the hue control is correctly set. Of course, when the hues are incorrect on the picture-tube screen, there is no way to tell what the correct setting of the hue control should be. Hence, start by adjusting the control for a B−Y null as in Fig. 6-11A. Then, transfer the low-capacity probe to the output of the B−Y demodulator. Now, the B−Y bar should be at full amplitude, and the R−Y bar should be nulled. If the R−Y bar is not nulled, then there is a phase error in the subcarrier voltages applied to the two chroma demodulators.

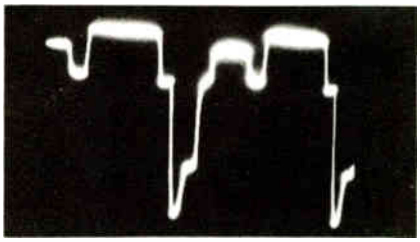
The question may be asked, why not use a simultaneous color-bar display to check the operation of the chroma demodulators? The reason is that the number of bars produces a signal that is unnecessarily complex for preliminary tests. Fig. 6-12 illustrates the output from a chroma demodulator when a simultaneous color-bar signal is applied to the receiver. Obviously, it is much easier to make a phase check with the simplified waveform such as the one in Fig. 6-11. The test can also be made with a color bar generator that



(A) Position of B−Y and R−Y color bars.



(B) B−Y bar nulled.



(C) B−Y bar not nulled.

Fig. 6-11. B−Y and R−Y color bars.

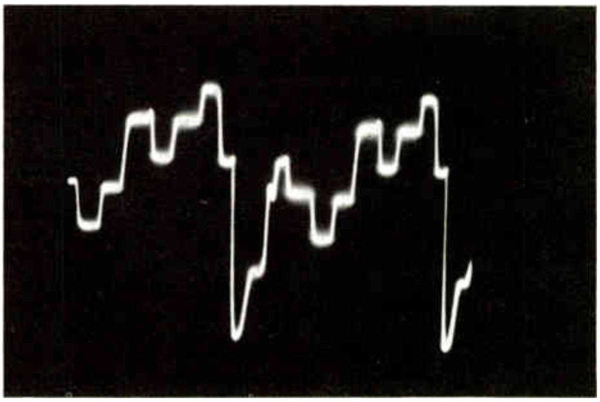


Fig. 6-12. Waveform at the output of the color demodulator.

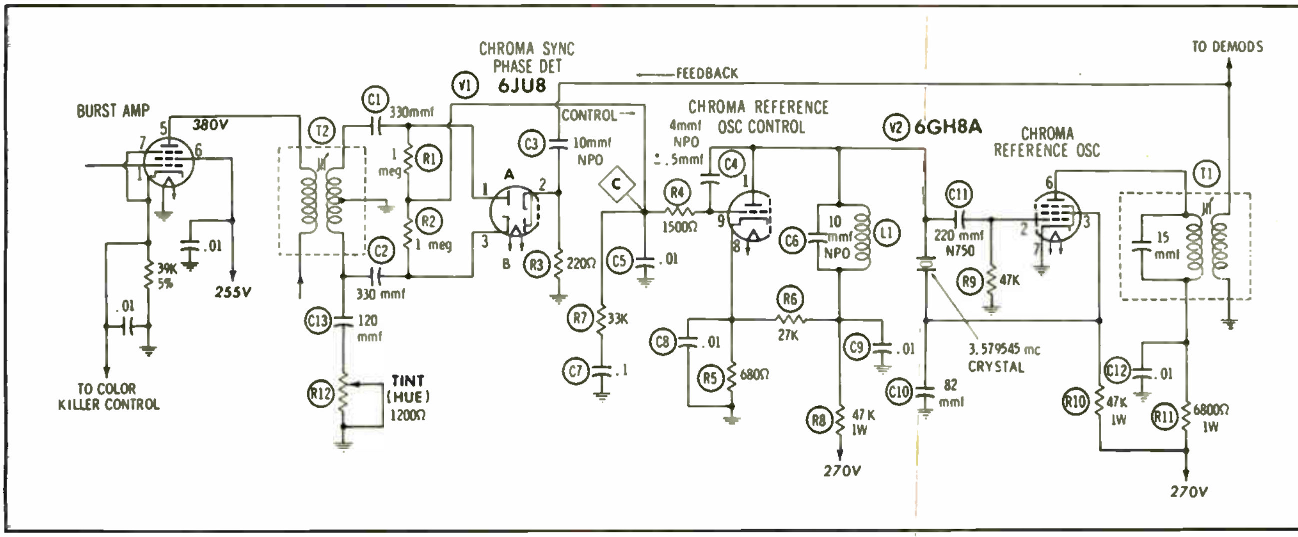


Fig. 6-13. Chroma-reference control system.

displays only one bar at a time. The generator must be switched between R−Y and B−Y signals during the test.

When a phasing error is found, d-c voltage and resistance measurements are made in the associated circuit to isolate the defective component. Open capacitors cannot always be pinpointed by d-c voltage measurements (unless signal-developed bias can be used for indirect indication). However, signal-tracing of chroma waveforms will often show whether a capacitor is open. In case of doubt, the suspected capacitor can be "bridged," or one end can be disconnected and the unit tested with a capacitor checker. Check for off-value resistors since they can be responsible for phasing errors. Inductors are checked last, as they are least likely to cause trouble.

COMMON SYMPTOMS

1. No Color Reproduction

This symptom throws immediate suspicion on the subcarrier oscillator (Fig. 6-2). If the local 3.58-mc oscillator signal stops, the chroma sidebands cannot be demodulated and this results in no output. It might be supposed that the chroma signal would feed through, however, chroma demodulators are designed to filter out the 3.58-mc component. Only frequencies below 1 mc are permitted to pass; the 3.58-mc signals are usually bypassed to ground through a 33 pf capacitor and blocked by an inductor of about 600 uh. Many receivers employ a 3.58-mc trap to remove the r-f component from the color-difference signals.

Possible causes of a "dead" subcarrier oscillator are:

a. Low plate or screen voltage to the oscillator tube.
b. Open or leaky capacitor in the oscillator circuit.
c. Off-value or burned resistor.
d. Serious mistuning of oscillator tank coil.
e. Defective tube socket.
f. Break in printed-circuit conductor.
g. Defective inductor in oscillator section.

A subcarrier-oscillator circuit is shown in Fig. 6-13. A shorted tube can cause resistor R10 or R11 to increase in value or burn open. If capacitor C12 shorts, resistor R11 will be burned. If capacitor C10 shorts, resistor R10 will be burned. In one instance, a short in a chroma demodulator tube caused excessive B+ drain, which burned out the primary winding of transformer T1 and increased the value of resistor R11. When the oscillator is not functioning, measure the screen and plate voltages, make a systematic check of the capacitors in the oscillator circuit, and check for off-value or open resistors. Don't overlook the possibility that capacitors enclosed in shield cans may also be shorted, open, intermittent or poorly soldered into the circuit. Serious mistuning, or a defect in Coil L1 can stop oscillator operation. In one case, the plate transformer appeared to be defective, but further checking revealed that the trouble was a cold-solder connection. Microscopic breaks in printed-circuit conductors can also be elusive troublemakers. Although it's possible for the quartz crystal to be defective, this is a comparatively rare situation. A crystal unit can become chipped or cracked by being mishandled, dropped on the floor, or struck with a tool.

2. All Hues Incorrect

Fig. 6-14 shows a keyed-rainbow pattern in which all of the colors are wrong but the color sequence of the bars is correct.

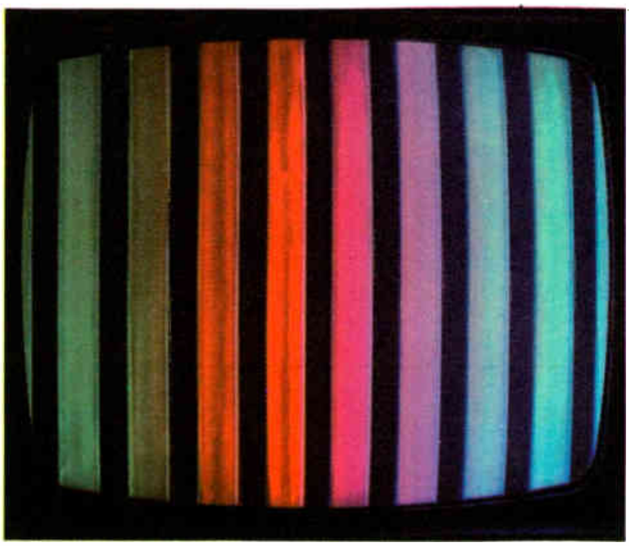


Fig. 6-14. Colors wrong but color sequence correct.

When all hues are shifted, and the hue control is out of range, the trouble is most likely to be in the phase-detector or burst-amplifier sections. A defect in the burst-amplifier circuit produces a substantial shift in the burst phase. Hence, the subcarrier oscillator operates at incorrect phase and feeds an out-of-phase voltage to the chroma demodulators. Check out the burst-amplifier:

a. Incorrect adjustment of T1, T2, L1.
b. Open bypass capacitor.
c. Off-value resistor.
d. Defecting crystal.
e. Open or leaky phase-shifting capacitor (C4).

Assuming the transformers and coils are tuned properly and since defective capacitors are the most likely troublemakers, investigate this possibility first. Systematic checks are necessary, because it is not practical to check 3.58-mc phases progressively through the circuits with the usual service equipment. It is assumed that a normal waveform is found at the input of the chroma demodulators. If the chroma input waveform has incorrect phase (due to trouble in the bandpass amplifier), you will observe subnormal peak-to-peak voltage and a badly distorted waveform. Also check for a defect in the phase detector that will cause the tint control to be out of range.

3. One Hue Incorrect

This symptom refers to the primary colors, red, green, and blue. For example, green and blue bars might be displayed satisfactorily, but the red bar may be off-hue. You must evaluate this type of symptom with respect to the chroma demodulator circuitry in the particular receiver. For example, consider the X and Z configuration depicted in Fig. 6-15. When the picture symptom is checked-out and only the red bar is off-hue, we do not suspect that there is a defect in the X and Z circuitry. The reason for this conclusion is that while the X demodulator processes the chroma signal in the vicinity of "red" (Fig. 6-7), it also contributes in part to "green" and "blue." Using the same line of reasoning, a defect in the X demodulator must affect *two* of the primary colors.

The color picture tube falls under suspicion in this case. You will probably find that the red gun is defective, if only the red bar is off-hue. A conclusive test is made with a wide-band scope and low-capacity probe at the grids of the picture tube. If you observe normal waveforms, as shown in Fig. 6-8, it is clear that the chroma demodulators are not at fault. Hence, do not waste time looking for a defect in the demodulator circuitry, but make a picture-tube substitution test. If you have a color picture-tube test jig available, considerable time can be saved. In many cases a picture-tube tester will indicate the defect.

Next, let us analyze the chroma-demodulator system depicted in Fig. 6-16. Here, each of the color-difference signals is demodulated by a separate circuit. If one of the primary colors is incorrect, waveform checks (Fig. 6-8) may indicate a defect in one of the demodulator circuits. Possible causes of this symptom are:

a. Defective coupling capacitor to a suppressor grid (C1 or C2).
b. Defective screen-bypass capacitor.
c. Mistuned or defective 3.58-mc coil (L1 or L2)
d. Poor contact of demodulator tube pins to socket terminals.
e. Control-grid resistor greatly increased in value.
f. Screen-grid resistor increased in value or burned.

Signal-tracing tests with a wide-band oscilloscope and low-capacity probe are the most informative of the preliminary checks. Distorted or attenuated waveforms will clearly show the particular circuit that it at fault. Then, d-c voltage and resistance measurements will usually pinpoint the defective component. Don't overlook the possibility of poor contact of tube pins, defective terminals and broken leads.

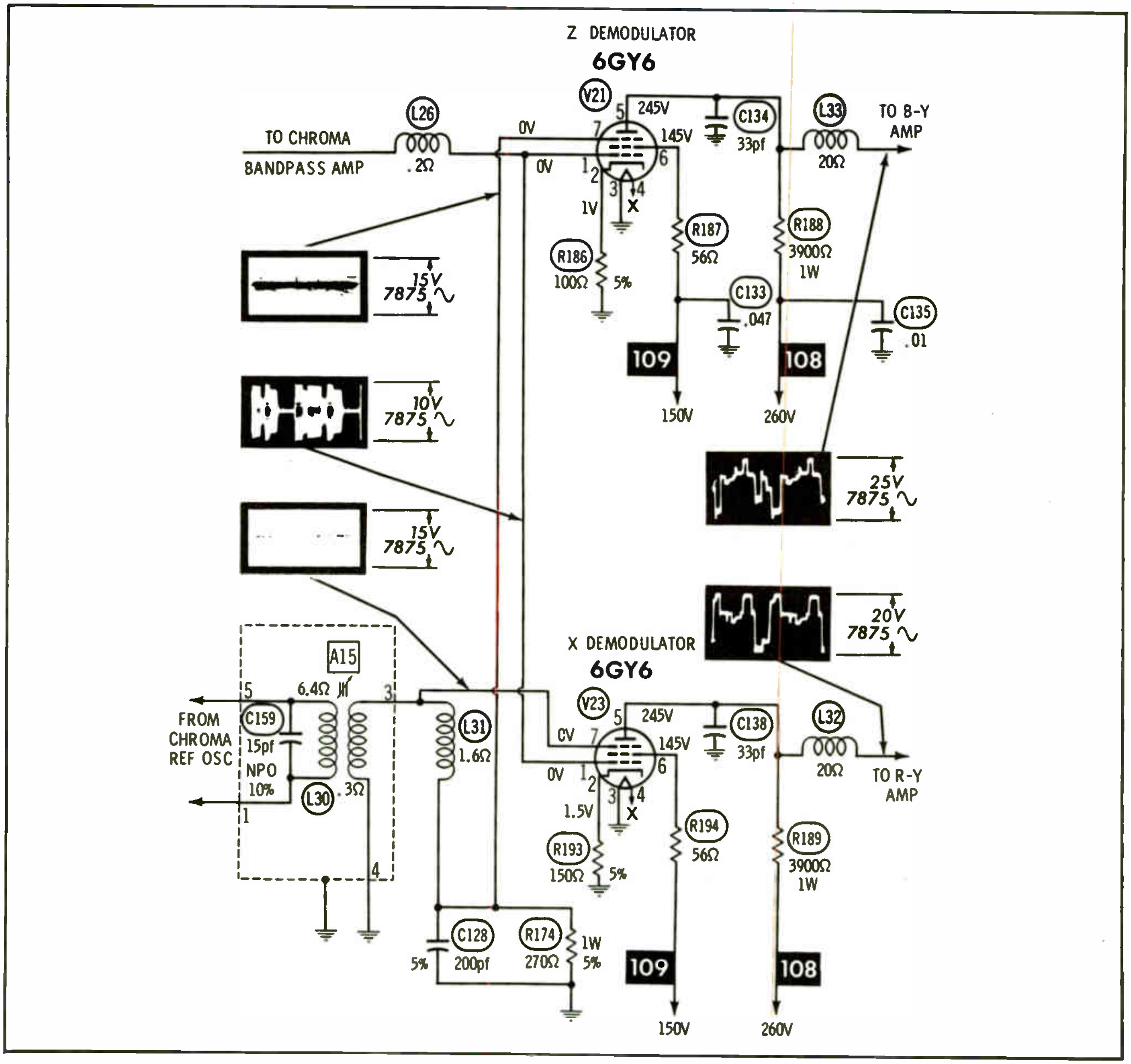


Fig. 6-15. X and Z demodulator.

4. Hues Correct, but Relative Intensities Are Incorrect

This symptom can be caused by more than one type of defect. For example, in Fig. 6-17 a change in the value of load resistance is the most likely cause. Localization is sometimes possible from an assessment of the picture symptoms. If red hues are weak, the plate-resistors in the R−Y demodulator circuit should be checked at the outset. A more accurate analysis and evaluation is made by observing the relative signal levels in the demodulator circuits. These output levels should be checked against those indicated in the same literature. A weak R−Y signal output, can be caused by a leaky plate-bypass capacitor, which reduces the plate voltage on the R−Y demodulator tube. A leaky capacitor in this location affects the color intensity but does not appreciably change the hue.

Localization is less clear-cut in the case of X and Z demodulator circuitry (Fig. 6-15). The reason is that each demodulator contributes a certain amount of

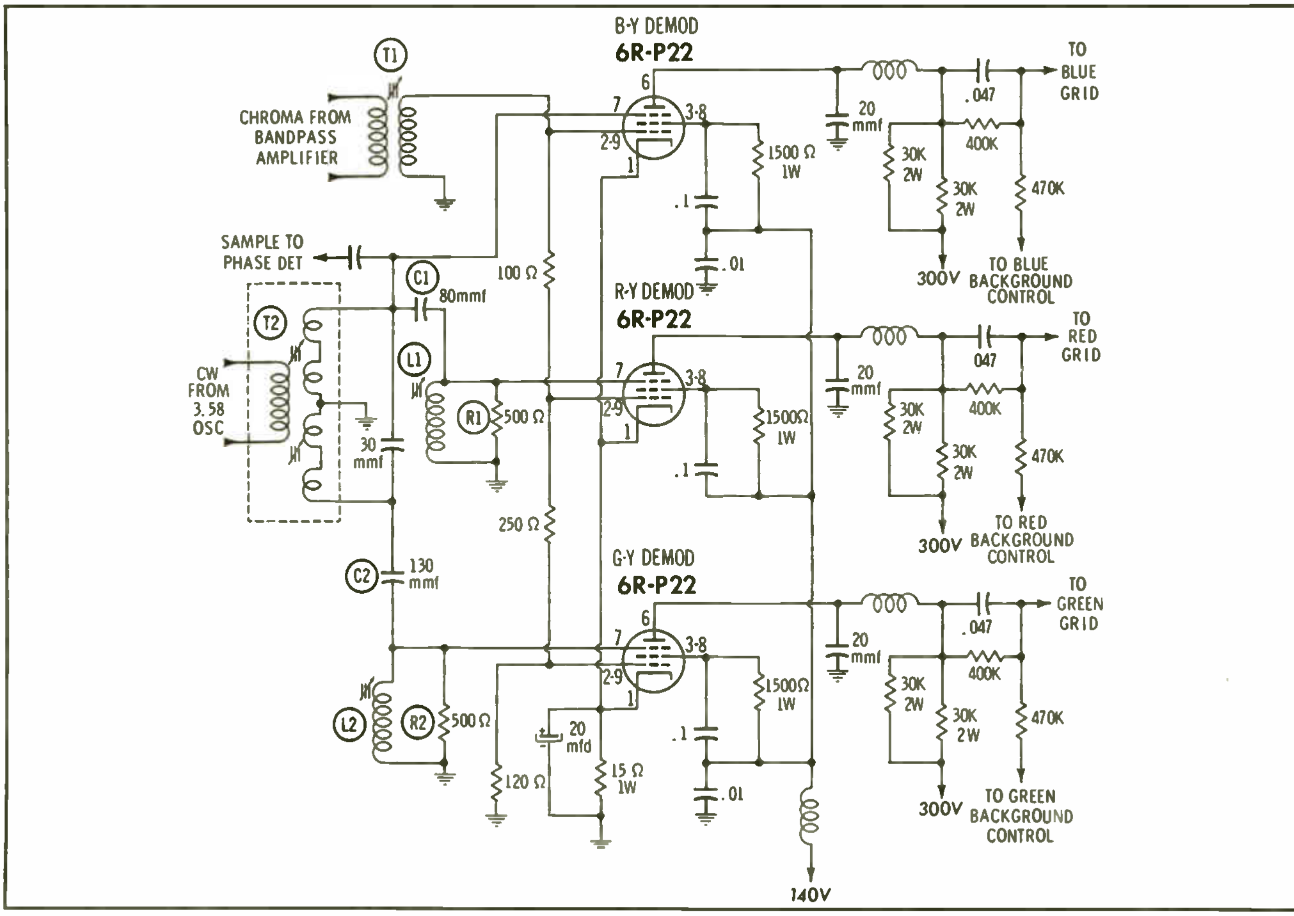


Fig. 6-16. Three separate chroma demodulators.

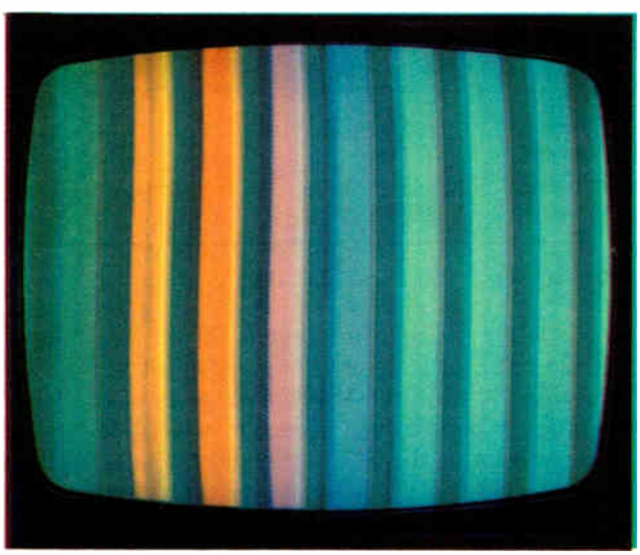


Fig. 6-17. Effect of a low-value load in the plate circuit of the G—Y amplifier.

signal to the reproduction of all three primary colors. However, definite clues can be obtained by chroma signal-tracing procedures. It is helpful to start at the chroma bandpass output, and observe waveforms progressively through the system to the picture-tube grids. The appearance of a distorted or attenuated waveform indicates trouble in that particular area. In most cases, there are numerous branch circuits which must be systematically checked out. However, d-c voltage and resistance measurements in the area will usually pinpoint the defective component. Tests in interacting circuits are necessarily more extensive and require more patience. In many instances a check of all components in a network may be necessary to locate a particular defect.

When three chroma demodulators are used, as in Fig. 6-16, their outputs are usually applied directly to the picture-tube grids. On the other hand, the X and Z demodulators in Fig. 6-16 are followed by three color-difference amplifiers. These amplifiers operate as matrices, and can be responsible for incorrect color intensities or hues. A good guidepost to keep in mind is this: If the trouble is located in the X and Z demodulator section, normal waveforms will not be found at the demodulator outputs. However, if X and Z demodulator outputs are normal, the trouble will be found in the color-amplifier section. Waveform analysis is one of the quickest methods of locating a defect in the demodulator portion of a color-television receiver.

5. One Hue Incorrect, Accompanied by Incorrect Relative Intensity

This symptom is often caused by a defective color-picture tube. Hence, the first step is to localize the trouble to the chassis or to the picture tube. You can make a picture-tube substitution test, or check the waveforms at the picture-tube grids. If the trouble is localized to the chroma circuitry, refer to the circuit diagram for the particular receiver, and check the waveforms against those in the service literature.

In most receivers the intensity of the beam for each primary color is controlled by d-c voltage applied to grid 1 of the picture tube (Fig. 6-16). The background control sets the grid bias, but the values of the resistors in the plates of the demodulators control both bias and signal-output level. A symptom of incorrect hue is usually accompanied by incorrect intensity when the trouble is located in the output portions of the demodulator or color-difference amplifiers.

An example of the effect on the screen of a low value of load resistor is shown in Fig. 6-17. In this picture the resistance of the load resistor in the G−Y amplifier is very low. This produces an increased bias on the picture-tube grid and causes the green gun to turn on. In most cases the degree of turn-on will be less because the resistor will probably not change to this degree.

Chapter 7

Chroma-Matrix Troubles

Certain colors can be obtained from suitable mixing of other colors. Remember that after the demodulation process, the 3.58-mc signal is filtered out, and the signal is in effect a d-c level change that represents one of the colors in the spectrum. Those colors generally used are X, Z, R−Y, B−Y, and G−Y. These colors can be designated as having a phase relation to the burst only while the signal is a component of the 3.58-mc subcarrier.

In this discussion, the line R−Y refers to a d-c signal that will be applied to the grid of the picture tube. The length of the vector represents the d-c value, and the position around the center represents the color. The burst in such a vector representation is a yellow-green color, not a 3.58-mc signal. The vector position represents a color, and the vector length represents the intensity of this color. For example, Fig. 7-1 shows how G−Y has components on the R−Y and B−Y axes. Practically, this means that G−Y signals can be obtained by combining suitable proportions of −(R−Y) and −(G−Y) signals to obtain the B−Y signal. This method is used in some receivers.

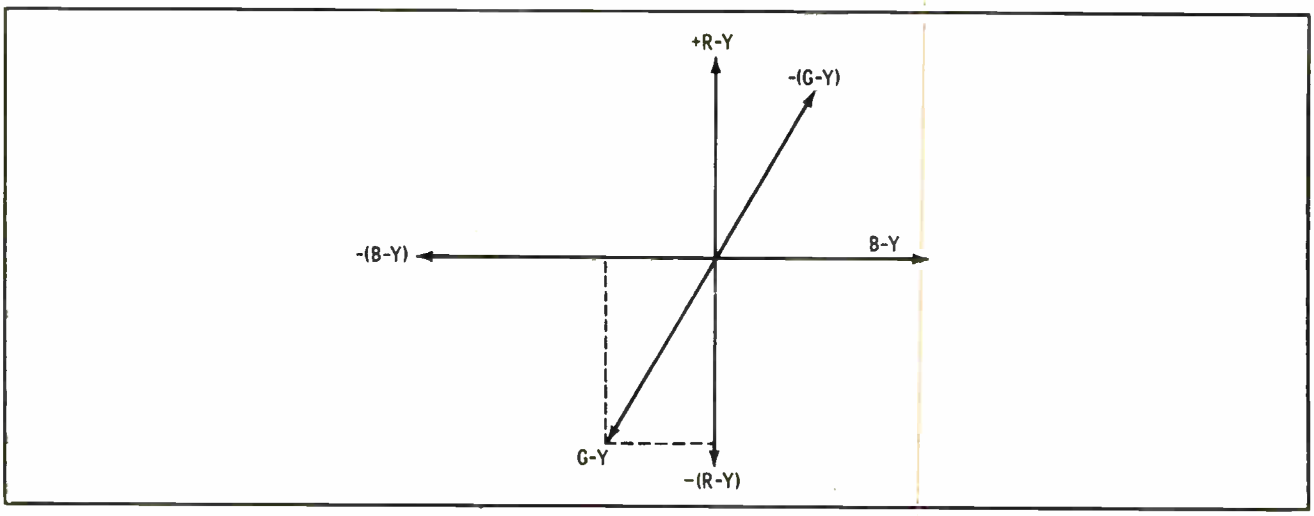


Fig. 7-1. Vector addition of −(B−Y) and −(R−Y).

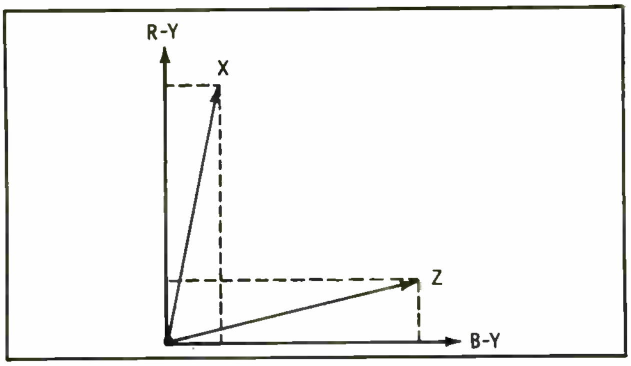


Fig. 7-2. Vector addition of R−Y and B−Y produced X and Z signals.

However, the most prevalent type of matrix is probably the arrangement which uses X and Z signals to form R−Y, B−Y, and G−Y signals.

Fig. 7-2 shows how X and Z signals have R−Y and B−Y components. We can obtain R−Y and B−Y signals by mixing X and Z signals in proper proportions. We can also obtain a G−Y signal by mixing suitable amounts of negative R−Y and negative B−Y signals, as depicted in Fig. 7-1. The basic circuitry for this action is shown in Fig. 7-3. Note that the X chroma signal is fed to the grid of V23B. The Z chroma signal is fed to the grid of V234A. Cathodes of both tubes are tied to the cathode of V20B. Hence, the signals mix in the 560-ohm common-cathode resistor. In turn, plate signals at V23A, V23B, and V20B are B−Y, R−Y, and G−Y signals, respectively. Some of the common trouble symptoms in various matrix circuits are:

1. No red hues reproduced.
2. No blue hues reproduced.
3. No green hues reproduced.
4. Two primary colors have incorrect hues.
5. Hues correct, but relative intensities are incorrect.
6. One or more hues incorrect, with incorrect relative intensities.

These difficulties can also be caused by a defective picture tube. Hence, it is necessary to make localization tests at the outset. If you have a color picture-tube jig available, it is easy to make a substitution test. Otherwise, check the signals at the picture-tube grids with an oscilloscope.

GENERAL DISCUSSION

Lack of one or more primary colors in bar patterns is a useful clue that can be evaluated with respect to the particular circuitry of a receiver. Fig. 7-4 illustrates this general principle. For example, no red reproduction appears in Fig. 7-4A. However, green is reproduced at the right and left edges of the pattern. This symptom indicates no output from the X demodulator. Why is there output from the G−Y amplifier? It is because the G−Y amplifier is driven in part from the Z demodulator. No blue reproduction appears in Fig. 7-4B. However, green is apparent on the right-hand side of the pattern. This symptom indicates that there is no output from the Z demodulator. However, there is output from the G−Y amplifier, because the matrix is driven in part from the X demodulator. Suppose the signal is stopped in the G−Y amplifier; then, we will see no green hues reproduced in the bar pattern as shown in Fig. 7-5.

We often find that matrix defects are accompanied by a disturbance of the grid bias at the color picture tube. In turn, the entire screen appears tinted in one of the primary colors. For example, observe the G−Y amplifier circuit in Fig. 7-3. This is a matrix tube, and its plate output is d-c coupled to the green grid of the picture tube. Any defect in the matrix circuit that changes the d-c voltage at the plate of V20B causes the entire screen to become tinted either green or magenta. If the d-c plate voltage is too high, the picture-tube screen becomes green (Fig. 6-17). On the other hand, if the d-c plate voltage is too low, the screen becomes magenta (the complement of green). There are certain types of matrix defects which do not change the grid bias at the picture tube, but which stop the chroma signal. For example, if the 0.01-mfd grid-coupling capacitor to V20B in Fig. 7-3 is open, only the chroma signal is affected—there will be little or no green reproduced in the bar pattern (Fig. 7-5).

Let us analyze the circuit action that occurs when tube V20B has an open grid-coupling capacitor. V20B (Fig. 7-3) is cathode-driven. In other words, signal is applied to the cathode from the 560-ohm common-cathode resistor. It might be assumed that an open grid-coupling capacitor would have no effect on this signal. However, since the grid is no longer clamped to a reference level, the chroma-driving circuit is actually open. In effect, the G−Y amplifier will have no signal-voltage drop produced between grid and cathode —the grid will rise and fall in potential along with the cathode and result in no green signal output (Fig. 7-5). The grid of the G−Y amplifier must have an a-c ground reference to operate. This is a grounded grid stage.

Note that the a-c ground return from the grid of V20B (Fig. 7-3) is made to the B+ line, instead of chassis ground. This might seem to be a curious arrangement; however, there is a very practical reason for this. As the chroma signals rise and fall at the plates

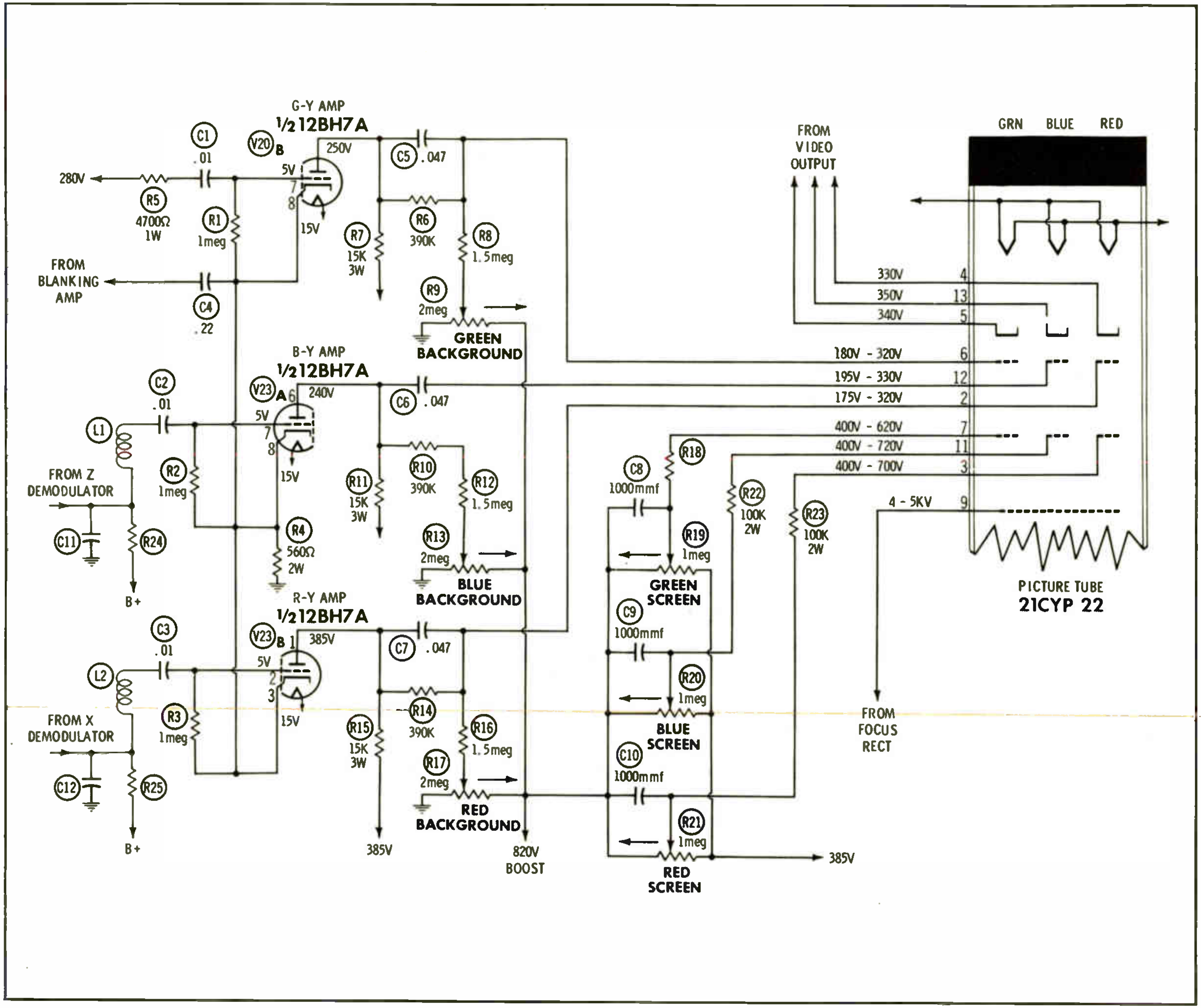
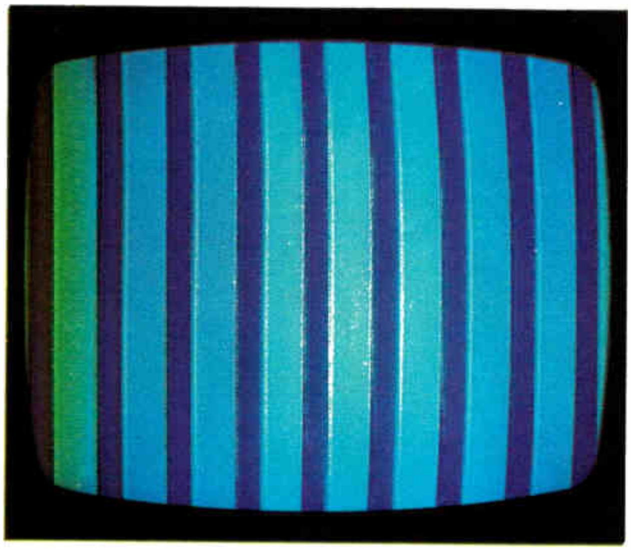
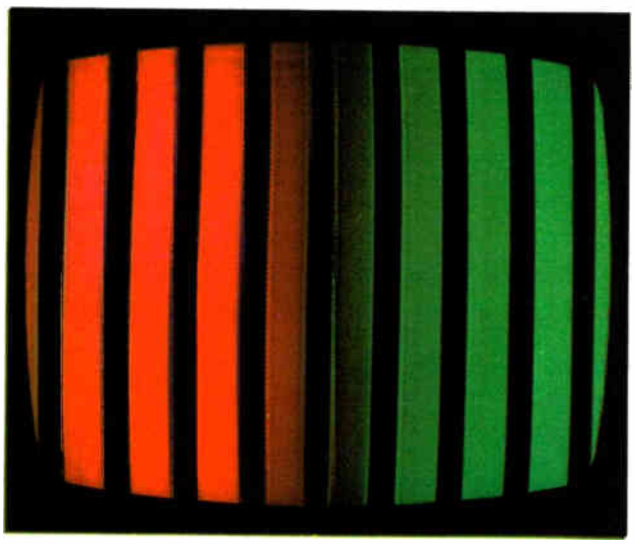


Fig. 7-3. Basic X and Z matrix.



(A) Loss of X signal.



(B) Loss of Z signal.

Fig. 7-4. Effect caused by loss of color signal at the output of the X and Z demodulators.

of the chroma demodulators, more or less current demand is imposed on the B+ line. In turn, there is a small change produced in the ripple waveform on the B+ line. Since only V23A and V23B are driven by the chroma demodulators, system balance with respect to ripple is improved by returning the grid of V20B to the B+ line.

Although the B−Y matrix system is not used as extensively, you will find the configuration of Fig. 7-6 in some color receivers. The B−Y amplifier uses the R−Y and G−Y signals from the output of the chroma demodulators to form the B−Y signal. In spite of the different circuit arrangement used, the end result is

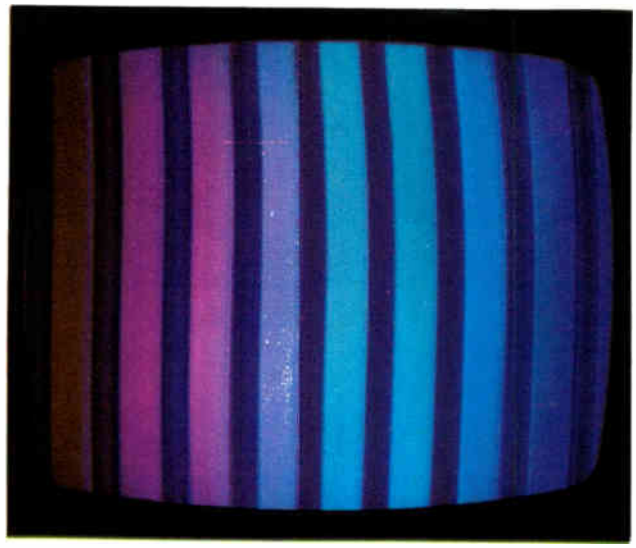


Fig. 7-5. Wrong colors produced when the coupling capacitor to the grid of the G−Y amplifier is open.

exactly the same as for any other matrix system. If there is no signal output from the B−Y matrix, there are no blue hues reproduced in a bar pattern (Fig. 7-4B).

GENERAL TROUBLESHOOTING PROCEDURE

A clear-cut interpretation of color-picture symptoms may or may not be possible wtih respect to matrix defects. As an example of a clear-cut symptom, consider the color-bar pattern illustrated in Fig. 7-7. Poor color fit is apparent, particularly at the leading edge of the red bar, and at the trailing edge of the magenta bar. Observe the matrixing circuitry depicted in Fig. 7-3. In case the .047 coupling capacitor from pin 6 of V23 to the picture tubes grid becomes open, the signal must pass through the 390K resistor to the grid of the picture tube. Since the grid has an input capacitance, an effective integrating circuit is formed. In turn, the bar signal, which is basically a square-wave signal, becomes distorted and results in a poorly defined and smeared blue color.

One of the most useful preliminary tests is to observe the waveforms at the outputs of the R−Y, B−Y, and G−Y channels, as depicted in Fig. 7-8. However, you may have difficulty sometimes in *counting bars*. The reason for this is that a blanking pulse is normally present at the beginning and end of the waveforms. In some receivers, the blanking pulse is sufficiently wide that either the first bar or the last bar, or both, are partially obscured. When you are in doubt concerning bar identification, use one of the following procedures to clarify waveform evaluation:

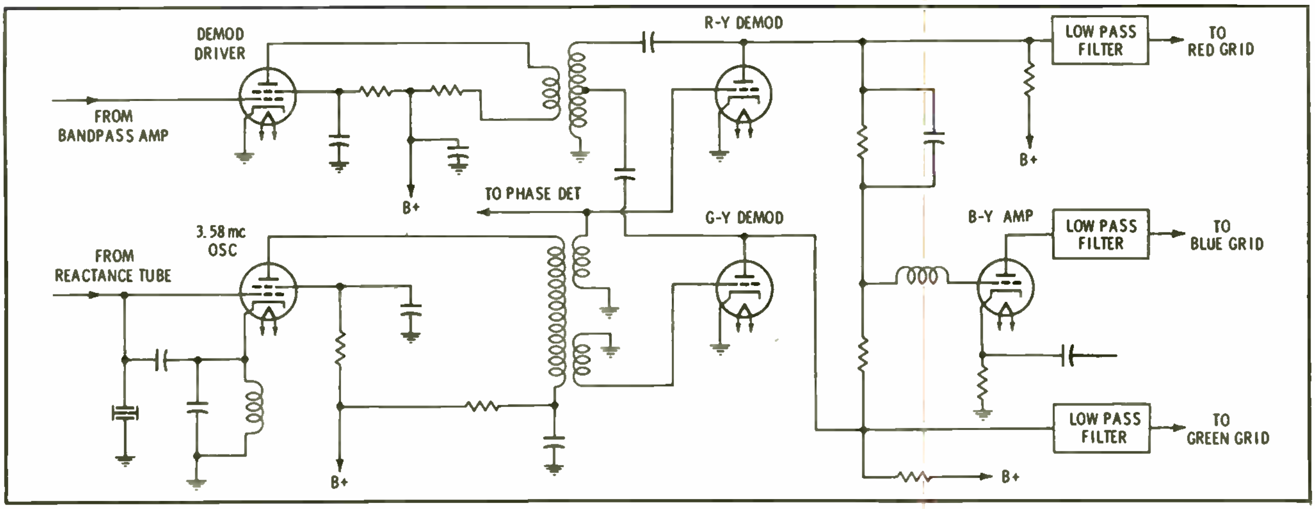


Fig. 7-6. Basic circuitry for a B–Y matrix.

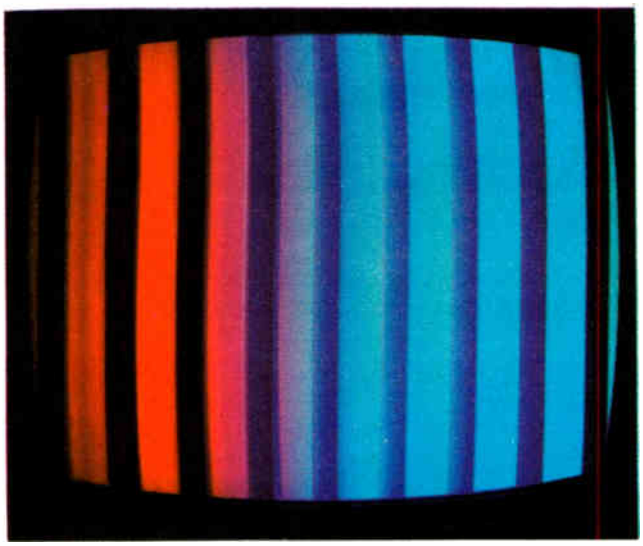
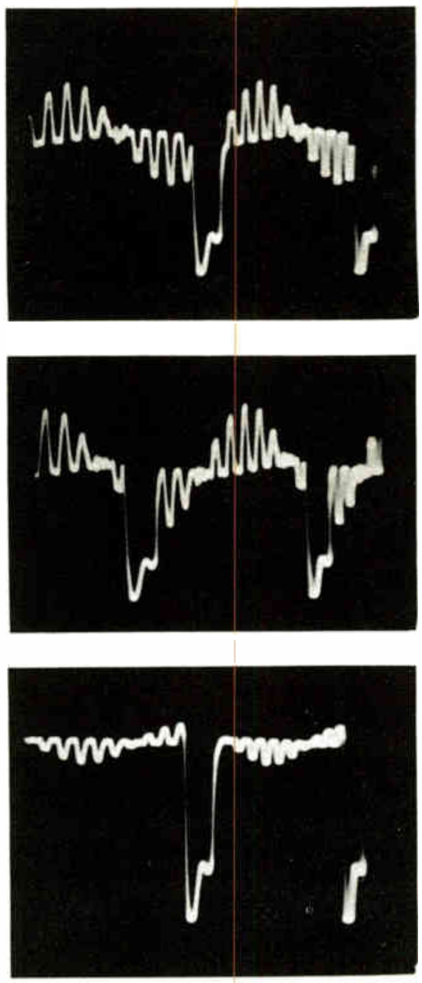


Fig. 7-7. Poor color fit and smear occurring in the bars containing blue color.

1. Rock the horizontal-hold control back and forth, while watching the ends of the pattern. This moves the waveform horizontally between the blanking pulses.
2. Temporarily disable the retrace-blanking circuit. When the blanking pulse is "killed," all ten pulses in the waveform become clearly visible.
3. Use R–Y, B–Y, or G–Y/90° signals from an NTSC generator.

These patterns have a maximum of two bars which permits easy identification of the desired signals.

Just as an R–Y circuit normally nulls on a B–Y signal, and a B–Y/90° signal. A G–Y/90° signal



(A) R–Y signal.

(B) B–Y signal.

(C) G–Y signal.

Fig. 7-8. Normal keyed-rainbow signals from R–Y, B–Y, and G–Y circuits.

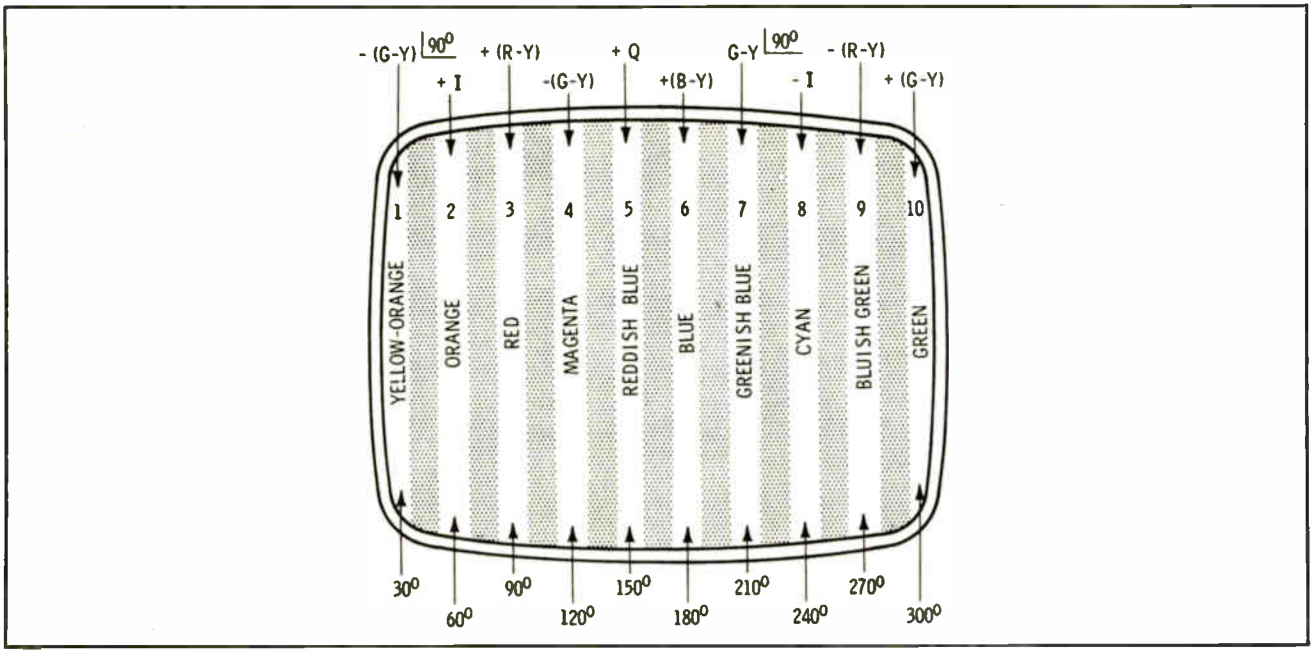


Fig. 7-9. G−Y/90° and −(G−Y)/90° in a rainbow pattern.

is in quadrature to the G−Y phase. Note that a keyed-rainbow signal has both G−Y/90° and −(G−Y)/90° phases, which correspond to the first and seventh bars, as shown in Fig. 7-9. Note that bars 1 and 7 in Fig. 7-8C normally display nulls.

COMMON SYMPTOMS

1. No Red Hues Reproduced

When no red hues are reproduced, and the picture-tube screen is not tinted we know that the R−Y signal is being stopped in such a manner that the d-c distribution is not affected (Fig. 7-11). C3 falls under immediate suspicion in this arrangement. When C3 is open, there is no R−Y input to the matrix. Since pin 5 V23B is returned to cathode via R3, the d-c distribution in the matrix circuit remains unchanged. In this situation, a scope test will show practically no signal at the grid of V23B. There are several possible causes of this symptom:

a. Open grid-coupling capacitor (C916 in Fig. 7-10), (C3 in Fig. 7-3).
b. Open peaking coil (L902 in Fig. 7-10), (L2 in Fig. 7-3).
c. Burned plate-load resistor (R926 in Fig. 7-10), (R25 in Fig. 7-3).
d. Shorted plate capacitor (C915 in Fig. 7-10), (C12 in Fig. 7-3).
e. Break in printed-circuit conductor, or cold-soldered connection to any of the components noted above.

Possible causes of no red-hue reproduction, accompanied by tinting of the picture-tube screen are:

a. Burned plate-load resistor, such as R220 in Fig. 7-12. The red gun is biased off. Only green and blue hues are reproduced.
b. Leaky capacitor, such as C216 in Fig. 7-12. The demodulated R−Y signal will be shorted to ground. Since the grid of V27A seldom operates at zero volts, the defect causes screen tinting; the tint may be either red or cyan.
c. Defective resistor, such as R265 in Fig. 7-12. If the resistor increases in value, V27A operates with a positive grid bias. The red gun is biased off.
d. Leaky capacitor, such as C208 in Fig. 7-12. This defect causes V27A to operate with a positive grid bias. The red gun is biased off.

2. No Blue Hues Reproduced

This trouble symptom may be accompanied by an untinted screen. On the other hand, off-value resistors or leaky capacitors can cause screen tinting in addition to "killing" reproduction of blue hues. In the circuit of Fig. 7-10, lack of blue reproduction is never accompanied by an untinted screen. Note that the matrix tube

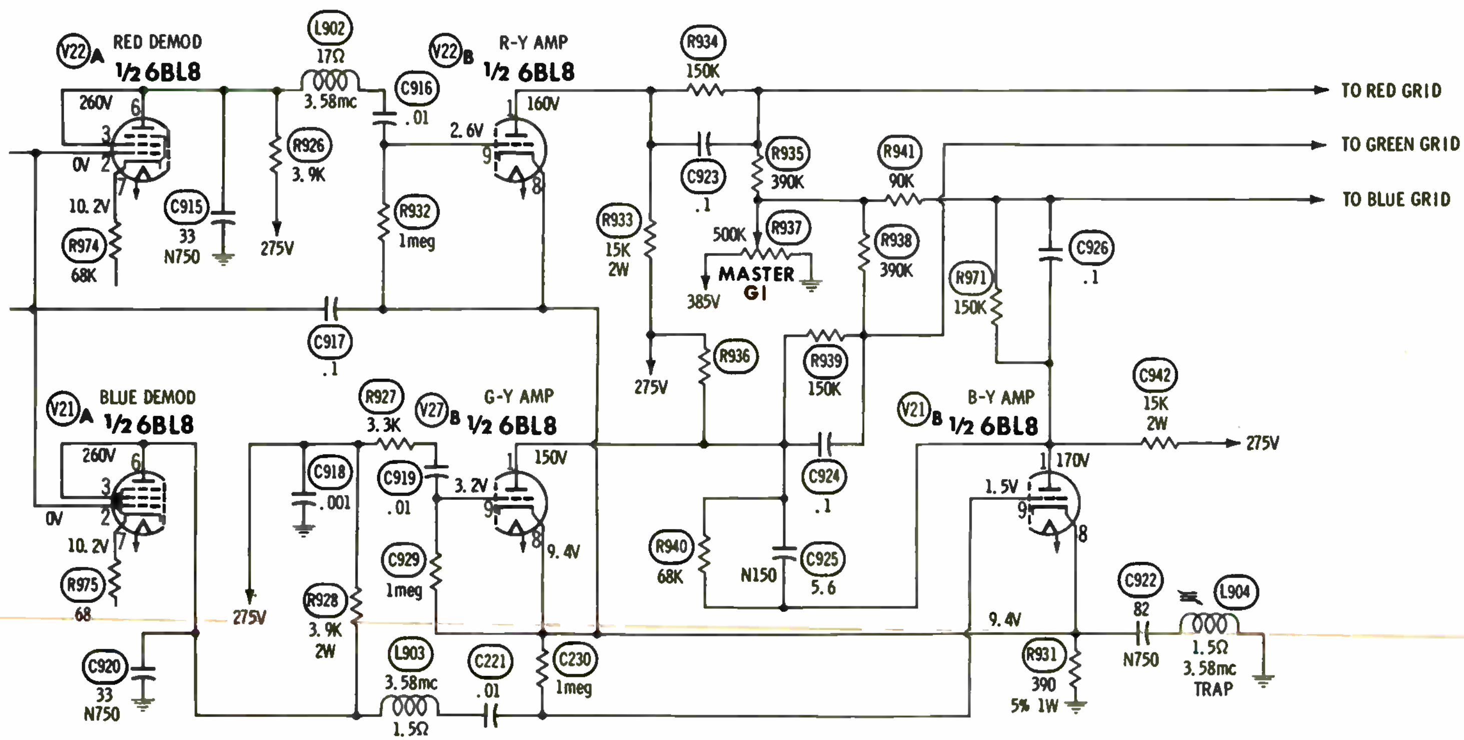


Fig. 7-10. Demodulators and color-difference amplifiers.

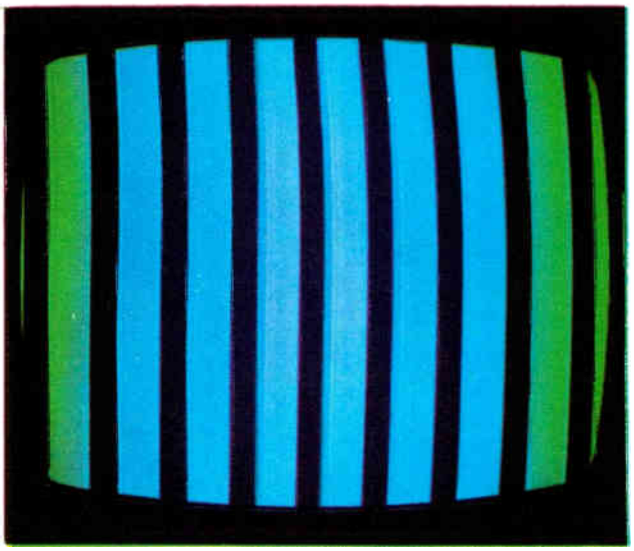


Fig. 7-11. Open coupling capacitor to the R–Y amplifier.

V21B is driven at both grid and cathode. In turn, reproduction blue hues occur if either grid or cathode drive is present. But if a circuit defect stops the drive to both grid and cathode, no hues are reproduced.

In the circuit of Fig. 7-12, it is possible for the screen to remain untinted, with lack of blue-hue reproduction. For example, if coupling capacitor C211 becomes open, no subcarrier voltage is fed to the B–Y channel. However, output continues from the R–Y channel. This output also drives the G–Y matrix. Accordingly, signals are applied only to the red and green guns in the color picture tube. Since the d-c distribution is unaffected when C211 is open, the screen remains untinted.

Lack of blue-hue reproduction when the screen of the color picture tube is tinted has the same type of causes as noted under (1). For example, a burned plate-load resistor, such as R221 in Fig. 7-12 biases off the blue gun. This stops reproduction of blue hues, and causes the picture-tube screen to become tinted yellow. Leakage or a short-circuit in C215 produces the same picture symptom, except that screen tinting may be either yellow or blue.

3. No Green Hues Reproduced

When no green hues are reproduced, but red and blue hues are displayed in a bar pattern, the signal is being stopped in the G–Y channel. This symptom is observed in circuits such as depicted in Fig. 7-6. If the plate coupling capacitor opens, there is no signal output from the G–Y tube. Since the B–Y matrix still obtains dive from the R–Y tube, we observe red and blue hues in the pattern. D-c distribution is unaffected by the open capacitor in the matrix system, and hence the picture-tube screen is not tinted.

Remember that open capacitors can be pinpointed easily by signal-tracing tests with an oscilloscope. There is no point in making d-c voltage measurements when this type of picture symptom occurs, because lack of screen tinting indicates that the d-c voltages will be correct throughout the matrix system. Of course, a capacitor which seems to be open might be good, because of a break in a printed circuit conductor.

4. Two Primary Colors Have Incorrect Hues

This symptom, in the absence of screen tinting, must be evaluated with respect to the matrix circuitry of the particular receiver. We know that the possibility of off-value resistors can be dismissed, because the d-c distribution is normal. Open grid-coupling capacitors in configurations such as shown in Fig. 7-10 are immediate suspects, because R–Y, and B–Y, and G–Y tubes have a common cathode coupling. In turn, an open coupling capacitor affects all three primary colors. When the hue control is adjusted to make one color correct, the other two colors are then displayed with incorrect hues.

In case capacitors are not the cause of the symptom, the associated circuitry becomes suspect. For example, if T204 in Fig. 7-12 has been mistuned, incorrect signals will be fed into the matrix. In rare cases, a transformer winding becomes defective. This trouble is evidenced by inability to align the circuit correctly for waveforms as shown in Fig. 7-8. Remember that coil trouble is suspected last—be sure that a defective capacitor, or resistor has not been overlooked before you replace a transformer.

5. Hues Correct, but Relative Intensities Are Incorrect

Since this symptom is often caused by a defective color picture tube, this possibility should be eliminated before looking for a defective component in the matrix circuitry. If the picture tube is not at fault, the most likely cause of this symptom is an open capacitor that decreases the gain of the matrix tube. For example, consider the circuit in Fig. 7-11. When C218B is open, the cathode circuit becomes degenerative. In turn, the output from V23B is weakened. Reproduction of green hues is much weaker than reproduction of red and blue hues. The screen of the picture tube is not tinted, inasmuch as the d-c distribution remains unchanged.

Considerable time can be saved in troubleshooting matrix circuits if the function of each capacitor is observed before it is tested. For example, a capacitor such as C221 in Fig. 7-12 has practically no effect on gain. If open, it does not affect the intensities of the repro-

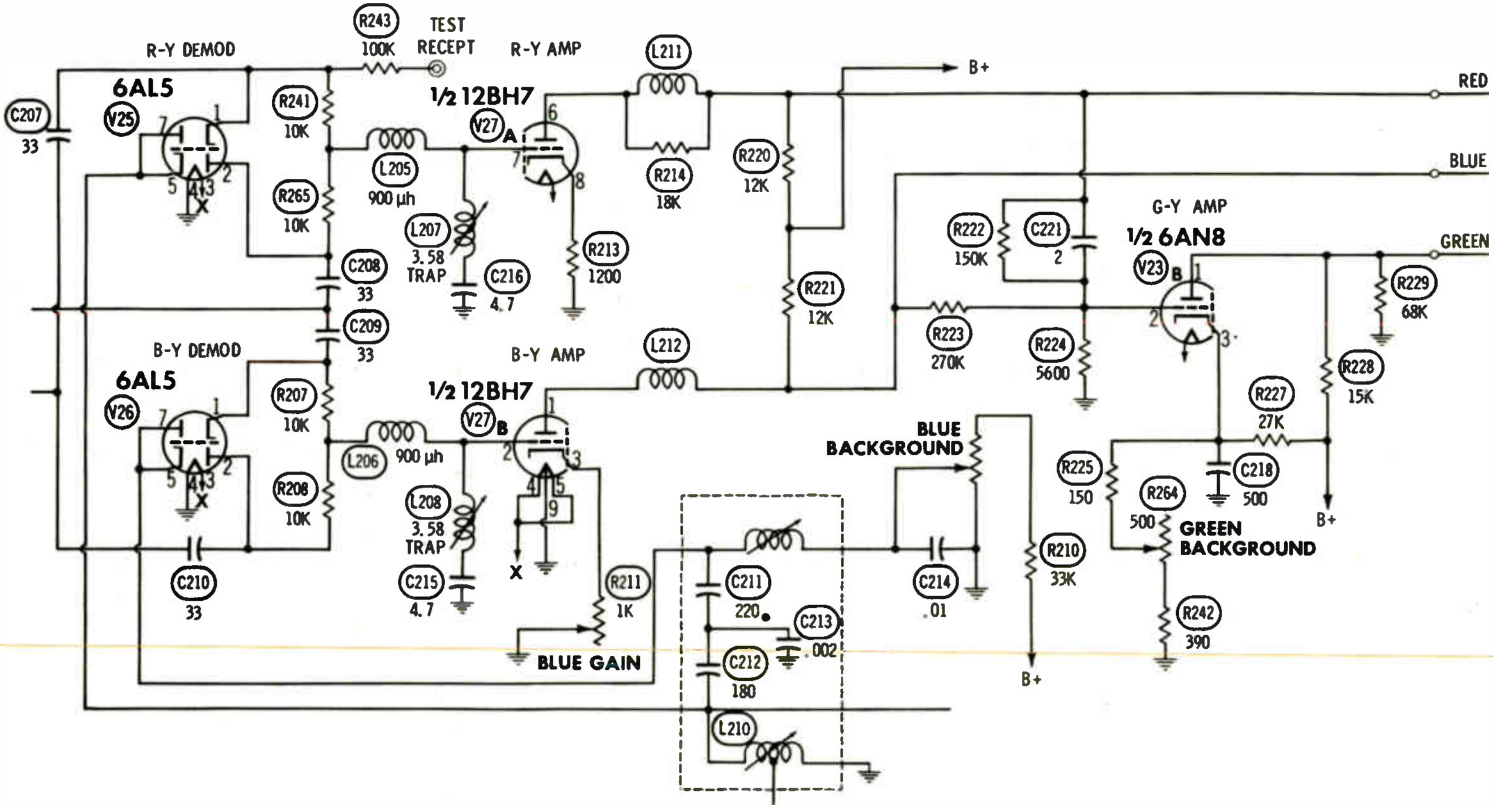


Fig. 7-12. Diode demodulators and color-difference amplifiers.

duced hues. The only symptom is a small error in color fit. Again, capacitors such as C215 or C216 have no effect on gain, and hence do not affect the intensities of hues. If one of these capacitors should be open, you will merely see a 3.58-mc dot pattern in the picture. The dot structure looks similar to "sound grain," except that it is coarser. No effect is produced by turning the slug in the coil.

6. One or More Hues Incorrect, With Incorrect Relative Intensities

This is a combination symptom that must be evaluated with respect to the circuitry used in the particular receiver. Since it can also be caused by a defective picture tube, good practice requires that this possibility be determined at the beginning. Do not suspect off-value resistors unless the screen is tinted. Combination symptoms are common in X and Z matrix systems, such as shown in Fig. 7-3. For example, if grid-coupling capacitor C2 to V23A is defective and has only a small stray capacitance left, the output from the B−Y amplifier is greatly weakened. In turn, the output from the G−Y amplifier is also weakened. The green hue becomes incorrect also, due to the attenuated B−Y component.

You may find that the trouble is due to an open capacitor in the associated circuitry. For example, if C207 is open in Fig. 7-12, the R−Y output is weakened and distorted. In turn, the output from the matrix tube V23B is also weakened and distorted. The most helpful instrument in this type of trouble localization is the oscilloscope. Check back step-by-step until you find correct waveforms as depicted in Fig. 7-8. Then, look for an open capacitor in the circuit which follows.

A relatively easy check for the R−Y, B−Y and G−Y output can be made reviewing the screen with tube of the guns turned off. A rainbow-pattern generator is connected to the receiver and each primary color, red, blue, and green is observed for proper phase.

The grids of the color picture tube can be connected to ground through a 100K resistor. The procedure used to check for a correct pattern is as follows:

Red Bars—Ground the green and blue color-picture tube grids. This will present a completely red screen as shown in Fig. 7-13. The sixth bar should have approximately the same brightness level as the background. The brightness should be turned up slightly so

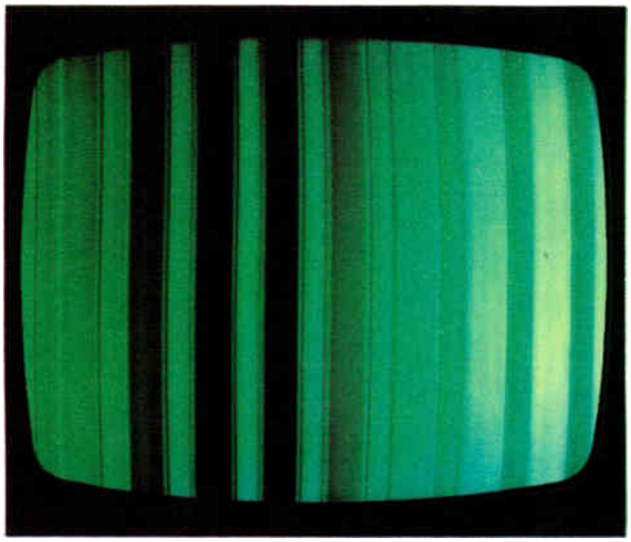


Fig. 7-14. Correct pattern with first and seventh bars nulled.

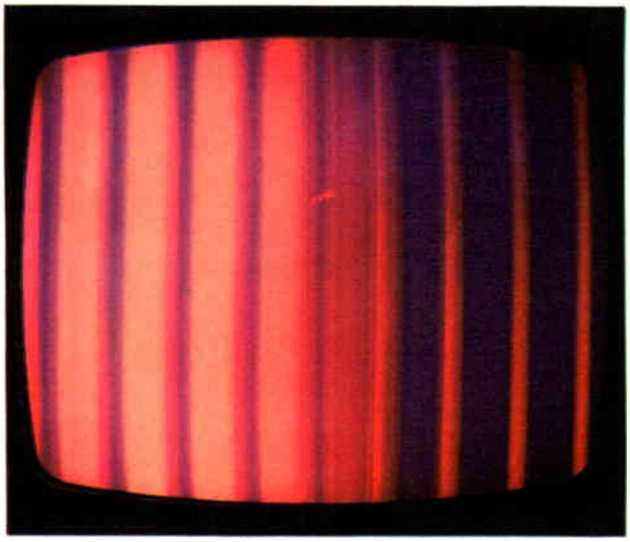


Fig. 7-13. Correct pattern with the sixth bar nulled.

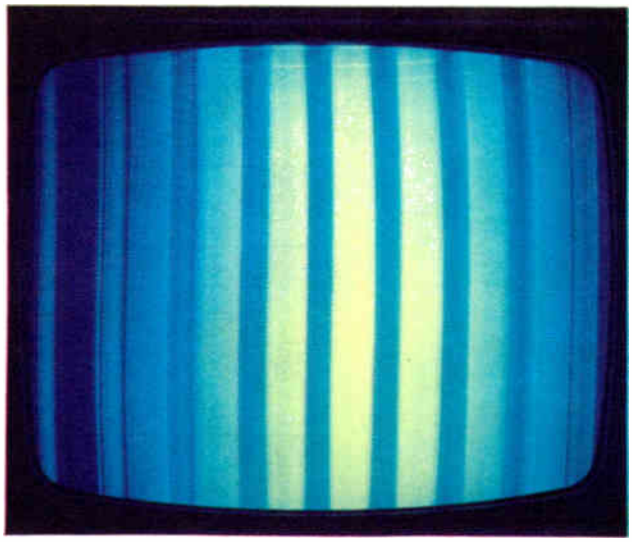


Fig. 7-15. Correct pattern with third and ninth bars nulled.

that the background is colored instead of black. This will aid in matching the color of the bar to the color of the background. The tint control should be near the center of its range for this condition. The tint control can be checked for control range by observing the amount of shift in the pattern. The tint control should provide about 30 degrees each side of normal. Set the tint control for a normal pattern and do not change its position for the green and blue pattern checks.

Green Bars—Remove the 100K resistor from the green grid and connect it to the red grid. The green pattern shown in 7-14 should appear on the screen. The first and the seventh bars should match the background. A null pattern is not quite as prominent for the green screen due to the reduced amplitude of the G−Y signal (see Fig. 7-8C).

Blue Bars—Disconnect the 100K resistor from the blue grid and connect it to the green grid. The pattern should appear as shown in Fig. 7-15. Bars three and nine have the same brightness as the background.

These three checks will indicate whether or not the demodulators or matrix are defective. If the nulls do not appear as shown in the pictures it is possible that an alignment of the color circuits will have to be performed.

Chapter 8

Convergence Troubles

The color-picture tube employs three electron guns arranged around the central axis in the neck of the tube. The three beams will not meet (converge) at the face of the tube because the face plate is relatively flat and the beams sweep in an arc. Fig. 8-1 shows the points of convergence in relation to the tube face. The beam is converged at the mask in the center of the tube, but at points "A" and "C," the beam converges before it reaches the aperture mask. A convergence system is required to prevent separation of the beams as they scan toward the edges of the screen. The primary purpose of the convergence adjustment is to cause the three electron beams to pass through the same hole in the aperture mask at any given instant during the scanning process.

Some common convergence-trouble systems are as follows:

1. One or more static convergence controls out of range.
2. One or more dynamic convergence controls out of range.
3. All controls have adequate ranges, but good convergence cannot be obtained.
4. Convergence adjustments drift or fluctuate.
5. Loss of convergence accompanied by additional trouble symptoms.

GENERAL DISCUSSION

In order to make the three electron beams pass through the same hole in the aperture mask at any given instant of scanning, a magnetic system for controlling the individual beams is provided in the color picture tube.

Since a color picture tube has three electron guns, a separate magnet assembly must be provided for each gun, as depicted in Fig. 8-2. The d-c convergence magnets are adjusted to make the three electron beams coincide at the center of the aperture mask; the spot size, or focus, is controlled by an electrostatic focus system. Note in Fig. 8-2 that each convergence unit

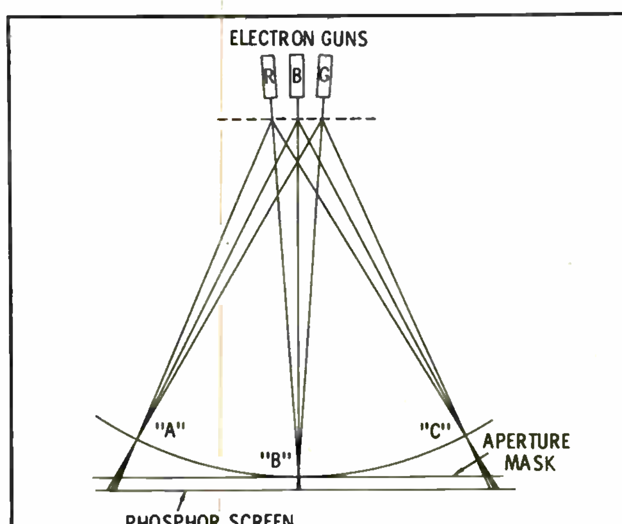


Fig. 8-1. Convergence of the three beams in relation to the distance from the mask.

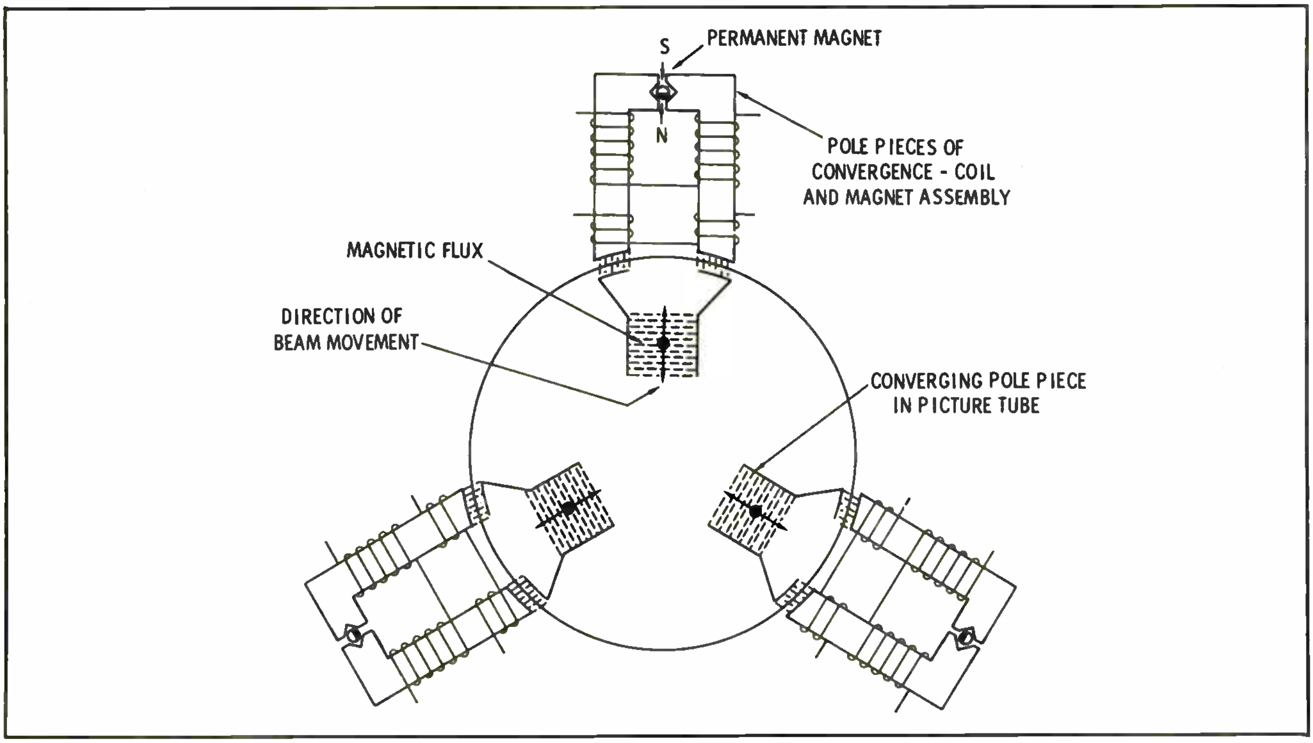


Fig. 8-2. Description and position of convergence assembly.

consists of a permanent magnet, an electromagnet, and two windings. Briefly, the permanent magnets are adjusted to converge the three electron beams at the center of the screen only (point B in Fig. 8-1). The current through the electromagnets is adjusted to converge the three beams at points away from the center of the screen (points A and C in Fig. 8-1).

As the scan approaches the edge of the screen, more current is required by the convergence-magnet winding. The distance from the electron guns to the aperture mask is greatest at the edges of the screen. Hence, a changing current must be present in the windings of the convergence coils. The three electron beams can be brought into convergence at any point on the aperture

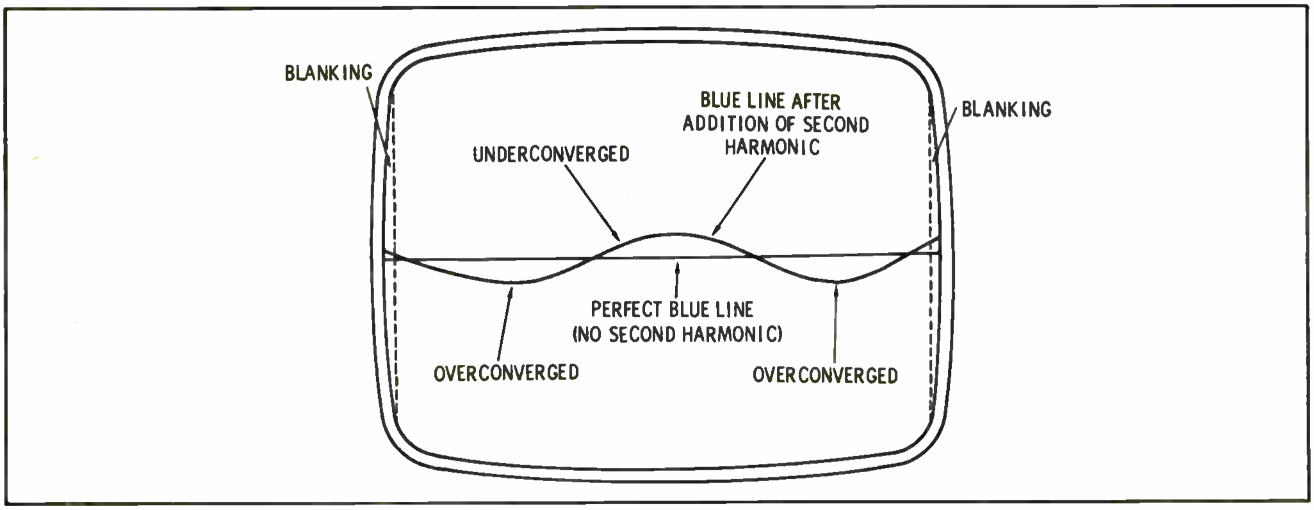


Fig. 8-3. The second harmonic as it may appear on a picture-tube screen.

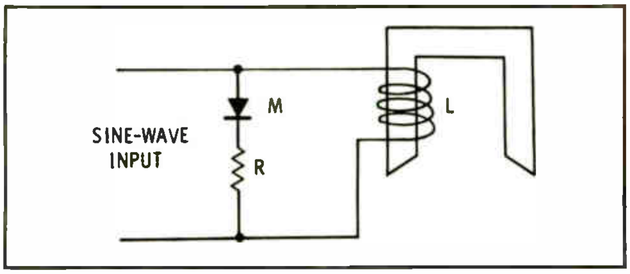


Fig. 8-4. One type of horizontal-convergence circuit.

mask if the current has a *parabolic* waveform.

Compensating for the difference in convergence from the center to the edges of the screen requires that a parabolic waveform be supplied to the convergence coils. The current for these coils is obtained from the sweep circuits in the form of pulse, sawtooth, and sine waveforms. These waveforms must be modified before they can be applied to the convergence magnets. Hence, many present-day receivers have waveshaping circuitry in the convergence section to produce parabolic waveforms. Two general methods of waveshaping have been employed. One method mixes a certain amount of second-harmonic current with a half sine current. This system is used in the horizontal phase of the second-harmonic component. It is adjusted so that its combination with the half sine wave gives a close approximation to a parabolic wave. Fig. 8-3 shows how the second harmonic becomes apparent in the sweep pattern when its amplitude is excessive.

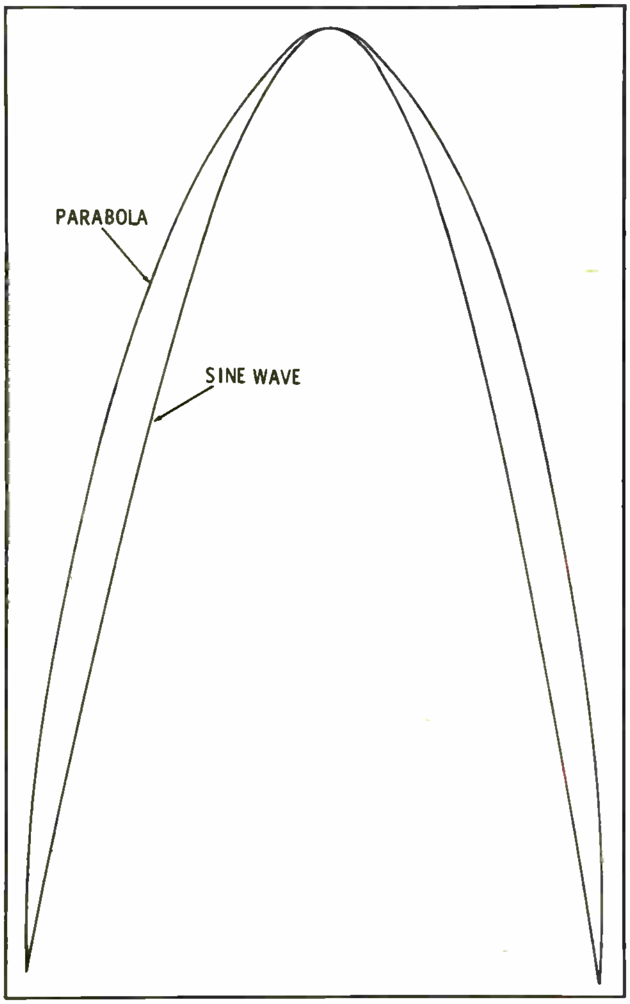


Fig. 8-5. Comparison between a sine and parabolic wave.

Another method employs semiconductor diodes in the wave-shaping circuitry. Fig. 8-4 depicts this type of circuit. The half-wave input flows partly through L and partly through M and R. We know that a diode has less resistance when more voltage is applied; in other words, the diode is a nonlinear resistance. As the applied voltage rises to its peak, more current is shunted through M and R. Hence, the sine wave depicted in Fig. 8-5 has its peak compressed. Then, when the amplitude is brought up to the original peak value, the modified sine wave approximates the outline of the parabola. The amount of wave-shaping action produced by M in Fig. 8-3 depends on the value of R. Typical color receivers use a value of 100 ohms for this resistor.

It is common practice to use a ringing circuit as the source of the sine-wave input in Fig. 8-4. The flyback pulse is coupled to a tuned circuit that is shock-excited; the circuit rings at its resonant frequency. One-half cycle of ringing occurs during one horizontal-deflection interval. Then, the flyback pulse is applied again to the LCR circuit, and the half cycle of ringing is repeated. The decay rate of the ringing waveform is unimportant, because the LCR circuit is pulsed at the end of each half cycle to produce a new cycle.

Next, let us briefly consider the vertical convergence circuitry. A simple circuit is shown in Fig. 8-6. A peaked-sawtooth waveform is fed into the vertical-tilt potentiometer from the vertical-output transformer. This sawtooth current exists in two circuits. The 100-ohm vertical-tilt potentiometer is center tapped, which permits the peaked-sawtooth waveform to be reversed in polarity, as well as adjusted in amplitude. We know that a peaked-sawtooth voltage causes a sawtooth current in an inductance-resistance circuit. Accordingly, a sawtooth current exists in the tilt coil.

The purpose of this sawtooth current is to tilt the associated line of color dots to make them line up vertically with the two other lines of color dots, as depicted in Fig. 8-7. In this example, we see that the line of blue dots can be tilted to the right or to the left, depending on the setting of the vertical-tilt control with

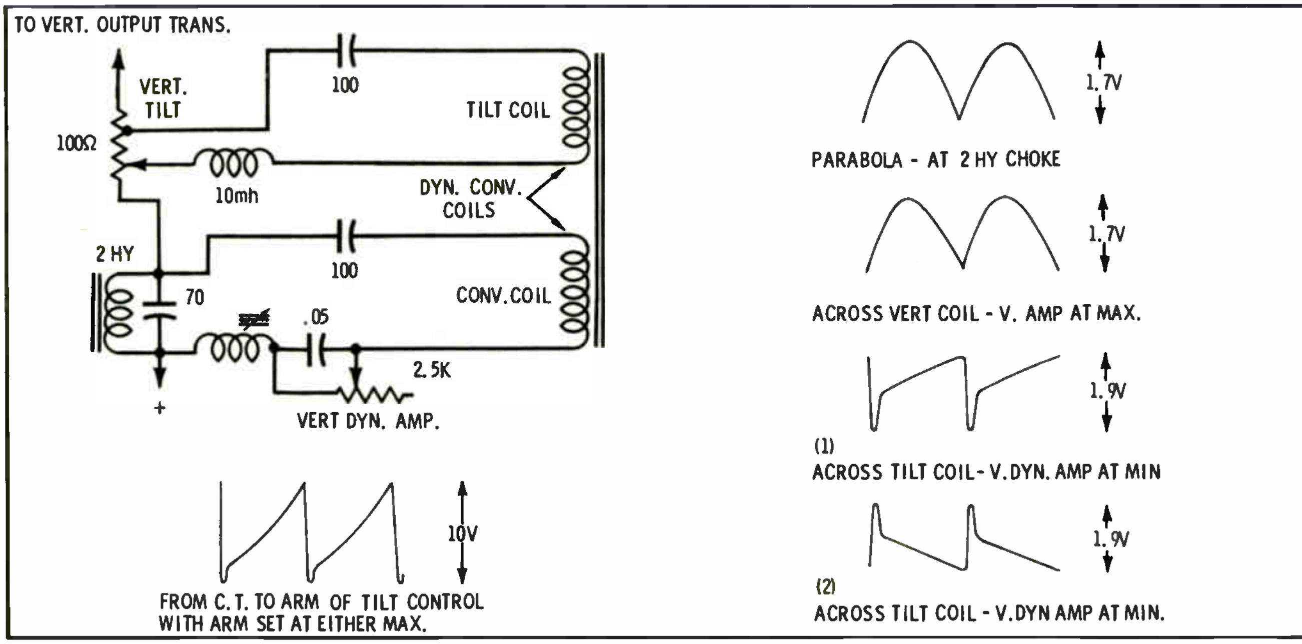


Fig. 8-6. Controls for vertical tilt and vertical amplitude.

respect to its center tap. The purpose of the 100-mmf capacitor and 10-mh choke in the vertical-tilt circuit is to shape the input peaked-sawtooth waveform into optimum form for driving a sawtooth current through the vertical-tilt coil.

The input peaked-sawtooth waveform is also fed to the LCR circuit, which includes the convergence coil in Fig. 8-6. This is a ringing circuit that is shock-excited by the rapid fall of the peaked-sawtooth wave. In turn, half sine waves of voltages are applied to the convergence coil. These half sine waves approximate a parabolic waveform, as was depicted in Fig. 8-5. The vertical dynamic-amplitude potentiometer adjusts the spacing of the blue color dots, vertically, so that they coincide with the red and green color dots.

As its name indicates, a vertical-dynamic-amplitude control adjusts the amplitude of the parabolic current flow through the convergence coil. The waveform rises to its peak as the scanning approaches the edges of the screen on the picture tube. Adjustment of the amplitude control changes the relative spacing of the color dots more at the screen edges than in the center. In the

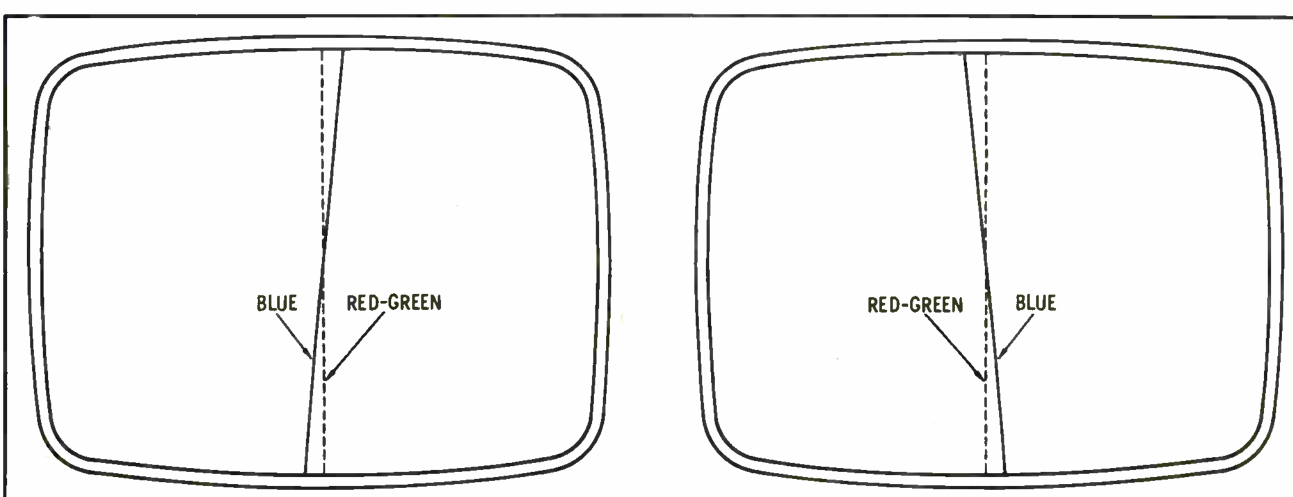


Fig. 8-7. Effect produced by blue-vertical-tilt adjustment.

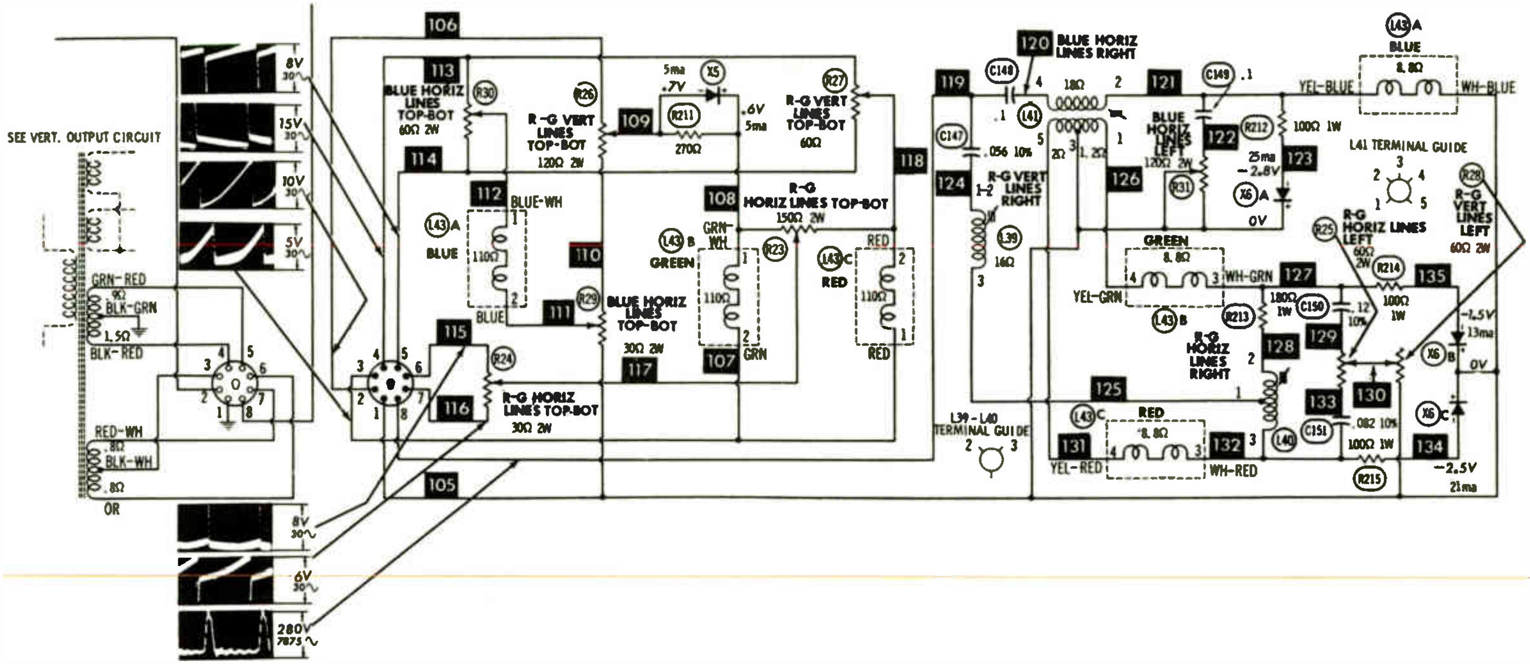


Fig. 8-8. Waveforms shown at the input to the convergence system.

practical procedure of converging the color dots, we keep adjusting the permanent magnets (Fig. 8-2) so that all three color dots coincide at the exact *center* of the screen. In effect, then, adjustment of the amplitude control brings the color dots at the *top and bottom* of the screen into convergence.

Color receivers generally have twelve dynamic-convergence controls. On the older receivers were independent controls, for adjustment of horizontal amplitude and horizontal tilt, and vertical amplitude and vertical tilt, at each of the three electron guns. The twelve dynamic controls on the late-model receivers also have been designed to adjust the blue amplitude and tilt independently. The red and green tilts and amplitudes are adjusted simultaneously. This arrangement somewhat simplifies the difficult chore of converging the color picture tube. On a late-model receiver, you will probably find the following dynamic controls:

1. Blue vertical amplitude.
2. Blue vertical tilt.
3. Red-green vertical amplitude.
4. Red-green vertical tilt.
5. Red-green vertical difference tilt No. 1.
6. Red-green vertical difference tilt No. 2.
7. Blue left horizontal.
8. Blue right horizontal.
9. Red-green left horizontal No. 1.
10. Red-green left horizontal No. 2.
11. Red-green left horizontal No. 3.
12. Red-green right horizontal.

Different manufacturers use somewhat different terminology for the same controls. Always refer to the service data for the particular receiver before attempting the convergence procedure. We are not concerned with the convergence procedure as such in this chapter. Instead, the functions which have been described are explained in relation to trouble symptoms that occur in the convergence system. These symptoms can be generally classified as relating to defects in the static-convergence section, or to defects in the dynamic-convergence section. In some cases, the defects may produce trouble symptoms in both static and dynamic sections.

GENERAL TROUBLESHOOTING PROCEDURE

When trouble symptoms occur, the most useful general approach is to check the waveforms at the input of the convergence network. Waveshapes and peak-to-peak voltages for a typical network are shown in Fig. 8-8. Technicians sometimes dismiss the possibility of trouble if a waveform has acceptable shape. However, it is equally important to check the peak-to-peak voltage of the waveform. If the waveform voltage is subnormal, associated controls will lack sufficient range. It might be supposed that a convergence waveform could be traced through the complete network with a scope. Unfortunately, this is not practical with ordinary service-type scopes. Most of the components (Fig. 8-8) operate above ground. Since most oscilloscopes have a single-ended input, floating components, such as convergence coils, present a somewhat difficult problem. Check the indicated points against the waveforms shown in the service literature.

When the driving waveforms are normal, the following tests should be made with a meter to pinpoint the defective component. An ohmmeter is the workhorse in this area. It is used to check potentiometers and fixed resistors, to measure the front-to-back ratio of semiconductor diodes, and to test coils for continuity. Unless a capacitor has high leakage or is short-circuited, it cannot be properly checked with an ohmmeter. A capacitor tester should be used, or a substitution test made. Although continuity checks of coils will show up open windings, incorrect inductance values elude service tests. A few shorted turns cannot be detected by means of an ohmmeter, even though the coil inductance is greatly reduced. Measure suspected coils on an inductance bridge or make a substitution test. Be on the alert for coils that indicate leakage resistance to their cores or mountings. This type of defect has proved to be "tough dogs" in the recollection of most technicians.

Don't confuse incorrect component placement with circuit defects. The convergence system cannot operate properly unless components are positioned properly on the picture-tube neck (see Fig. 8-9). Since color-picture tubes differ in constructural details, it cannot be assumed that the same component placement will be appropriate for different types of tubes. The receiver service data usually gives pertinent instructions. However, in case of doubt, refer to the service manual for the particular receiver being serviced.

COMMON SYMPTOMS

1. One or More Static-Convergence Controls Out of Range

The static-convergence controls are permanent magnets (Fig. 8-9). If a magnet does not produce the required placement of color dots in the center of the picture-tube screen, although the magnet is moved completely to one end or the other of its holder, the control is said to be *out-of-range*. Possible causes of this symptom are (Fig. 8-9):

a. The permanent magnet has become weak.

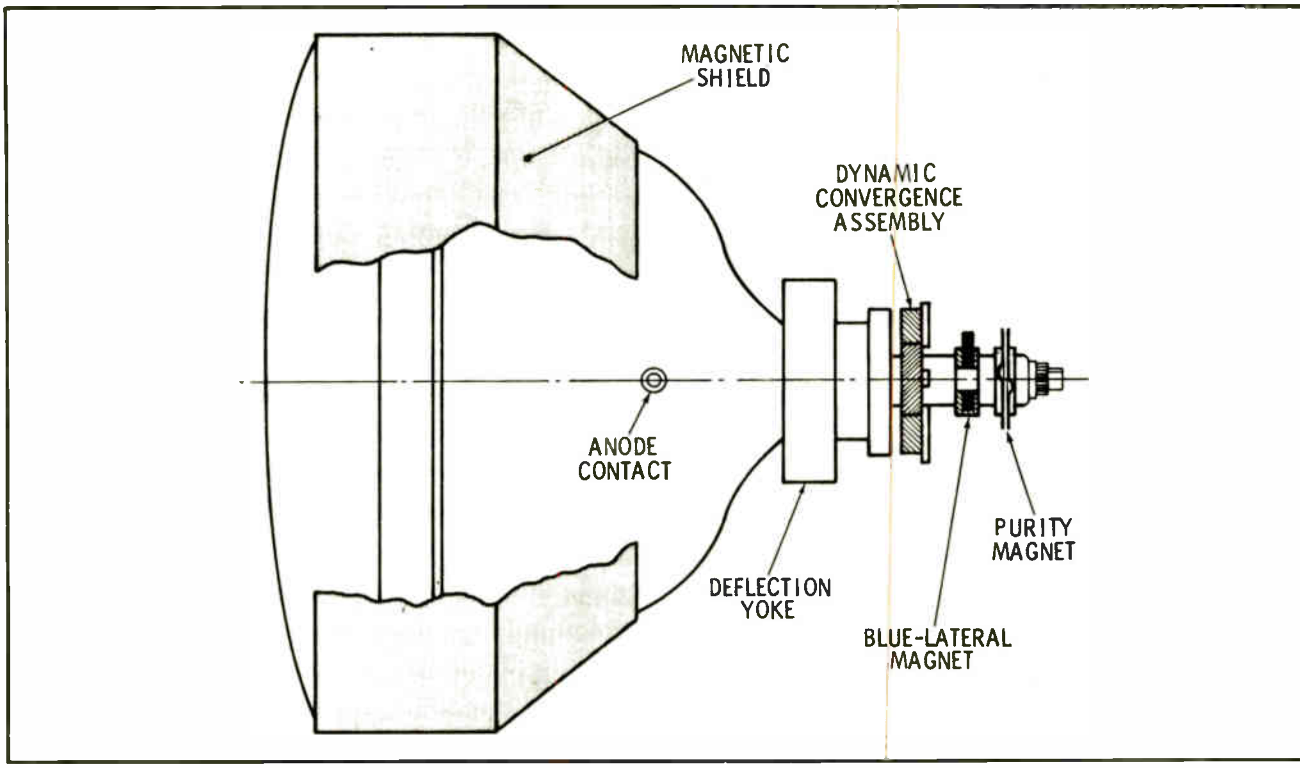


Fig. 8-9. Position of components on color-picture tube.

b. Wrong end of magnet has been inserted into the holder.
c. Magnet is rotated 180° in its holder.
d. Convergence assembly incorrectly placed on picture-tube neck.
e. Warped convergence assembly.

Permanent magnets often weaken with age, and must be replaced after long service. However, mistreatment of magnets can cause rapid loss of strength. For example, if a permanent magnet is dropped on the floor, it may lose quite a bit of its flux. Again, if a permanent magnet is accidentally placed close to a degaussing coil, its flux will be appreciably weakened. If the wrong end of a convergence magnet is inserted into the holder, it will have an opposite effect on the electron beam. Sometimes the control action is out of range because the magnet has been turned 180° in its holder—therefore, always check this possibility in case of trouble. The convergence yoke housing sometimes warps with age and the magnets are twisted from their correct positions. In such cases, the housing must be replaced. Fig. 8-10 is a description of an assembly that may twist with age. The components must be removed from the warped holder and replaced in a new one.

The static controls are intended to maintain convergence *only* at the center of the screen. Convergence away from the center and at the screen edges *must* be obtained by suitable adjustment of the dynamic controls. As the dynamic controls are changed, the center-screen convergence changes, and this change must be corrected by readjustment of the static controls. If this basic principle is not kept in mind, it may *seem* that some of the controls are out of range.

2. One or More Dynamic-Convergence Controls Out of Range

This is a tricky trouble symptom, because it can be caused by defects outside the convergence system. For example, incorrect supply voltage to the screen controls of the color-picture tube can be the culprit. In such case, the screen control(s) also lack(s) sufficient range, and you will not be able to "track" the picture tube over its normal operating range. Furthermore, there is considerable interaction between the dynamic-convergence controls. If one control is accidentally turned far off its correct operating position, other controls will often seem to lack sufficient range. However, if there is actually a defect in the convergence system, the possible causes include:

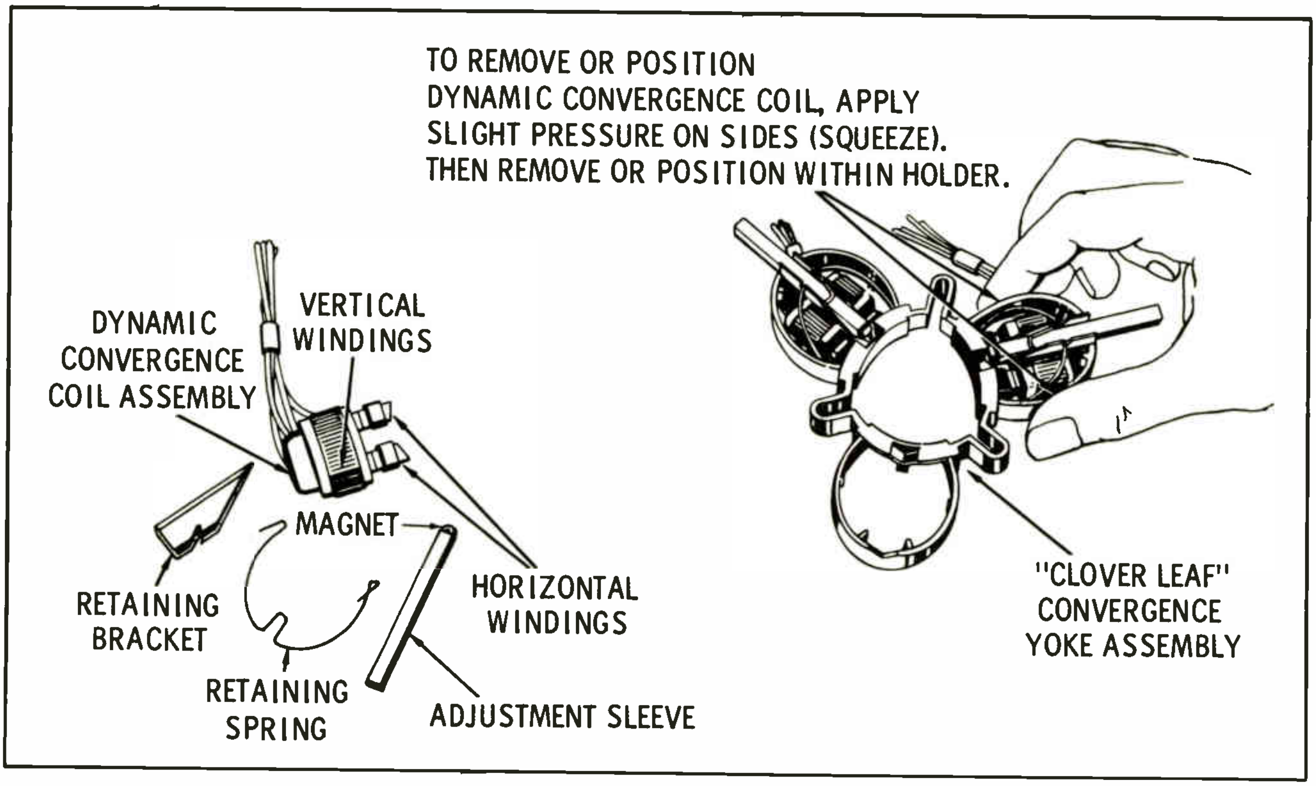


Fig. 8-10. A convergence assembly that may warp or twist with age.

a. Defective coupling capacitor, such as C148 or C149 in Fig. 8-8.
b. Poor contact of convergence plug to socket terminals.
c. Defective semiconductor diode, such as X5 or X6 in Fig. 8-8.
d. Noisy or worn potentiometers.
e. Off-value resistor, such as R211 or R213 in Fig. 8-8.
f. Break in printed-circuit conductor.
g. Defect in a convergence coil.

It is assumed, of course, that the driving waveforms (Fig. 8-8) have been checked for correct shape and amplitude. Make certain that the convergence-assembly plug is pushed down firmly into the socket so that there is no chance for poor contact. Some of the convergence coils, such as L40 and L41 in Fig. 8-8 are exposed to mechanical damage, and this possibility should be checked. If the convergence board is accidentally dropped, a winding can be dented or mashed, and the connection to the printed board can be broken. If the winding is touched by a hot soldering gun, insulation becomes charred and turns may be short-circuited. Turns that are short-circuited consume power, and often can be detected by touch to see if the coil is hot.

Defective semiconductor diodes can be pinpointed by d-c voltage measurements. Refer to Fig. 8-8. Diode X6, for example, normally has a drop of 2.5 volts. If it is open or shorted, you will measure zero volts. Or, if it has a poor front-to-back ratio, you will measure only a fraction of the 2.5 volts.

3. All Controls Have Adequate Range, But Good Convergence Cannot Be Obtained

The trouble is usually caused by marginal component failures, which distort the shapes of the convergence waveforms. Satisfactory wave shaping depends on the tolerances of capacitors, resistors, and semiconductor diodes. Possible causes of poor wave shaping are:

a. Marginal leakage in capacitors, such as C148 or C149 in Fig. 8-8.
b. Reduction in front-to-back ratio of a semiconductor diode.
c. Out-of-tolerance resistor, such as R212 or R214 in Fig. 8-8.
d. Marginal leakage between convergence-coil winding and core.
e. Increase in total resistance of a potentiometer, such as R30 in Fig. 8-8.

It is seldom possible to pinpoint this type of defect by evaluation of the trouble symptom—circuit interaction makes the analysis prohibitively complicated. Accordingly, a systematic check of components must be made step-by-step through the convergence network. Time can be saved in some cases by *comparative* tests. In other words, if you have a similar receiver available which is in good operating condition, you can make cross-checks of resistance measurements on both convergence boards. This approach will sometimes localize the trouble area, even if it does not pinpoint the defective component. Be sure to adjust the potentiometers on the defective board to approximately the same setting as on the "good" board.

You can also make comparison checks of waveforms on the two boards. All waveforms are necessarily referenced to ground and are not specified in receiver service data. However, the important point is to determine whether or not the waveforms at intermediate points on the defective board are the same as those found on the "good" board. This is a test that serves at best to localize the trouble area. Due to extensive circuit interaction, the pinpointing of a defective component usually requires individual component tests.

4. Convergence Adjustments Drift or Fluctuate

This trouble can be caused by defects in areas other than the convergence network. For example, a check of the d-c voltages at the socket of the picture tube may indicate trouble in a branch of the power supply. It is also possible that the trouble can be in the picture tube. In case of doubt, use a picture-tube tester or substitute a good picture tube to eliminate this possibility. If you must dig deeper, start by checking the driving waveforms to the convergence networks. Drift or fluctuation in convergence can be caused by leakage between a winding on an output transformer and the core.

However, in case the trouble is localized to the convergence board, the most likely causes are:

a. Varying leakage in a coupling capacitor.
b. Potentiometer element making poor contact.
c. Fluctuating semiconductor-diode characteristic.
d. Poor contact of a component to the printed circuit board.
e. Unstable fixed resistor.

5. Loss of Convergence Accompanied by Additional Trouble Symptoms

We have seen that convergence is affected by incorrect voltages on the screens of the color picture tube. Convergence is also affected by the purity and focus adjustments. Good practice requires that these possibilities be checked out before condemning the convergence system. In other words, we adjust the vertical height and linearity, center the picture, adjust purity and focus, and check the high voltage first. If the picture is tilted, correct this condition before starting convergence adjustments. After eliminating the symptoms accompanying misconvergence (which is possible in the vast majority of situations), it is then time to make an analysis of the convergence system.

Remember, if you can't get satisfactory convergence, check first to see if the convergence yoke might have been moved from its correct position. Unless it is secured tightly to the neck of the picture tube, it is possible to unknowingly move the yoke while attempting to center the raster. After all of the more common trouble sources have been checked out, it is then logical to start looking for a defect in the convergence network.

Chapter 9

High-Voltage and Focus-Circuit Troubles

The high-voltage circuitry used in color receivers is similar to that in black-and-white receivers, except that the output ranges up to 25 kv and the current drain can be as high as 1.3 ma. There are two additional tubes in the color-receiver supply; a focus rectifier and a high voltage regulator (Fig. 9-1). The high-voltage output must be regulated to maintain a constant potential during variations in current demand. Some of the common high-voltage trouble symptoms are:

1. No raster.
2. Insufficient width.
3. Dim picture.
4. Poor focus.
5. Blooming.
6. Corona discharge or arc-over.
7. Horizontal foldover.
8. Horizontal nonlinearity.
9. Drifting or fluctuating output.

Evidently, many of the trouble symptoms are basically the same in color receivers as in black-and-white receivers. However, there are more sources of difficulty in a color chassis because of the increased circuit complexity, as seen in Fig. 9-1. This chapter is chiefly concerned with troubles unique to the color portion of the chassis.

GENERAL DISCUSSION

You will find several different arrangements used in various receivers to obtain the focus voltage. Fig. 9-2 depicts three basic arrangements. Older receivers use circuitry such as that shown in Fig. 9-2A. The voltage applied to the plate of the focus rectifier is adjusted by a potentiometer connected across a portion of the secondary winding on the flyback. The focus potentiometer in circuits such as this have given a certain amount of trouble. Supplementary service data has been issued in some cases which specifies modification of the original circuit.

Perhaps the most widely used focus circuit is shown in Fig. 9-2B. A comparatively low-amplitude positive pulse is coupled to the filament of the rectifier tube through C1. The slug in the focus coil adjusts the amplitude of this pulse. When the pulse is set to a higher amplitude, the voltage between the plate and filament is reduced, which in turn reduces the focus output voltage. A positive pulse applied to the filament opposes the positive pulse applied to the plate. In other words, the output voltage depends on the difference in pulse amplitude between plate and filament.

Another arrangement (Fig. 9-2C) provides for adjustment of pulse amplitude applied to the plate of the rectifier tube. Components L1, C1, and R1 comprise a ringing circuit which changes the flyback pulse into a damped sine wave. This wave has a typical amplitude of 2000 volts p-p. As the slug is turned, a scope test will show that the phase of the sine wave is changed. If the first half cycle of the ringing waveform is in phase with the flyback pulse, maximum amplitude of the ringing waveform is obtained. On the other hand, if the first half cycle of the ringing waveform is out of

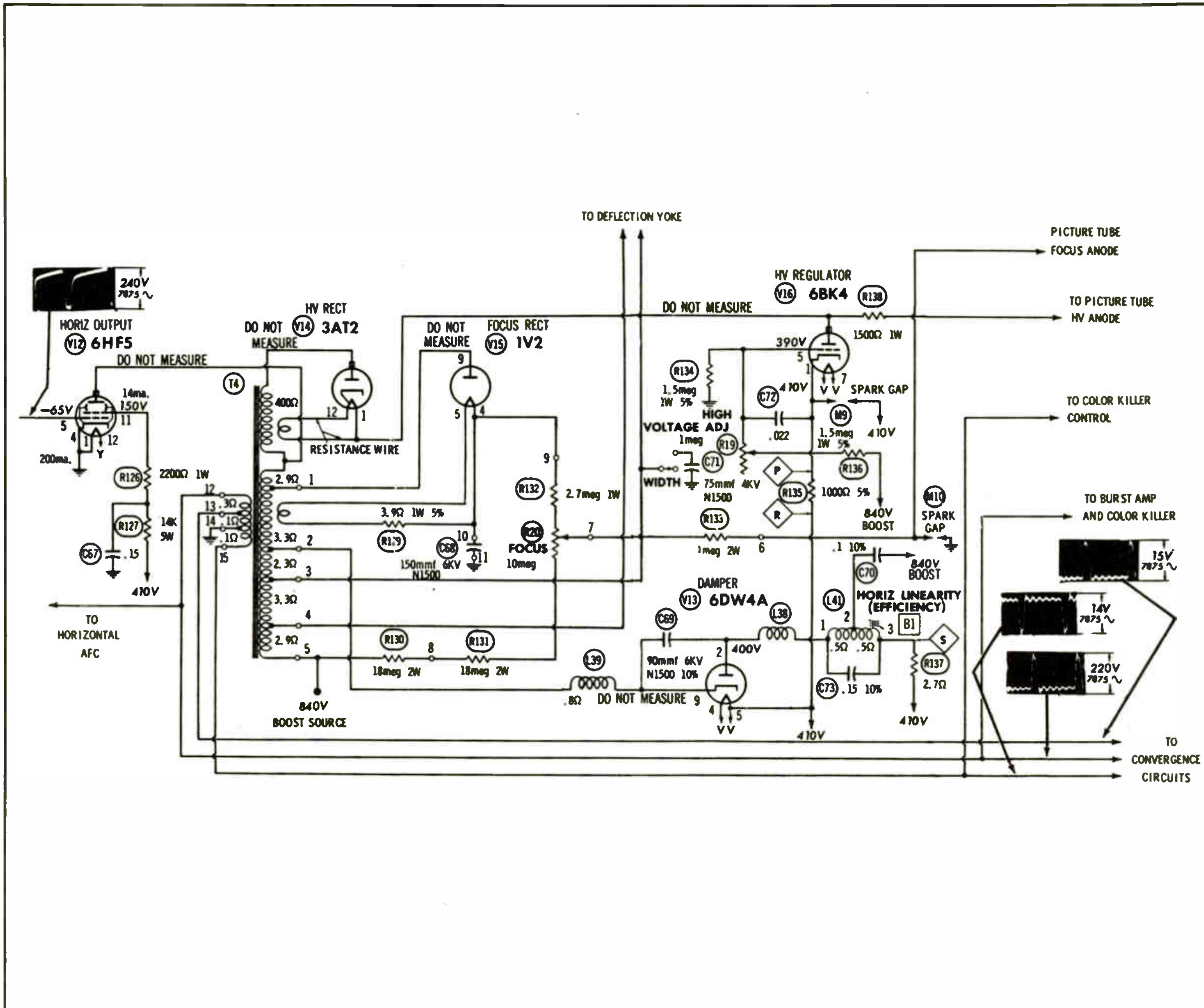
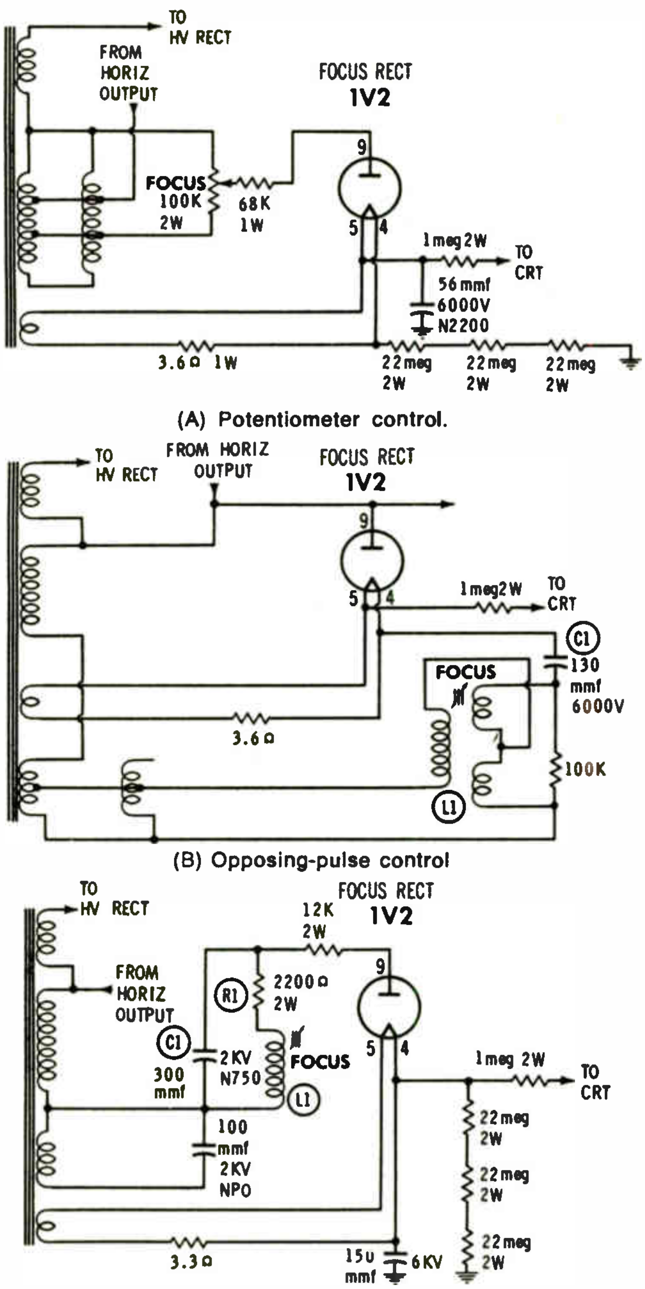


Fig. 9-1. High voltage and focus supply for a color-television receiver.



(A) Potentiometer control.

(B) Opposing-pulse control

(C) Phased sine-wave control.

Fig. 9-2. Methods used to adjust focus voltage.

phase with the flyback pulse, minimum amplitude of the ringing waveform is obtained.

GENERAL TROUBLESHOOTING PROCEDURE

It is not practical to measure peak-to-peak voltages in the high-voltage and focus circuits with most service scopes, because few shops are equipped with suitable high-voltage capacitance-divider probes. However, the shape of waveforms at any point in the circuits can be observed by bringing a test lead into the vicinity of the terminal or lead of interest. Be very careful to avoid arcing which will damage the scope input circuit. Stray pickup must also be considered when a high-voltage capacitance-divider probe is unavailable—the stray pickup sometimes distorts the waveform of interest and causes misleading conclusions.

Measurements—A milliammeter is usually available in the shop, and d-c current measurements are required in many high-voltage set-up procedures. Use an ordinary low-capacitance probe with a scope to check the drive waveform at the grid of the horizontal-output tube. Ohmmeter tests are also very useful, but remember that the same limitations in troubleshooting the high-voltage section in a black-and-white chassis apply to the color-receiver chassis. Note that you can use a high-voltage d-c probe with a vtvm to measure d-c supply voltages when strong pulses are present. A high-voltage d-c probe operates as a low-pass filter and blocks the high-amplitude pulse voltage. For example, suppose you wish to measure the d-c voltage at the plates of the horizontal-output tubes in Fig. 9-1. Since the probe has an attenuation of 100-to-1 (in a typical case), set the vtvm to its 5-volt range. The full-scale reading becomes 500 volts.

Check the current drawn by the high-voltage regulator tube to help analyze the operation of the high-voltage section. The high-current limit in typical color receivers is from 0.8 to 1.3 ma. Maximum screen brightness without blooming is obtained only while the regulator is drawing current, because the total current is divided between the regulator tube and the picture tube. A test is made by connecting a milliammeter in series with the cathode of the regulator tube, or across the cathode resistor, if one is present. For example, a 1000 ohm cathode resistor (R135) is present in Fig. 9-1. The current is noted as the brightness control is turned from minimum to maximum; the meter reading normally varies from specified maximum to zero in this test.

Suppose the rated maximum current is not reached. In such case, the regulator tube may be defective. It is assumed, of course, that tubes have been previously checked or replaced. A test with a high-voltage d-c probe might show that the output from the high-voltage section is low. The high-voltage control may have been set incorrectly or the line voltage could be too low. In case the high-voltage control has been turned too high, the output voltage from the regulator tube will be abnormally high, and the tube will draw excessive current when the brightness control is turned down.

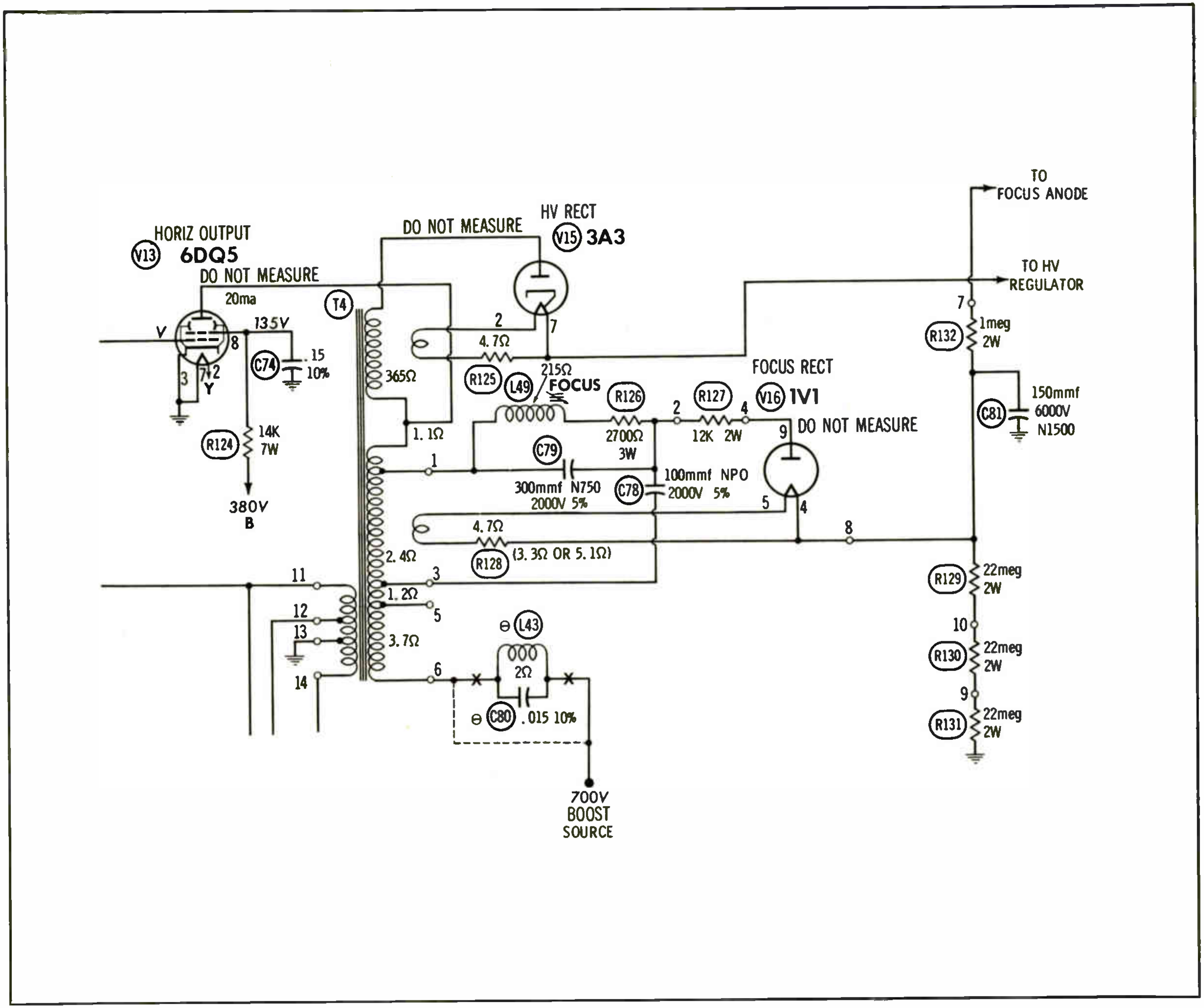


Fig. 9-3. Focus circuitry in high-voltage supply.

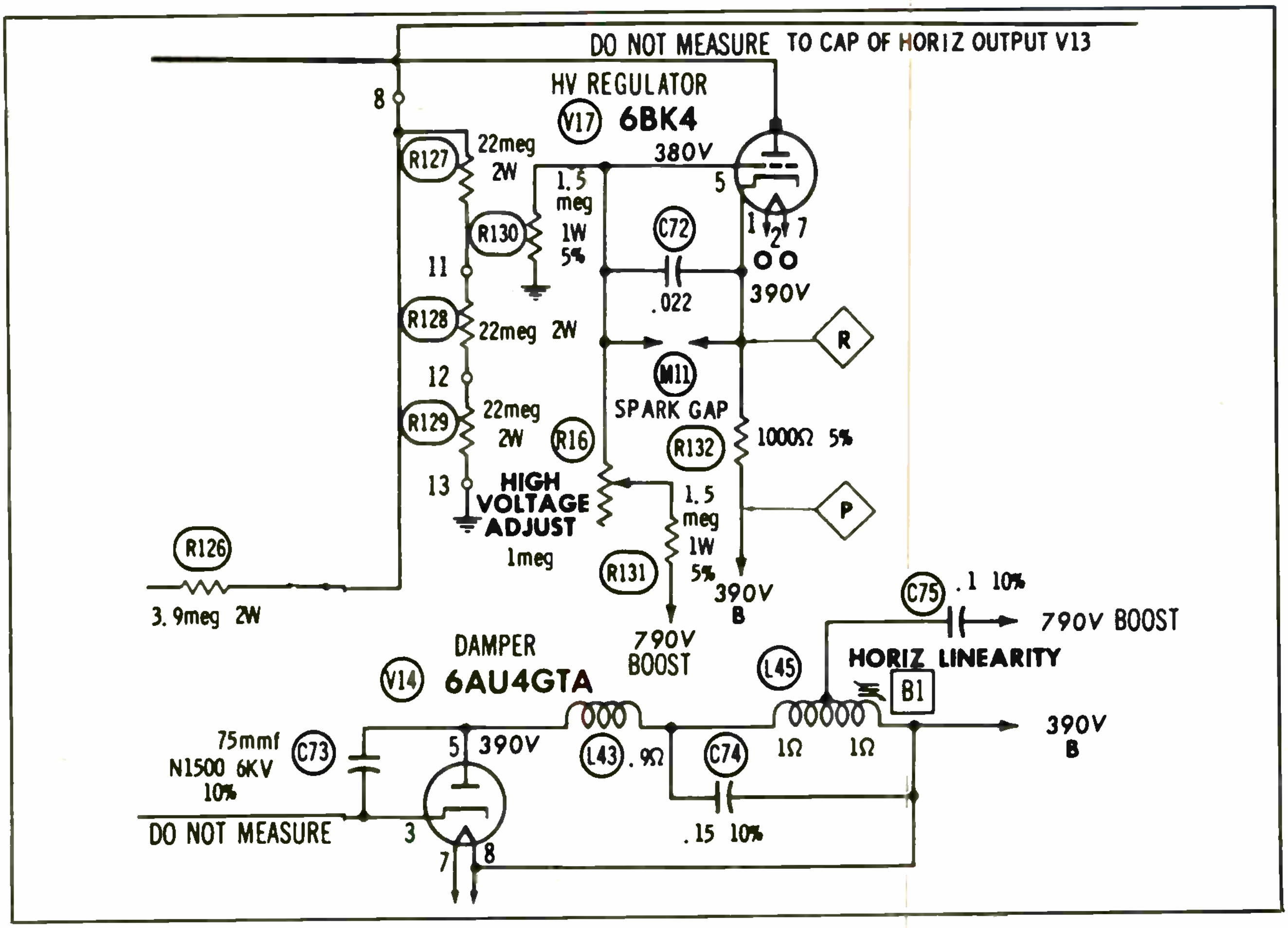


Fig. 9-4. High-voltage supply with spark-gap protection.

You will find occasionally that the current through the regulator tube does not decrease when the brightness control is turned up. This trouble can be caused by a gassy regulator tube, or serious misadjustment of the high-voltage control. If you must dig deeper, look for a leaky capacitor or off-value resistor in the grid circuit of the regulator tube. Substantial leakage in the grid-cathode capacitor is accompanied by poor focus and blooming.

COMMON SYMPTOMS

1. No Raster

This symptom is basically the same as for a black-and-white receiver, except there are more components that must be checked out in a color chassis. In a typical case history, the disappearance of the raster was accompanied by smoke and a burning odor from the flyback cage. Visual inspection showed that L49, R126, and R127 (Fig. 9-3) were burned. A short in C78 was the cause, and the heavy current drain also burned out the flyback transformer. When this type of trouble occurs, it is advisable to check all the capacitors in the high-voltage section—more than one capacitor may have broken down. The boost capacitor (C75 in Fig. 9-4 is also a suspect). Finally, check the drive to the horizontal-output tube, measure the regulator current, and adjust the high-voltage control.

Other possible causes of no raster are:

a. Failure of drive to horizontal-output tube—use a scope to find out where the drive signal stops.
b. Burned screen resistor at horizontal-output tube(s).
c. Heavy arcing from second-anode lead. Check insulation and lead dress.
d. Picture tube biased off—check d-c voltages at socket of picture tube.
e. No focus voltage at picture tube.

2. Insufficient Width

Insufficient width can be caused by several defects, just as in black-and-white receivers. For example, the drive voltage to the horizontal-output tube may be too low. The screen resistor may have increased in value. The B+ supply voltage might be subnormal. Again, the line voltage could be too low. If you must dig deeper, check the grid-cathode capacitor at the regulator tube (C72) in Fig. 9-4). When this capacitor is shorted, the picture is narrow, with blooming at all brightness levels. The regulator current does not fall to zero when the brightness level is increased. Note that if you do not measure the exact rated value of high-voltage output when the regulator current varies between specified limits, it is good practice to adjust the high-voltage control for correct current. Be sure to check the service literature for the correct procedure before making the high-voltage adjustments.

Insufficient width can also be caused by incorrect adjustment of the horizontal-linearity coil (L45 in Fig. 9-4). The slug should be adjusted for minimum cathode current at the horizontal-output tube(s). In case horizontal linearity is unsatisfactory when the cathode current is minimized, suspect a marginal defect in the horizontal-output system. Check the waveform at the grid of the horizontal-output tube; the trouble may be located in the horizontal-oscillator section. Leakage in a damper capacitor can also be responsible. Corona discharge can reduce the picture width in some cases (see Topic 6).

3. Dim Picture

A dim picture can be caused by obvious defects, such as incorrect cathode bias on the color picture tube. When the symptom is due to subnormal high voltage, this fact becomes immediately apparent from a measurement of the high voltage. It is assumed, of course, that the picture-tube high-voltage rectifier and regulator have been checked. The causes of subnormal high voltage have been noted under the two previous topics. Circuit checks should be started with a measurement of the high-voltage regulator current.

4. Poor Focus

Normal focus voltage ranges from 4000 to 5000 volts. Subnormal focus voltage not only causes poor focus, but it is often associated with a dim raster, or no raster at all. Possible causes of insufficient focus voltage are:

a. Leaky filter capacitor (Fig. 9-2).
b. Defective focus-voltage control.
c. Increased value or burned filter resistor (Fig. 9-2).
d. Regulator-tube control incorrectly adjusted.
e. Defective capacitor or resistor in focus circuit (Fig. 9-2C).

A tough-dog defect can be caused by a defective damper tube. It has been found that such a defect may produce symptoms only in the focus circuit. When the supposedly "good" damper tube is replaced, focus returns to normal. If you find that the focus-rectifier tube requires frequent replacement, it is likely that the filament voltage on the tube is too high. Supplementary service data may have been issued which specifies the use of a larger resistor in series with the filament. Note also that resistors which operate in pulsed circuits have a shorter life expectancy than those which carry d-c only. It is good practice to check the resistors in the high-voltage section with an ohmmeter.

Remember that a poor-focus symptom can also be caused by defects in the color picture tube. Hence, do not start digging into the focus circuitry until the picture tube has been cleared from suspicion. However, if the trouble is localized to the focus section, start by checking the variation in focus voltages as the focus control is turned slowly through its range. Normally, the voltage will change smoothly, without any jumps. Sudden variations point to a defective component in the control circuit.

5. Blooming

Blooming is often observed in a weak color picture tube, although the high-voltage and focus circuits are operating properly. It may be associated with other symptoms, such as dim raster, or a "metallic" appearance in the picture; screen impurity and poor convergence sometimes occur with blooming. However, if a circuit defect is the cause, the most likely trouble area is the high-voltage regulator circuit, as explained previously. Don't forget to check the high-voltage rectifier.

6. Corona Discharge or Arc-over

Corona is a blue glow caused by escape of high-voltage energy into the surrounding air. If intense, it is accompanied by a hissing sound. An abnormal current demand is imposed on the high-voltage system, that impairs regulator action. The picture width becomes reduced in some receivers. Arc-over is a surge-type discharge which is always audible. Even if the arc is not directly audible, as when damped by insulation, crackles and frying sounds are heard from the speaker. Streaks and flashes will also be seen in the raster.

Modern color receivers are not plagued by this trouble, to the extent that older receivers were. Nevertheless, corona or arc-over can occur on occasion in

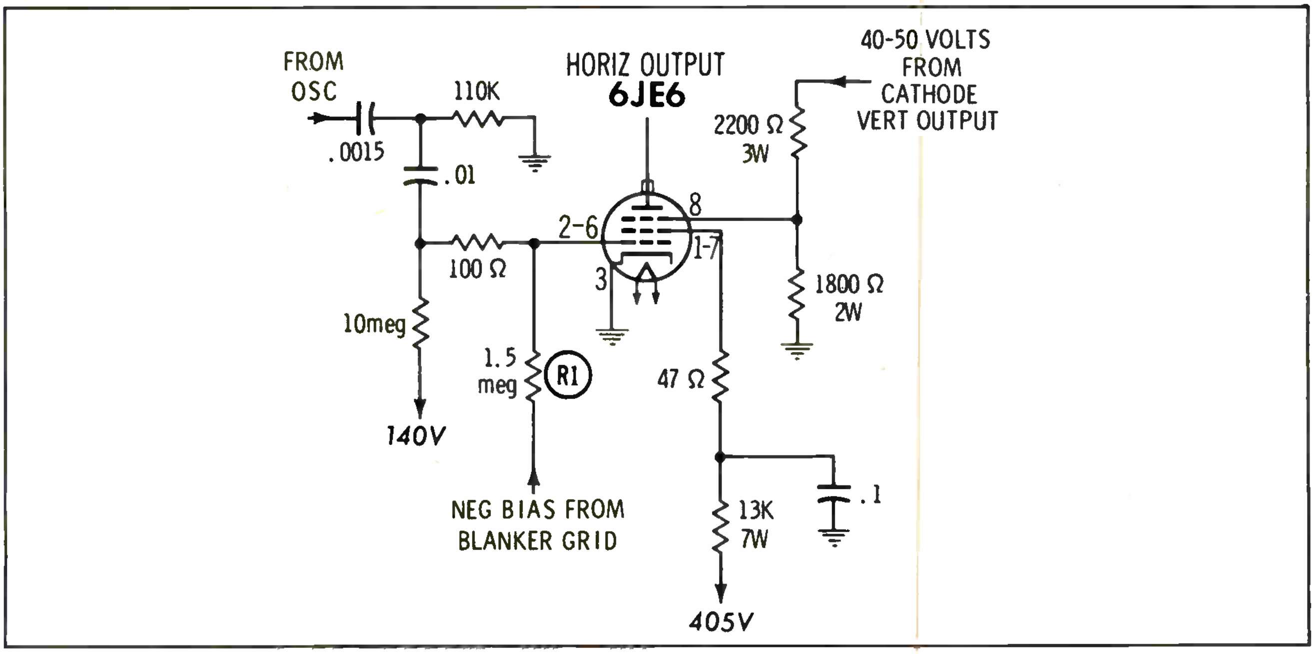


Fig. 9-5. High-voltage runaway protection.

any receiver. For example, if the high-voltage regulator tube does not conduct for some reason, *high-voltage runaway* can take place—the high-voltage output rises to 30 kv in typical cases and destructive arcing is quite likely to result. You will find that some of the late-model color receivers have a protective circuit to prevent high-voltage runaway, as shown in Fig. 9-5. In case the high-voltage regulator fails, the blanker tube generates more signal-developed bias, which is in turn applied to the grid of the horizontal-output tube via resistor R1.

Possible causes of corona discharge or arcing include:

a. Excessive drive voltage to horizontal-output tube.
b. Damaged insulation on high-voltage leads.
c. Leaky grid-coupling capacitor at horizontal-output tube.
d. Open protective resistor (R1 in Fig. 9-5).
e. Improper dress of high-voltage leads.
f. Color-picture tube installed incorrectly.
g. Open ground lead to "floating"component.

High humidity can be a contributing cause in some cases. If a color receiver has been stored in a damp basement for some time, it is good practice to dry it out thoroughly before applying power. A film of moisture on the high-voltage components is very likely to initiate corona or arcing. Arcs are accompanied by considerable heat, which rapidly breaks down insulation. Finally, remember to observe good practices when soldering connections to high-voltage components. Be sure the solder flows into a smooth round ball. Sharp solder points are frequently sources of corona, which may develop into destructive arcs. Some color receivers are provided with spark gaps, as depicted in Fig. 9-4. This is an auxiliary protective device which must not be tampered with. Frequent discharges across the spark gap indicate trouble in the high-voltage system—do *not* be tempted to increase the spacing of the gap electrodes. Instead, make systematic tests to localize the cause of excessive voltage.

7. Horizontal Foldover

In general, color receivers have a longer flyback time than black-and-white receivers. For example, when you are displaying a keyed-rainbow pattern, part of the first bar and part of the last bar may be blanked out. This is normal, and must not be confused with foldover. True foldover is symptomized by visibility of part of the retrace, which produces a light vertical band at the edge of the picture. Foldover can also occur in the central area of the picture. This symptom is caused by distortion of the horizontal-deflection voltage.

Common causes of foldover are:

a. Leaky coupling capacitor at the grid of the horizontal-output tube.

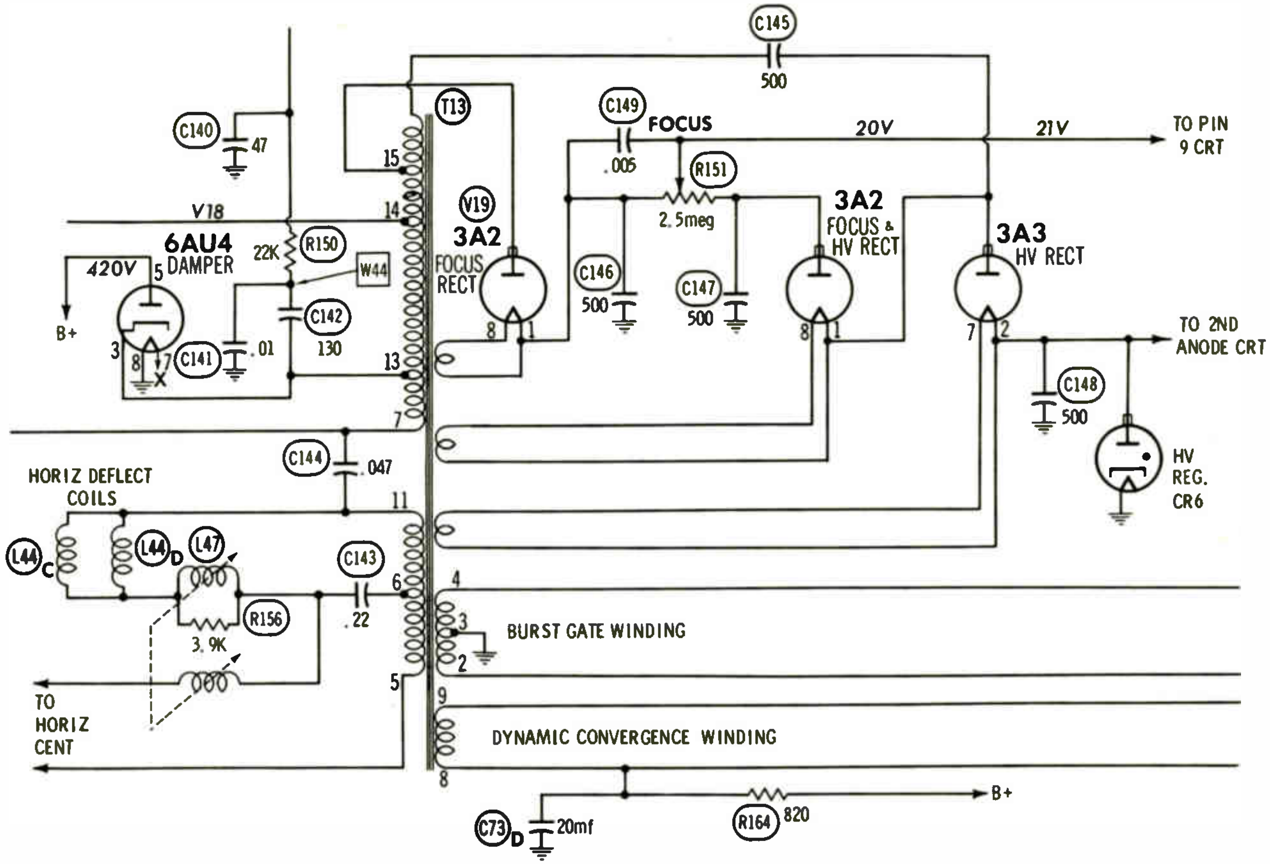


Fig. 9-6. High-voltage circuit using a gaseous-regulator tube.

b. Misadjusted or defective drive control.
c. Off-value grid resistor in horizontal-output stage.
d. Open or leaky screen capacitor in horizontal-output stage.
e. Defective horizontal-linearity coil.
f. Open or leaky boost capacitor.
g. Open capacitor in deflection-yoke circuit.
h. Defective yoke or flyback transformer.

Foldover can also occur when incorrect replacement components are installed in the flyback circuit. Always consult the receiver service data for recommended replacement parts. Components such as flyback transformers have numerous leads. It is helpful to tag each lead immediately after it is disconnected to avoid possible confusion when connecting the replacement transformer.

As in black-and-white receivers, vertical foldover is a common trouble symptom in color receivers. The vertical system is comparatively simple, and the causes of foldover are well known. Analysis of vertical foldover is omitted from this book.

8. Horizontal Nonlinearity

Horizontal linearity is normally best when the linearity coil is adjusted for minimum cathode current at the horizontal-output tube. In case of horizontal nonlinearity, check the following possible causes:

a. Open or leaky boost capacitor.
b. Open screen capacitor in the horizontal-output stage.
c. Off-value grid resistor in the horizontal-output stage.
d. Off-value screen resistor in the horizontal-output stage.
e. Defective yoke.
f. Leaky grid capacitor at the horizontal-output tube.
g. Defective capacitor in the yoke circuit.

9. Drifting or Fluctuating Output

When the output voltage drifts or fluctuates, suspicion falls on the high-voltage regulator circuit. Resistors such as R130, R131, or R132 in Fig. 9-4 may become thermally unstable. In turn, the high-voltage output drifts as the receiver warms up. A potentiometer such as R16 in Fig. 9-4 can also become unstable. Capacitors with marginal leakage can cause voltage fluctuation; for example, varying leakage in C72 (Fig. 9-4) causes a change in grid bias on V17. Monitor the d-c voltage at suspected trouble points, using a high-voltage d-c probe with the vtvm. It is not always possible to pinpoint the unstable component because of circuit interaction. However, monitoring tests will localize the trouble to a particular area.

In older types of color receivers, drift and fluctuation were more common in the focus circuit than in the regulator circuit. A monitoring test will localize the trouble to the focus circuit if there is an unstable component in this section. Finally, a few color receivers use a gas tube in the high-voltage regulator circuit (Fig. 9-6). In such cases, drifting or fluctuating high-voltage output is commonly caused by changes in the tube characteristics due to age. Try replacing the tube first. If this does not correct the trouble, monitor the d-c voltages step-by-step through the circuit to isolate the defective component.

Chapter 10

Color-Signal Generator Troubles

From time to time you must troubleshoot your color test equipment. Servicing the color-signal generator will present a certain amount of difficulty but, only because it is the most recent addition to the shop equipment. As previously noted, all color-signal generators, with the exception of the unkeyed-rainbow type, provide bar-type displays. Thus, they are termed color-bar generators. All of the chroma signals provided by a color generator have the same frequency: either 3.578545 mc or 3.563785 mc (usually abbreviated to 3.58 mc and 3.56 mc). NTSC-type generators supply 3.58-mc signals, and rainbow-type generators supply 3.56-mc signals. Since a series of color bars is produced by signals that have the same frequency, let's investigate what causes the difference in hues.

Recall that each color corresponds to a certain *phase* of the chroma signal. The phase of the signal simply denotes the relative position of the wave at a given time. For example, Fig. 10-1 shows a sine wave which has been shifted progressively in phase. Each waveform starts at the *same* time, but it starts at a different point in the cycle. The two 3.58-mc bar signals illustrated in Fig. 10-2 have different phases, and they correspond to cyan and blue hues. We recall that all chroma phases are relative to the phase of the color burst. The color burst is transmitted on the back porch of the horizontal-synchronizing pulse. The phase of the burst is used as a zero reference for the color signals and corresponds to a yellow-green color. Fig. 10-3 shows the color bars moved to the point where yellow-green is the third bar. This bar is not seen on a color-bar display because it is used as the burst phase.

In Chapter 6 we discussed how a chroma demodulator nulls when the input signal differs in phase by 90° from the burst phase. In other words, a demodulator nulls on a quadrature signal. Now, let's see how to check the chroma phases in bar signals. It is easier to start with the type of generator which supplies only one color-bar signal at a time. The principles to be explained will apply to generators which supply one, two, six, or any number of color bars at the same time.

Common phasing trouble symptoms include:

1. One color-bar signal has incorrect phase.

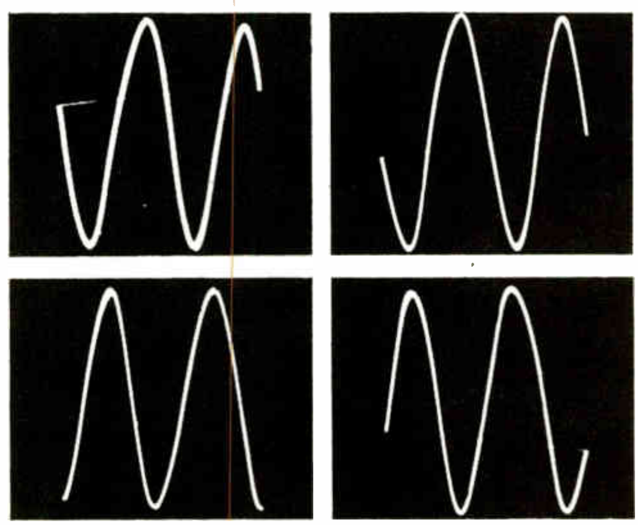


Fig. 10-1. Various phases of a sine wave.

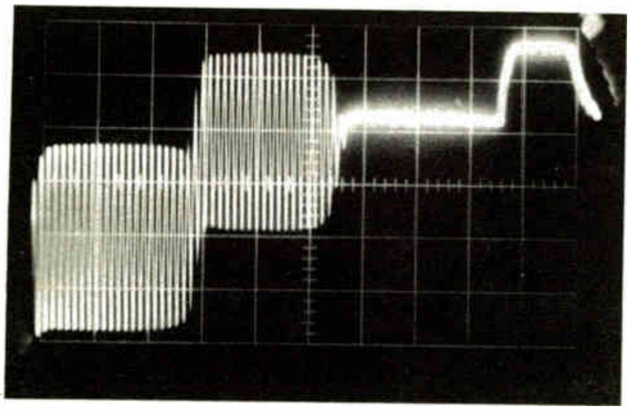


Fig. 10-2. Two 3.58-mc bar signals.

2. Two or more color-bar signals have incorrect phases.
3. Only the chroma signals have incorrect phases.
4. Only the primary color-bar signals have incorrect phases.
5. One or more signals drift or fluctuate in phase.

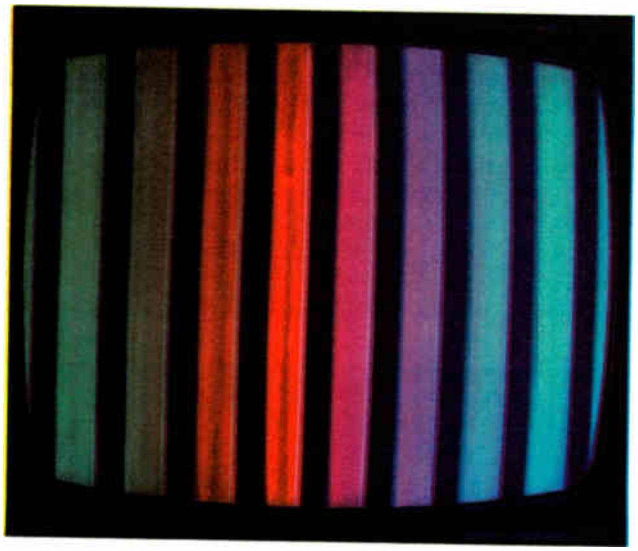


Fig. 10-3. Bar pattern showing the yellow-green burst phase.

GENERAL DISCUSSION

Check the phases of the 3.58-mc generator signals by means of *one* of the chroma demodulators in a color receiver. By restricting ourselves to one demodulator, any inaccuracy in receiver phasing is eliminated. Accordingly, we may proceed as follows:

1. Connect a scope and low-capacitance probe to the output of the R−Y demodulator (Fig. 10-4).

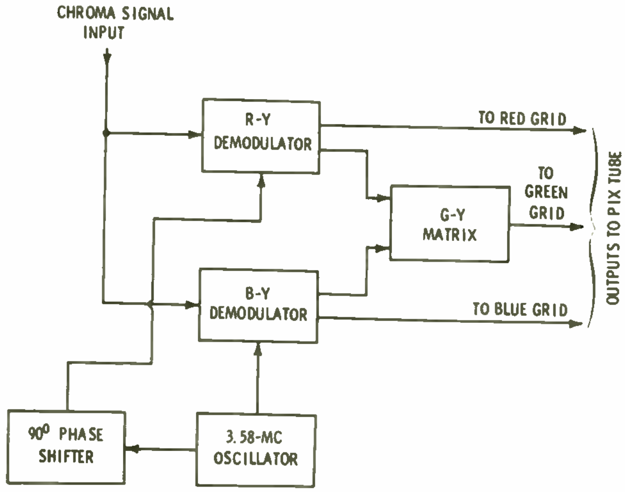
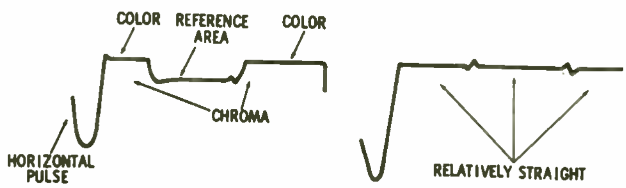


Fig. 10-4. Block diagram of the chroma section.

2. Set the color-bar generator to R−Y chroma output.
3. Apply the output from the generator to the input terminals of the color receiver.
4. Tune in the applied signal (Fig. 10-5).
5. Adjust the receiver's color-phasing control for maximum amplitude of the "color" segments in the scope pattern (Fig. 10-5A).
6. Switch the generator to B−Y output. The scope pattern should now indicate a null (zero "color" output).

Note that this test does *not* require that the color receiver be in accurate adjustment, because the scope is connected only to the R−Y demodulator output. If the B−Y demodulator or G−Y matrix is more or less out of adjustment, it makes no difference in the test results.

Suppose the test is satisfactory, as depicted in Fig. 10-5. In such case, you know that the generator is supplying R−Y and B−Y signals exactly in quadrature, as required. On the other hand, if the test results are not satisfactory, it is advisable to repeat the procedure. Be sure that you start by adjusting the color-



(A) Not nulled. (B) Nulled.

Fig. 10-5. Oscilloscope trace of chroma null.

phasing control carefully for maximum R−Y output. Then, switch the generator again to B−Y output to see if a null is obtained. If you do not obtain a satisfatcory null on the second trial, you can conclude that the generator is not supplying R−Y and B−Y signals in quadrature.

GENERAL TROUBLESHOOTING PROCEDURE

Chroma phases are generated by delay lines similar to the one depicted in Fig. 10-6. Any defective component will cause the chroma phase to be incorrect. In the present example (R−Y and B−Y phases not in quadrature), there will be a defective component between the R−Y and B−Y takeoff points shown in Fig. 10-6. The most likely component is an open or leaky capacitor. However, it is possible that a coil has been damaged and has an incorrect value of inductance. Capacitors must be checked by disconnecting one end and testing the unit on a capacitance bridge. Inductors can be checked on a good impedance bridge, or by substitution. Replacement inductors should be obtained from the manufacturer of the particular generator.

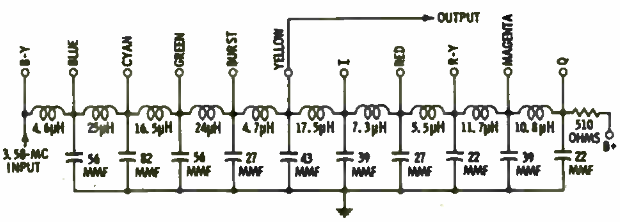


Fig. 10-6. Chroma-delay line used in a color-bar generator.

All NTSC-type generators have R−Y and B−Y signal outputs. Many have G−Y outputs and a few also have G−Y/90° outputs. The phases of these signals are shown in Fig. 10-7. After the R−Y and B−Y phases have been checked out satisfactorily (or restored to accurate quadrature by delay-line troubleshooting), you can proceed to check the G−Y and G−Y/90° phases. Connect the scope to the output of the G−Y matrix (Fig. 10-4). Set the generator to G−Y output. Adjust the receiver's color-phasing control for maximum height of the color segments in the scope pattern (Fig. 10-5). Then, switch the generator to G−Y/90° output. A null pattern should now be observed.

As in the R−Y and B−Y phase checks, this test is highly accurate, regardless of receiver adjustment. If the test results are unsatisfactory, repeat the procedure to make sure that you started with maximum output from the G−Y matrix. If you confirm the unsatisfactory test results, you can conclude that the generator is not supplying G−Y and G−Y/90° signals in quadrature to each other. Hence, look for a defective component in the chroma delay line. Check the capacitors and inductors between the G−Y and G−Y/90° takeoff points. Note that the delay line depicted in Fig. 10-6 does not supply these phases; hence, this test would be skipped for an instrument having this particular type of delay line.

If your generator supplies I and Q chroma signals, you might suppose that you need an I and Q-type of receiver to make a check of these signal phases. However, this is not so. You can use an R−Y and B−Y receiver just as well. Connect the scope at the output of the R−Y demodulator, set the generator to I output, and adjust the receiver's color-phasing control for maximum output on the scope screen. This can be done, because the color-phasing control has a wide range, and the I phase is 33° from the R−Y phase, as shown in Fig. 10-8. Then, switch the generator to Q output.

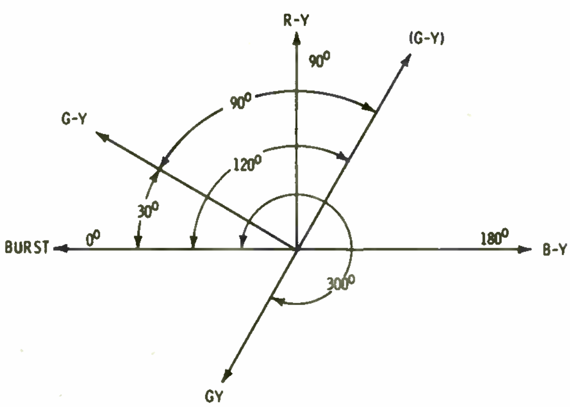


Fig. 10-7. Phases of G−Y, R−Y and B−Y signals.

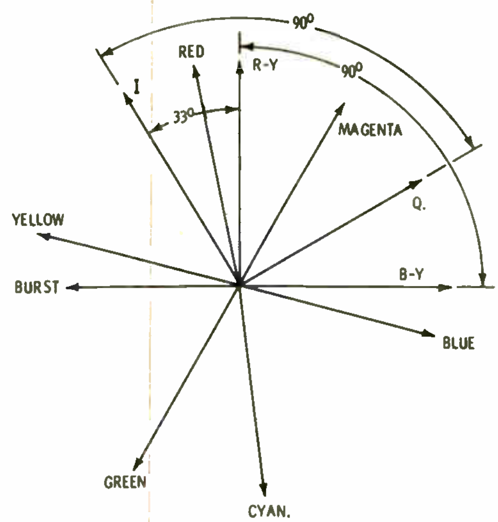


Fig. 10-8. Vectors for the important color phases.

A null should be observed on the scope screen. If the Q signal does not null, repeat the check to make sure that there is no testing error. If the null does not appear on recheck, you can conclude that there is a defect in the chroma delay line. The defective component will be found between the I and Q takeoff points.

After the basic chroma phases have been checked out satisfactorily, you can make an additional overall evaluation of generator operation. For example, in Fig. 10-6, B−Y is taken off at the beginning of the delay line, and Q is taken off at the end of the delay line. The R−Y phase is known to be correct with respect to B−Y, and the I phase is known to be correct with respect to the Q phase. In turn, it is reasonably safe to conclude that the other chroma phases (red, green, blue, etc.,) will be correct. In this case, you will probably terminate your phase checks and give the generator a stamp of approval.

On the other hand, some generators have chroma delay lines that are not as simple as the circuit in Fig. 10-6. In such instances it may be necessary to make additional phase checks of the green, red, blue, yellow, magneta, and cyan chroma signals. This might seem to be a difficult job, but it is really very easy. The procedure is based on the fact that the primary colors are 180° out of phase with their complementary colors. As shown in Fig. 10-9, magenta is the complement of green, and the resultant of red and blue.

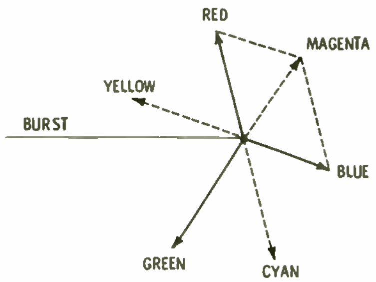


Fig. 10-9. Complimentary colors are 180° out of phase.

Referring again to Fig. 10-8, we see that blue and yellow have phases near the B−Y axis. We will proceed to check the blue phase and its complement, the yellow phase. Connect the scope to the output of the R−Y demodulator (directly to the red grid of the picture tube in recent model receivers). Set the generator for a blue output. Adjust the color-phasing control to null the blue signal (Fig. 10-5B). Then, switch the generator to yellow output. You should see a null pattern on the scope screen. If you do not, look for a defect in the chroma delay line between the blue and the yellow takeoff points.

After the blue and yellow phases have been checked out satisfactorily (or corrected by troubleshooting the delay line), proceed to check the red and cyan phases. Connect the scope to the B−Y demodulator output. Set the generator to red output. Adjust the receiver's color-phasing control to null the signal on the scope screen. Then, switch the generator to cyan output. You should again see a null pattern. If you do not, look for a defective component between the red and cyan takeoff points in the delay line.

When the red and cyan phases have been verified (or corrected by troubleshooting the delay line), proceed to check the green and magenta phases. The scope is left connected to the B−Y demodulator output. Set the generator to green output, and adjust the receiver's color-phasing ocntrol to null the signal on the scope screen. Then, switch the generator to magenta output. You should again see a null pattern. If a satisfactory null is not obtained, look for a defect in the chroma delay line between the green and magenta takeoff points.

There are many different types of color-TV receivers in present-day use and in each type of receiver the R−Y, B−Y, and G− outputs are provided. When you check R−Y output from a receiver, the scope might need to be connected to the R−Y amplifier output instead of the R−Y demodulator output. In all cases, R−Y signal is the signal that is present at the red grid of the color picture tube. The B−Y signal is present at the blue grid, and the G−Y signal is present at the green grid.

Let us consider the more elaborate types of color-bar generators that provide a number of NTSC color bars simultaneously, and which supply R−Y and B−Y, I

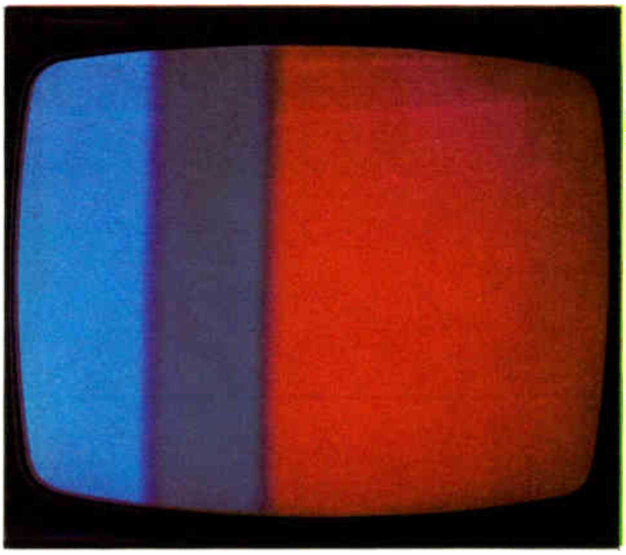


Fig. 10-10. B−Y and R−Y color bars.

and Q, or G−Y and G−Y/90° signals in simultaneous pairs. The same basic principles which have been explained apply to simultaneous displays, although the pattern details and evaluations necessarily differ. Three delay lines are commonly employed in the simultaneous type of generator, and troubleshooting is somewhat more complex. Color-difference bars are ordinarily generated in pairs, as the B−Y and R−Y shown in Fig. 10-10. Since this is a comparatively simple type of simultaneous signal, phase checks for this signal will be explained first.

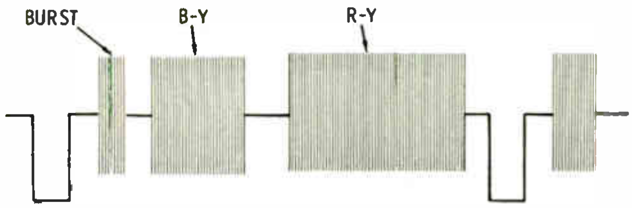


Fig. 10-11. Location of the bars in Fig. 10-10.

The waveform in Fig. 10-11 shows the position of the burst, R−Y, and B−Y signals for the pattern in Fig. 10-10. Phases of the bar signals are established by and R−Y and B−Y delay line shown in Fig. 10-12. Connect a scope and low-capacity probe at the output of the R−Y demodulator or amplifier in the color receiver. Observe the pattern on the scope screen while rocking the receiver's color-phasing control back and forth. The R−Y "square wave" should reach its peak amplitude as the B−Y "square wave" nulls (Fig. 10-13B). If the B−Y signal does not null when the R−Y signal is maximum, the color-bar generator is not supplying the signals in quadrature. The most likely trouble is a defective component in the R−Y and B−Y delay line.

Fig. 10-14 shows the R−Y and B−Y delay line used in a typical generator. For the symptom under discussion, the defect will be found between the R−Y and B−Y takeoff points. Note that a defect between the 3.58-mc input and the R−Y takeoff point will affect only the setting of the color-phasing control in the receiver. The 7-45 pf trimmer capacitors are adjusted at the factory to provide quadrature signals. They require readjustment only in case a component is replaced. The 4-30 pf trimmer capacitors are automatically switched in and out to compensate for switch-circuit capacitances. These trimmers are also adjusted at the factory and do not require readjustment unless lead dress is distrubed.

Hence, do not attempt to correct phasing troubles by adjusting the trimmer capacitors. Instead, look for a defective component in the delay line. Fixed capacitors are the most usual troubles. Check the resistor which terminates the delay line. Coils seldom become defective unless they are accidentally damaged, or have become corroded by acid soldering flux. In some color-

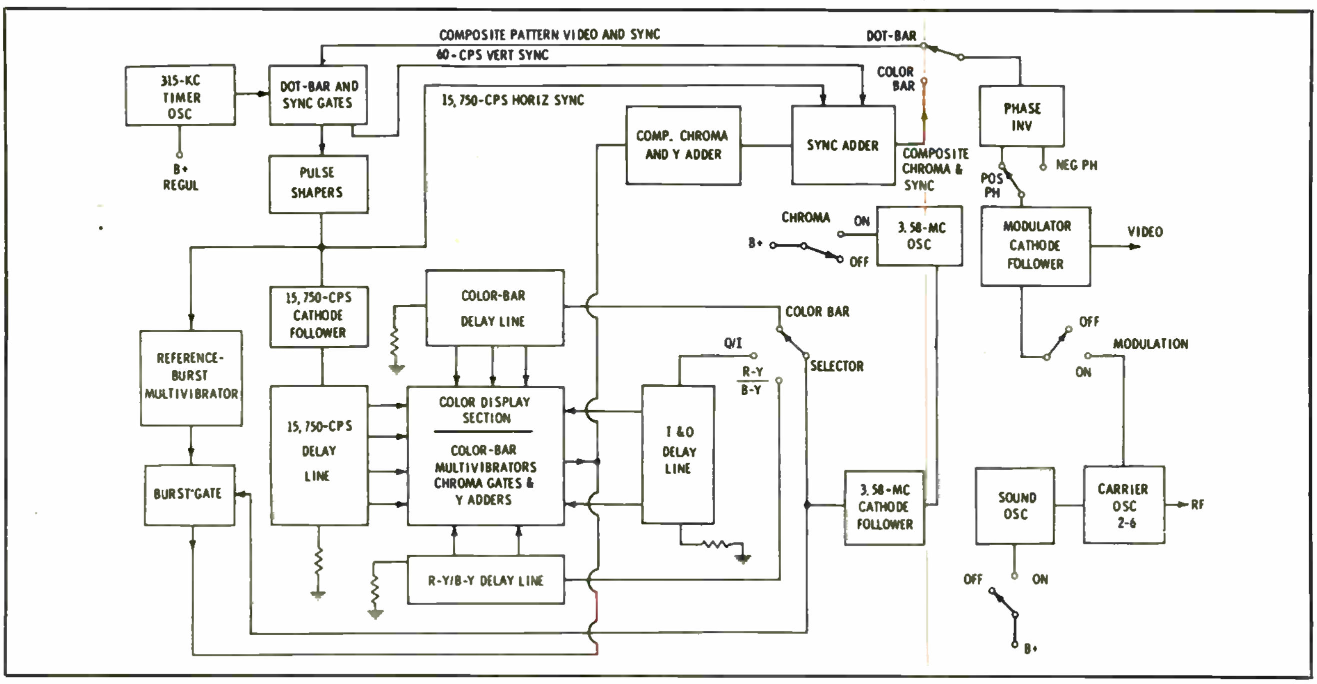
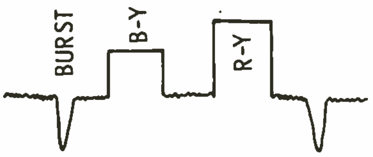
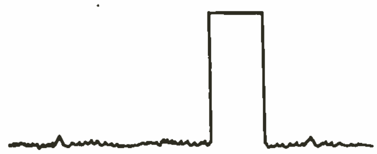


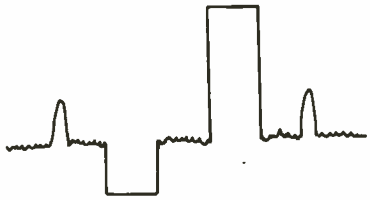
Fig. 10-12. Block diagram of a color-bar generator.



(A) Wrong pattern. B—Y is positive.



(B) Correct pattern. B—Y is nulled.



(C) Wrong pattern. B—Y is negative.

Fig. 10-13. Signals at red grid for the R—Y and B—Y signals.

bar generators, the coils are mounted very close to tie studs or lugs, that may puncture the enamel insulation. Pressing against coils which are suspiciously close to sharp metal edges may clear up the troubles. If a coil must be replaced, check the R—Y phase against the B—Y phase after installation. In case the delay line shows a small phase error, touch up the 7-45 pf trimmer nearest the new coil. However, do not change the adjustment of a 4-30 pf trimmer.

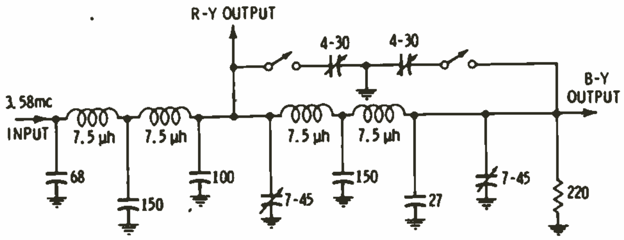


Fig. 10-14. Delay line for generating R—Y and B—Y signals.

A simultaneous I and Q waveform has different hues and occupies the same position as shown in Fig. 10-11. If differs from the R—Y and B—Y waveform only in its signal phases. As previously noted, you do not need an I and Q type of receiver to check the I and Q signals. Connect a scope and low-capacity probe to the output of the R—Y demodulator (or amplifier). Apply the I and Q signal to the receiver. Observe the pattern on the scope screen while rocking the receiver's color-phasing control back and forth. You will see the same type of display as shown in Fig. 10-13. The I signal should reach its peak amplitude as the Q signal nulls. If it does not do so, look for a defective component in the I and Q delay line (Fig. 10-15).

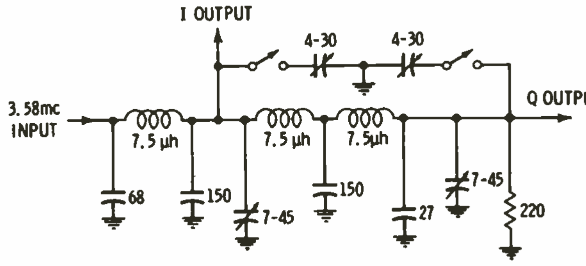


Fig. 10-15. Delay line for generating I and Q signals.

The I and Q delay line shown in Fig. 10-15 is similar to the R—Y and B—Y delay line (Fig. 10-14), except that three sections are used instead of four. The same general troubleshooting principles apply. Remember not to disturb the trimmer adjustments unless a fixed capacitor or coil is replaced. Then, adjust only the 7-45 pf trimmer nearest the replaced component, as required to bring the two signals into exact quadrature.

A number of color-bar generators supply simultaneous G—Y and G—Y/90° signals. In such case, you will find another delay line in the generator that is somewhat similar to the I and Q delay line depicted in Fig. 10-15. You can connect the scope at the output of the R—Y demodulator to check G—Y and G—Y/90° phases. The same troubleshooting principles apply as described previously. However, suppose you have a generator which supplies a G—Y/90° signal only, and that it has no G—Y signal output. This type of generator has a single-section delay line, such as depicted in Fig. 10-16. The unavailability of a G—Y signal makes a check of the G—Y/90° signal somewhat more difficult.

In this event, you must have a color receiver which is *in good adjustment*. This means that phase checks must have been made recently with another generator which was in good operating condition—and the R—Y, B—Y, and G—Y outputs in the receiver were found to be quite accurate. You cannot *assume* that even a brand-new receiver is sufficiently well adjusted to make this type of test. Remember the color-bar generators are manufactured to much tighter tolerances than color receivers. If you have a color receiver that is known to be in very accurate adjustment, the following procedure can be used.

First apply the R—Y and B—Y signal to the receiver. Connect the scope at the output of the B—Y demodulator and adjust the receiver's color-phasing control to null the R−Y bar. Then, transfer the scope to the output of the R−Y demodulator. The B−Y bar will now be nulled, assuming that the receiver *is* in accurate adjustment, and that the generator has accurate R−Y and B−Y outputs. You are now ready to check the G−Y/90° signal. Connect the scope at the output of the G−Y matrix or amplifier. Apply the G−Y/90° signal to the receiver. A null pattern will normally be displayed on the scope screen. In case the null is unsatisfactory, adjust the slug in the 4-10 μh coil (Fig. 10-16) as required to obtain an exact null.

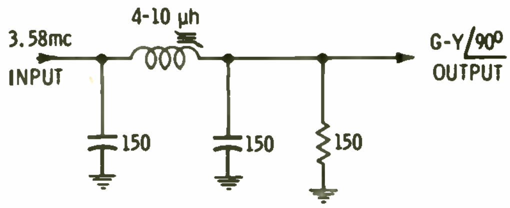


Fig. 10-16. Delay line for generating a G−Y/90°.

Next, you may proceed to check out the color-bar delay line (see Fig. 10-12). The color receiver does not have to be in accurate adjustment for this test. A multiple color-bar video signal is illustrated in Fig. 1-17. The sequence of colors in this example is: green, yellow, red, magenta, white, cyan, and blue. Connect the scope at the output of the R−Y demodulator in the receiver. Apply the multiple color-bar signal to the receiver. As you rock the receiver's color-phasing control back and forth, you will see a pattern such as illustrated in Fig. 10-18. Note that all the "square waves" change in height during this procedure, except the white bar. The white bar remains fixed at the zero reference level.

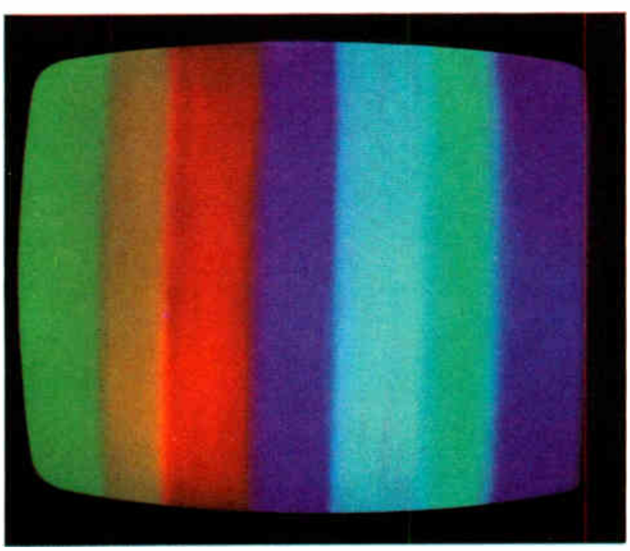


Fig. 10-17. Multiple-bar color display.

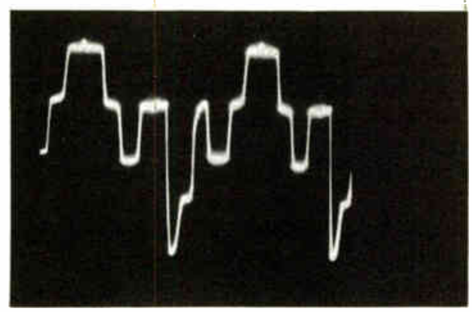


Fig. 10-18. Yellow and blue bars are nulled.

Since yellow is the complement of blue, these two chroma phases are normally 180° apart. This simply means that the yellow and blue bars should null simultaneously. Simultaneous nulling of the yellow and blue bars is seen in Fig. 10-18. At the null, both bars are lined up with the zero reference level. At the same time, this null corresponds to equal heights of the red and magenta "square waves," which appear as a single double-width "square wave." If you observe this pattern, the delay line (Fig. 10-19) is functioning correctly. This single test suffices, because any defective components between the red and green takeoff points will prevent a simultaneous-null pattern.

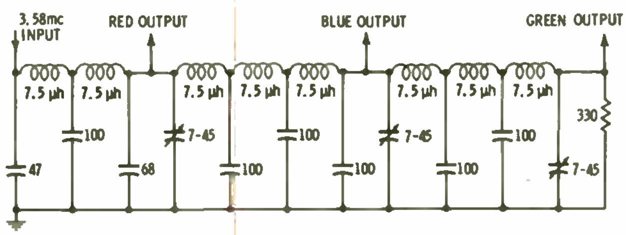


Fig. 10-19. Delay line for generating R, G, and B signals.

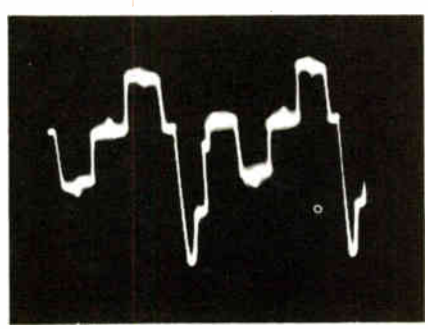


Fig. 10-20. Green and magenta bars are nulled.

You can make a cross-check, if you wish, by connecting the scope at the output of the B−Y demodulator. Since green is the complement of magneta, their chroma phases are normally 180° apart. This means that the green and magenta bars should null simultaneously, as seen in Fig. 10-20. When a satisfactory test is not obtained, it is necessary to make a systematic check step-by-step of components in the delay line (Fig. 10-19). Although it would be convenient to pinpoint a defective component by waveform tests at the terminals of each coil, this is not practical with ordinary service scopes.

Finally, let us briefly consider signal phases in a rainbow generator. This type of instrument does not have delay lines. Hence, it is only necessary that the oscillator be adjusted to correct frequency. Off-frequency operation causes the rainbow pattern to "pull" to the right or left, and shifts all the hues. The oscillator in either an NTSC generator or a rainbow generator can be adjusted accurately by the following methods:

1. Tune in a color television program on a color receiver.
2. Disable the receiver's color-afc network.
3. Carefully adjust the subcarrier oscillator in the receiver to hold the colors into correct display.
4. Disconnect the antenna, and connect the generator to the receiver.
5. Adjust the oscillator in the generator to hold the color pattern into correct display.

The subcarrier oscillator in the generator is then operating very close to correct frequency, because the color burst is maintained to a very tight tolerance at the television transmitter. Finally, reactivate the receiver's color-afc circuit.

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COLOR-TV SERVICING GUIDE

by Robert G. Middleton

The techniques employed in troubleshooting a color-television receiver are the same as those used in servicing a monochrome receiver, except for the addition of the color circuits which gives rise to a number of unfamiliar trouble symptoms. This TV servicing guide contains actual color photographs of the television screen, showing the symptoms and explaining the possible circuit defects that can cause the symptom.

The screen of the picture tube is the most important trouble indicator that the technician can employ. In this guide, emphasis is placed on interpreting the screen indications before attempting to repair the trouble. The screen symptoms are shown in color wherever possible; where this is impossible, they are explained in detail. Then the probable location of the defect producing the symptom is discussed.

The receiver is divided into eight sections, and the trouble symptoms are grouped according to the section in which they occur. Two of the sections perform the same functions as in a black-and-white receiver, but they are discussed here because they can affect the color reproduction even though they may have no direct effect on the color signal. The remaining six divisions are the circuits that directly control the color reproduction. They are the color control, color sync, bandpass amplifier, color demodulator, chroma matrix, and the convergence circuits.

General troubleshooting procedures and basic equipment requirements are discussed in the first chapter. The variety of color-pattern generators and the way in which they are used to locate color-television defects are also outlined in this chapter.

The last chapter includes a series of tests that can be performed to ensure the accuracy of any troubleshooting procedure. It explains what signals to expect from a generator and the general troubleshooting procedures that must be employed to repair and maintain the color-pattern generator so that it will provide accurate and reliable outputs.

This servicing guide is a complete reference for checking servicing, and adjusting all color-television receivers. In addition, it provides students, apprentices, and technicians with a basic explanation of the various circuits employed in a color-television receiver.

ABOUT THE AUTHOR

Bob Middleton is one of the few full-time professional free-lance technical writers in the electronics field. His many books have proven invaluable to technicians and engineers, because they are based on his own practical experience. His home workshop is filled with a wide variety of test instruments, receivers, and other equipment which he uses in preparing the factual and practical content of his many books.

Other Sams books by Mr. Middleton include: nine volumes of his famous *101 Ways to Use Test Equipment* series, *TV Tube Symptoms and Troubles, Using the Oscilloscope in Industrial Electronics, Solving TV Tough-Dogs, Bench Servicing Made Easy, Troubleshooting With the Oscilloscope, Troubleshooting With the VOM & VTVM, Electronic Tests and Measurements, Test Equipment Circuit Manual, Practical TV Tuner Repairs, Elements of Transistor Technology, Scope Waveform Analysis, TV Servicing Methods Guidebook, Test Equipment Maintenance Handbook, Electronic Component Tests and Measurements, Pulse Circuit Technology, Know Your Color-TV Test Equipment,* and *Know Your Signal Generators.*

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