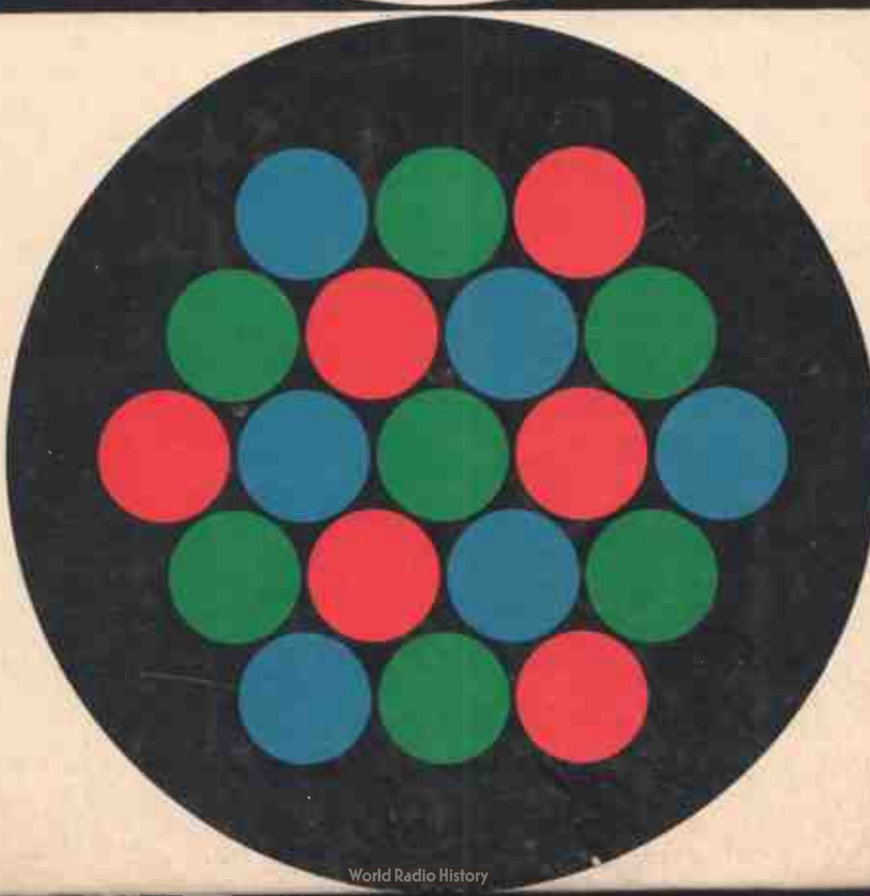
RCA

COLOR TV Troubleshooting PICT-O-GUIDE



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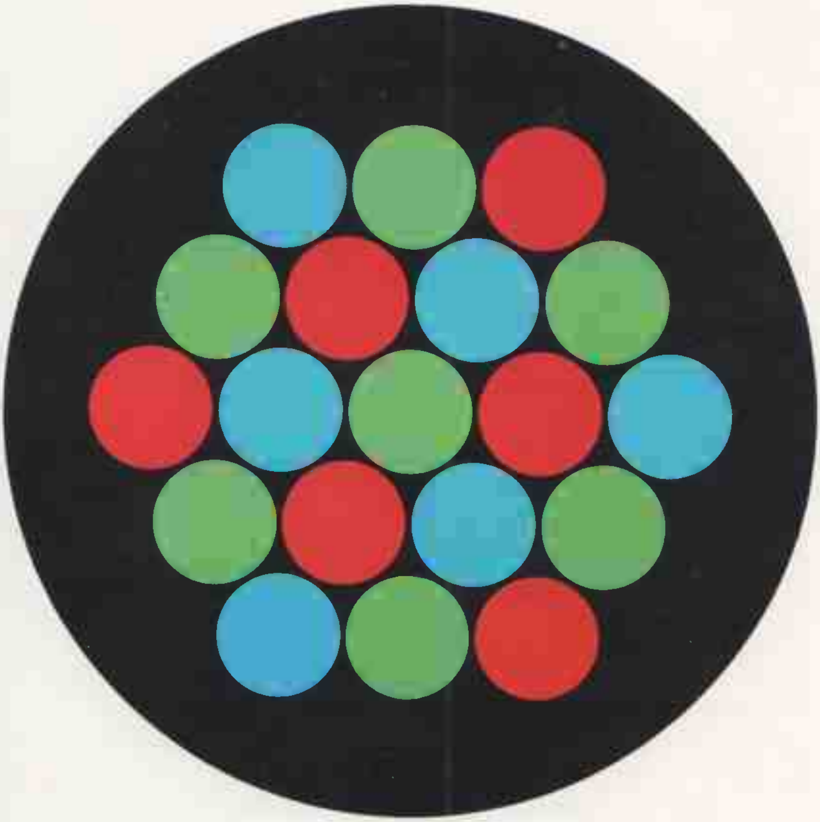

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The RCA Color TV Trouble-shooting Pict-O-Guide was conceived by and produced under the guidance of **John R. Meagher**, RCA's nationally recognized authority on practical television servicing.

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PICT-O-GUIDE

INTRODUCTION

This brand new, completely updated RCA Color TV Troubleshooting Pict-O-Guide is designed as a quick and easy aid for TV technicians interested in troubleshooting and adjusting color TV receivers.

The many true-to-life color photographs throughout this new Pict-O-Guide and the illustrated step-by-step instructions make it possible for you to recognize and understand the visible symptoms of troubles and maladjustments.

The Color TV Troubleshooting Pict-O-Guide was prepared by RCA with the following ideas in mind:

1. Pictures tell the story best. Just as it is true that one picture is worth a thousand words, no amount of words can duplicate the experience you get when someone shows you a trouble symptom on the screen of a receiver. In order to duplicate this experience for you, we use good photographs—lots of them. In addition, the concepts and knowledge you need to do practical service work are best explained through the use of color photographs. For example, the easy to follow RCA Pict-O-Guide demonstrates color mixing by showing you the actual results of color mixtures on the TV screen. There will be no mathematics or discussions of vector analysis. Fortunately, a detailed knowledge of the exact workings of such circuits as the demodulators is not needed to do most actual service work.

2. A new look at setup procedures. Some of the most dramatic improvements in color receivers are related to setup procedures. Purity, convergence and black and white tracking adjustments have been vastly simplified. Adjustments are more positive, interact less and are not likely to drift off with time. Here again, our Pict-O-Guide's color photographs show best how each setup job is done and what the results look like on the screen.

3. Expanded Troubleshooting Section. There is no substitute for experience when it comes to recognizing trouble symptoms and pinpointing the faulty section of the receiver. The photographs you will find in this up-to-the-minute Pict-O-Guide offer you the benefit of RCA's many years of experience in Color TV servicing, by showing you the symptoms of many kinds of troubles that are unique with color receivers.

4. Learn by doing. In order to become proficient in color TV servicing, you must acquire actual experience with the color TV chassis, learn the locations of the important test points and controls and gain the confidence that comes only with familiarity. If it is at all possible, obtain a color receiver and a wideband oscilloscope and follow along with all the adjustments and troubleshooting checks that are shown in this Pict-O-Guide. A large number of oscilloscope waveforms will also be shown in addition to the pictures of the picture-tube screen. The significance of these pictures and waveforms is best understood and best remembered when you observe a particular condition on the screen or see the waveform on an oscilloscope. If you complete this "guided tour" you will know your way around the color TV chassis like an expert.

For a complete course in the principles and practices of color television, you will find the 8-lesson Color Television Home Study Course by RCA Institutes invaluable.

LEARNING TO MIX COLORS

One of the basic skills you must master is that of mixing colors, using the primary colors provided by the color picture tube. Before the color receiver can reproduce color telecasts accurately, the receiver must be set up to provide a correct black-and-white picture. You mix the primary hues on the picture tube by adjusting the relative beam currents of the three electron guns in the color picture tube.

The ability to mix colors on the picture-tube screen can be acquired easily—a little practice and you will be an expert. Late-model receivers are particularly easy to set up, as the chore of tracking the brightness control (maintaining the correct color balance throughout the range of the brightness control) has been greatly simplified. When you have acquired color mixing skill you will be able to "size up" a color-balance problem as an excess or deficiency of a particular primary hue. Corrective measures are easy once the problem has been localized to a primary hue.

The only hurdle that most of us have to overcome in learning to mix light on the picture-tube screen is to realize that light and paints or crayons mix differently. For example, childhood experiences have taught us that green can be obtained by mixing yellow and blue paint. It is always a shock to the beginner in color TV when he learns that yellow light is obtained by mixing red and green light. The reason is that paints represent a *subtractive* light mixing process, where individual pigments ABSORB particular hues. Whereas, in the color picture tube we are dealing with an *additive* process where lights are added directly. But experiment, not colorimetry, taught us to mix paints, and we can just as easily accept the results of our experience with the color picture tube.

Figure 1-1 shows the three primary hues obtained from the 21FJP22 color picture tube. Each primary hue is displayed by biasing off the electron guns for the unwanted hues.

The guns of the picture tube are adjusted so that all guns cut off (go to black) at the same point; then beam currents are proportioned so that the primary-color light outputs add to produce the white

FIG. 1-2. White, is made by adding the primary-color lights in the correct proportions.

FIG. 1-1. The three primary colors of the color television system.

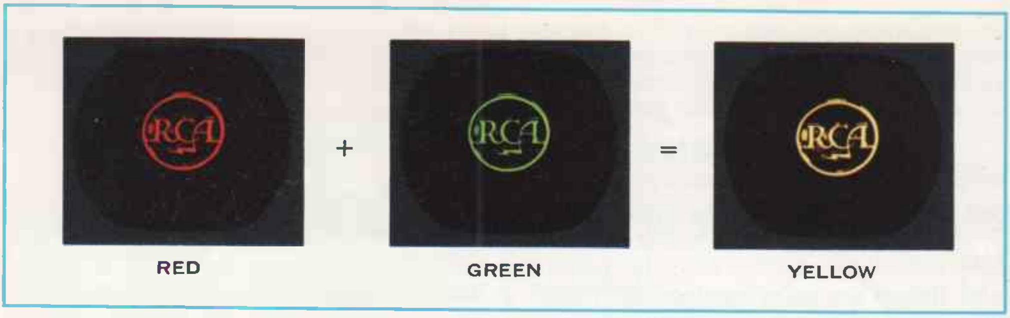


FIG. 1-3. Red plus green produces yellow.

shown in Fig. 1-2. White is thus made by adding the three primary hues in the correct proportions.

Note. *You will find many references to "red", "blue", or "green" electron guns. Of course, the guns themselves are not colored. This notation is a short way of referring to the electron gun that is responsible for emission of red, green, or blue light from the screen of the picture tube.*

As shown in Fig. 1-3, *yellow* is obtained by adding red and green. To make this picture, the red and green guns were permitted to operate, as in making Fig. 1-2, but the blue gun was biased off. Thus red *plus* green equals yellow. This yellow pattern was obtained by simply turning off the blue gun after the desired white (Fig. 1-2) was obtained. Therefore, white *minus* blue also equals yellow. A yellow raster that is supposed to be white is therefore deficient in blue.

Cyan is a mixture of blue and green, as shown in Fig. 1-4. Here the red gun was biased off after the correct white was obtained. Thus, cyan is also white *minus* red.

Magenta, or purple, is red light plus blue light. The pattern in Fig. 1-5 was obtained by first setting up white and then biasing off the green gun. Magenta therefore is also white *minus* green.

The basic color mixtures shown in the previous figures are so basic to color TV that you must commit them to memory. However, with a little practice on a color receiver, you will never forget these relationships. Let's summarize them:

red + green + blue = white
red + green = yellow
green + blue = cyan
blue + red = magenta
white − blue = yellow
white − red = cyan
white − green = magenta

Remember that the proper proportions of each color must be added or subtracted. When a primary hue is subtracted from white, the resulting hue is called the *complementary hue* or *complement* of the primary that was removed. Thus, yellow is the complement of blue; cyan and red are complements; and green and magenta are complements.

FIG. 1-4. Blue plus green produces cyan.

By reversing the process of the previous paragraph, that is by adding a primary hue to its complement, you obtain white. Thus

yellow + blue = white
cyan + red = white
magenta + green = white

Of course the proper proportions of relative primary-color brightness must be maintained to obtain the correct white.

Other Hues. All intermediate hues are obtained by altering the relative proportions of the primaries. Orange, for example, is a mixture of green and red, with an excess of red. A pea-green or chartreuse hue is also a mixture of green and red, but here green predominates. Other colors are more difficult to describe, because surface conditions and various degrees of brightness and saturation affect the color that you see. Gold, for example, is really yellow or yellow-orange in which a smooth reflecting surface gives the metallic luster. Colors such as brown, olive, and navy blue are actually yellow, yellowish green, and blue respectively, but at relatively low brightness levels.

Unsaturated Colors. With the exception of white, the hues shown in the previous photographs are saturated colors. The terms vivid and deep are sometimes used to describe saturated colors. Unsaturated colors are said to be pale, tinted, or washed-out. The terms vivid red and pink describe red of high and low saturation respectively. Pink is really white light with a slight excess of red light. White and gray have no excess of any hue; whites and grays have zero saturation.

Fully saturated colors are produced by the color picture tube when one or two (but not three) of the primary-emitting phosphors are lighted. If all three of the primary color phosphors emit light, the resultant has some proportion of white light even though one hue may predominate. Any color produced when all three primaries are present must be unsaturated. To illustrate, suppose you start with the picture tube adjusted to produce white light. If you then bias off the blue gun you will have a fully saturated yellow. If blue light is then returned gradually, the yellow color will become paler or less saturated until the original amount of blue is obtained and white is restored. If you look at the phosphor screen with a microscope when pale yellow is displayed, you will see all three phosphors lighted, but the red and green spots will be much brighter than the blue spot.

Fully saturated colors are seldom seen in nature. Therefore, it seldom happens that one or more phosphors are completely extinguished during an actual telecast. Look at a blue sky reproduced on the screen with a microscope or magnifying glass. You will see that all phosphors are lighted, but the blue spots are brightest. Sky blue is an unsaturated blue.

The Color Picture Tube. The color mixtures seen on the screen of the color picture tube are actually mixed by our vision. Only the primary hues — red, green, and blue, appear on the picture tube. Our eyes see mixtures because we are unable to resolve the tiny individual phosphor dots at normal viewing distances.

The screen of the RCA shadow-mask picture tube contains about one million tiny phosphor dots. One third of these

FIG. 1-5. Red plus blue produces magenta.

dots are made of phosphors that emit red light, one third of the phosphor dots emit green light, and the remaining third of the phosphors emit blue light. The light emitted by the primary phosphors is controlled individually by controlling the beam current of each of the three associated electron guns. The shadow-mask arrangement prevents interaction between electron guns by allowing only electrons from the gun designated as the red gun to strike red phosphor dots. Electrons from the "blue" and "green" guns similarly can strike only blue and green phosphors, respectively. (We will refer to the phosphors according to the hue of the light that they emit. A reference to the *red phosphor,* for example, refers to the phosphor that emits red light when struck by the electron beam. The phosphor dots are actually quite colorless as you look at them on a nonoperating picture tube).

By looking at the phosphor screen with a low-power microscope (20-50 power) or a magnifying glass, you can see the lighted phosphors that produce the various hues. Figure 1-6 shows a composite photograph displaying the primary and complementary hues plus white. This pattern was made by taking a series of exposures on a single frame of film. The entire screen was masked. The first exposure was made by unmasking the center area and exposing the film to white. Successive exposures were made by unmasking the segments, one at a time, and biasing off the appropriate gun or guns to produce the desired hue. The details near each segment show magnified views of the phosphor dots.

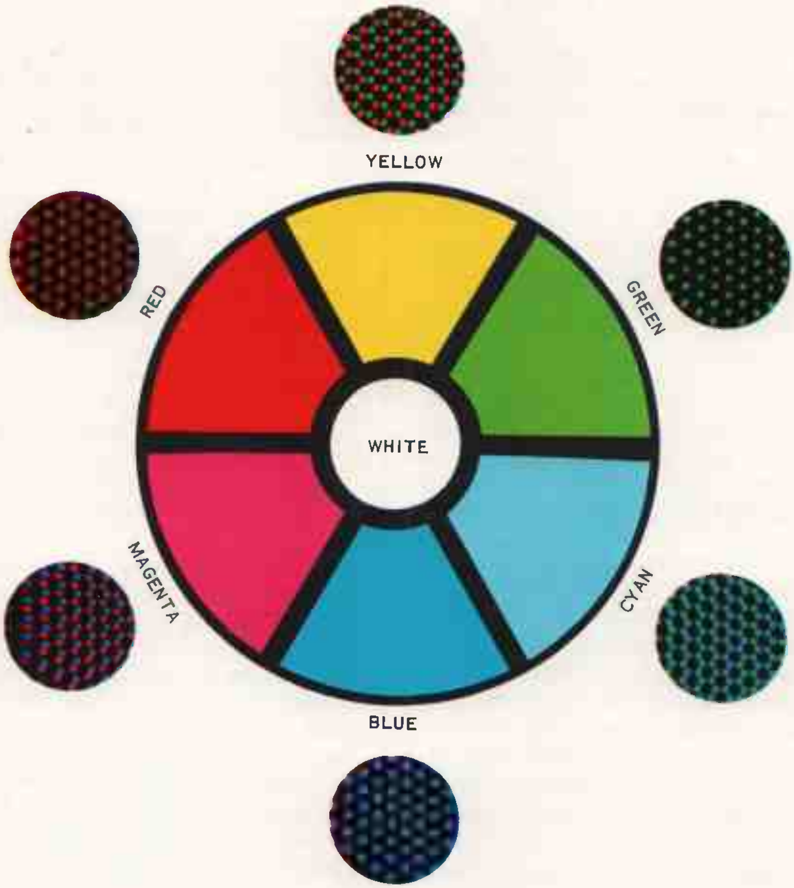


FIG. 1-6. Color mixing chart made from the light produced by a color picture tube.

RCA COMPATIBLE COLOR TV

Let us turn our attention to the basic principles of the compatible color television system. For those of you who have acquired a knowledge of color TV theory, this section will serve as a review and summary of basic concepts. For the newcomers, this section will provide a brief introduction to the subject. We will concern ourselves only with those principles which you should know to become a proficient service technician.

A Simple Color TV System. The basis for a color TV system was shown in the preceding section on color mixing. We learned that any color, including white, can be reproduced by adding appropriate amounts of light from three primary-color sources. The reverse is also true; almost any color can be *resolved* into certain proportions of primary-color components. Thus, a very simple color TV system can be set up using three standard TV channels, as shown in Fig. 2-1.

Three cameras are used to resolve the televised scene into its red, green, and blue light components. Filters placed in front of the camera lenses allow only light of a particular primary hue to enter each camera. Thus, the red camera "sees" only brightness values in red; the blue and green cameras produce outputs that correspond to the brightness values of the blue and green components (respectively) of the picture. If the scene should contain a spot of highly saturated yellow, you would find outputs from the red and green cameras, but no output from the blue camera, at the instant that the yellow spot is scanned.

In this simple system, three separate transmitting and receiving channels carry the separated red, green, and blue signals to the control elements of a tricolor picture tube. Here the primary color components are displayed simultaneously, and our eyes mix the images to reconstruct the original scene.

Bandwidth and Compatibility. The simple system of Fig. 2-1, although capable of producing excellent color pictures, cannot be used. An obvious objection is that it requires the bandwidth of three TV channels. Fortunately our eyes cannot resolve different hues in very small areas of the picture, so that the full 4-mc bandwidth needed to transmit black-and-white signals need not be used for color. Good color resolution requires a bandwidth of only about 1.2 mc. In the present system, "color" information in this band of frequencies is transmitted inside the standard channel bandwidth.

The simple system of Fig. 2-1 is *incompatible* because the millions of black-and-white receivers, now in homes, could not make use of it. To be compatible, color TV signals should produce a normal black-and-white picture on standard black-and-white receivers. A fully compatible system meets the following conditions:

1. Color transmissions are reproduced in full color on color receivers.
2. Color transmissions are reproduced in black-and-white on black-and-white receivers — (no changes are required in new or old black-and-white receivers to meet this condition).
3. Black-and-white transmissions are reproduced in black-and-white on color receivers.
4. Color receivers automatically adapt themselves to reproduce color or black-and-white telecasts.

Brightness Signals. Compatibility requires the color TV signal to have a brightness component just like the signal developed by a black-and-white camera. This camera, shown in the block diagram of Fig. 2-2, responds to *brightness* variations in the televised scene. The camera has a spectral response that is very similar to human vision, so that the *brightness* signals correspond to the brightness

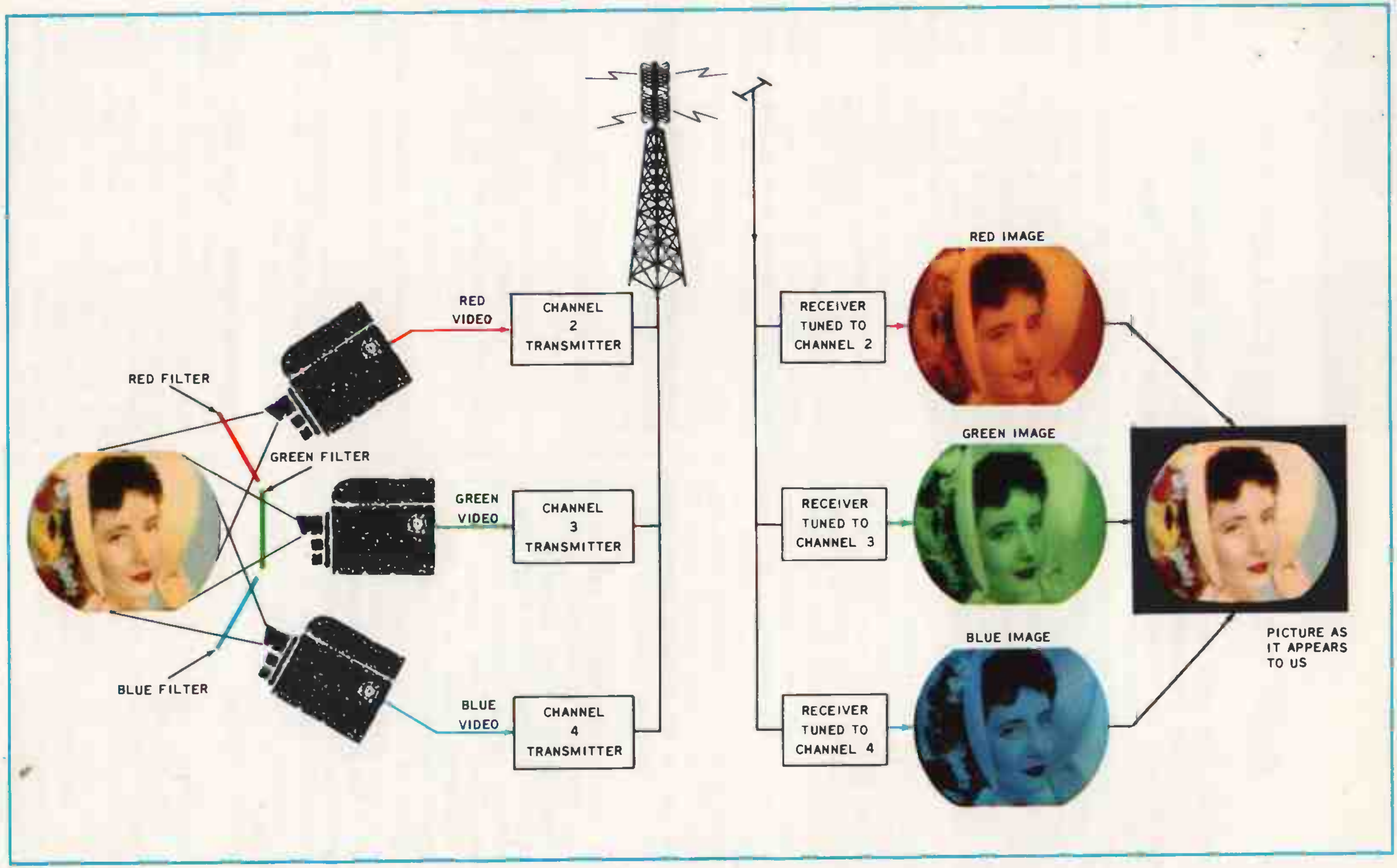


FIG. 2-1. A hypothetical color television system using three standard television channels.

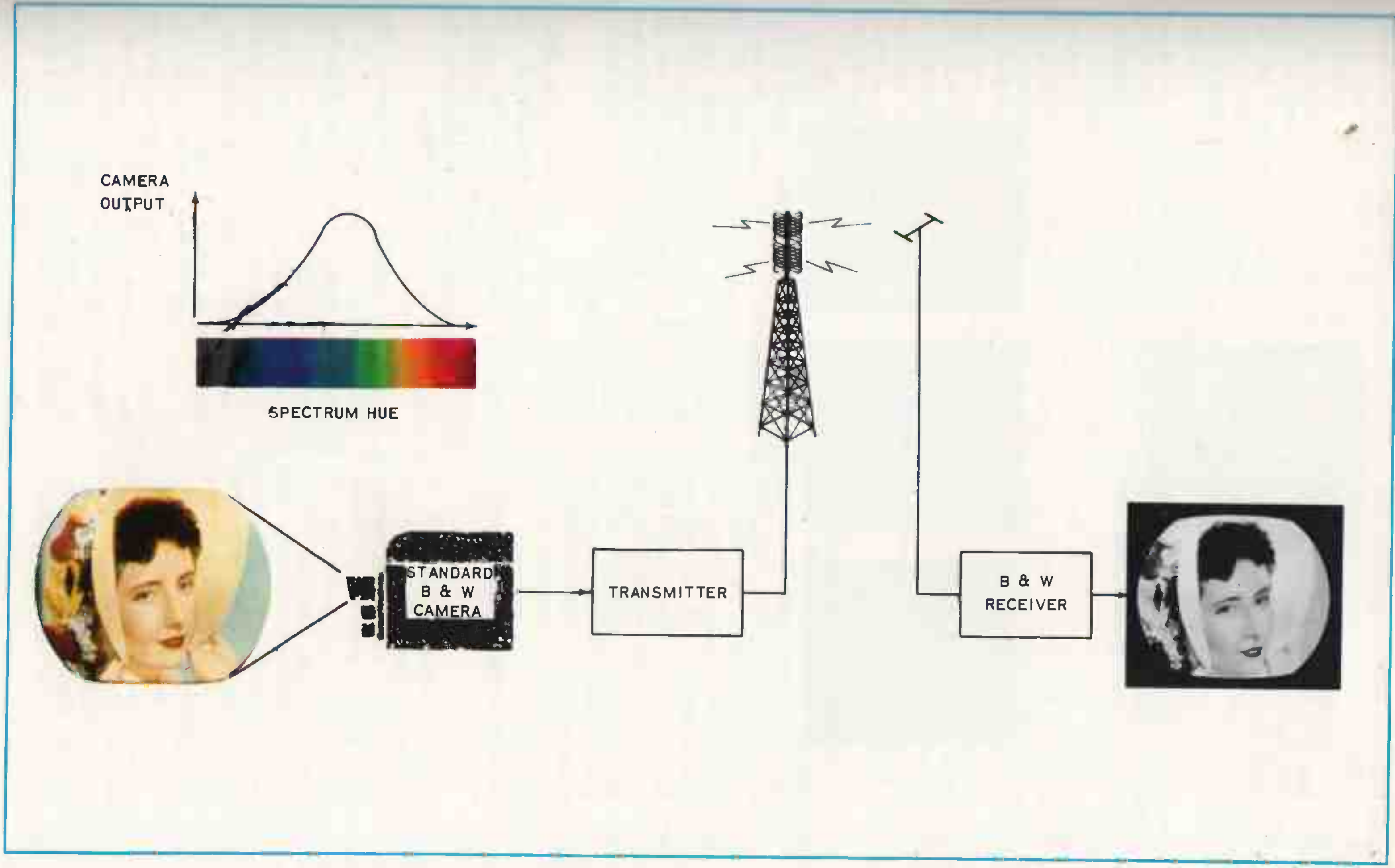


FIG. 2-2. Elementary components of the black-and-white television system.

sensations we get when observing the same scene. Our eyes are most sensitive to green light, and a brightness response curve for our eyes shows a peak in the green part of the visible spectrum. The black-and-white picture tube displays the brightness variations in terms of black-and-white.

Color receivers also process the brightness signal in the conventional way. However, at the color picture tube, the brightness signal, in today's receivers, is applied to the cathodes of all three guns, as shown in Fig. 2-3. (Due to unequal phosphor efficiencies, the relative amplitudes of the signals applied to the cathodes are altered somewhat.) Since all three primary colors vary in the same relative proportions, the reproduced picture is displayed in terms of whites, grays, and blacks.

The tricolor camera can also produce a brightness signal (also called a *luminance* or Y signal). By adding together correct proportions of the red, green, and blue signals, a brightness signal like that of the black-and-white camera is produced. The proportions are 30% of the red signal, 59% of the green signal, and 11% of the blue signal, as shown in Fig. 2-4. Note that the largest percentage is taken from the green camera. When the video signal, together with the standard blanking and sync pulses, is transmitted in the conventional way, black-and-white receivers reproduce normal black-and-white pictures.

The additional information needed to reproduce color pictures on color receivers is modulated upon a *subcarrier* signal that is placed near the high-frequency end of the video bandpass, at about 3.58 mc. Although black-and-white receivers receive the color signals, the black-and-white picture is not degraded. A high-frequency signal of this type produces a pattern of very fine dots in the picture. By carefully selecting the subcarrier frequency to be numerically related to an odd harmonic of the scanning frequencies, the dot pattern is made stationary and inclined at an angle of 45° to the horizontal. Under these conditions, the fine dot pattern is very nearly invisible.

Color Signals. The color or *chrominance* signals are transmitted separately on a phase-and-amplitude-modulate subcarrier signal. Since the brightness signal is already present in the color receiver, the color signals must be arranged so that they can be combined with the brightness signal to reproduce the original red, green, and blue signals. This is done by *subtracting* the brightness signal from the red, green, and blue signals at the transmitter to produce the *color-difference* signals. For example, the brightness signal, called the Y signal, is subtracted from the red signal, R, to produce the color difference signal R-Y. Signals B-Y and G-Y are produced in similar fashion. These color-difference signals are sent via the color subcarrier, along with the brightness signal, to the receiver, as shown in Fig. 2-5. At the color receiver, the color-difference signals are detected separately and are *added* to the brightness signal. Here R-Y is added to Y to produce R (the red signal). Similarly, B-Y and G-Y are added to the Y signal to produce the blue and green signals. In nearly all color receivers the addition of the brightness and color-difference signals takes place in the electron beams of the picture tube. Brightness signals are applied to the cathodes; color-difference signals are applied to the appropriate control grids.

In actual practice, only two color-difference signals need be transmitted. The remaining color-difference signals is reconstructed in the receiver by combining the two transmitted color-difference signals in the correct proportions.

To simplify matters, the discussions that follow describe transmission of color signals in terms of the color-difference signals R-Y and B-Y. However, present transmission standards are based upon a slightly different set of signals labeled I and Q. The complexities added by a discussion of I and Q signals would be of little help to the service technician, especially as I and Q signals are not demodulated in present-day receivers. A complete discussion of the effects of I and Q upon system capabilities can be found in the RCA Institutes' Home Study Course entitled Color Television.

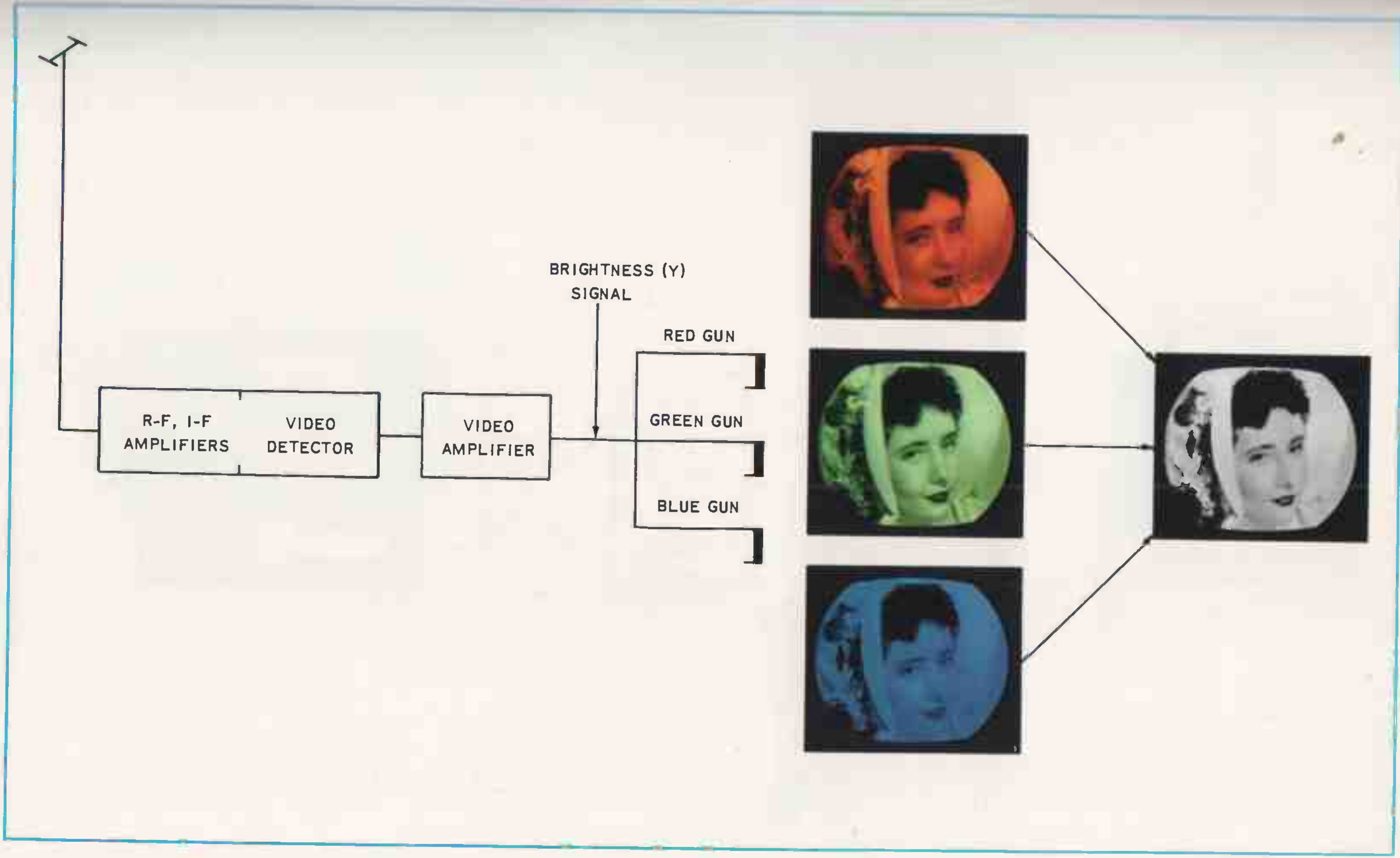


FIG. 2-3. In color sets the brightness signal causes the primary colors to vary in the same relative proportions; a black-and-white picture results.

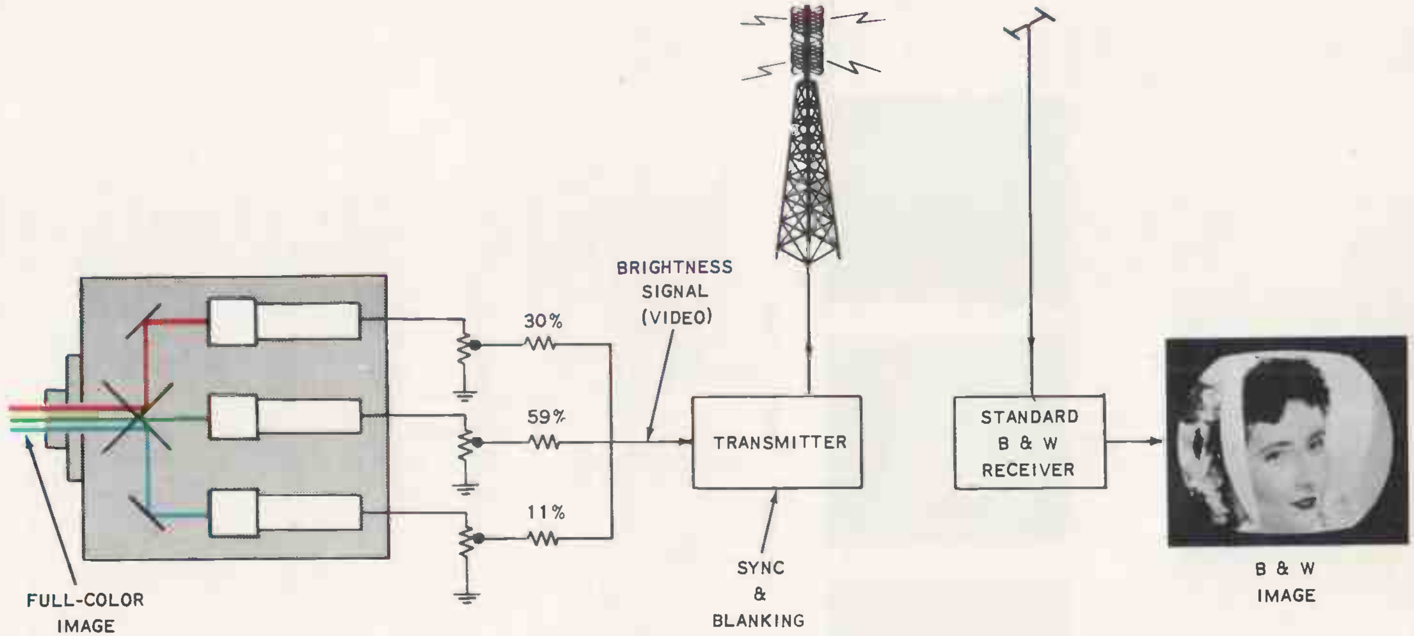


FIG. 2-4. The brightness signal produces the black-and-white picture in conventional black-and-white receivers

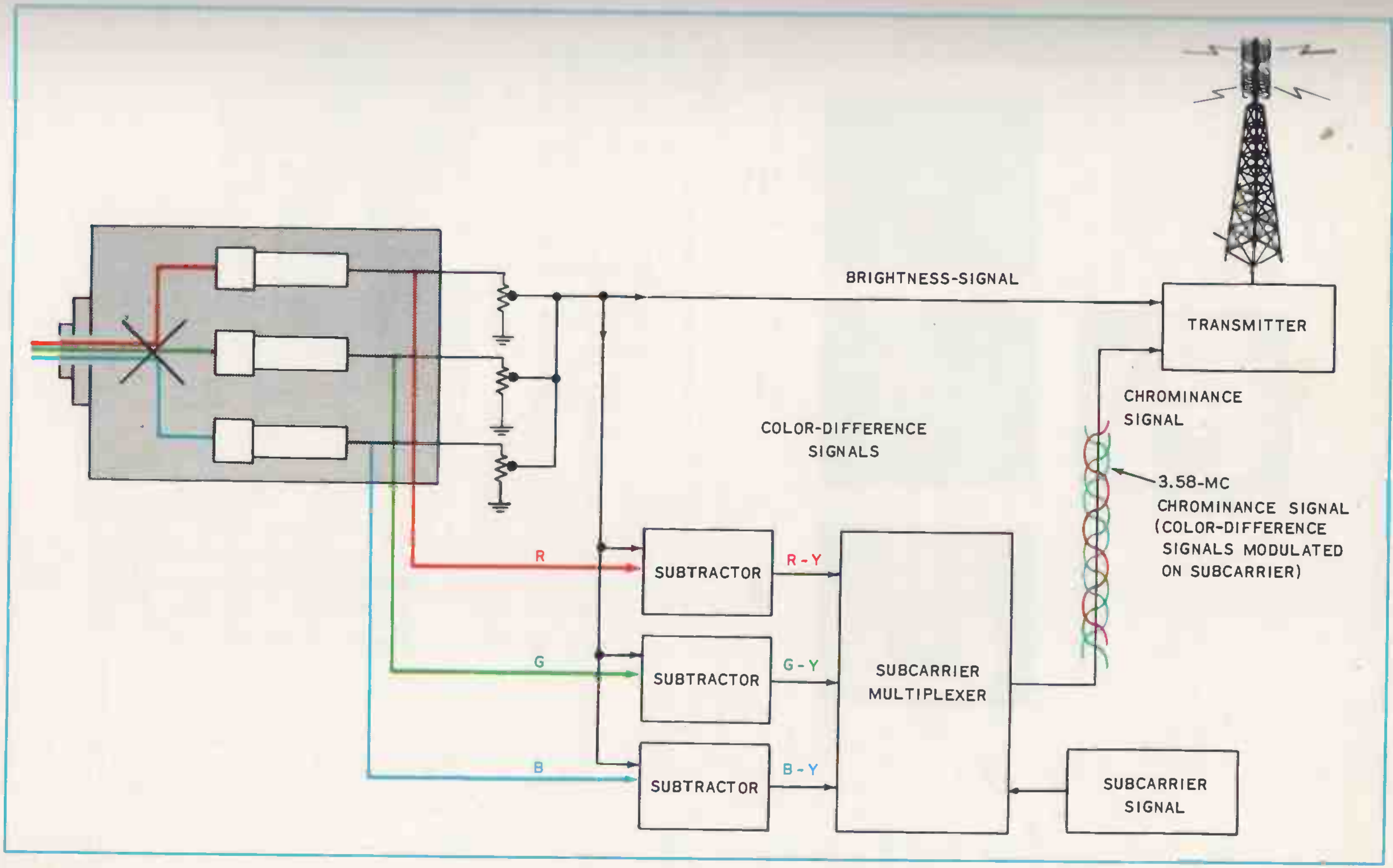


FIG. 2-5. Transmitting and receiving color signals within the standard television-channel bandwidth. (sheet 1 of 2).

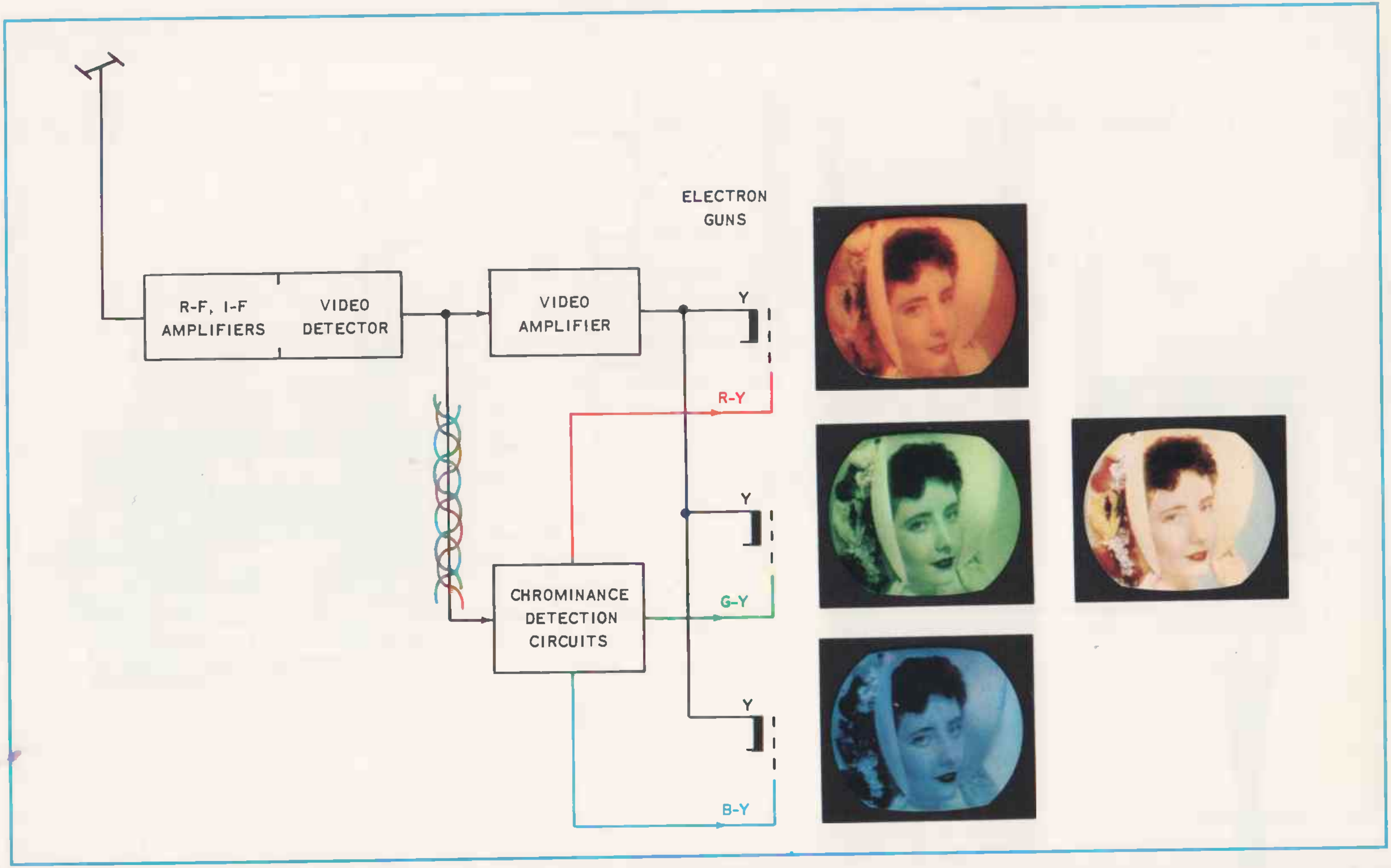


FIG. 2-5. Transmitting and receiving color signals within the standard television-channel bandwidth (sheet 2 of 2).

Hue and Saturation. The color-difference, or *chrominance,* signals carry information as to the hue and degree of saturation of the color being scanned. Color is described in terms of three attributes: hue, saturation, and brightness. We use the terms red, blue, green, orange, yellow, etc. to describe dominant hue. Saturation describes the "strength" or "depth" of the dominant hue. A deep red, not diluted with white, is said to be a "saturated" red. A pale red or pink, which is white light with an excess of red (or you might say pure red light diluted with white light), is said to be a color of low saturation. Brightness refers to the intensity of light reflected or radiated by an object. We use such terms as bright, dim, and dark to describe variations in brightness. In the color TV system, the brightness component of the scene is transmitted as the brightness or luminance signal. The chrominance signals contain the information about the remaining attributes — hue and saturation.

Developing Color-Difference Signals. Figure 2-6 shows how the color-difference signals can be made at the transmitter. A network of voltage dividers develops the brightness signal, as was shown in Fig. 2-4. The Y signal produced by these dividers is applied to a phase inverter to produce two negative (—Y) signals. The negative Y signals are added to the red and blue signals to produce R-Y and B-Y signals, respectively.

Remember that the color-difference signals are used in the receiver to combine with the Y component to restore the original red, blue, and green signals. Consider that a highly saturated red area is being scanned by the system. Only the red camera has an output; the blue- and green-camera outputs are zero. However, the divider networks produce a brightness signal to be used by both color and black-and-white receivers. In the color receiver, the brightness signal is applied to all three guns of the color picture tube to reproduce the black-and-white picture. Thus the brightness signal *alone* increases the beam current of all three guns. Full color reproduction is accomplished by adding the color-difference signals to the appropriate picture-tube gun signals. The effect of the R-Y signal is to increase the beam current of the red gun. The B-Y and G-Y signals, in this case, are of such polarity and amplitude that they *cancel* the brightness component at the blue and green guns. With the red gun producing high beam current and the blue and green guns cut off, a fully saturated red is reproduced.

Saturation Control. A color saturation control, called the COLOR control, is used in most color receivers. This con-

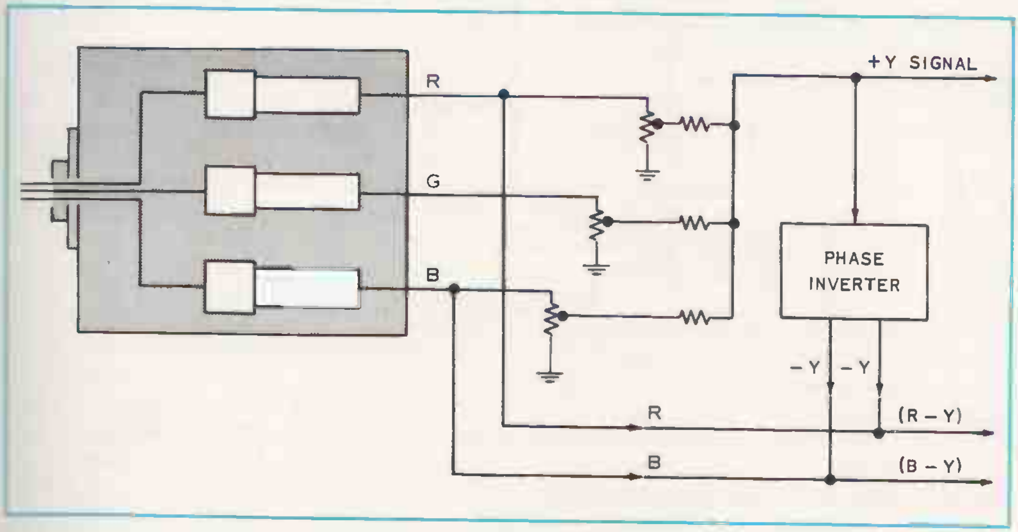


FIG. 2-6. Production of the color-difference signals in the simplified television system described in the text.

trol makes it possible to adjust the amplitude of the color-difference signals in the receiver. When the control is fully CCW, the color-difference signals are cut off, and the receiver produces a black-and-white picture. When the control is adjusted correctly, the colors are reproduced with the proper degree of saturation. Consider the saturated red in the previous example, if the COLOR control is turned CCW from the correct position. The red beam current diminishes somewhat, and the blue and green guns are not driven to cutoff. The result is a red mixed with white (red, green, and blue), producing pink. The viewer, therefore, can control saturation to suit individual tastes and to compensate for variations in chrominance levels between TV channels.

Transmitting the Chrominance Signals. Two chrominance signals must be impressed upon the color subcarrier. This is accomplished at the transmitter by means of a pair of modulators. Both modulators are supplied with 3.58-mc CW signals, as shown in Fig. 2-7. Note that the phase of the CW signal applied to one of the modulators is shifted in phase by 90°. The outputs of the two modulators are added, and the resultant 3.58-mc sideband signal is combined with the brightness signal, the sync and blanking pulses, and the color sync signal, to form the composite video signal. At the receiver, the color information, contained in the sidebands of the 3.58-mc subcarrier, is passed on to the color circuits by a bandpass amplifier. A pair of synchronous detectors (or demodulators) is used to recover the color-difference signals from the subcarrier sideband signals.

Suppressed-Carrier Operation. The chrominance modulators at the transmitter are a special form of balanced modulator designed to cancel the subcarrier signal.

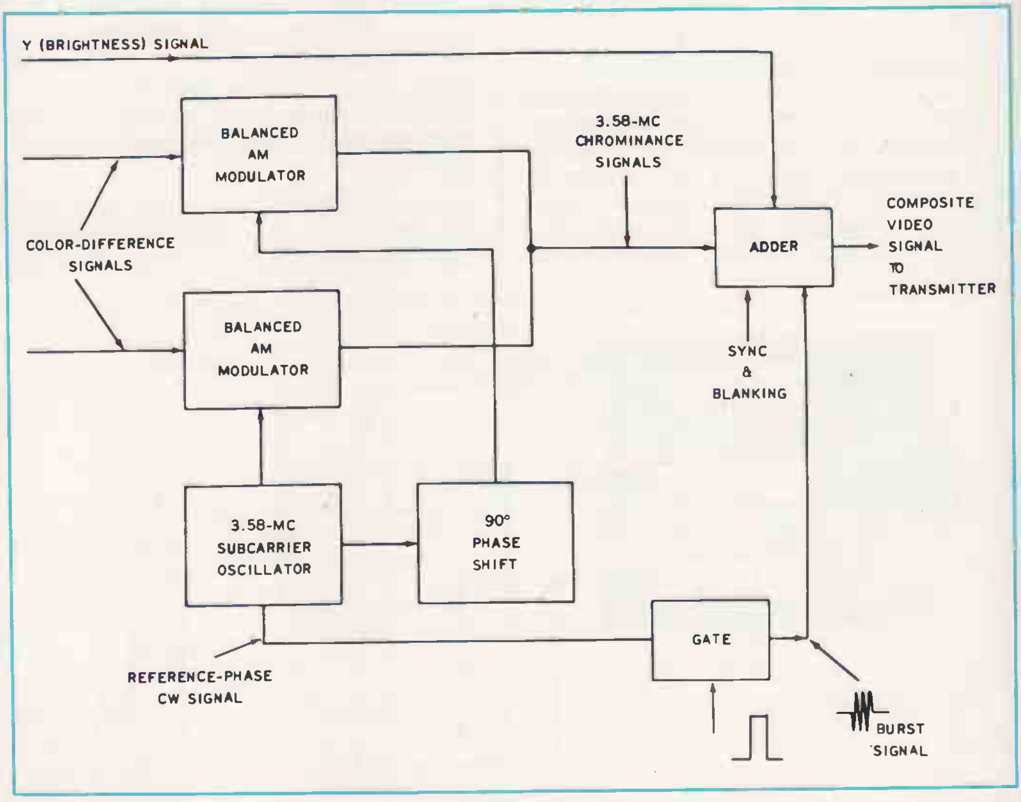


FIG. 2-7. The color-difference signals are applied to a pair of balanced modulators. The resultant transmitted color signal exists in the form of sidebands of the color subcarrier signal.

Only the sideband signals, which carry the intelligence, are produced. Henceforth, when we refer to the 3.58-mc subcarrier signal, we mean the *sideband* signals. When there are no modulating chrominance signals, the 3.58-mc output of the modulators is zero. Due to the manner in which the color-difference signals are assembled (refer to Fig. 2-6), the color-difference signals add up to zero when white or gray parts of the picture are scanned. Thus, there are no chrominance signals when white or gray parts of the picture are scanned. This accounts for the fact that you never see the 3.58-mc dot pattern in the white and gray parts of the picture. The dot pattern can be seen, if you look closely, only in those areas of the picture that have highly saturated colors.

Hue and Phase. The *phase* of the 3.58-mc chrominance signal determines the *hue* of the color being transmitted. Note that the block diagram of Fig. 2-7 shows the outputs of the two chrominance modulators in the transmitter being combined. When two signals that differ in phase are added, the resultant signal has a phase angle of some intermediate value. The exact phase of the resultant depends upon the phase difference between the original CW signals and the instantaneous amplitudes of the original signals. For example, suppose the two color-difference signals are equal in amplitude and one of the CW signals has a phase angle of zero (compared to some reference), while the other CW signal has a phase angle of 90°. The outputs of the modulators are two signals of equal amplitude but 90° apart in phase. When the two signals are added, the resultant phase angle is 45°. The output of a B-Y modulator can be 0° or 180°, depending upon the polarity of the B-Y signal. Similarly the phase of an R-Y modulator output can be 90° or 270°. Depending upon the instantaneous polarities and amplitudes of the two color-difference signals, the phase of the resultant 3.58-mc chrominance signal can have any value between 0° and 360°. Since hue determines the relative polarities and amplitudes of the color-difference signals, hue also determines the phase of the 3.58-mc subcarrier signal. Table 2-1 shows the

Hue	Subcarrier Phase (with respect to burst phase)
Red	77°
Yellow	13°
Green	299°
Cyan	257°
Blue	193°
Magenta	119°

TABLE 2-1

approximate subcarrier phase angles for various hues.

Saturation and Amplitude. The saturation of a particular spot in the picture determines the over-all amplitude of the 3.58-mc subcarrier signal. There is no 3.58-mc signal when the color-difference signals are zero (white or gray). Increased saturation results in increased amplitude of both color-difference signals and greater output from the modulators. If saturation increases, but hue remains the same, the amplitude of the subcarrier signal increases but the phase angle remains unaltered.

The important facts to remember about the parts of the signal that convey the three attributes of the color scene are as follows:

1. *Brightness* information is conveyed in terms of the amplitude of the brightness signal. This signal is exactly like the familiar video signal of black-and-white transmissions. It requires a bandwidth of about 4 mc.
2. *Hue* information is conveyed by the *phase* of the 3.58-mc subcarrier signal.
3. *Saturation* information is conveyed by the *amplitude* of the 3.58-mc subcarrier signal.

The color information (chrominance signal) consists of hue and saturation information. Since our eyes cannot resolve differences in hue and saturation in small areas of the picture, much less bandwidth is allocated to the transmission of chrominance signals. Color-difference signals applied to the modulators are contained in a video bandwidth of less than 1.2 mc. After modulation, the chrominance information exists in the sideband signals that extend above and below the 3.58-mc subcarrier signal.

I and Q Signals. The chrominance signals selected to be transmitted under the present color TV standards are not R-Y and B-Y, but a similar pair of chrominance signals designated as I and Q. This particular pair of chrominance signals was chosen to obtain the greatest degree of color resolution by taking advantage of certain characteristics of human vision. (The human eye seems to be able to distinguish some hues better than others in very small areas of the picture.) However, very few receivers have been built to take full advantage of the system, partly because the added complexities in the receiver add other forms of distortion, and little over-all improvement in picture quality results. Although I and Q signals are used to modulate the subcarrier signal at the transmitter, it is possible to adjust the receiver circuits to demodulate the R-Y and B-Y signals directly from the subcarrier signal with a negligible loss of color resolution. For the purpose of the TV technician, it is not necessary to go into detail regarding the I and Q signals.

Color Synchronization. The synchronous detectors in the receiver that recover the color-difference signals must be supplied with a reference subcarrier signal. Demodulation is accomplished by reinserting the carrier signals that were suppressed at the transmitter. These reinserted carriers are generated in the receiver, but they must be made to operate at specific phase angles with regard to some system reference. This reference is provided by a short burst of 3.58-mc signal generated by the gating circuit in Fig. 2-7. This short burst of 3.58-mc signal is sent out during the horizontal blanking period, following the trailing edge of the horizontal sync pulse, as shown in Fig. 2-8.

At the receiver, the pulse of 3.58-mc signal, called the *burst*, is separated from the remainder of the signal, and is used to synchronize the frequency and phase of a local subcarrier oscillator.

Signal Corrections at the Transmitter. The signal is corrected or "predistorted" at the transmitter for two reasons. First, a correction is built in to overcome the nonlinear relation between signal drive voltage and light output that exists in all picture tubes. This correction, which is called *gamma correction* and is applied to all TV signals, need not concern the TV technician. The second correction is taken to prevent the peak excursions of 3.58-mc signals from over-modulating the transmitter. This is accomplished by attenuating the color-difference signals by specified amounts, before they are applied to the modulators. Correct relative amplitudes are restored in the receiver in the circuits that recover and amplify the color-difference signals. We will see later how to check to see that proper relative amplitudes are restored in the receiver.

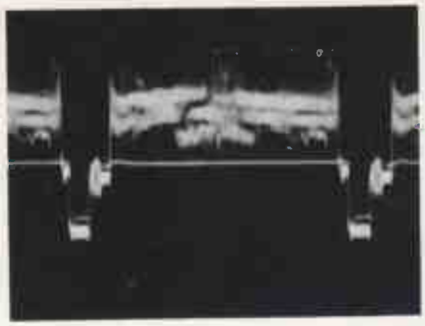


FIG. 2-8. You can see the burst signal following the horizontal sync pulse in this waveform of the signal produced by the video detector in a receiver.

Composite Color Signal. Figure 2-9 shows how the different parts of the composite color signal are put together. A pattern of saturated bars of color is employed in this illustration. Note that there are no 3.58-mc color signals when the white bar is scanned.

Signal Paths in the Color Receiver. Basically, the color receiver is very similar to the black-and-white receiver. Major additions are the circuits that separate and reproduce the color-difference signals, and the circuits that supply the special electrical requirements of the color picture tube.

Figure 2-10 shows the paths taken by various parts of the color signal. Let us

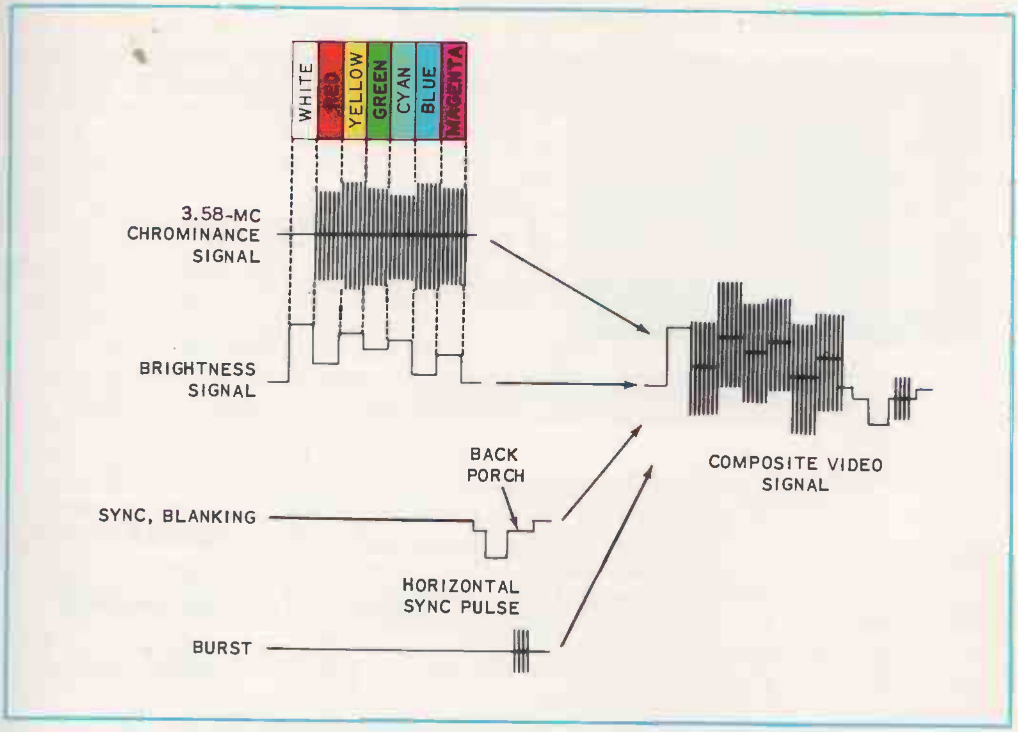


FIG. 2-9. Appearance of the composite video signal when a simple pattern of colored bars is scanned.

trace these signals from the antenna terminals to the color picture tube.

Tuner, I-F Amplifier, and Detector. Basically no different than r-f and i-f sections of a black-and-white receiver, these sections select and amplify the r-f signal, yielding the composite video signal at the output of the video detector. There are differences in detail, however. Greater attention is paid to the response curves of the tuner to ensure flat response throughout the band of each channel. This precaution is necessary to make sure that signals in the region about the color-subcarrier frequency are not attenuated. In the i-f amplifier in particular, care is taken to make sure that sideband signals of the color subcarrier are not lost. In the i-f amplifiers of most modern receivers, amplification is not uniform near the color-subcarrier frequency, but proper relative amplitudes are restored later in the color circuits. Careful alignment is needed so that all circuits work together properly to provide uniform over-all amplification of the color sideband signals.

Particular attention is paid to efficient trapping of the sound i-f signals *ahead* of the video detector. This is done to minimize the interference pattern produced by a beat between the sound carrier and the color subcarrier. The sound and color-subcarrier signals are 920 kc apart. To prevent the 920-kc beat from being developed in the video detector circuit, the sound i-f signal of 41.25 mc is trapped out in the i-f feed to the video detector. As shown in Fig. 2-10, a separate detector, also fed from the last i-f stage, supplies the 4.5-mc sound signal to the sound system.

The composite signal developed at the video detector contains the brightness signal, sync and blanking pulses, chrominance signals in the form of 3.58-mc sidebands, and the burst or color synchronizing signal. The signal is similar, in form, to that shown in Fig. 2-9.

The video amplifier serves as the distribution point for the components of the composite video signal. Composite signals are fed to the following circuits:

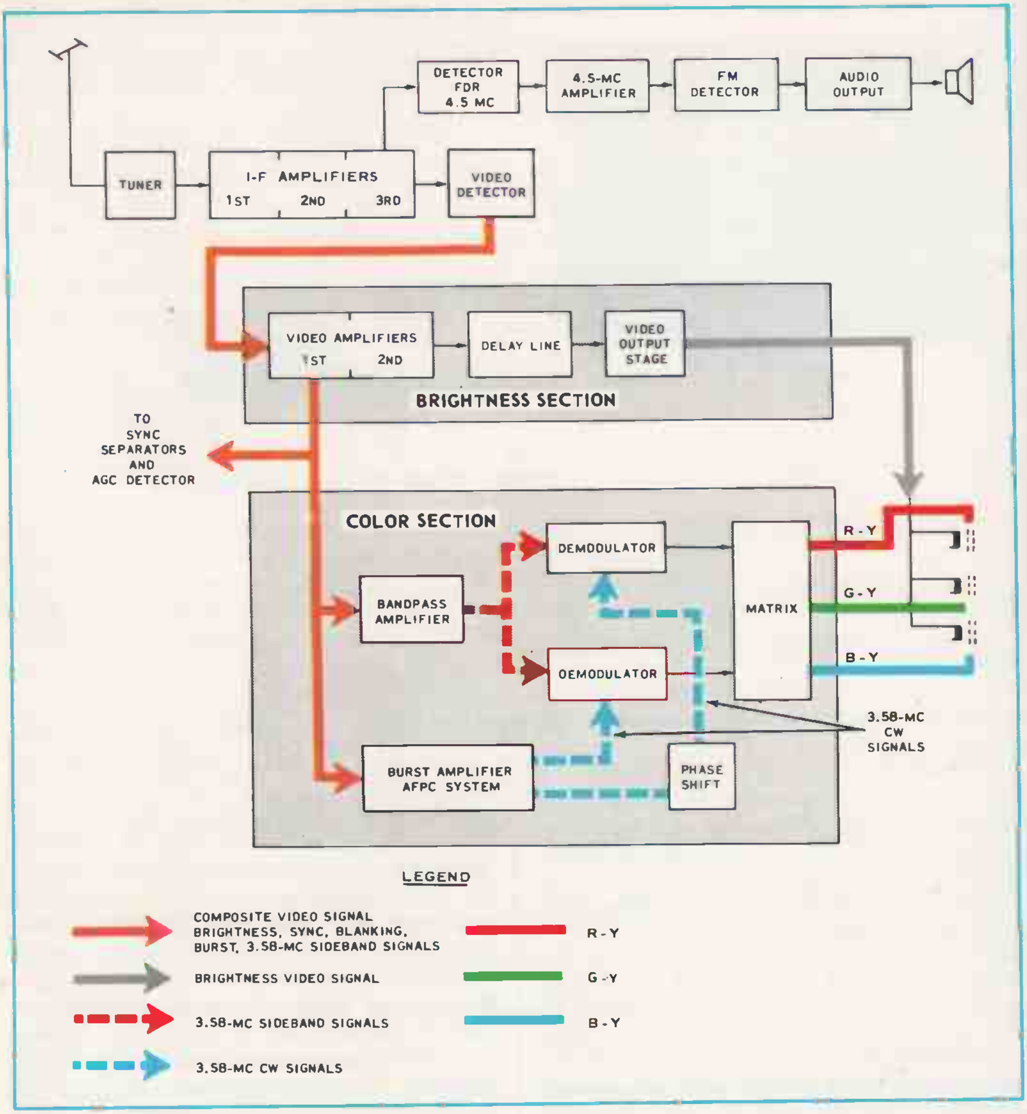


FIG. 2-10. Paths of various parts of the composite color signal in the receiver.

1. *Additional video amplifier and output stages*. Here the brightness signal is amplified to the level required to drive the picture tube. The video signal is applied simultaneously to the *cathodes* of all three electron guns in the picture tube.

2. *Sync separator and AGC detector stages*. Here sync pulses are stripped from the remainder of the composite signal to be fed to the deflection oscillators. Keyed AGC systems sample the amplitude of the sync pulses to establish the value of automatic-gain-control voltage.

3. *Bandpass amplifier*. A narrow-band amplifier, similar to an i-f amplifier tuned to 3.58 mc, the bandpass amplifier rejects most of the composite video signal and passes the 3.58-mc sideband signals. The bandpass amplifier feeds the 3.58-mc chrominance signals to the color demodulators.

4. *Burst amplifier*. Color sync signals are separated from the composite video signal by the burst amplifier. This narrow-band tuned amplifier is normally cut off, but is keyed into conduction at the time

that the burst signal arrives. Keying pulses to gate the burst amplifier into operation are obtained from the horizontal deflection circuits. Separated burst signals are supplied to the 3.58-mc AFPC (automatic frequency and phase control) system to control the frequency and phase of the local 3.58-mc oscillator.

Brightness Section. The amplifiers that handle the brightness signal (sometimes called the luminance amplifiers) are similar to the video amplifiers of a black-and-white receiver. Their main purpose is to amplify the video (brightness) signal to the level needed to drive all three cathodes of the color picture tube. An important additional requirement is the preservation of the d-c component of the signal. Preservation of the d-c component of the signal is important to proper color reproduction, and some form of d-c coupling or d-c restoration is employed in both the brightness and chrominance sections of the receiver.

Delay Line. A unique requirement of the brightness amplifier, not found in black-and-white receivers, is a fixed time delay. Brightness and color signals take different routes in the receiver, but they must arrive coincident in time at the control elements of the picture tube. The color signals undergo a longer natural time delay in passing through the narrow-bandwidth chrominance circuits. Thus, a delay is needed in the brightness section so that brightness and color delays match. Figure 2-11 shows the effect of the delay in the brightness amplifier in making the color and brightness signals "fit" together on the picture-tube screen. Time delay is provided by a form of coaxial delay line. A typical delay line is shown in Fig. 2-12.

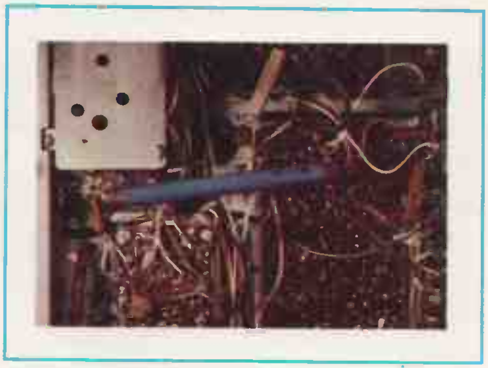


FIG. 2-12. The long cylindrical object under the chassis is the video delay line.

Color Section. The color or chrominance section of the receiver lies between the input to the bandpass amplifier and the control grids of the color picture tube. Here the color information, in the form of sidebands of 3.58 mc, is demodulated and processed to produce the color-difference signals. Separated chrominance signals in the form of sidebands of 3.58 mc are supplied by the bandpass amplifier to a pair of color demodulators. Here the carrier signals, at the correct phase angles, are reinserted, and the demodulation process yields two color-difference signals. The demodulators in some receivers produce R-Y and B-Y, but other combinations, such as I and Q, R-Y and G-Y, and X and Z, have been used. The third color-difference signal is produced by combining specified negative amounts of the demodulated color-difference signals. The network used to develop the third color-difference signal is sometimes called a *matrix*.

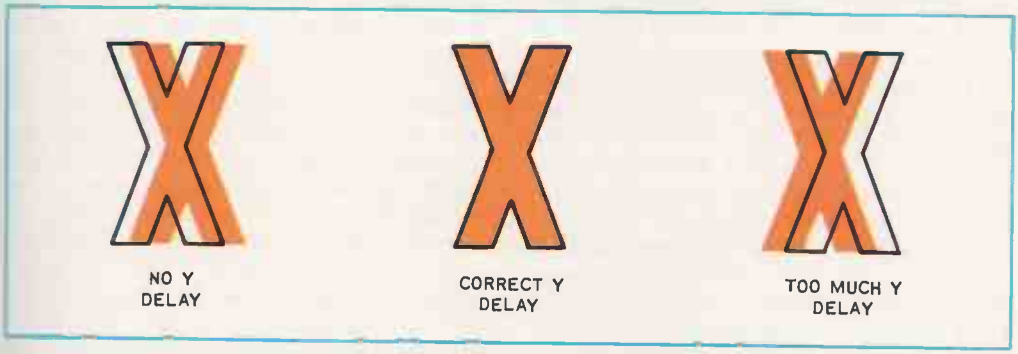


FIG. 2-11. Effects of time delays in the brightness channel of the receiver.

Color-difference signals developed in the chrominance section are applied to the *control grids* of the color picture tube. Since the brightness signal is applied to the cathodes, the addition of brightness and color-difference signals takes place in the electron beams of the three electron guns. As a result, beam currents are reproduced versions of the red, green, and blue signals that are found at the output of the color camera at the transmitter.

Demodulators. The color demodulators are phase-sensitive detectors. Two input signals are required for the operation of each demodulator: (1) the chrominance signal, in the form of 3.58-mc sidebands; and (2) a 3.58-mc CW signal which has the desired phase with regard to the system reference (burst). The polarity and amplitude of the signal delivered by each demodulator depends in part upon the amplitude of the chrominance input signal (and to a small degree upon the amplitude of the CW input signal) and in part on the *phase relation* between the chrominance-input and CW-input signals. If we consider the amplitudes of the chrominance and CW signals to be held constant, phase relations have the following effects. When the chrominance input signal and the CW input signals are in phase, the output of the demodulator is at maximum amplitude, and is negative going. When these two input signals are 180 degrees out of phase, output amplitude reaches a maximum in the positive direction. A 90-degree phase shift between chrominance- and CW-input signals results in zero output. At all intermediate phase angles, the output is between zero and the maximum value.

An illustration of how a simple synchronous demodulator responds to signals of various phase angles is shown in Fig. 2-13. Consider a large-amplitude 3.58-mc reference applied to the suppressor grid of the pentode, as indicated during time interval, t_1. This signal gates the tube into conduction for all of the positive half cycle. During the negative half cycle the tube is cut off. With no signal applied at the control grid, plate current flows in the form of 3.58-mc pulses causing the plate voltage to drop as shown. A low-pass filter removes the 3.58-mc component in the plate circuit so that a steady d-c voltage is found at the plate. Plate voltage is less than the supply voltage, and depends upon the average conduction of the tube. During this time the output of the circuit is zero since the coupling capacitor C has charged to the average plate voltage. Only *changes* in the average plate voltage are found at the output.

When a signal applied to the control grid is *in phase* with that at the suppressor, the tube conducts more heavily during the time that the suppressor-grid signal permits conduction. Average plate current increases and the plate voltage becomes less positive. The output waveform shows a negative excursion, as shown during time interval t_2.

If the signal at the control grid is 180° out of phase with that at the suppressor grid, the tube does not conduct as much during the gated periods. The signal at G_1 is going negative as the G_3 voltage swings positive. Average conduction drops, and the plate voltage shows a positive excursion, as shown at time t_3 of the figure.

Consider the control grid signal to be 90° out of phase with the suppressor-grid signal. During the interval that the suppressor grid permits conduction, the grid signal first swings positive and then (midway in the conducting period) swings negative. Since tube current increases and then decreases an equal amount during the conducting period, the result is no change in *average* plate current. Note that during time t_4, plate voltage is the same as when there is no signal applied to the control grid.

Summarizing demodulator action, plate voltage drops when the two input signals are in phase, rises when the signals are 180° out of phase, and remains unchanged (zero detected voltage) when the two signals are 90° apart. *Thus the demodulator produces maximum output when the phase difference between input signals is 0° or 180°, but practically ignores a signal whose phase is 90° or 270° from the locally-injected signal.* At intermediate phase angles between 0° and 90°, the demodulator output has some intermediate value. Figure 2-14 shows a graph of output voltage versus the phase

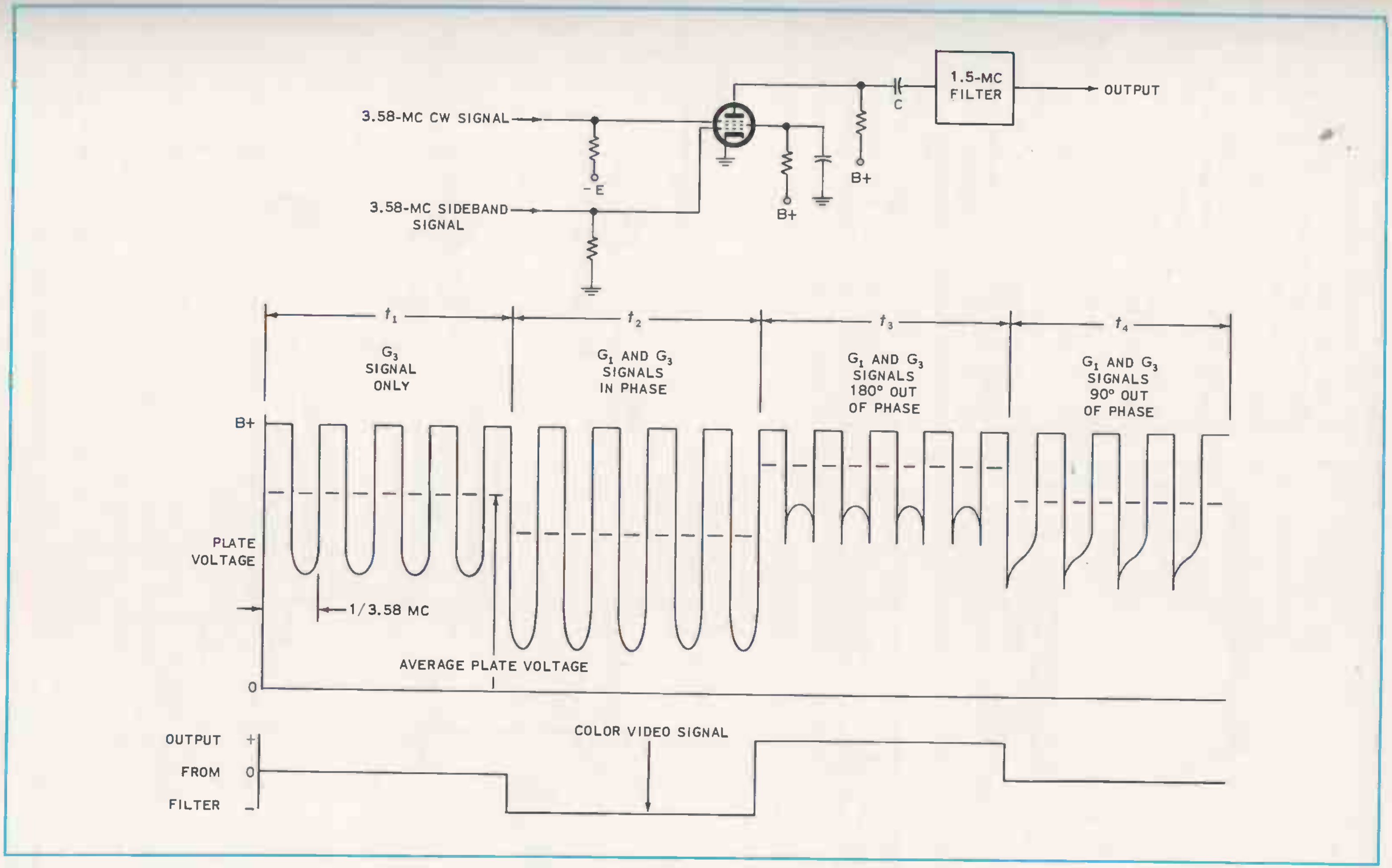


FIG. 2-13. Basic operation of a color demodulator.

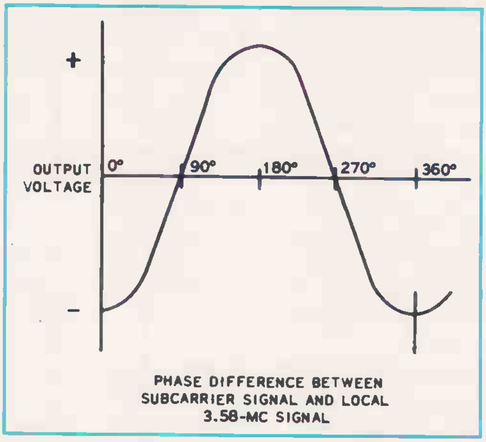


FIG. 2-14. Output voltage plotted against phase of the chrominance signal for a typical demodulator.

difference between the two input signals. If the CW signals applied to a pair of demodulators are arranged to have the same phase, relative to burst, as the CW feeds to the *modulators* at the transmitter, the original color-difference signals (I and Q) can be detected. The color-difference signals R-Y, B-Y, and G-Y can also be demodulated directly from the sideband signals by simply altering the phase of the CW signals applied to the demodulators. A three-demodulator system, detecting all three color-difference signals directly, can be arranged as shown in Fig. 2-15.

B-Y, R-Y Demodulators. Some receivers have been designed to demodulate the B-Y, R-Y signals directly. The third color-difference signal, G-Y, can be made by adding the proper proportions of negative B-Y and R-Y signals. The Zenith sheet-beam demodulators, for example, produce both positive and negative B-Y and R-Y signals, as shown in Fig. 2-16. The positive B-Y and R-Y signals are applied to the control grids of the blue and red guns in the picture tube; the negative

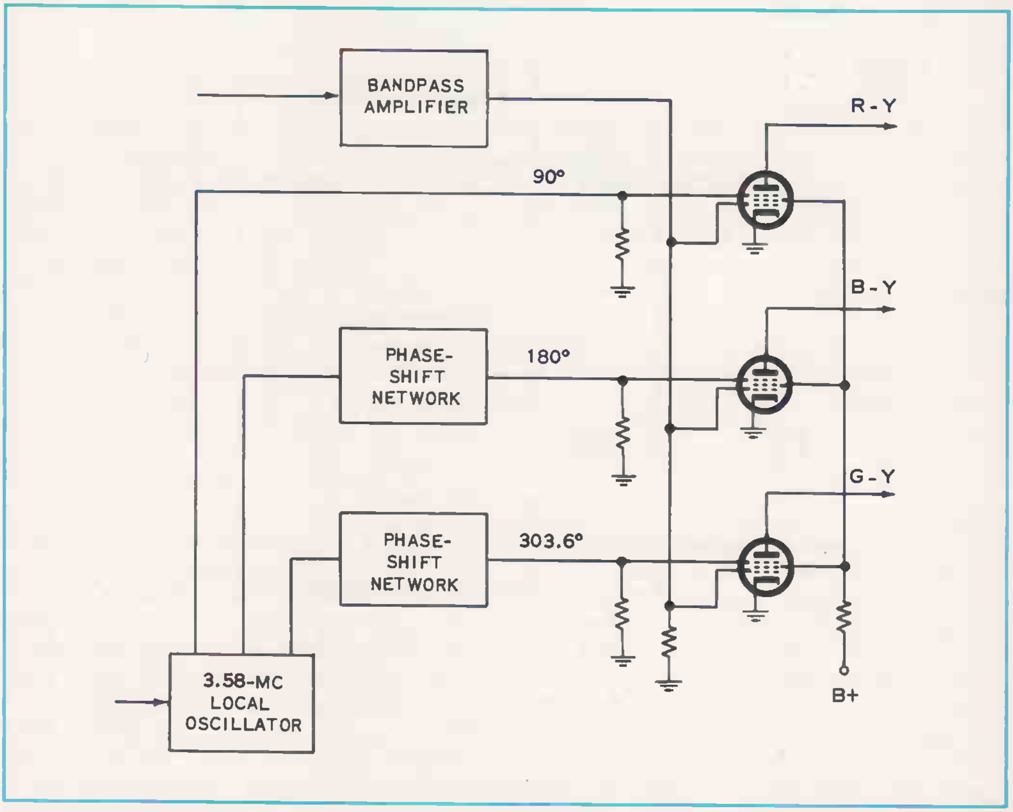


FIG. 2-15. An elementary three-demodulator system for reproducing the three color-difference signals.

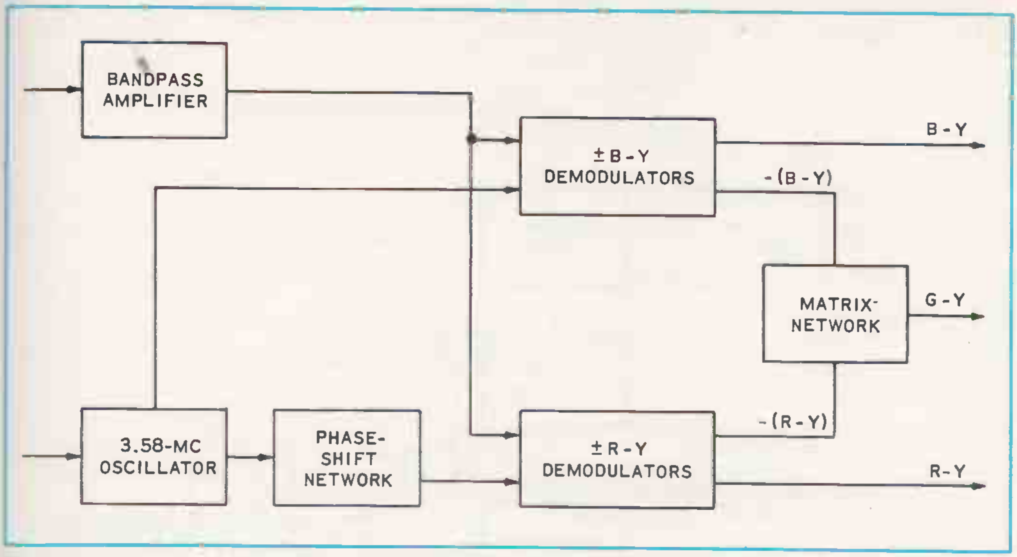


FIG. 2-16. The demodulation system used in Zenith receivers develops positive and negative R-Y and B-Y signals. The negative signals are combined to generate the G-Y signal.

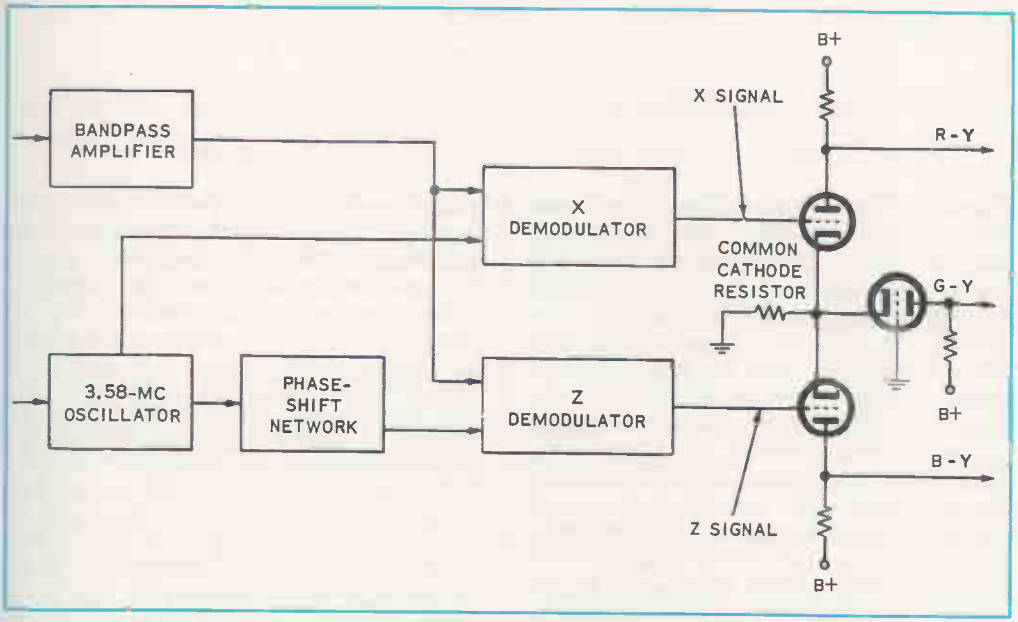


FIG. 2-17. The X and Z demodulators found in late-model RCA receivers.

color-difference signals are added together in the correct proportions to produce the G-Y signals.

X and Z Demodulators. Most late-model RCA receivers use demodulation axes that lie close to, but not on, the B-Y and R-Y phase axes. These axes are designated the X and Z axes. A unique matrix amplifier combines the X and Z signals to produce all three color-difference signals, as shown in Fig. 2-17.

Color Synchronization Section. The color sync section of the color receiver is very similar to the familiar horizontal AFC

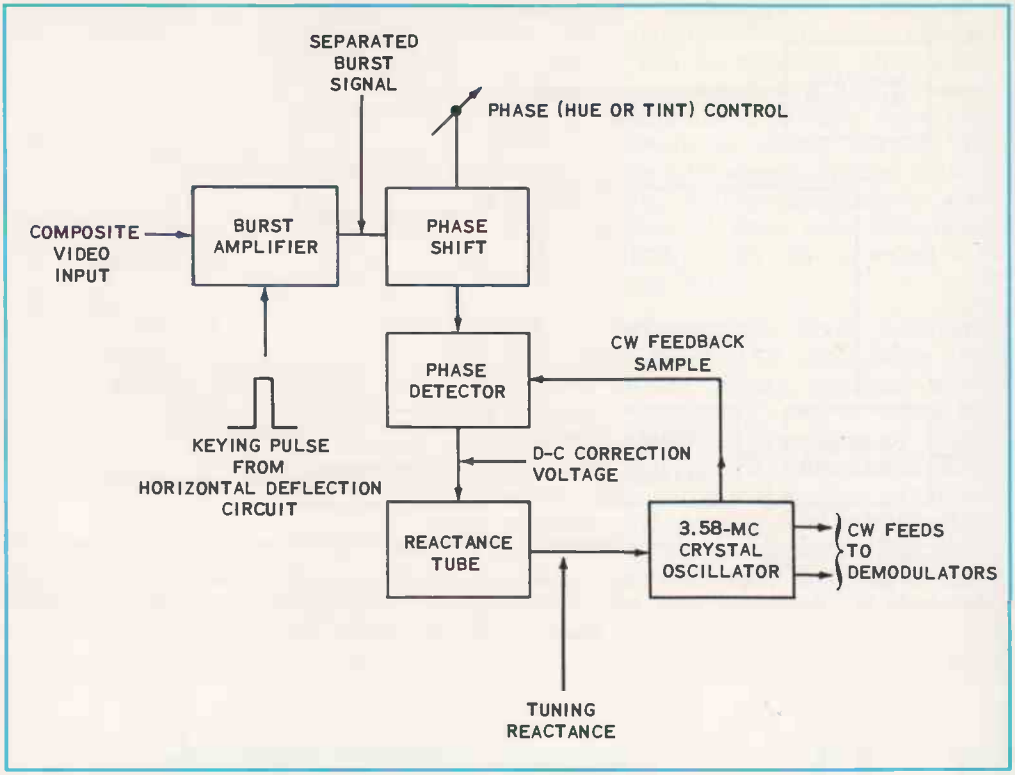


FIG. 2-18. The basic AFPC system in the receiver.

system. Figure 2-18 shows the basic AFPC (automatic frequency and phase control) system of a color receiver. The heart of the system is a crystal-controlled oscillator operating at the subcarrier frequency of 3.58 mc. Outputs from this master oscillator feed the two color demodulators. A sample of the 3.58-mc signal is applied to a phase detector that compares the oscillator signal with the separated burst signal. The phase detector produces a d-c correction (or error) voltage when the phase of the oscillator signal is incorrect. The direction and amount of phase error is indicated by the polarity and amplitude of the voltage produced by the phase detector. A reactance-tube circuit transforms the variable d-c correction voltage into a variable capacitance that tunes the oscillator. Any shift in oscillator phase from the correct value causes an automatic change in the capacitance across the oscillator's tuned circuit (the crystal) to restore the correct phase condition.

When a frequency error occurs, the correction voltage swings the oscillator frequency back and forth throughout the range of control. As frequency passes through the correct value, the correction voltage passes through zero, and the system "locks up" in frequency and phase.

Tint Control. The TINT or HUE control is a master phase control that allows the viewer to change hues by adjusting the phase of the 3.58-mc oscillator. This control is usually part of a tuned circuit that makes it possible to alter the phase of the separated burst signal. It is also possible to control hue by altering the phase of the CW signal applied to the phase detector. Any change in the phase of the separated burst signal is "followed" by the AFPC system. Correct phase is indicated when the hues reproduced on the screen are correct. Viewers use flesh tones as the criterion. Precise phase adjustments, using color test signals, will be shown later in this book.

Color Killer. If the color circuits are permitted to function during black-and-

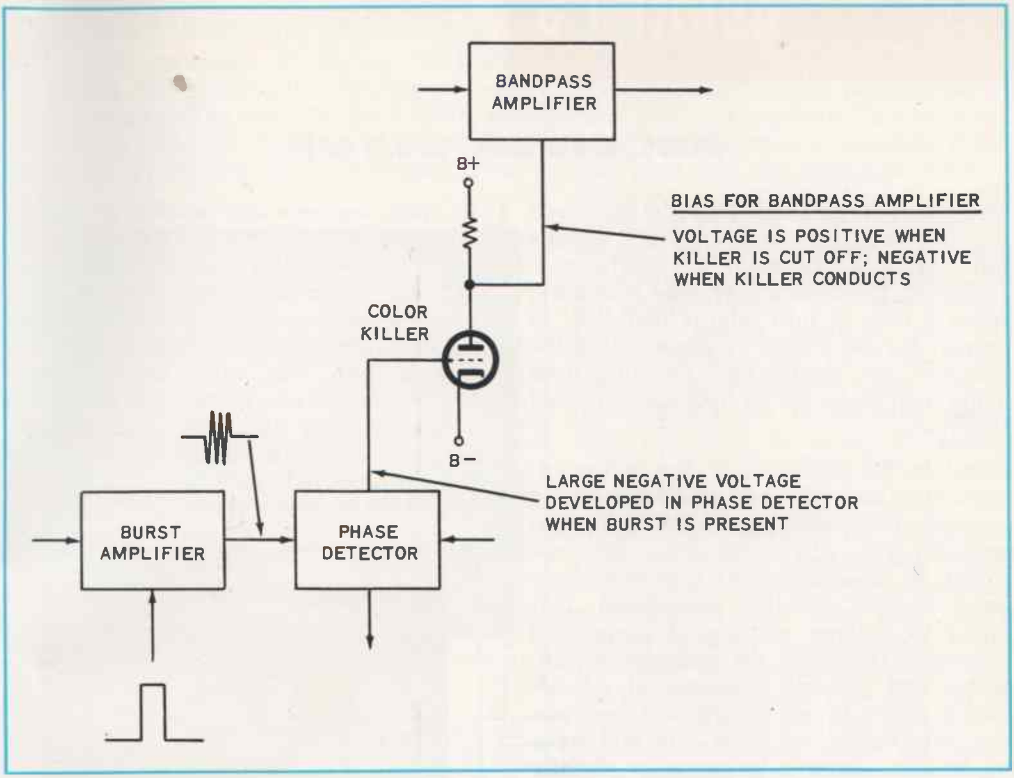


FIG. 2-19. A basic color-killer system.

white telecasts, they will attempt to demodulate black-and-white information near 3.58 mc into color. The results are rainbows and color fringes in areas of the picture that contain narrow vertical stripes, such as the patterns that appear in fabric. To prevent this "color" in black-and-white pictures, a circuit called the *color killer* acts to bias off the bandpass amplifier during black-and-white telecasts, as shown in Fig. 2-19. To detect whether black-and-white or color telecasts are being received, the killer circuit senses the presence of burst signals in the burst amplifier or phase detector. During black-and-white telecasts, when burst is absent, the killer conducts and generates a bias that cuts off the bandpass amplifier. When the bandpass amplifier is disabled, the supply of signals to the color demodulators is effectively cut off.

Late-model receivers employ a separate killer-detector circuit to provide the bias that actuates the color-killer circuit. This system makes the killer insensitive to the effects of noise on weak signals. Other circuits cannot differentiate between burst and the gated noise that comes through the burst amplifier when weak signals are received. The noise-immune killer detector is actuated only when the AFPC system is "locked up" on a burst signal. The bandpass amplifier is permitted to conduct only when the AFPC system is locked in-phase with a normal burst signal.

RECEIVER SETUP

The setup adjustments must be mastered before you attempt any color TV service jobs. Setup adjustments are performed: following the delivery of new receivers; when a new picture tube is installed; to correct for the effects of transporting the receiver; to compensate for long-term aging; and as an aid in diagnosing circuit failures.

Learn to be proficient at the setup adjustments and you will profit by saving valuable time, and by the favorable impression you will make upon the customer. In the discussions that follow we have chosen specific procedures that apply to a large number of late-model receivers. However, the underlying principles and general sequence of adjustments apply to all receivers. Once you see how things are done you will have no trouble adapting to newer or slightly different procedures that apply to newer receivers or sets made by different manufacturers.

The complete setup job includes three distinct tasks. These are purity adjustments, convergence adjustments, and black-and-white setup adjustments. Practice the procedures that follow. You will find that all the setup adjustments are surprisingly easy to master.

Purity. A tricolor shadow-mask picture tube is really three picture tubes in one. Its three sections are capable of producing three independent, but superimposed, rasters of the primary colors—red, green, and blue. You may view each of these primary-color rasters or *fields* by biasing off the appropriate electron guns in the picture tube. The word *purity* is used to describe the quality of these individual fields. We say that the red field, for example, is "pure" when the red raster is a uniform red, with no contamination from blue or green light.

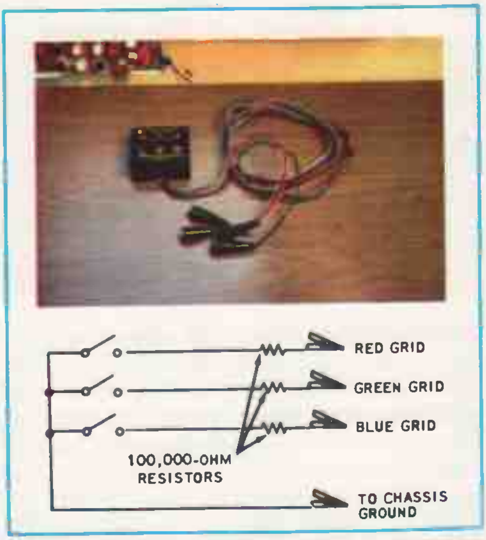


FIG. 3-2. Grid shunt switch used to cut off selected guns in the picture tube.

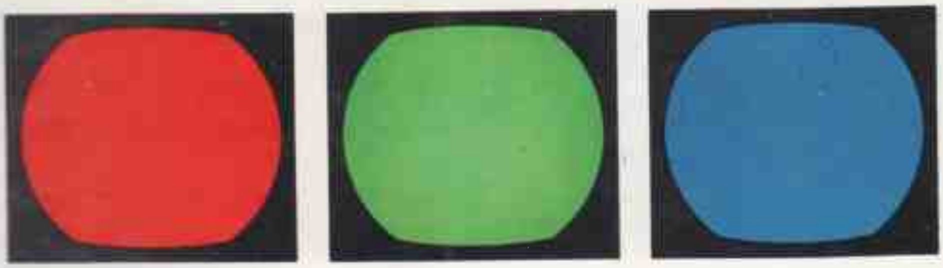


FIG. 3-1. Pure fields of the three primary hues.

Figure 3-1 shows pure fields for each of the primary colors. To display the blank rasters, the signal path was broken and the appropriate electron guns were cut off. For example, the red field was displayed by biasing off the blue and green guns.

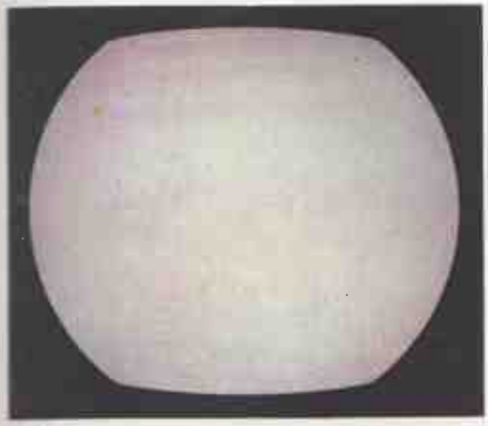


FIG. 3-3. White raster with normal purity.

Selected electron guns may be cut off conveniently by means of a grid-shunt switch, shown in Fig. 3-2. The switch places a 100,000-ohm resistor between the selected control grid and ground. This alters the control grid-to-cathode bias sufficiently to cut off the selected gun. Use of this switch allows the technician to view individual fields without altering the settings of any of the color-balance (black-and-white setup) controls.

When all three primary-color fields are *uniform* and uncontaminated, a pure, uniform, white raster, as shown in Fig. 3-3, can be obtained.

A word of explanation is needed about the *uniformity* of the primary color fields mentioned in the previous paragraph. It is possible to see pure, uncontaminated red, green, and blue fields and yet the white raster may show tinted areas. The reason is that light output in one or more of the fields is low in those areas. The cause is a beam landing error that is not large enough to cause impure fields, but is large enough to cause insufficient light output (the beam lands half-on and half-off the phosphor dots). Keep this in mind when adjusting purity — try to get uniform light output (no dark areas) as well as purity in the individual fields.

Shadow-Mask Principle. The phosphor screen of the shadow-mask picture tube is covered with about one million phosphor dots, arranged in tiny trios of the three primary colors. Between the electron guns and the phosphor screen is a shadow mask, a sort of sieve containing about one-third of a million holes — one for each phosphor-dot trio. The mechanical arrangement of the phosphor screen, the shadow mask, and the sources of electrons permit electrons from a particular electron gun to strike phosphor dots of one particular color only when the picture tube is adjusted correctly. Each gun, and its group of associated primary-color phosphor dots, operates independently.

Figure 3-4 describes the shadow-mask principle. To simplify the idea, using this two-dimensional drawing, a hypothetical color picture tube using only two guns and two groups of phosphors is shown. The paths of electrons from the blue and red guns are colored blue and red in the diagram for identification purposes only. Electron beams are, of course, invisible. Electrons proceed down the neck of the tube in a beam until they enter the field of the deflection yoke. Here the beams are deflected to the left or right, and up or down as required for scanning. As a result of deflection, electrons seem to originate from a point source inside the field of the yoke. This point source of electrons is called a *deflection center*. Consider the deflection center for the blue electron beam. Electrons that emerge from this spot hit either the sieve-like shadow mask, or pass through the holes and strike blue phosphor dots. Electrons traveling in straight lines from the "blue" deflection center cannot hit red phosphor dots. You can verify this by laying a straight edge on the diagram so that it pivots on the blue deflection center. Regardless of the deflection angle, any beams that pass through the holes in the shadow mask strike only blue phosphor dots. Red may be checked in the same way.

The detail in Fig. 3-4 shows that the edges of the holes in the shadow mask are tapered. Note how this arrangement cuts down the spray of secondary-emission electrons that would result if the holes were cylindrical. Such spray would cause

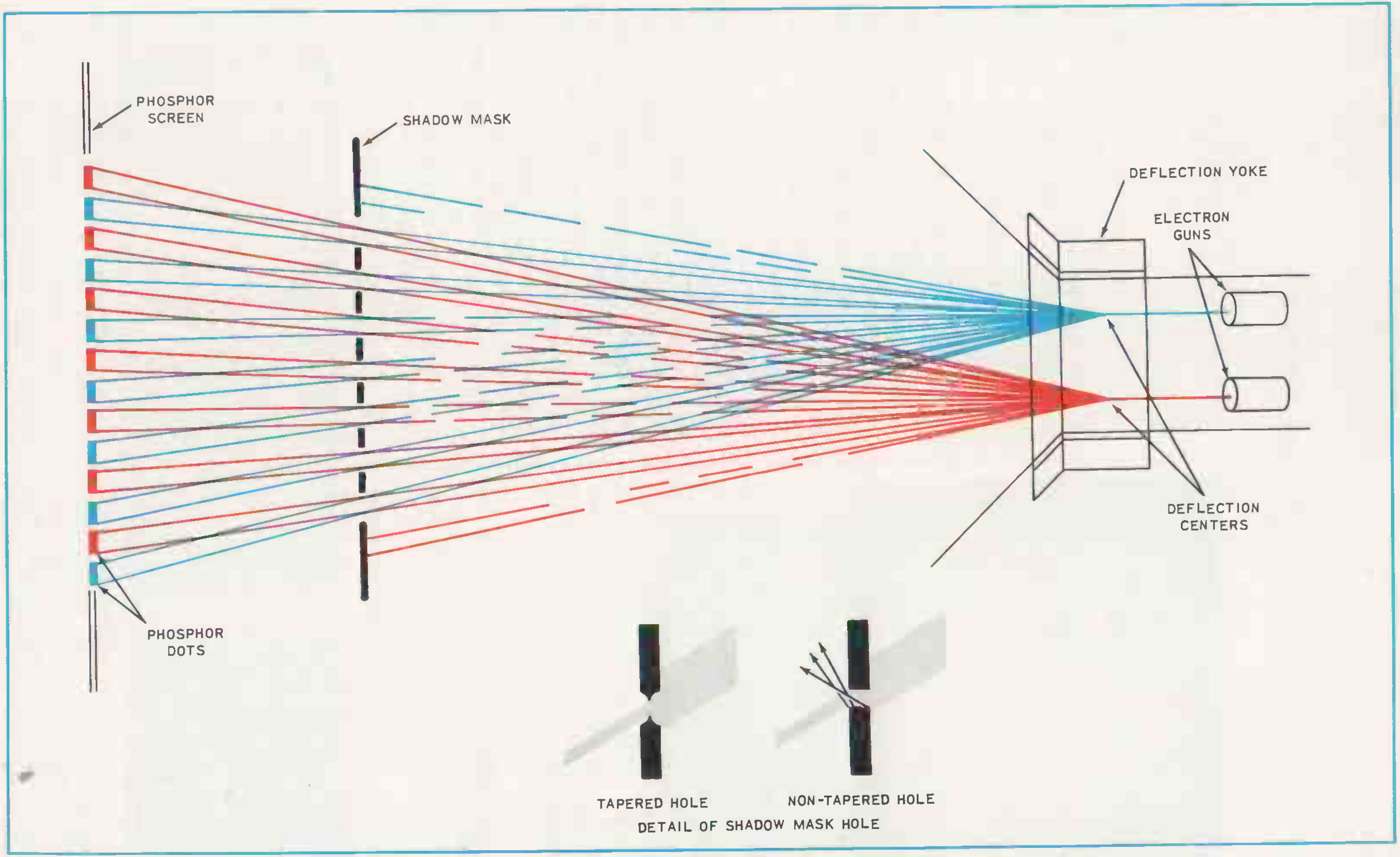


FIG. 3-4. A simplified illustration of the shadow-mask principle. The detail shows how the holes in the mask are tapered to reduce the spray of electrons that would occur if cylindrical holes were used.

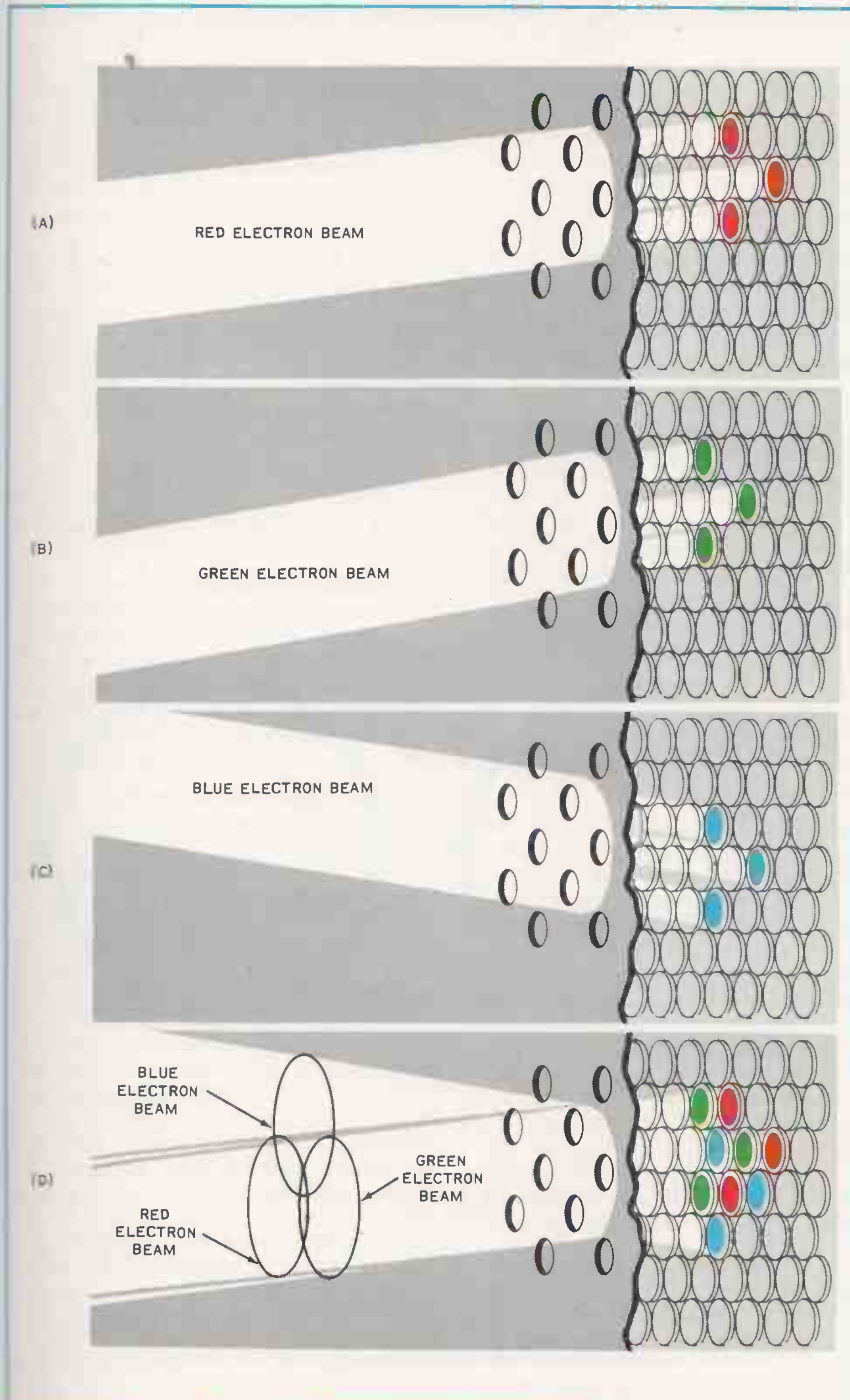


FIG. 3-5. A close-up view of the phosphor screen and shadow mask, showing how electron beams strike selected phosphors.

all nearby phosphors to be lighted. Tapered holes also help to preserve the circular shape of the electron beam near the edges of the screen.

To maintain purity over the entire face of the screen, the deflection centers must be accurately placed inside the neck of the tube. If you pick some other point in Fig. 3-4 for a deflection center you will find that electrons emerging from this new point strike both red and blue phosphor dots at some point on the screen. The result is impurity — that is, contamination from an unwanted primary hue.

Figure 3-5 shows an enlarged view of a small section of the shadow mask and phosphor screen. Note that the electron beam is larger in diameter than the holes in the shadow mask. In fact, the beam usually straddles three holes, as shown. Since the beams approach the mask from three separated deflection centers, they approach at different angles and strike only the designated phosphor dots.

There are two adjustments to be made in adjusting purity. Both are made to locate the deflection centers in the correct positions. Figures 3-6 and 3-7 illustrate the two adjustments.

A circular magnet, very similar to the familiar PM centering device, is placed on the neck of the picture tube as shown in Fig. 3-6. The field of this magnet cuts right through the neck of the tube and causes the electron beams to move at right angles to the field as shown in the cross-sectional view of Fig. 3-6. Rotating the entire magnet rotates the field and causes the beams to move in a circular fashion as shown. Field strength is adjusted by spreading the tabs on the magnet. Increasing field strength increases the amount of deflection. By proper adjustment of the neck purity magnet, the beams are aimed towards the correct deflection centers in the neck of the tube.

Placement of the deflection yoke, as shown in Fig. 3-7, adjusts the positioning of the deflection center along the axis of the picture tube. Correct purity is obtained when the yoke deflection center is correctly placed.

Note that the position of the yoke does not affect those beams that pass through the yoke without being deflected. Thus the position of the yoke has no effect upon purity in the center of the picture. Only the neck-purity magnet affects purity in the center of the picture. Yoke positioning has most effect upon purity at the outer edges of the picture area.

Effect of Magnetic Fields. Before considering purity adjustments, we must consider the effects of local or stray magnetic fields. These fields can have a marked effect upon the angle at which the electron beams approach the picture tube screen, and hence, upon the purity of individual fields.

Figure 3-8 shows the effect of a small bar magnet taped to the screen of the picture tube. Note the impure areas close to the magnet in this red field.

Stray magnetic fields may result from the magnetization of the steel parts of the chassis and supporting members of the color picture tube, or magnetization of the steel shadow mask itself. These fields may be induced by strong external magnets, heavy electric currents in nearby conductors, or the earth's magnetic field.

Magnetic fields are neutralized or demagnetized by the use of a *degaussing coil* — a large coil of wire which is connected to the 120-volt 60-cps supply line. Placing this energized coil near the receiver and picture tube causes severe agitation of the magnetic elements in the iron or steel members. The result is random orientation of these elements and demagnetization. However, degaussing does more than neutralize magnetic fields. It actually causes a built-in correction for the earth's magnetic field. When steel or iron is degaussed in the presence of a static magnetic field, like the earth's compass field, the metal becomes magnetized by the earth's field. The local magnetic field induced in this way *counteracts* the field that caused it. Thus, degaussing eliminates the effects of nearly all static magnetic fields including the earth's magnetic field.

Degaussing. Before performing any purity adjustments the picture tube should be degaussed. Proceed as follows:

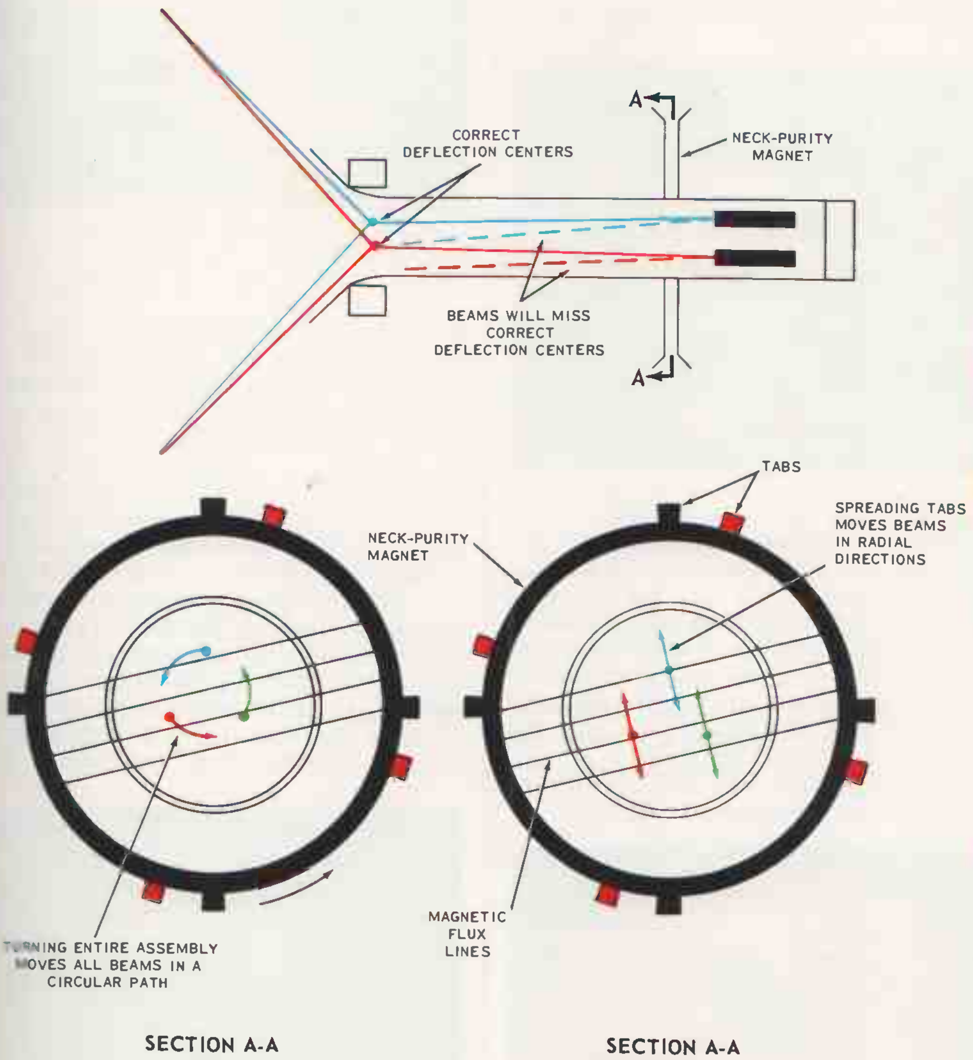


FIG. 3-6. Action of the neck-purity magnet. The field of this magnet is at minimum when the tabs are brought together.

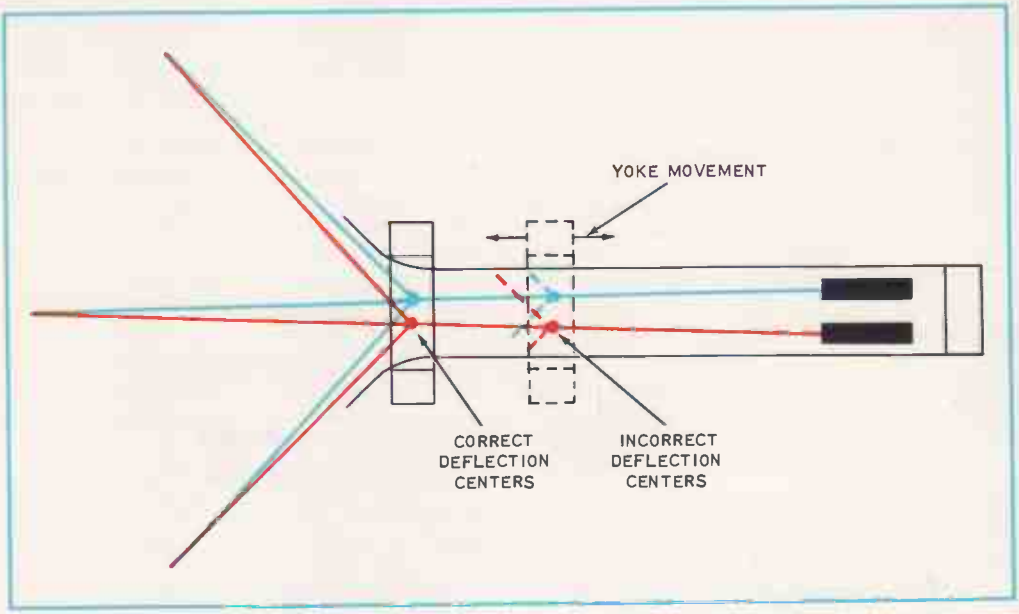


FIG. 3-7. Effects of deflection yoke positioning.

1. *Place the receiver in its actual viewing position*. The correction for the earth's magnetic field that is "built-in" by degaussing will not be correct if the receiver is turned or faced in another direction after the degaussing operation. Therefore make sure that the receiver is facing in the direction in which the customer intends to view it before using the degaussing coil. If it is necessary to pull the receiver out from the wall — pull it straight out, but do not face the receiver in a different direction.

FIG. 3-8. A small bar magnet placed near the screen upsets purity.

2. Plug the degaussing coil into a nearby wall outlet, and, holding the coil parallel to the front of the receiver, place the coil close to the screen (safety glass) of the picture tube. Move the coil slowly about the front of the cabinet. The top and sides of the cabinet should be treated in similar fashion, positioning the coil parallel to these surfaces as needed. Work in the general area of the front of the cabinet, and keep away from the

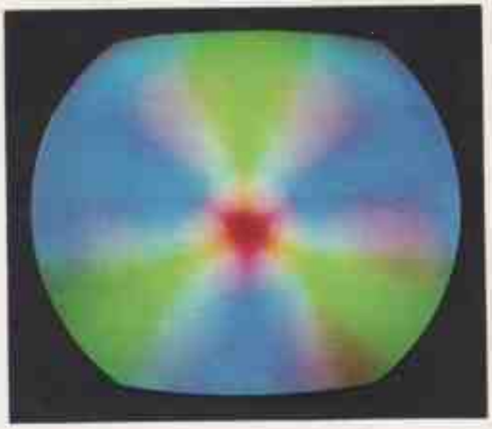


FIG. 3-9. This severe case of bad purity was obtained by disconnecting the degaussing coil while the coil was near the screen. The red field is shown.

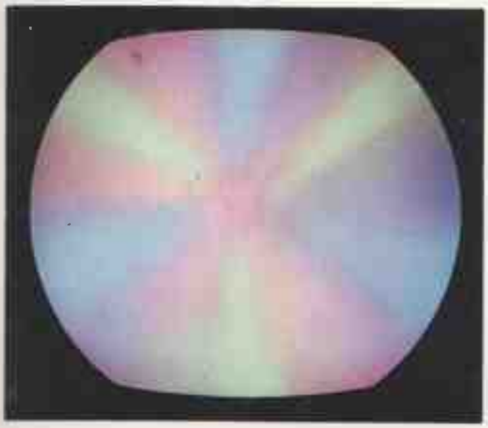


FIG. 3-10. The effect of the bad purity condition obtained in Fig. 3-9 on a white raster.

magnetic assemblies mounted on the neck of the picture tube. The degaussing operation should take no longer than about one minute. At the end of the degaussing operation, slowly move the coil as far away from the receiver as possible (at least six feet). Place the coil flat on the floor and unplug it from the a-c line. *Be careful not to unplug the coil while it is close to the receiver.* If so, the circuit is broken as current flows in one direction through the coil, and a permanent field is likely to be induced into the steel parts of the picture tube. Figure 3-9 shows the effect on the red field of unplugging the degaussing coil when it is held close to the screen. Figure 3-10 shows the same effect on a white raster, and Fig. 3-11 shows how this form of impurity appears

FIG. 3-11. Appearance of bad purity on a black-and-white picture.

to a viewer watching a black-and-white telecast.

The receiver may be turned on during the degaussing operation. In fact the colorful patterns displayed on the picture tube during degaussing are very impressive. An example of the patterns appearing during degaussing is shown in Fig. 3-12.

FIG. 3-12. This pattern is produced by placing the degaussing coil near the screen. The red field is shown.

Degaussing Precautions. Here are some tips to remember during the degaussing operation:

1. Make sure, before degaussing, that the receiver is facing in the direction in which the customer intends to view it.

2. Keep the degaussing coil away from the permanent magnets in the assemblies on the neck of the picture tube.

3. Always place the coil at least six feet from the receiver before disconnecting the coil from the power line.

4. Do not leave the coil plugged in for more than a few minutes or it will overheat.

5. Some older receivers employ edge correction (rim) magnets to correct impurity at the screen edges. These magnets must be set for minimum effect during degaussing operations. There are two types of edge correction magnets. Both mount on the picture tube between the yoke and the screen. One type uses small magnets that can be retracted into cup-like shields during degaussing. The other

type looks like pairs of hairpins that pivot on a mounting post. The latter type is set for minimum effect by lining up both hairpins on each pair.

Purity Adjustment Procedure. Follow this sequence in setting purity to minimize needless loss of time in rechecking and redoing adjustments.

1. *Preliminary adjustments.* Make the standard "black-and-white" type of adjustments such as picture size and linearity, centering, and focus. Check the service notes for each particular receiver model.

2. *Demagnetize the receiver.* Place the set in its final viewing position and follow the degaussing operation outlined earlier.

3. *Check static convergence.* Obtain a black-and-white picture, or preferably, obtain a crosshatch pattern from a crosshatch generator. Check static convergence of the three beams in the center of the screen. Convergence is discussed in the next section, and perhaps you should read the paragraphs on static convergence before continuing with actual adjustments at this time. *A rough adjustment of static convergence should be made before purity is set up,* as there is some interaction between purity and static-convergence adjustments.

4. *Obtain a blank red raster.* Bias off the blue and green guns using the grid-shunt switch. A blank raster may be obtained by biasing off the i-f section of the receiver, or unplugging the cable that connects the tuner to the i-f strip, or removing an i-f tube (parallel heaters only). A convenient way of obtaining a steady blank raster is to connect the RCA WR-64A color-bar/dot/crosshatch generator, set up the generator and the set to produce the color-bar display, and then turn the CHROMA control on the generator fully counterclockwise.

5. *Position the yoke.* Loosen the clamp that secures the deflection yoke to the neck of the picture tube, and slide the yoke back towards the picture-tube socket as far as it will go. This upsets purity severely at the edges of the screen. But the deflection yoke has little effect in the center of the screen, and by observing purity at center screen you can judge the effects of the neck-purity magnet.

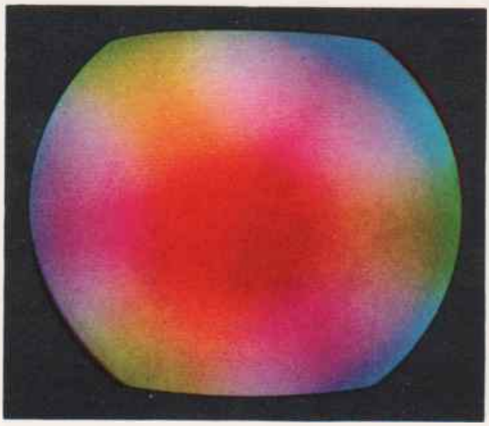


FIG. 3-13. Adjustment of the neck purity magnet. The yoke is pulled back and the blue and green guns are cut off. Center the red spot on the screen by adjusting the neck purity magnet. Ignore neck shadows when making this adjustment.

6. *Adjust the neck-purity magnet.* This magnet aims the beams of the electron guns towards the proper deflection centers. When proper adjustment is made, a red "blob" should appear in the center of the screen as shown in Fig. 3-13. If the red blob is off-center, as shown in Fig. 3-14, the neck-purity magnet requires adjustment. Spread the tabs on the magnet to increase field strength and increase movement of the red blob in a radial direction. Rotate the entire assembly to move the blob in a circular path. The action is similar to that of a PM centering device in black-and-white receivers. With a little practice you will learn how to center the

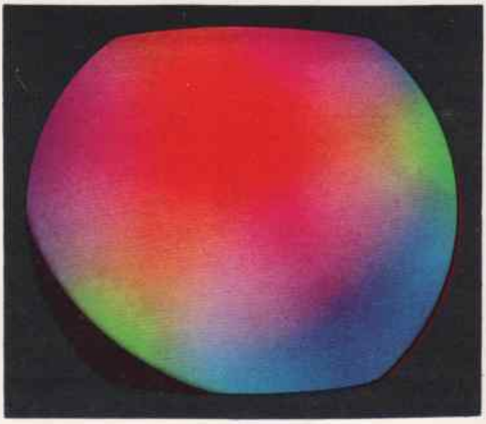


FIG. 3-14. Incorrect adjustment of the neck-purity magnet.

red blob quickly. Note — ignore neck shadows during this adjustment; the red blob should be centered in the screen area whether the entire screen area is lighted or not.

7. *Reposition the deflection yoke.* Move the yoke forward while observing the entire screen. A large mirror propped upon a chair is helpful at this point. Position the yoke to obtain the most uniform red over as much of the screen area as possible. Figure 3-15 shows correct and incorrect yoke settings. The yoke should be clamped in the position for best purity. However, before tightening the yoke clamp, check for tilt. This may be done conveniently by turning the NORMAL-SERVICE switch, on the rear apron of the chassis, to the *service* position. This disables the vertical deflection circuit and produces a thin horizontal line on the screen. Tilt the yoke to make the line parallel with the top or bottom of the front mask, and tighten the screw on the yoke clamp.

8. *Check remaining fields.* Check purity on the individual green and blue fields. A slight readjustment of the yoke and the purity magnet might be necessary. In some instances a compromise might be needed; you may have to sacrifice perfect purity on one field to obtain best over-all purity on all fields.

Rim Magnets. Some older-type receivers employ rim magnets to correct small areas of impurity near the screen edges. In these receivers, the previous steps are performed with the rim magnets set for minimum effect. As a final adjustment, the

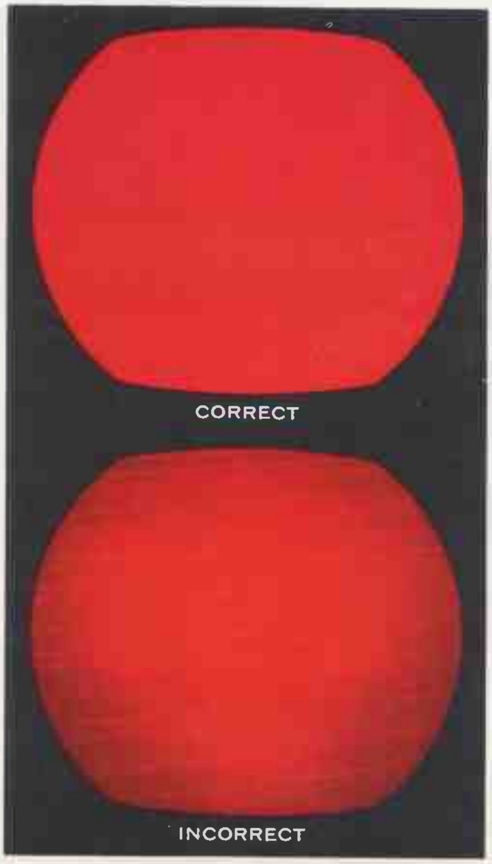


FIG. 3-15. Adjustment of deflection yoke position to obtain good purity.

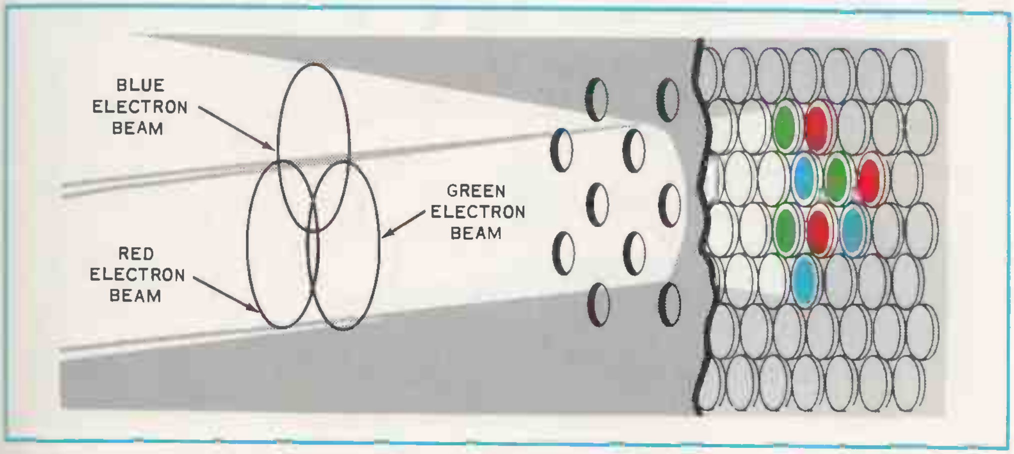


FIG. 3-16. The three electron beams of the picture tube are converged when they strike the screen at the same spot.

rim magnet closest to any small impure area is pushed out of its cup-shaped holder and rotated to produce best purity. In slightly later models, hairpin-shaped magnets close to the contaminated area are spread and turned to produce the same effect. Rim magnets are not needed in late-model receivers due to improvements in the color picture tube.

Convergence. You have seen how the shadow-mask principle permits three separate electron guns to control the light emitted by three groups of phosphors. These phosphors are applied like tiny mosaic tiles to the screen of the picture tube. Our next consideration is the *convergence* or *registry* of the individual red, green, and blue rasters upon the screen.

Consider Fig. 3-16, which is repeated from an earlier page. Note that the three beams converge or meet at the illuminated spot at the screen. The result is that a compact cluster of red, green, and blue dots is lighted. This cluster of lighted phosphors appears, from a distance, as a tiny white spot. Now suppose that the blue beam is out of alignment as shown in Fig. 3-17. This new blue beam still emanates from the correct blue deflection center and so strikes only blue dots *(purity remains good)*. However, the blue beam strikes the screen below the area at which the green and red beams land. As a result, the blue cluster is separated from the red and green clusters. If the separation is great enough, you can see blue at the lower fringes of every white area. Since blue is *missing* from the top, the upper fringes of white areas appear *minus* blue or yellow (red plus green). If this type of misalignment were uniform over the entire screen, the blue raster would be shifted downwards from the yellow (red and green) areas, as shown in Fig. 3-18. Severe misconvergence, involving all three beams, appears as shown in Fig. 3-19.

Convergence involves the *individual* aiming of the three electron beams. This is accomplished magnetically by a system of external magnets and internal pole pieces shown simplified in the cross section of the picture-tube neck in Fig. 3-20. The pole pieces, mounted on the forward edge of the electron-gun assembly inside the neck of the picture tube, act to confine the fields of the external magnets. The effects of these magnets on individual electron

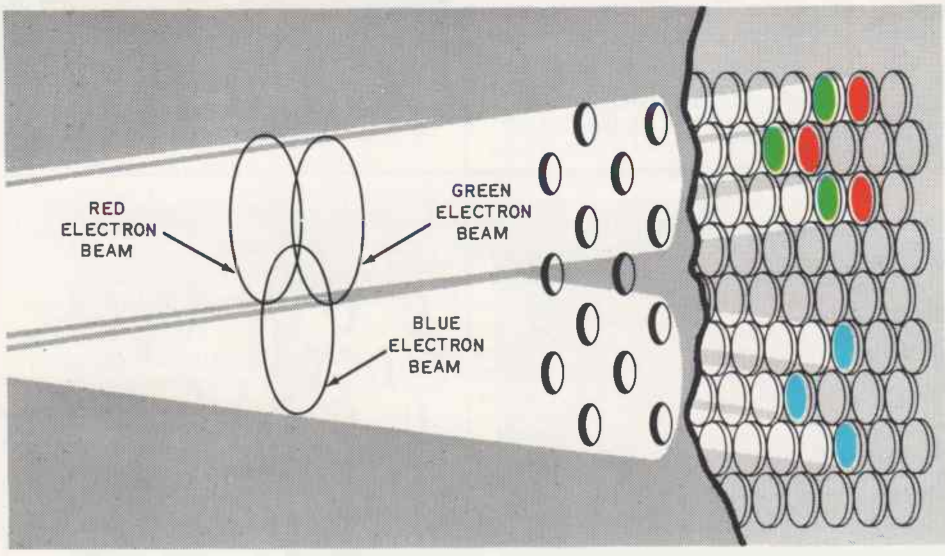


FIG. 3-17. An example of misconvergence. The blue beam, although striking only blue dots, hits the screen below the point where the red and green beams converge.

FIG. 3-18. Effect of the condition noted in Fig. 3-17. The bottom edge of this white object is blue. The top edge is "missing" blue; hence the top appears yellow.

FIG. 3-19. An example of severe misconvergence.

beams are as shown. Note that the blue beam moves straight up and down, but the green and red beams move along lines that are inclined 30° to the horizontal.

Static and Dynamic Convergence. Permanent magnets are used to converge the three electron beams in the center areas of the picture-tube screen. However, unless additional corrections are made, the beams do not stay converged as they sweep towards the outer edges of the screen. In order to maintain convergence, the strength of the converging fields must be changed in synchronism with the scanning signals. This a-c form of convergence is called *dynamic* convergence, and will be covered shortly.

Convergence Magnets. The external convergence assembly for a late-model receiver is shown in Fig. 3-21. It is placed

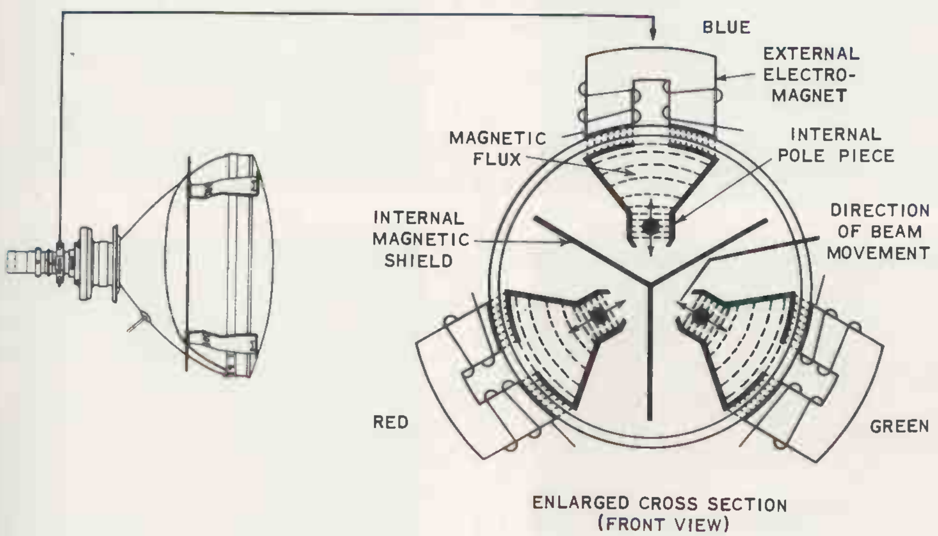


FIG. 3-20. Position of the convergence yoke on the neck of the picture tube. The cross section shows the relation between the external electromagnets and the internal pole pieces.

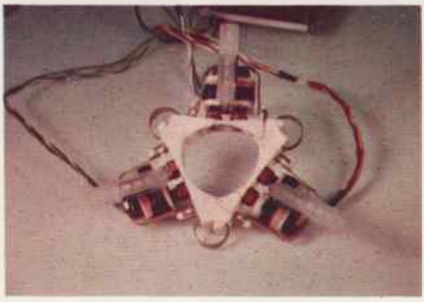


FIG. 3-21. The convergence assembly.

on the neck of the picture tube so that the faces of the external pole pieces mate with the internal pole pieces inside the neck of the picture tube. The side view of Fig. 3-22 shows the convergence assembly in place. Note the nylon supports that hold the small static-convergence magnets. These supports permit the static-convergence magnets to be moved closer or further from the external pole pieces and so regulate the static field strength in the internal pole pieces. The large coils of wire supply the alternating fields for dynamic convergence.

Other receivers employ different forms of static convergence magnets. Some use small magnets that rotate within sockets in the ferrite pole pieces. Others produce static convergence by means of a controllable direct current in the windings of the pole pieces.

Convergence Patterns. Misconvergence can be spotted easily by watching a

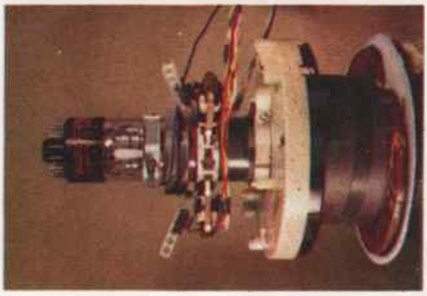


FIG. 3-22. Line-up of the external components on the neck of the picture tube.

black-and-white program and looking for colored fringes surrounding objects in the picture. However, misconvergence shows up only where there are objects in the picture; it is impossible to see misconvergence in an area that is a uniform white or shade of gray. The ideal patterns for detecting and adjusting convergence in any area of the screen are the dot and crosshatch patterns shown in Fig. 3-23. These patterns are produced by the RCA WR-64A color bar/dot/crosshatch generator.

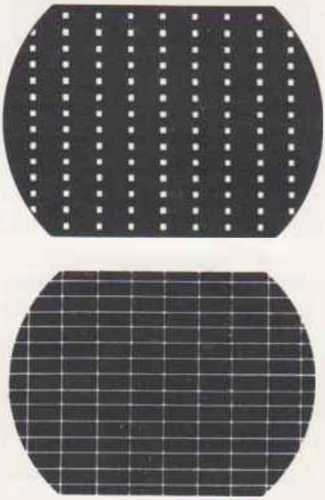


FIG. 3-23. Dot and crosshatch patterns used for convergence adjustments.

Static-Convergence Adjustments. The permanent magnets in the convergence assembly are adjusted to obtain convergence of the red, green, and blue beams at the center of the screen. Dynamic adjustments are applied to correct the edges, so you must look only at the *center screen* when adjusting the static-convergence magnets.

Figures 3-24, 25, and 26 show the effects of the three static-convergence adjustments. Note the directions of the straight lines in which the individual colors move. Note also that there is some interaction between magnets — the red magnet affects blue and green beam movement to some extent. If you push the blue-beam magnet, for example, towards the picture-tube neck, you might cause the blue spot to move straight down. If the opposite direction (up) is desired, it is necessary to reverse the direction of the blue magnet's field. To do this, simply pull the nylon holder out of its clip, rotate the entire holder 180° along its long axis, and replace it in the clip.

By reversing the static-convergence magnet you effectively double the range of this control. To illustrate, suppose that when you pull the blue magnet straight up (less magnetic field strength), you cause the blue spot to move straight up. Further, suppose that it is not possible to move the blue spot up far enough to obtain convergence before the magnet holder reaches the end of its travel. If you now *reverse* the magnet and push it *down* towards the neck of the picture tube (increasing magnetic field strength) the blue spot will continue to move upwards towards the converged condition.

Blue-Lateral Convergence Magnet. The adjustments provided by the three static-convergence magnets normally cannot secure convergence of all three beams. An example is shown in Fig. 3-27. Here the green and red spots converge at a point that is not immediately beneath the blue spot. It is necessary, in this case, to move the blue spot sideways. An additional magnet-and-pole-piece assembly is placed on the picture tube to move the blue spot sideways. The adjustment provided by this assembly is called the *blue-lateral* adjustment. Its action is shown in Fig. 3-28. Note that the green and red spots also move laterally, but the blue spot moves farthest. By applying all four static-convergence adjustments, the three spots can be converged from any set of starting positions.

It is difficult to detect small static-convergence errors, especially blue errors, when you stand behind the receiver and look at the screen through a large mirror. It is somewhat easier to stand at the side of the receiver as shown in Fig. 3-29. This position allows closer examination of the screen while making adjustments.

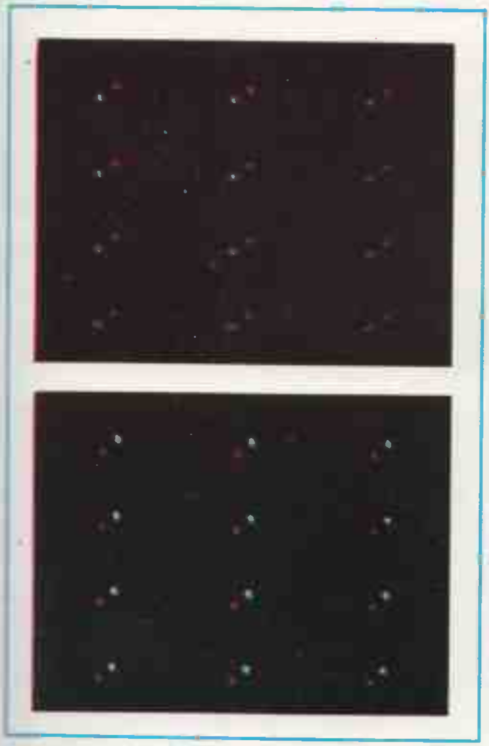


FIG. 3-24. Range of the red static-convergence adjustment.

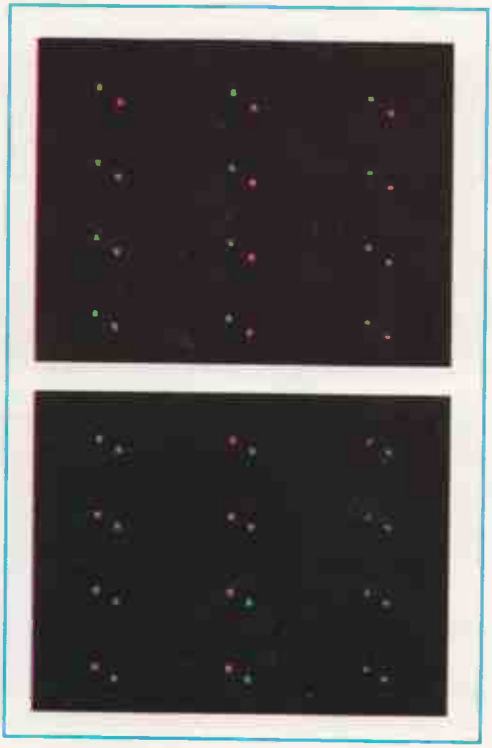


FIG. 3-25. Range of the green static-convergence adjustment.

FIG. 3-26. Range of the blue static convergence adjustment.

FIG. 3-28. Range of the blue-lateral convergence adjustment.

The small hand mirror is not heavy, and it forces you to confine your attention to a small area on the screen. (Hold the mirror so that you can see the center of the screen.)

A Cause of Large Errors in Static Convergence. It is possible to make a large error in static convergence when working with a dot pattern that contains many closely-spaced dots. The error comes

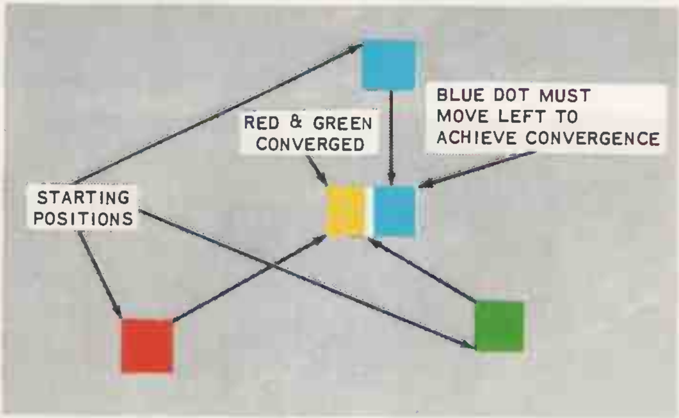


FIG. 3-27. Movement of the beams from three typical starting positions shows the need for lateral adjustment of the blue beam.

FIG. 3-29. A small hand mirror helps in making static convergence adjustments (center screen).

about when one set of primary-color dots is moved far enough to converge with an adjacent set of dots of the remaining primary colors. This actually causes one of the rasters to be shifted one whole dot position. Since you cannot normally see the edges of the raster, this condition may not be detected during adjustments. The dot pattern may appear converged, but severe misconvergence is seen on black-and-white program material. The amount of convergence error will then be seen to be equal to the spacing between the dots in the dot pattern. To avoid this error, make very rough static convergence adjustments while looking at a broadcast picture before you switch to the dot pattern. This problem is not encountered when using convergence patterns with widely spaced dots.

Dynamic Convergence. The distance between the shadow mask and the deflection centers is greater at the edges of the screen than it is at center screen, as in Fig. 3-30. Thus, if the beams converge properly at the shadow mask near center screen, they converge short of the mask as the beams are deflected outwards toward the edges.

Figure 3-31 shows how edge misconvergence looks when all dynamic correction is removed.

Convergence can be maintained at the screen edges if the magnetic convergence fields are altered in synchronism with the scanning signal. This is accomplished by passing a current through the coils of the convergence pole pieces so that the magnetic field is opposed and weakened near the top, bottom, and both sides of the picture. Currents for this purpose are obtained from the vertical and horizontal deflection circuits. Ideally, the waveform of current in the convergence coils is parabolic in shape, as indicated in Fig. 3-30. This figure shows the correction needed to secure convergence from top to bottom of the picture, vertically. No correction is made at the center, but correction becomes stronger near the top and bottom of the screen. The source of the current waveforms needed to correct convergence at the top and bottom of the picture is the vertical output stage. The same sort of correction must be made at the sides of the picture, so that a parabolic waveform, synchronized with the *horizontal scanning* frequency, is also needed in all three coils.

Tilt. The parabolic waveforms of current in the convergence magnets must be altered somewhat to correct for certain practical aspects of picture-tube construction. One reason for modifying the parabolic waveform is that the three guns and electron beams do not lie on the long axis of the picture tube but are displaced from center somewhat. As a result, electrons from the blue gun, which is above the axis of the picture tube, must travel further when deflected towards the bottom of the screen. Similarly, electrons from the red and green guns, mounted below the tube axis, must travel further when deflected towards the top of the screen. The correction needed is achieved by modifying the shape of the parabolic waveform by the addition of a sawtooth component. The resulting waveshape is shown in Fig. 3-32.

Dynamic Convergence Adjustments. The adjustments required to converge all three beams at every point on the screen involve control of the *amplitude* and *tilt* of parabolic current waveforms applied to all three electron beams. Since parabolic waveforms are applied at both the *vertical* and *horizontal* scanning frequencies, there are twelve controls in all.

Convergence Controls. The twelve dynamic convergence controls are mounted on a separate printed-circuit assembly. The unit is usually fastened to the inside of the cabinet, near the top. Provision is made to mount the dynamic convergence assembly on the rear of the top rail of the cabinet as shown in Fig. 3-33. This permits easily manipulation of the controls while viewing the screen directly. Figures 3-34 shows the names and arrangement of the twelve dynamic convergence controls.

Convergence Control Action. Older color receivers employ four separate controls (vertical amplitude, vertical tilt, horizon-

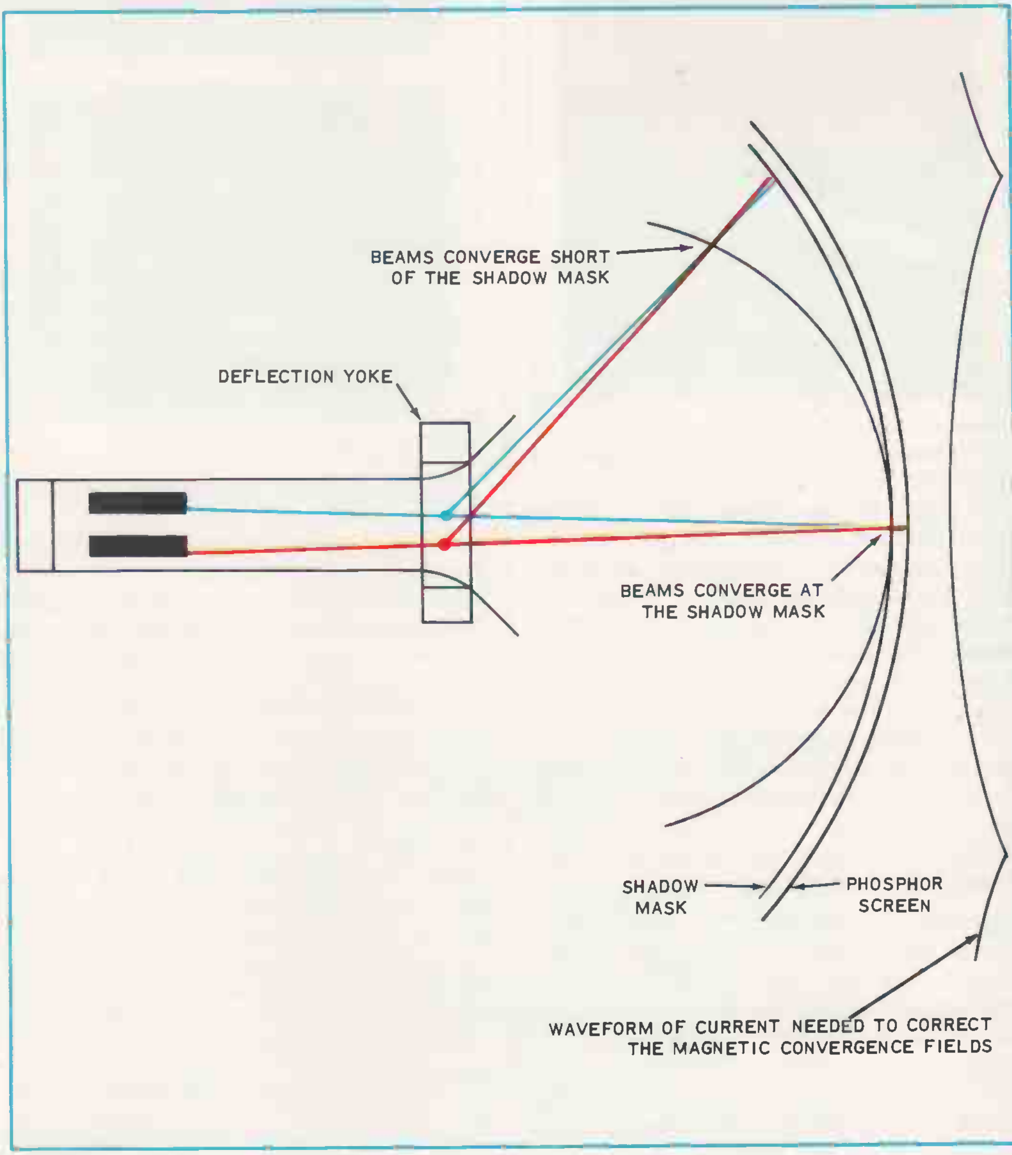


FIG. 3-30. The uncorrected electron beams converge short of the screen at the screen edges. Dynamic correction of the convergence fields, by means of a parabolic current waveform in the convergence electromagnets, makes the beams converge at the screen edges.

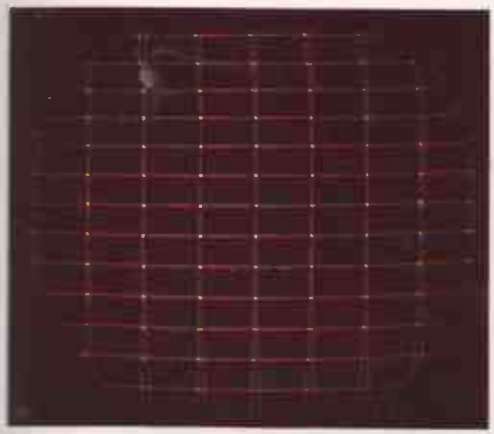


FIG. 3-31. The crosshatch pattern with all dynamic convergence correction removed.

tal amplitude, and horizontal tilt) for each of the three primary colors. In newer receivers, only the blue controls operate independently; the red and green controls are designed to work together and affect red-and-green beam movement simultaneously. Although the new system is a little more difficult to understand, the adjustment procedure is far *easier* to follow and results in much quicker convergence adjustments. The following section gives

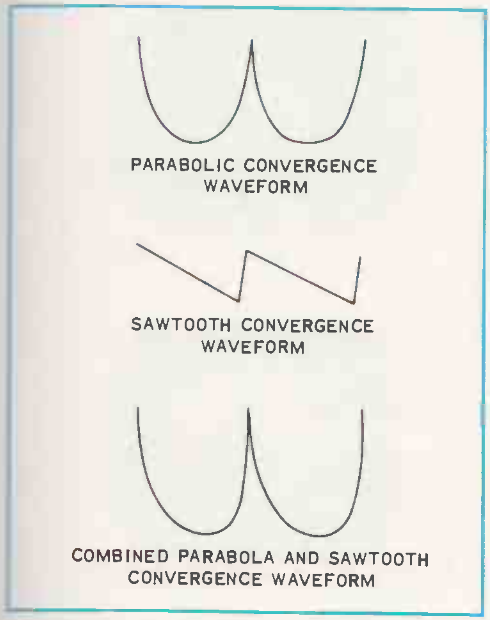


FIG. 3-32. Action of the tilt waveform on the parabolic convergence-waveform.

FIG. 3-33. The dynamic convergence service panel placed in the service position on the top rail of the cabinet.

the step-by-step sequence for convergence adjustments. After you have gained some experience with the results of the adjustments, we will discuss the convergence circuits and the functions of the combined red/green controls.

Convergence Adjustment Procedure. Assuming that purity adjustment has been made, you may begin convergence adjustments. Recommended equipment includes a dot and crosshatch pattern generator and a grid shunt switch. The latter is not absolutely necessary, but it does add convenience. The job involves three major operations: static convergence, vertical dynamic convergence, and horizontal dynamic convergence.

In the following procedures, each step is accompanied by a series of pictures that show the location of the controls, the area on the picture tube screen upon which you should direct your attention, and a pair of photographs showing a before-adjustment and after-adjustment condition.

STATIC CONVERGENCE ADJUSTMENTS

Preliminary Requirements. Make the following preparations:

a. Obtain a dot pattern. Connect a dot/crosshatch generator and obtain a dot pattern on the screen.

b. Bias off the blue gun. Use the grid-shunt switch. You will find it easier to converge the red and green dots if the blue dots are absent.

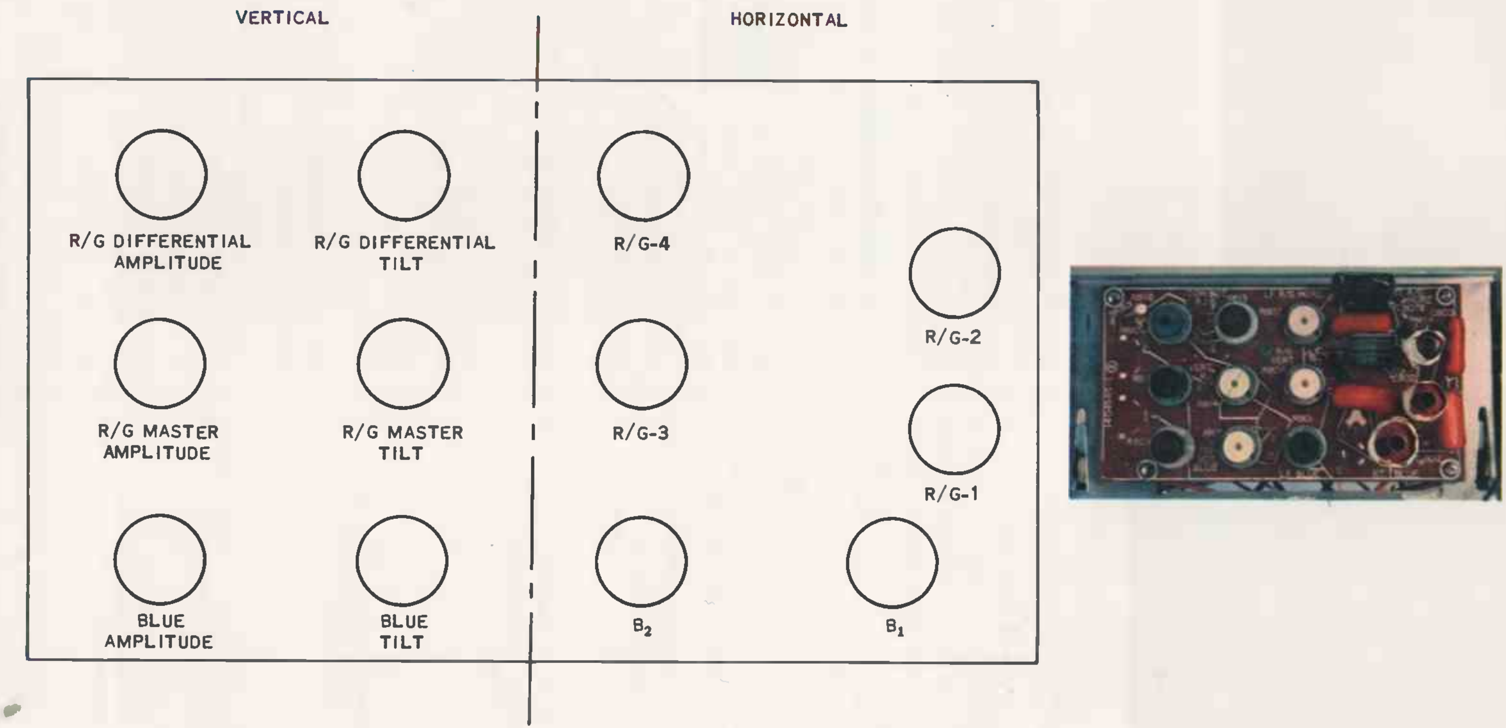
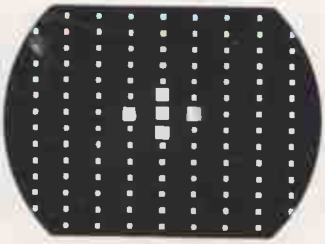


FIG. 3-34. The dynamic convergence board for the CTC-15 chassis.



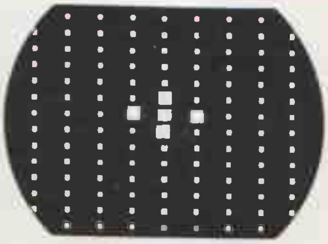
CONVERGE RED AND GREEN DOTS IN CENTER SCREEN

BEFORE ADJUSTMENT

CONTROLS

AFTER ADJUSTMENT

Step 1. Adjust the red and green static convergence magnets until the *centermost* red and green dots overlap. Keep the path of travel of each beam in mind. Place either the red or green dots in the anticipated path of the other. Move the remaining color dots until they converge with the first. Readjust both red and green magnets as needed to obtain a perfect yellow dot in the center of the screen.



CONVERGE BLUE AND YELLOW DOTS IN CENTER SCREEN

BEFORE ADJUSTMENT

CONTROLS

AFTER ADJUSTMENT

Step 2. Switch on the blue gun. Using the blue static convergence magnet and the blue-lateral magnet, overlap the center blue dot with the yellow dot obtained in Step 1.

Adjustment of the blue-lateral magnet may change the position of the red and green dots slightly. If so, repeat Steps 1 and 2 until a white dot, free of color fringing, is obtained in the center of the screen.

Occasionally, one of the dots will not move far enough along its normal path of travel. To extend the range of travel, pull the plastic sleeve out of its holder, rotate the sleeve 180° (turn the plastic sleeve along its long axis, not end over end) and reinsert it in the holder. This reverses the polarity of the magnet.

The plastic sleeve in some older receivers has a square cross section. This sleeve can be inserted into its holder by rotating the sleeve only 90° from its starting position. However, the magnet will be facing the wrong way if you do this. *Make sure that the sleeve is always rotated a full 180° before reinserting it into its holder.*

VERTICAL DYNAMIC CONVERGENCE.

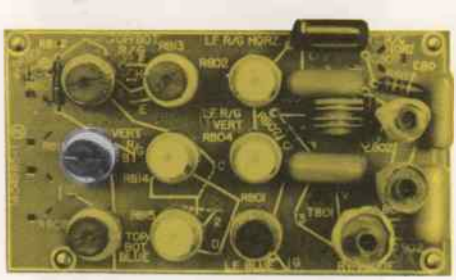
Preliminary Requirements. Make the following preparations:

a. Obtain a crosshatch pattern. Switch the pattern selector on the color-bar/dot/crosshatch generator to the crosshatch position.

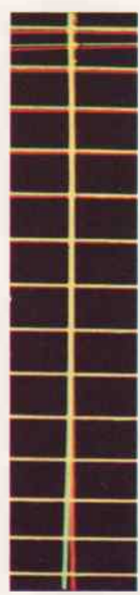
b. Move the convergence board to the adjustment position. Fasten the convergence board to the mounting position on the top rear rail of the cabinet. A pair of screws is used to hold the board in place.

c. Bias off the blue gun with the grid shunt switch.

CONVERGE RED AND GREEN VERTICAL LINES IN THIS AREA



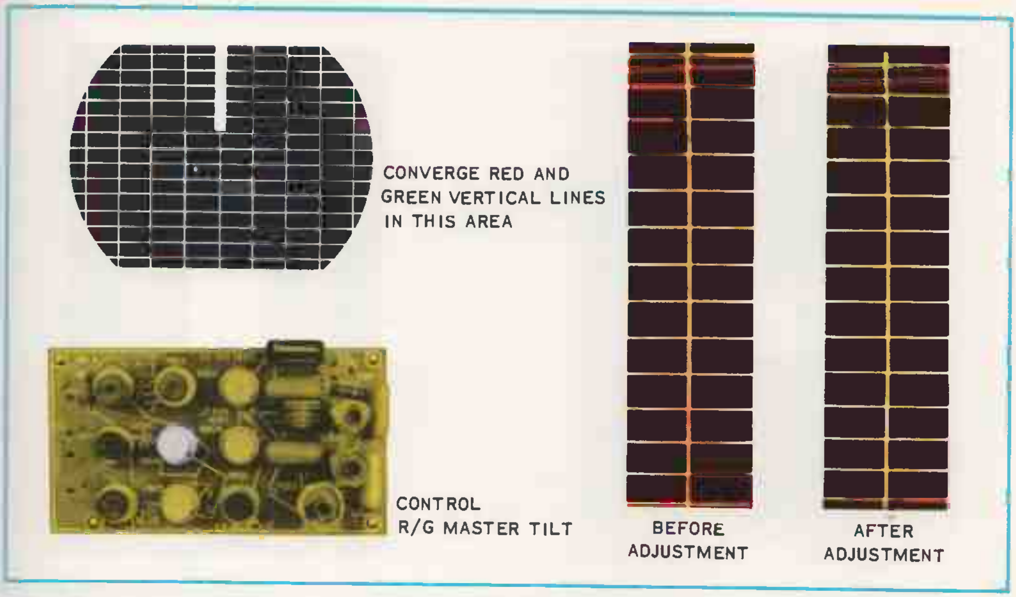
CONTROL
R/G MASTER AMPLITUDE



BEFORE ADJUSTMENT

AFTER ADJUSTMENT

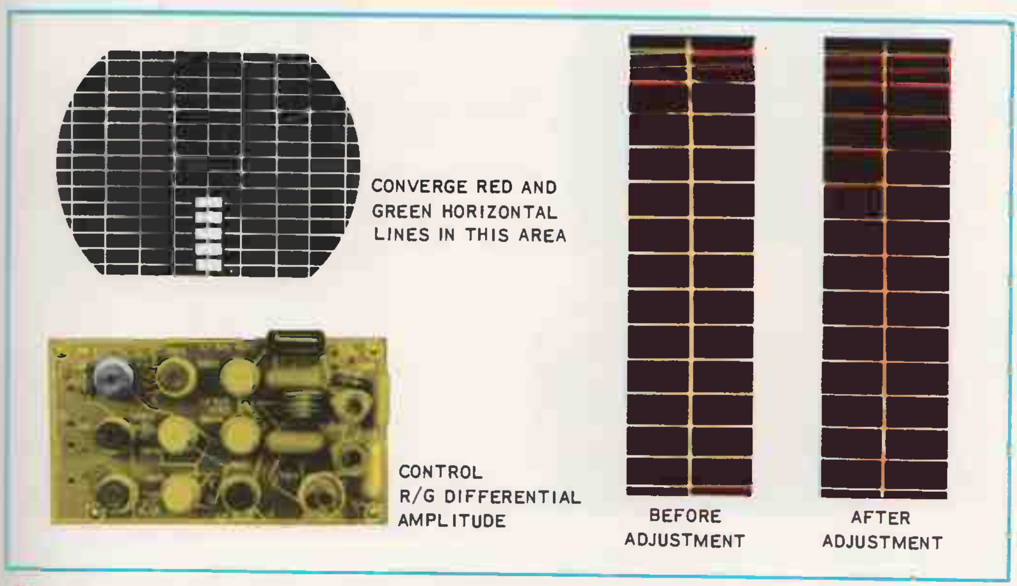
Step 1. *Adjust R-G master amplitude.* Obtain best convergence between red and green along the *lower portion of the centermost vertical line.*



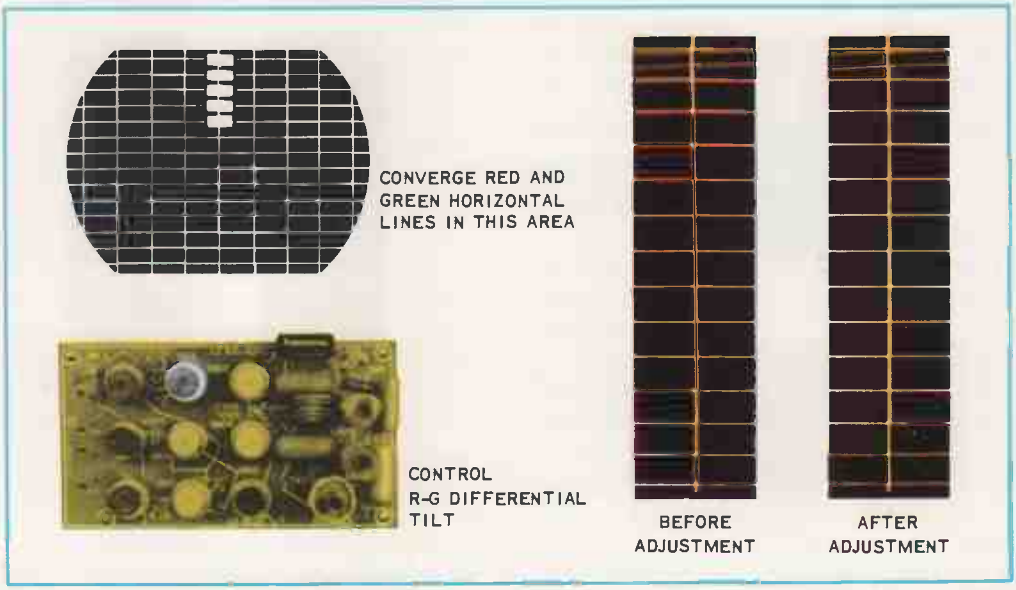
Step 2. *Adjust the R-G master tilt.* Obtain best convergence between red and green along the *upper portion of the centermost vertical line.*

A certain amount of interaction exists between Steps 1 and 2. However, the action of each control is decisive, and the desired results are obtained in a few quick tries.

In some cases, final results are obtained faster by reversing the roles of the R-G master-amplitude and tilt controls. That is, confine your attention to the *upper* portion of the centermost vertical line when adjusting *R-G master amplitude,* and look at the *lower* portion of the centermost line when adjusting R-G master tilt. This is the only pair of controls in which a variation in procedure occurs.



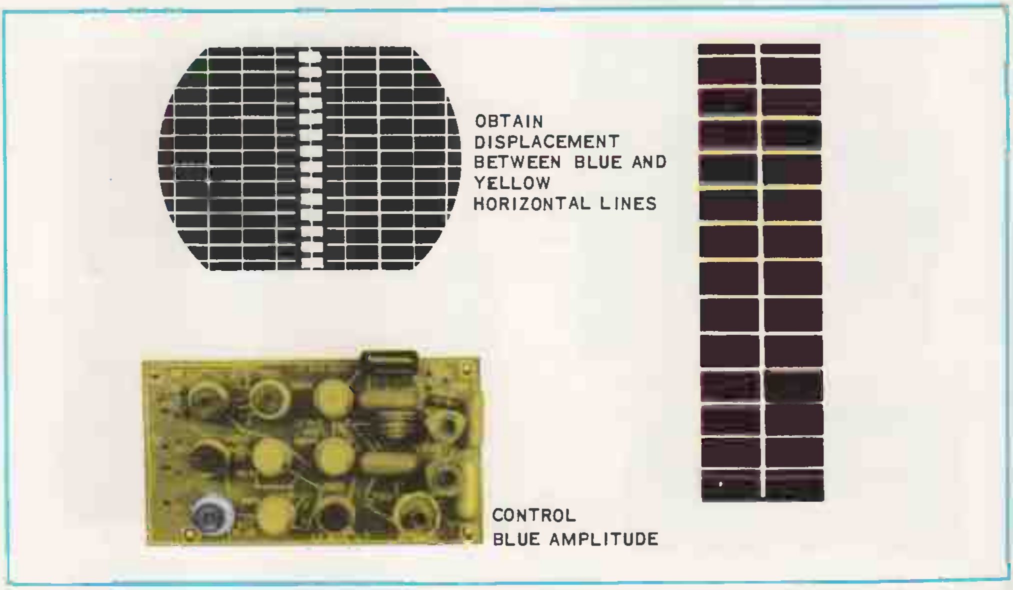
Step 3. *Adjust R-G differential amplitude.* Obtain best convergence between red and green on the lower horizontal lines in the center area of the picture.



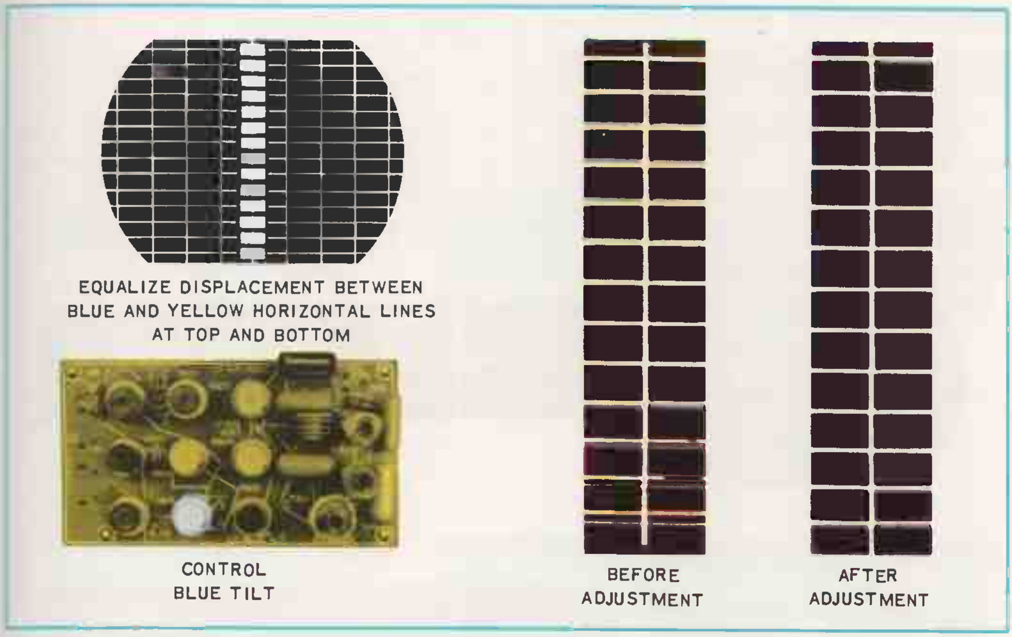
Step 4. *Adjust R-G differential tilt.* Obtain best convergence between red and green on the *upper horizontal lines* in the center area of the picture.

A certain amount of interaction occurs between Steps 3 and 4. In addition, some interaction might be noted between the *master* and *tilt* controls. But, again, the decisive action of the individual controls makes short work of the entire process.

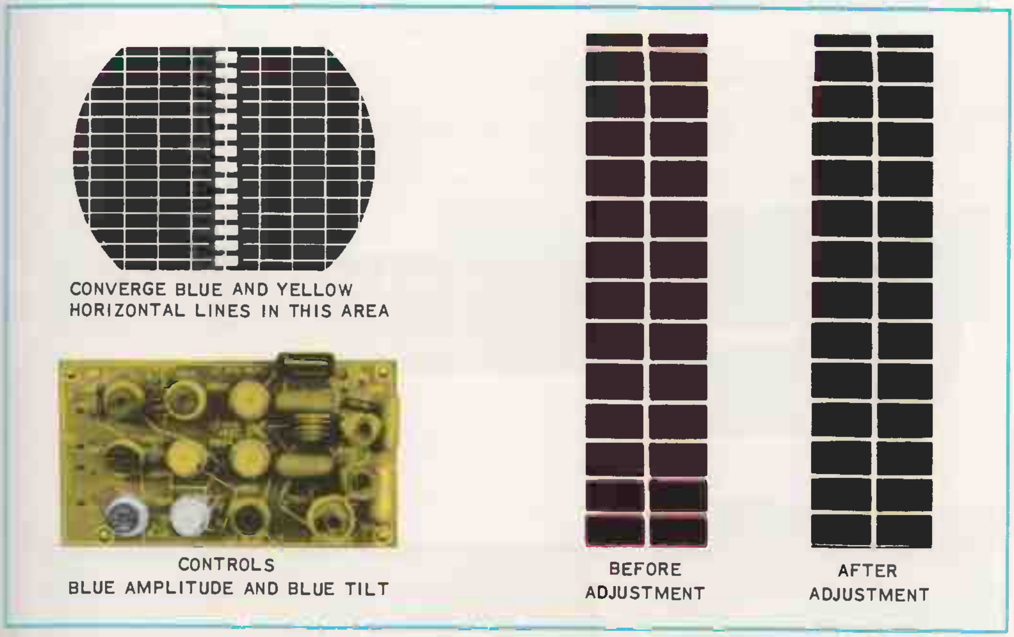
Should center convergence be off at the completion of Step 4, readjust the red and green static-convergence magnets to re-converge the *center-screen* area. This will require a slight additional touch up of Steps 1 through 4.



Step 5. *Reactivate the blue gun; adjust blue amplitude.* Advance the control setting in a clockwise direction until the displacement between blue and yellow horizontal lines at the *top and bottom of the picture area becomes visible.*



Step 6. *Adjust blue tilt.* Set the control to equalize the displacement between blue and yellow horizontal lines at the top and bottom of the picture.



Step 7. *Readjust vertical blue amplitude.* Turn the control counterclockwise until the blue and yellow horizontal lines converge at the top and bottom of the picture. Sometimes the top or bottom may come into convergence first. In this case divide the remaining displacement equally between the top and bottom horizontal lines by adjusting the vertical blue tilt control. Next, continue to turn the blue vertical amplitude control in a counterclockwise direction until the blue and yellow horizontal lines converge at the top and bottom of the screen.

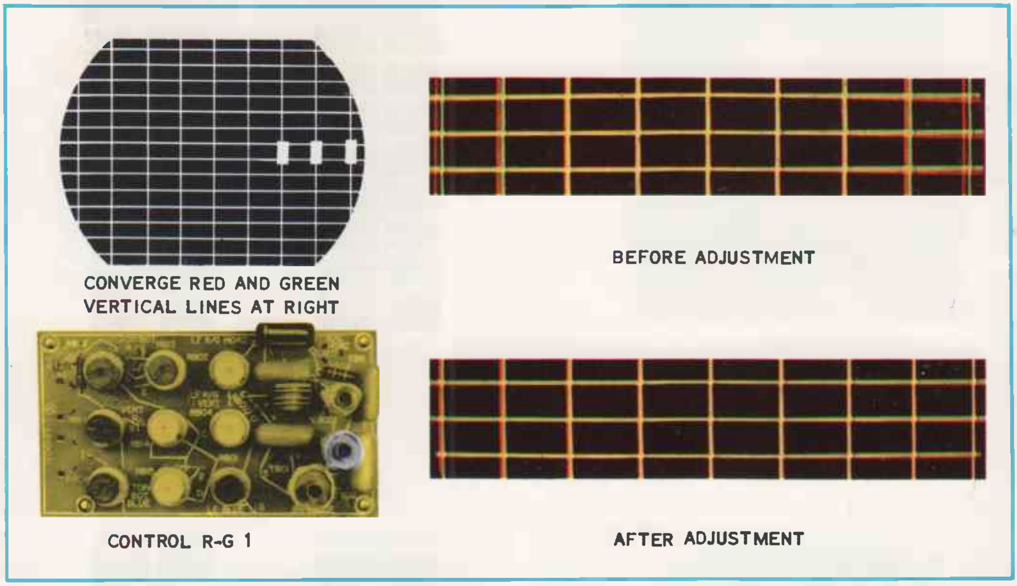
Horizontal Dynamic Convergence.

Preliminary Requirements. Make the following preparations:

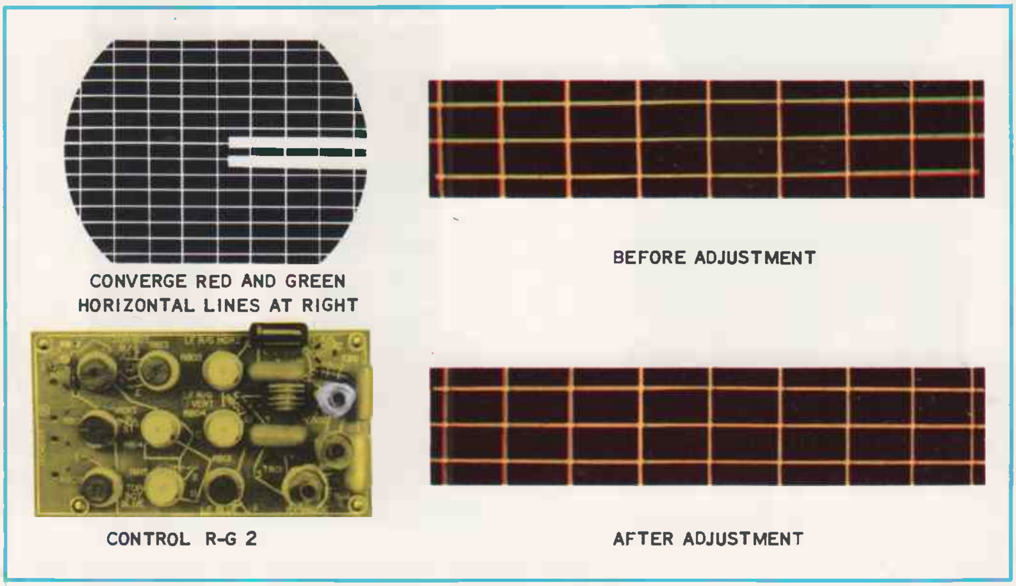
a. Adjust the pattern generator to produce a dot pattern. Check center convergence; readjust if necessary. Adjust the generator to produce a crosshatch pattern.

b. Bias off the blue gun.

c. Obtain a hexagonal alignment tool (0.1 inch across the flats), which is needed for some of these adjustments.

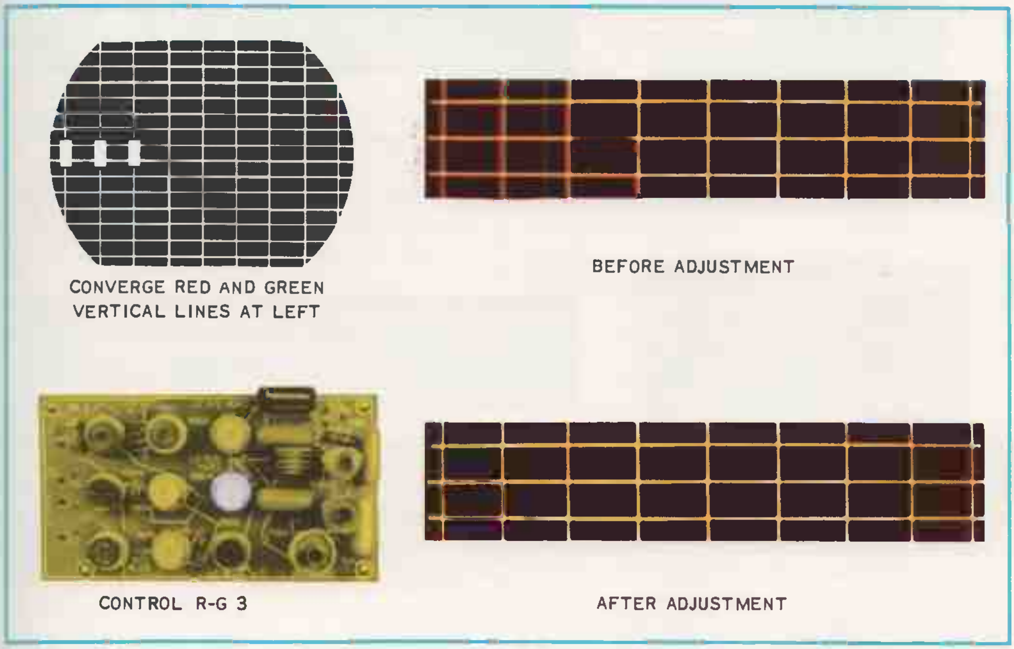


Step 1. Adjust R-G_1. Use the alignment tool for this adjustment. Obtain best convergence between red and green along the *vertical lines* at the *right* side of the screen.

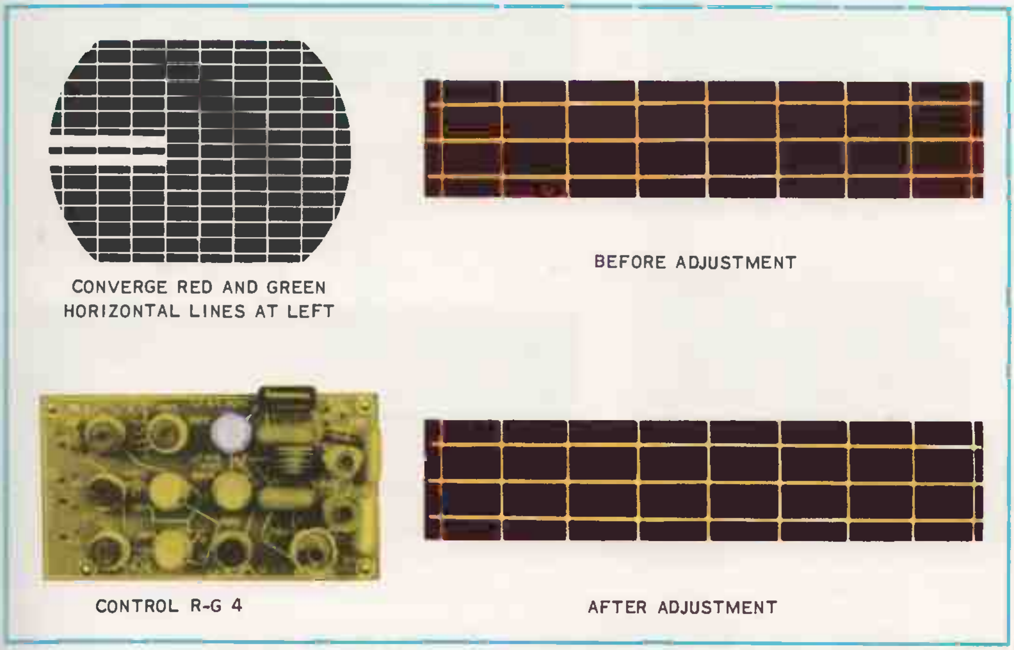


Step 2. Adjust R-G_2. Obtain best convergence between red and green on the *horizontal lines* that lie at the *right* side of the screen.

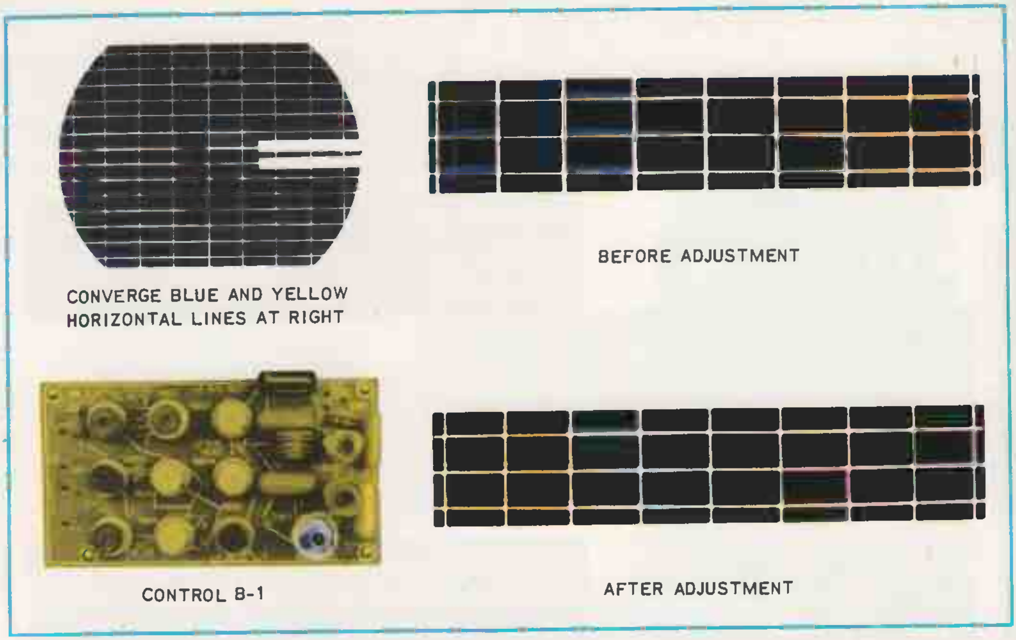
Some interaction exists between the four red-green horizontal convergence controls. However, the effects of misconvergence are easily identified with the controls, and a slight touchup is all that is needed to obtain optimum convergence.



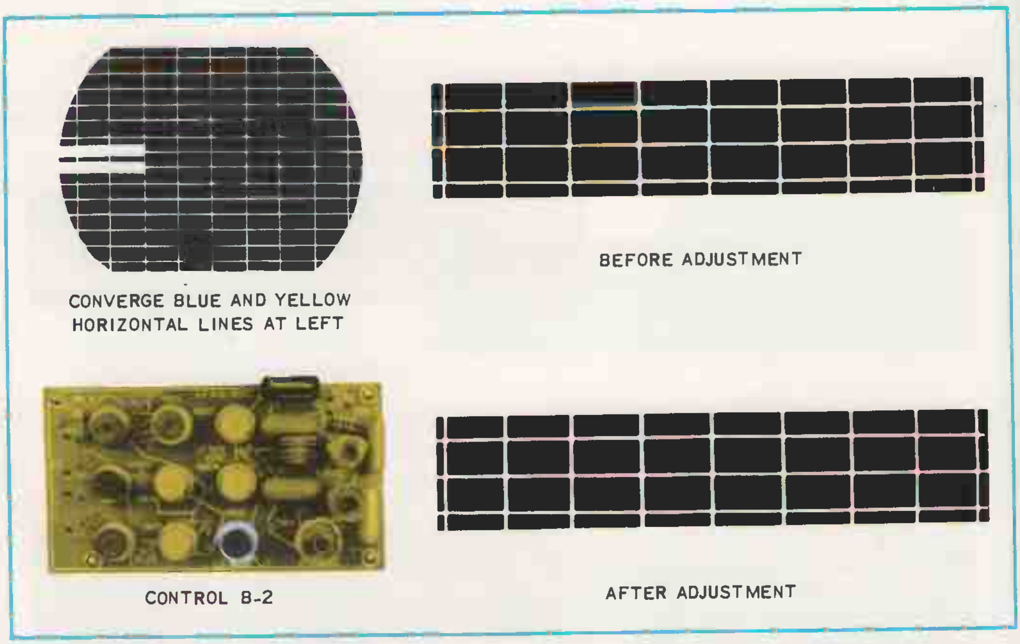
Step 3. Adjust R-G_3. Set this control to obtain best convergence between red and green on the *vertical lines* found at the *left* side of the screen.



Step 4. Adjust R-G_4. Obtain best convergence between red and green on the *horizontal lines* at the *left* side of the screen.



Step 5. Adjust B_1. Set this control so that the *blue horizontal lines* on the *right* side of the picture converge with the yellow horizontal lines (converged red and green lines) in this area.



Step 6. Adjust B_2. Obtain best convergence between blue and yellow *horizontal lines* on the *left* side of the screen.

This concludes the procedure for convergence adjustments covering most late-model RCA receivers. As a final check, the entire screen should be observed closely and fine touch-up adjustments made.

The foregoing procedure does not apply to those older-model receivers in which separate controls are used for red and green. However, literature describing the procedures that apply to these older sets has been in existence for some time and should not be hard to find.

Note: The positions of R-G_1 and R-G_2 are reversed on the convergence control boards of some receivers such as the CTC-11 and CTC-12. The arrangement of controls on the convergence control board shown in the preceding steps (CTC-15) has been made to help you associate the controls with their functions. For example, all the controls in the top row (differential controls) are used to converge red/green horizontal lines; all the controls on the second row from the top (master amplitude controls) are used to converge red/green vertical lines.

Action of the Red/Green Master and Differential Controls. In the adjustment procedures just given, you set the master red/green controls to converge *vertical* red and green lines. When you adjust the red/green differential controls, you direct your attention to red/green *horizontal lines*. Let's see why.

Figure 3-35 shows how the master and differential controls cause the red and green lines of the crosshatch pattern to move. Focus your attention in some small area of the screen away from the center, and adjust the controls that affect convergence in that area.

The master controls alter the total amplitude of the convergence signal that is applied to *both* the red and green convergence coils simultaneously. Thus, advancing a master control makes both red and green lines move an *equal amount*. Consider the hypothetical starting points for the red and green lines shown in Fig. 3-35. Note that the vertical lines can be made to converge by moving the red and green lines an equal distance. The highlighted square at the intersection of the horizontal and vertical lines shows how the lines move. But notice that though the vertical lines can converge by moving the dots (highlighted squares), the dots end up one above the other — the horizontal lines are not converged. Keep in mind that the high-lighted squares can only move along the paths indicated by the slim lines that are 30° to the horizontal. Perfect convergence can be achieved at Point P by advancing the red highlighted area farther along its line of travel, and making the green highlighted area back up an equal distance. This action is achieved by the *differential controls,* which increase convergence current in the red coil while decreasing current a like amount in the green coil, or vice versa. When the highlighted areas are converged at Point *P*, the horizontal lines in the crosshatch

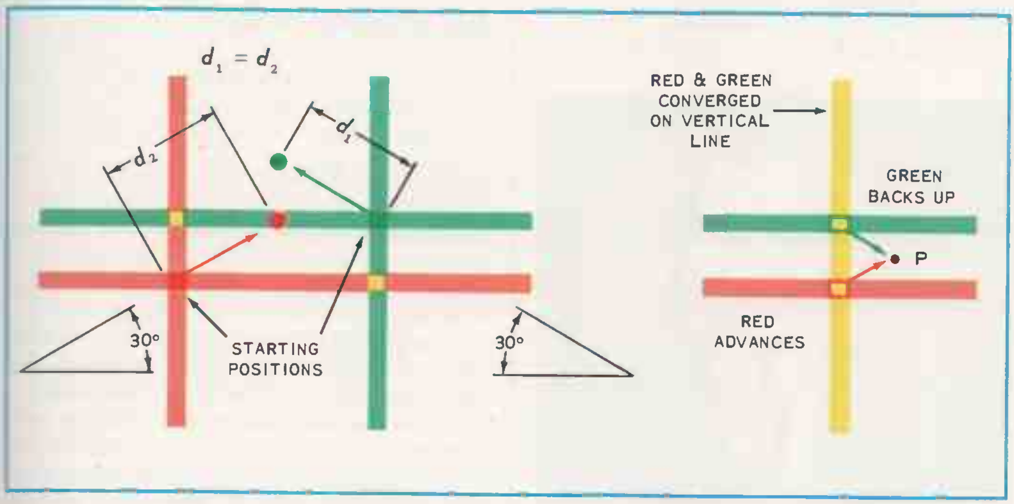


FIG. 3-35. Action of the red/green master and differential convergence controls.

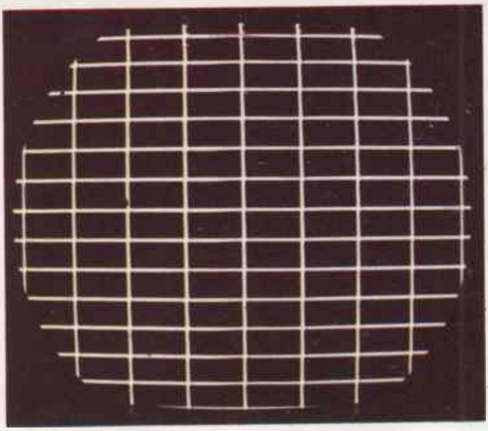


FIG. 3-36. An example of the finished convergence job.

pattern will be converged. Thus red/green convergence at the top, bottom, or sides of the screen requires two adjustments —first the master control to converge vertical lines, then the differential control to converge horizontal lines.

Figure 3-36 shows the finished convergence job for a typical color receiver. The black-and-white picture produced by this receiver is shown in Fig. 3-37.

Black-and-White Setup. When purity and convergence adjustments have been completed you are ready to "mix" the primary colors provided by the picture tube to produce a uniform "black-and-white" picture. A black-and-white telecast must be used for this operation.

To obtain the correct "white", the beam

FIG. 3-37. Black-and-white picture on a normally-converged receiver.

currents of the three electron guns must be adjusted to definite relative values. These values depend upon the desired "white" and the relative light-producing abilities of the red, green and blue phosphors. The proper relative beam currents are found by experimentation — after adjusting the cutoff point, you adjust the relative beam currents by altering the voltages applied to electron guns until the desired white is obtained.

There is more to black-and-white setup than just establishing the correct relative beam currents in the electron guns. The beam currents must be *maintained* in the same ratios throughout the range of the brightness control, and throughout the excursions of the applied video signals. In other words, proper color balance must be maintained from black, through gray, to white. The procedure for maintaining the correct color balance is sometimes referred to as black-and-white tracking.

A word about the "correct white". The color TV system requires the color receiver to produce the correct shade of white when only the brightness signal (black-and-white telecast) is displayed. Color pictures cannot be accurate if the black-and-white picture is too red or too blue to begin with.

We usually take the word *white* for granted. But the term white covers a multitude of shades. Compare your white shirt with the paper upon which this page is printed. Probably the paper will appear slightly yellow or blue compared to your shirt. Incandescent light bulbs and "daylight" fluorescent tubes both produce "white" light, but the incandescent bulbs' light is definitely yellow by comparison.

The correct white for color TV is recommended as 9300° Kelvin, a specification which is somewhat cryptic to most of us. This figure refers to the light emitted by a so-called black body when it is heated to a temperature of 9300° as measured by the Kelvin (absolute) temperature scale. At present there is no handy reference that a technician can carry to the job that will yield a satisfactory reference source of light. It's best to be guided by the "white" produced by current black-and-white picture tubes. In addition, the customer's preference or remarks may occasionally influence your final setup.

Black-and-white tracking required considerable skill and judgement in the early days of color TV. However, improvements in receiver performance (better purity), and a new system to facilitate setup renders this job routine. It can be done in a minute or two.

The tracking job in all late-model RCA receivers is done in two stages. First the control grid-to-cathode bias on all three guns is made equal and the screen-grid voltages are adjusted so that all three guns are very nearly at cutoff. Next, video (brightness) signals are applied to cathodes of the picture tube and the amplitude of the video signal applied to the blue and green guns is adjusted to produce a monochrome picture of the desired white. When the job is done, beam currents are in the correct proportions to maintain a neutral white or gray for all values of the video signal. In addition, as brightness is turned down, all guns extinguish or cut off at the same setting of the brightness control. Thus color balance is maintained throughout the range of the control. The setup procedure is as follows:

Step 1. Turn all three screen grid controls fully CCW. Refer to Fig. 3-38.

Step 2. Turn the KINE-BIAS control fully CCW. If the receiver uses a PIX TUBE BIAS switch, set the switch so that the slider is farthest from the bottom edge of the chassis apron.

Step 3. Switch the NORMAL/SERVICE switch to the service position. When the normal switch is in the service position, all video drive is removed from the picture tube, the three picture-tube cathodes are placed at the same d-c potential, and the vertical output stage is disabled. As a result of the last action, a thin horizontal line is substituted for a full raster. Since only one line is scanned repeatedly on a black background, even a very small beam current produces a visible line, and you can readily see the point at which the electron guns are just cut off.

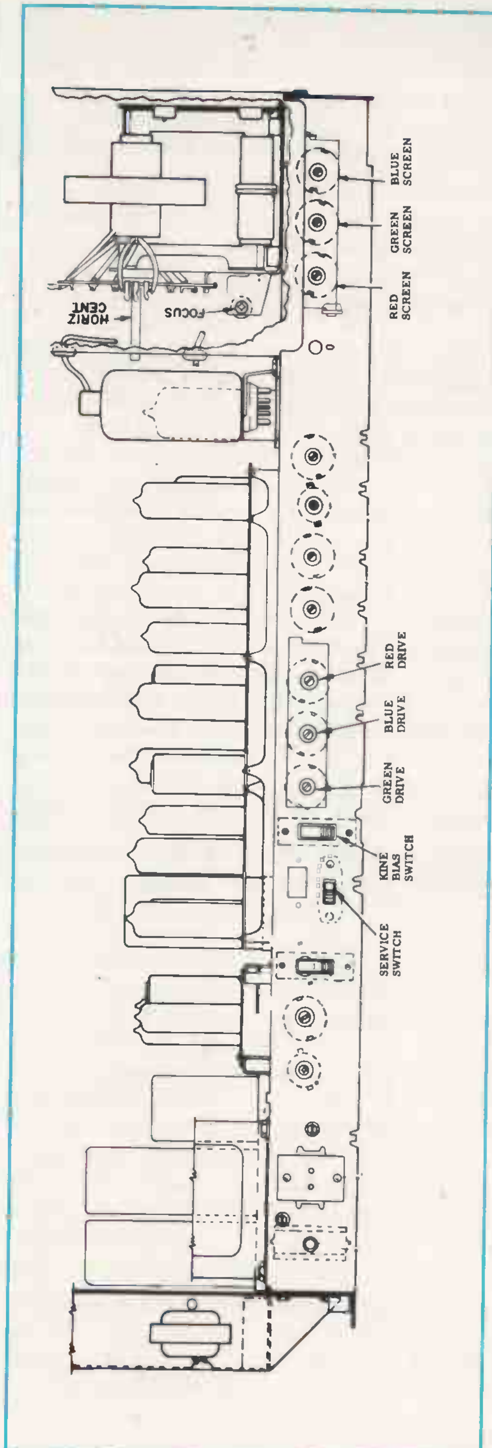


FIG. 3-38. Rear apron of a typical chassis showing location of the black-and-white setup controls.

Step 4. Advance the RED SCREEN control until a dim, barely-visible horizontal red line can be seen. Do likewise with the blue and green screen grid controls. In each case a given screen grid control should produce a barely visible trace of the associated color on the screen.

It might not be possible to produce a visible trace with one or more of the screen grid adjustments in Step 4. In this case proceed to Step 5.

Step 5. If one or more of the screen grid controls cannot produce a visible trace, leave the control(s) at the maximum CW position and advance the KINE BIAS control (a master bias control) until the desired trace becomes visible. On receivers equipped with a PIX TUBE BIAS switch, advance the switch one or two notches until the desired trace becomes visible. It will then be necessary to reduce the settings of those screen grid controls that were set successfully in Step 4. Use the lowest setting of the KINE BIAS or PIX TUBE BIAS switch possible. These controls should be advanced only far enough to obtain a dim trace with the electron gun that appears weakest (has the highest screen setting).

Step 6. Switch the NORMAL/SERVICE switch to the normal position, and set the brightness and contrast controls for a normal-contrast black-and-white picture.

Step 7. Adjust the BLUE and GREEN DRIVE controls to produce a neutral white-to-gray scale. The picture should appear white, with no predominant hue. If possible, compare the picture with the picture on a black-and-white receiver. Use your knowledge of color mixing when setting the drive controls. If the picture appears pinkish, advance both blue and green drive controls. A purple or violet cast indicates a lack of green — advance the green drive control. Experiment with these controls until you are satisfied with the whites and grays.

Check the tracking of the brightness control by turning this control CCW. The picture should maintain a neutral gray scale — no predominant hue — until the picture is quick black. If not, recheck the screen settings in Steps 4 and 5.

We have made no attempt to show black-and-white setup in pictures here. The very slight differences in shade between abnormal and correct whites are difficult to maintain in the printing process. Small errors are introduced by variations in film, developing processes, printing inks, and the color of the paper stock itself.

WHAT THE OPERATING CONTROLS DO

The owner of a new color receiver finds that there are only two operating controls that are unfamiliar to him. These may have different names from time to time. RCA currently labels these controls TINT and COLOR. More technical terms for these controls are "hue" and "saturation".

You should be thoroughly familiar with the effect of these controls upon the picture, so that you can instruct your customers in their use. You should also know how the "color" controls work in the color circuits. This will help in determining the causes of color troubles.

The remaining operating controls, such as contrast, brightness, and the hold controls, operate in the same way as their counterparts in black-and-white receivers. The fine-tuning control, however, has a pronounced effect upon color reproduction and demands special attention. We will show the effects of the controls that affect color in the sequence in which they are normally adjusted to produce a correct color picture. Fine tuning is adjusted first, followed by saturation (COLOR) and hue (TINT) in that order.

Fine Tuning. When you turn the fine-tuning control, you alter the intermediate frequencies to which the signals of the selected channel are converted. When fine tuning is correct, the converted channel "fits" into the passband provided by the i-f amplifiers. In order to obtain uniform amplification of the brightness and color signals, the converted picture carrier frequencies and color-subcarrier frequencies must be at the points indicated on the receiver response curve of Fig. 4-1.

Ever since the introduction of the intercarrier-sound system, which renders sound almost insensitive to fine-tuning errors, we have tuned the TV set by looking at the picture. We look for maximum crispness or sharpness without overshoot. This method is not accurate enough for

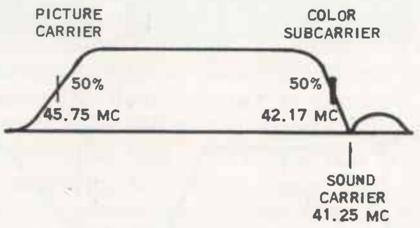


FIG. 4-1. I-f response curve for a color receiver.

color receivers, as the color subcarrier must be placed accurately to obtain good color reproduction. In addition, misadjustment can result in severe interference between the color subcarrier and the sound carrier.

Fortunately, color receivers provide a precise indicator for accurate fine tuning. This is accomplished by the very sharp sound i-f traps (41.25 mc) in the i-f amplifier. The traps attenuate the sound i-f carrier ahead of the video detector. If fine tuning is off, the sound i-f signal passes through the i-f amplifiers and a severe beat pattern appears in the picture. This pattern is the result of the 920-kc beat between the sound and color subcarriers. When the sound i.f. is converted accurately to the 41.25-mc trap frequency, the sound signal produced by the video detector falls practically to zero, and all trace of the beat pattern vanishes.

The action of the fine-tuning control in a color receiver (color telecast) is shown in Fig. 4-2. On one side of the correct setting, the color carrier is down too far on the response curve. Color is unsaturated (weak, pale) or nonexistent as shown in *a* of the figure. At the correct setting, colors appear stronger and might be over-saturated if the saturation control is set too high. There is no beat

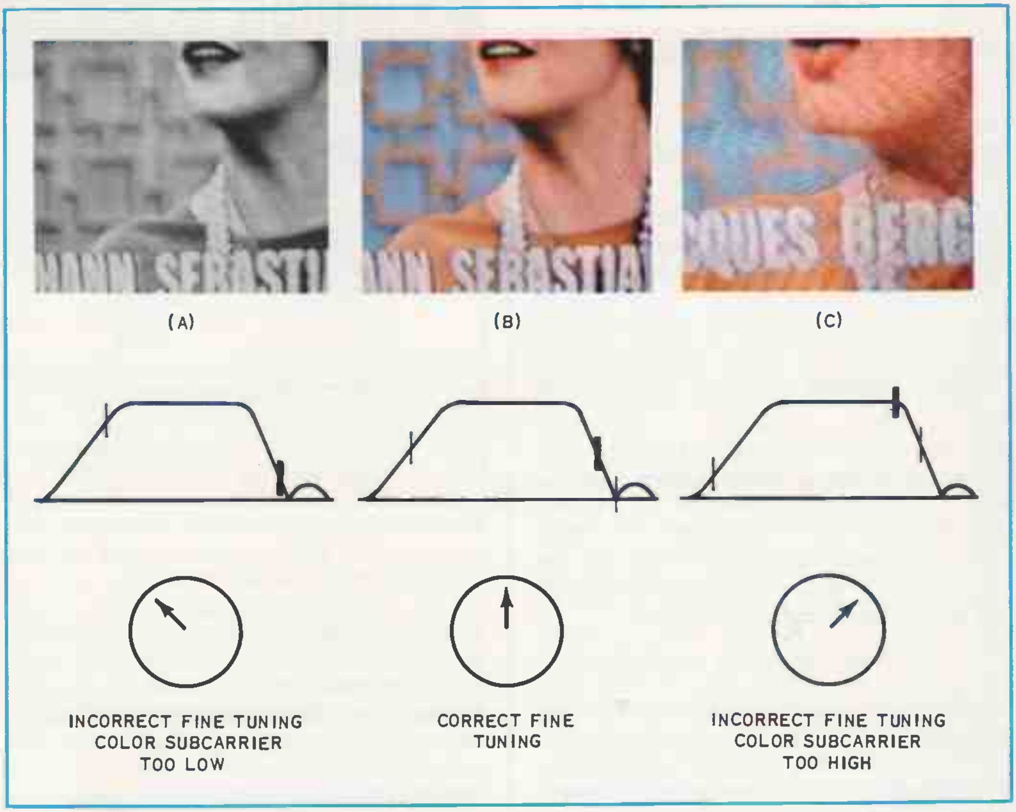


FIG. 4-2. Action of the fine-tuning control.

pattern in the picture, as shown in *b* of the figure. As you tune past the correct point, the sound beat appears abruptly and colors appear oversaturated as shown in Fig. 4-2*c*.

The procedure for fine tuning is as follows. Make sure that the COLOR control is set to mid-range or higher. Tune in the direction to produce highest color saturation. Continue tuning in this direction until the sound-beat pattern appears. Reverse the direction of rotation and tune slowly until the beat pattern just disappears. The beat pattern is easiest to see in those areas of the picture that contain highly saturated colors. The correct tuning adjustment, found in this way, is also precisely correct for black-and-white reception.

The COLOR (Saturation) Control. This control is simply a gain control in the bandpass amplifier. When turned fully CCW, the bandpass amplifier is cut off and no color-difference signals are produced by the demodulators. The result is a monochrome picture as shown in Fig. 4-3*a*. As the control is advanced, color begins to appear in the picture, but the color-difference signals are too small to make any particular hue predominate. All hues are mixed with white; the picture appears pale or washed out, as shown in Fig. 4-3*b*. At the correct setting, colors are normally saturated. Flesh tones appear normal—neither too pale, nor too ruddy, as shown in Fig. 4-3*c*. Flesh tones are the best guide in setting both color controls, for the viewer has no accurate information as to what color a particular item in the picture, such as a dress, flag, or background scene, actually is.

As the COLOR control is advanced past the "correct" point, colors become oversaturated. Faces appear very ruddy, as shown in Fig. 4-3*d*. Noise, in the form of coarse colored snow, appears in the picture. Noise is first noticed in blue areas

FIG. 4-3. Action of the COLOR (chroma, saturation) control.

of the pictures, since the circuits that handle the B-Y signal in the receiver have higher gain than the circuits that process the R-Y or G-Y signals. This inequality in gain is needed to correct for the previously mentioned alterations in the amplitudes of the color-difference signals at the transmitter. Recall that such alterations are needed to keep certain parts of the combined signal from overmodulating the transmitter.

The TINT (Hue) Control. The setting of the TINT control determines the phase of the local subcarrier oscillator in the receiver as compared with the system reference signal — the transmitted burst signal. When this control is set correctly, the proper color-difference signals are reproduced by the demodulator/matrix sections of the receiver, and all hues are reproduced accurately. When the TINT control is misadjusted, the subcarrier oscillator operates at the wrong phase. This causes the demodulators to produce incorrect color-difference signals. Suppose, for example, that a particular hue is represented by a 3.58-mc signal that normally produces equal video outputs from the two demodulators. If the phase of the CW signals applied to these demodulators shifts, the output of one demodulator increases, while the output from the other drops. Thus the instantaneous *relative* amplitudes of the color-difference signals change. It is the relative amplitude of these color-difference signals, expressed in terms of the phase of the transmitted subcarrier signal, that determines the hue of the reproduced image.

The effect of the TINT control on the picture is shown in Fig. 4-4. The center photograph shows the correct setting. The range of the control is shown by the remaining photographs. These were made with the control at the extremes of its range. Note that flesh tones appear too yellowish or greenish with the TINT control fully CCW. Full CW rotation produces a violet or purple flesh color. Again flesh tones are used for the correct setting criterion.

The TINT control is usually part of a tuned circuit in the burst amplifier or phase detector. By altering the phase of the *separated* burst signal, we can alter the phase of the subcarrier oscillator. Any shift in burst phase is simply followed automatically by the AFPC system. It is not necessary to know the exact phase shift that the separated burst signal undergoes. There are several additional phase shifts introduced by the phase detector and other circuits. We simply manipulate the phase of the separated burst signal, and hence the phase of the sub-

FIG. 4-4. Action of the TINT (hue, phase) control.

carrier oscillator, until the desired results are obtained. The viewer makes this adjustment by setting the control so that *normal* flesh tones are produced.

USING COLOR TEST EQUIPMENT

Anyone seriously considering color TV service work must provide himself with the necessary test equipment. Those who try to get along without a dot/crosshatch/color-bar generator soon find themselves wasting too much time in hit-or-miss attempts at convergence, and in guesswork about repairs to the color circuits. A source of convergence and color test signals is a must for color TV work.

Basic Requirements of Color Tests Equipment. Color test equipment must provide a source of signals for convergence and color-circuit adjustments. Here are some of the important requirements of color test equipment:

1. *Convergence patterns.* A source of signals is needed that can produce the crosshatch pattern shown earlier in this book. Most pattern generators provide both crosshatch *and* dot patterns. Many technicians prefer the dot pattern when making center-convergence (static) adjustments. The service literature of most set manufacturers describes dynamic convergence adjustments in terms of the crosshatch pattern.

2. *Color test signals.* Equipment made by various manufacturers provides a wide choice of color displays. To be most useful, the color display should provide all of the following:

a. a means of checking the receiver's ability to reproduce a wide range of hues;

b. an indication of accurate color phase adjustments;

c. a way of checking the relative gains of the three color-difference channels in the receiver (matrix check);

d. a way of checking the range of the TINT (hue, or phase) control.

e. a means of checking the time delay in the brightness amplifier (checking the time "fit" of the color and brightness signals).

f. a means of checking the color locking ability of the AFPC system in the receiver.

g. a means of determining accurate fine tuning.

3. *Portability.* Both dot/crosshatch and color patterns should be provided by one instrument. The unit should be small, and light enough to be carried to the home. This requirement is important, because the convergence and color adjustments and checks must be performed in the home. Remember that pulling a complete color receiver is a two-man job. If you pull only the chassis, you need a complete color setup including a color picture tube at your shop in order to make final color adjustments. Thus, many checks, and nearly all of the final adjustments, must be made in the home.

Keeping portability in mind, the patterns produced by the generator should be readily interpreted without the aid of *additional equipment*, such as an oscilloscope. You should be able to interpret the color patterns by looking at the picture-tube screen.

4. *Internal sync.* The pattern generator should provide stable, accurate synchronizing pulses. This requires an internal crystal-controlled sync generator. Convergence adjustments that are made when the receiver's scanning oscillators are running at the wrong frequencies are meaningless when the receiver locks up on the correct sync signals from a broadcast signal.

5. *Simple interconnections.* Connections between the pattern generator and the receiver should be as simple as possible. The most workable arrangement has the pattern signals modulated upon a carrier signal of one or more of the standard channel frequencies. In this case, only an r-f cable is needed, which connects the

FIG. 5-1. The RCA WR-64A Color/Bar/Dot/Crosshatch generator.

generator to the receiver's antenna terminals. Video feeds are sometimes helpful, but they require a knowledge of the amplitude levels required at various injection points. Sometimes minor circuit changes have to be made in the receiver to obtain satisfactory results using video feeds.

RCA WR-64A Color/Bar/Dot/Crosshatch Generator. The generator shown in Fig. 5-1 has been carefully engineered to provide all the requirements discussed in the previous paragraphs. Its color display is of the *gated-rainbow* type. This form of color display is extremely useful in making receiver adjustments and in diagnosing troubles. Setup procedures printed in much of the service literature are based upon interpretation and use of the gated-rainbow display. Hence, the color-circuit adjustments and color trouble discussions in this book will refer often to the pattern produced by a gated-rainbow generator. We will use the RCA WR-64A in our examples.

Circuit Description—Dot/Crosshatch Function. The crosshatch pattern consists of 9 or 10 vertical bars and fourteen horizontal bars. Vertical bars are formed by sharp pulses that occur twelve times during one complete horizontal scanning cycle. The source of these pulses is an accurate, crystal-controlled oscillator operating at 189 kc (12 × 15.75 kc = 189 kc). Although twelve pulses occur for each scanning cycle, only nine or ten vertical bars are visible. Two pulses occur during retrace, and one bar may be masked due to horizontal overscan (extra width).

Horizontal bars are produced by 900-cps pulses. These pulses occur fifteen times during each vertical scanning cycle (15 × 60 cps = 900 cps). One pulse occurs during the vertical retrace period, so only fourteen horizontal bars are seen.

Pulses for both the vertical and horizontal lines of the pattern, as well as horizontal and vertical sync pulses, are derived from the crystal-controlled 189-kc oscillator. A series of frequency-divider stages, called *counters,* divide the 189-kc signal by the appropriate factors to produce signals at 15.75 kc (horizontal sync), 900 cps (horizontal pattern bars), and 60 cps (vertical sync). The arrangement of the dividers is shown in the simplified block diagram of Fig. 5-2.

The signals provided by the counters are shaped to produce sharp pulses, and combined to produce the composite video signal. Next, the video signal is used to modulate a carrier signal provided by a VHF oscillator. This oscillator can be made to operate at the picture-carrier frequency of Channel 3 or 4. The choice depends upon the active channel in your locality. As it is shipped from the factory, the RCA WR-64A operates on Channel 3. If Channel 3 is operating in your area, you may tune the oscillator to Channel 4 to eliminate co-channel interference. A shielded cable couples the r-f output of the generator to the antenna terminals of the receiver.

To make accurate fine-tuning adjustments, the RCA WR-64A provides an unmodulated sound-carrier signal. This is produced by beating a 4.5-mc signal, obtained from a separate crystal-controlled oscillator, with the Channel 3 or 4 picture carrier produced by the instrument. Fine tuning is accomplished as usual by tuning for minimum sound beat in the color picture (use the color-bar display for the fine-tuning adjustment).

The pattern may be changed from *crosshatch* to *dots* by turning the PATTERN SELECTOR switch. In the *dot* position of the switch, a peak detector is placed in the video mixing circuitry. This detector produces a pulse whenever the horizontal-bar and vertical-bar pulses add (when they occur at the same instant of time). The pulses so produced make a "dot" whenever the horizontal and vertical bars of the crosshatch pattern intersect.

Color-Bar Pattern. The rainbow pattern produced by the RCA WR-64A is developed by a subcarrier signal whose frequency is 15,750 cps lower than the standard color-subcarrier frequency. This signal is impressed upon the Channel 3 (or 4) carrier signal and passes through the receiver in the same way as the station's subcarrier signal. In the receiver, the subcarrier signal beats with 3.58-mc local oscillator signal in the demodulators. The *difference* or *beat signal* produced in the demodulators is 15.75 kc. Thus, one complete cycle, or 360°, of the beat signal is completed in the time it takes to scan one horizontal line. The demodulators in the receiver sense the new subcarrier signal as one that shifts through 360° during each horizontal scan. Since *phase* determines *hue,* all the colors in the television system spectrum are displayed during each horizontal scan. The pattern would appear as a continuous rainbow of vertical colored stripes that blend into one another.

The color subcarrier signal produced by the RCA WR-64A is not present continuously, but is turned on in short bursts, or *gated,* twelve times during the horizontal scan. This is accomplished by passing the subcarrier signal through a gate tube that is turned on with pulses from the 189-kc pulse generator. The pattern appears as shown in Fig. 5-3.

Gating provides an excellent phase reference. Since there are twelve bars in the time that the signal shifts through 360°, the bars (actually the centers of the bars) are 30° apart in phase. The phase angles and hues represented by the bars are shown in Fig. 5-3.

In addition to the phase reference, gating provides a video signal that allows the technician to judge whether or not the brightness time-delay is correct. The spaces between the color bars are also put to use. They serve as a zero-signal reference, so that color phase adjustments may be made without an oscilloscope. We will show how these features of the gated rainbow pattern are put to use presently.

As in the case of the crosshatch pattern, only 10 color bars are visible. One bar is blanked out in the generator during the horizontal-sync period. The burst bar oc-

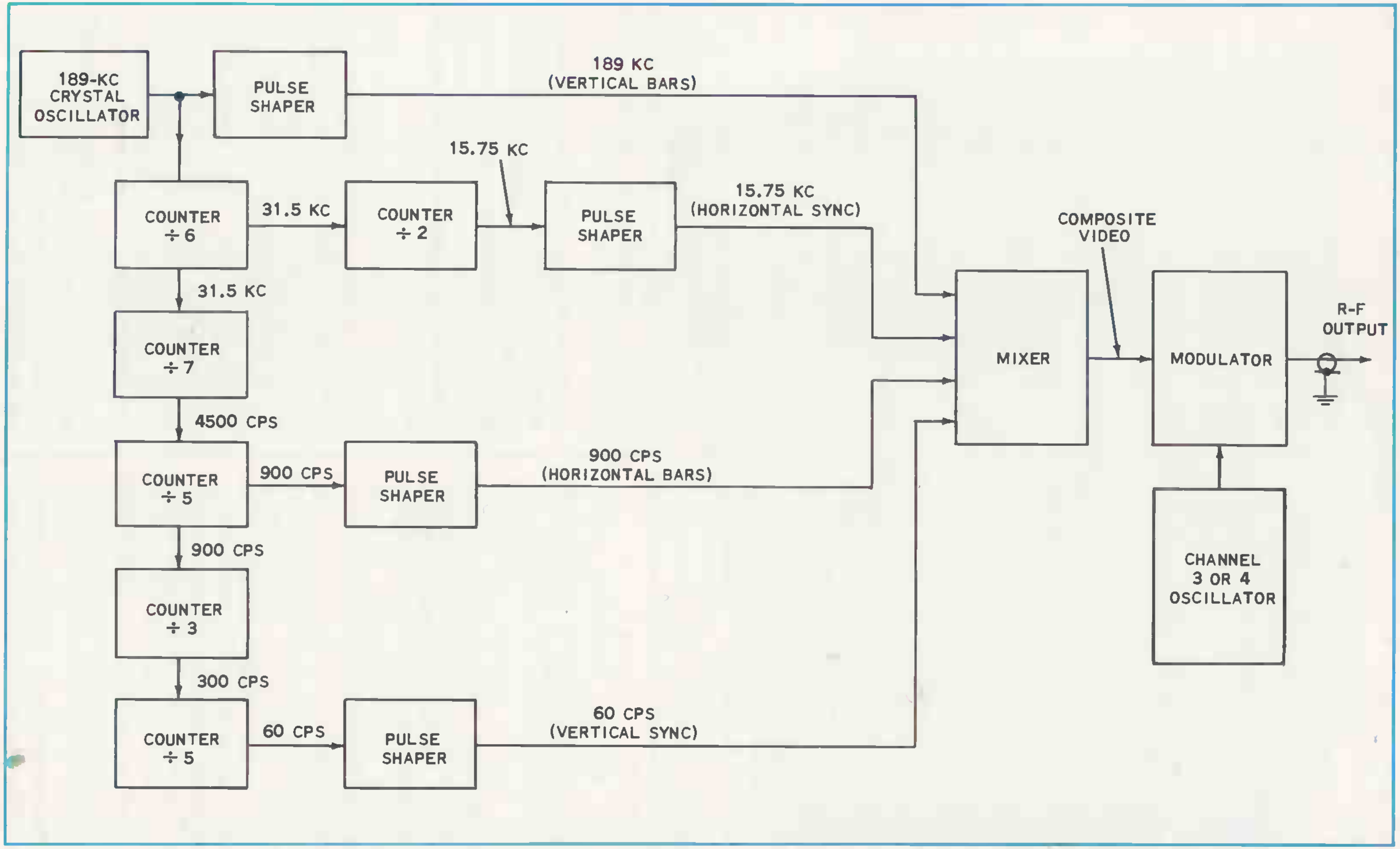


FIG. 5-2. Simplified block diagram of the circuits that generate the dot and crosshatch signals in the RCA WR-64A generator.

curs during horizontal retrace and is not seen on the picture-tube screen.

Interpreting the Color-Bar Pattern. A color receiver that is adjusted properly always reproduces the same sequence of color bars from the RCA WR-64A. The correct pattern is shown in Fig. 5-3. A correctly adjusted receiver reproduces the pattern in this way. Horizontal retrace is initiated in the receiver by the horizontal sync pulse produced by the WR-64A. The burst bar occurs shortly after horizontal sync, during the retrace interval. During retrace, the burst amplifier in the receiver is gated into conduction. The burst signal passes through to the AFPC system in the receiver, and the 3.58-mc oscillator "locks-up" on this signal. The phase of the 3.58-mc oscillator in the receiver remains constant during the remainder of the next horizontal scanning line. During the next complete scan, the phase of the color-bar signal rotates through 360° with respect to burst phase. If the burst signal (the system reference) produced a visible bar, that bar would be yellow. However, the phase of the first visible bar is rotated 30° from the signal the receiver has accepted as burst. Thus the first visible bar is a yellowish orange. Each succeeding bar represents a change in phase of 30°.

Consider the video signal produced by the color demodulators during each horizontal scan. A fixed-phase CW signal is applied from the local 3.58-mc oscillator. The subcarrier signal completes a 360° phase shift. When these two signals are in phase at the demodulator, the demodulator output is maximum negative. When they are 90° apart the demodulator output is *zero*. When they are 180° apart, demodulator output is maximum positive. In other words, the video signal produced by the demodulators is a sine wave that completes one cycle during each horizontal scan (15.75 kc). Due to the *gated action*, the demodulator output appears as a series of pulses whose tips form the sine wave. Figure 5-4 shows the +(R-Y) waveform as it appears at the grid of the red electron gun.

By remembering the positions of a few key color bars, you can make precise checks of the color reproducing ability of the receiver. Consider these examples with the aid of Fig. 5-3.

The *third* bar represents +(R-Y). The *sixth* bar represents +(B-Y). Now these two signals are 90° apart in phase. If you look at the waveform of the +(R-Y) signal in Fig. 5-4, you should see the third bar at maximum *positive* amplitude. (Positive in this case is opposite to the polarity of the blanking signal. The large, downward-going pulse in this waveform is the blanking signal.) Since the +(B-Y) signal is 90° from the +(R-Y) signal, output from the R-Y demodulator should be zero in the center of the +(B-Y) bar. Thus, the sixth bar is at the

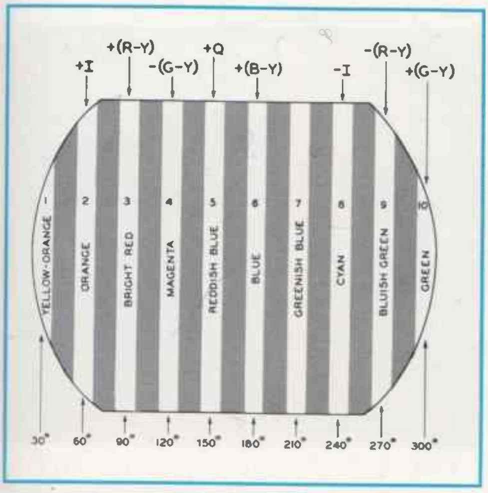


FIG. 5-3. The gated-rainbow display produced by the RCA WR-64A generator.

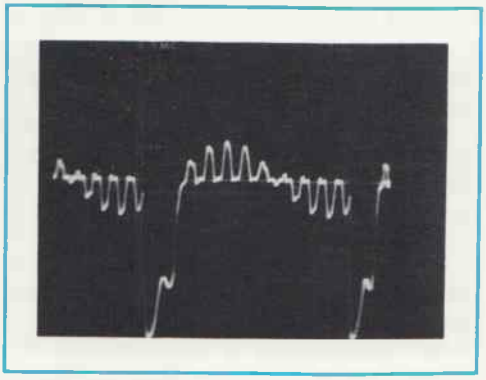


FIG. 5-4. The correctly-phased R-Y waveform at the control grid of the red electron gun.

zero-signal level in the waveform of Fig. 5-4.

In the procedures that follow we will show you how to use key bars in the color-bar signal to check many receiver functions. You will see how to interpret the color-bar signal with and without an oscilloscope.

Adjusting TINT (Phase) Basically, proper phase is achieved by getting the hues shown in Fig. 5-3 in their designated color-bar positions.

A *quick* check can be made as follows:

1. Connect the color-bar generator to the antenna terminals of the receiver.

2. Turn the PATTERN switch on the generator to the COLOR BAR position; turn the FUNCTION switch to the PATTERN + SOUND position; turn the CHROMA control (subcarrier amplitude) to 100%.

3. Switch the receiver to Channel 3 (or Channel 4 if the generator has been set up to provide Channel 4 signals).

4. Turn the TINT and COLOR controls on the receiver to their mid positions.

5. Rotate the fine tuning control until a definite sound beat pattern is observed. (Further rotation causes the picture to blank out.) Reverse rotation and tune until the sound beat pattern just disappears.

Turn the FUNCTION switch on the generator to the PATTERN position. The pattern should appear as shown in Fig. 5-5. Pick out one of the bars to use as a reference. The eighth bar is a good example. It should be cyan. Count eight bars from the left and examine this bar closely. If phase is set incorrectly, the eighth bar will appear too green or too blue. If the eighth bar is not cyan, rotate the TINT control to make it so. If it is necessary to rotate the TINT control more than 20° from its mid position to make the eighth bar cyan (or if it is impossible to make the eighth bar cyan) phase must be reset in the color synchronizing circuits.

Phase is usually adjusted by tuning the core of the transformer that couples the burst amplifier to the phase detector. Figure 5-6 shows the circuit location of this adjustment. Check the service notes for the physical location of this transformer. To readjust phase, set the TINT control to mid range and adjust the core of the burst-phase transformer to make the eighth bar appear cyan.

Oscilloscope Checks. Precise phase adjustments can be made with the aid of the oscilloscope. You may observe any one of the color-difference signals at the control grids of the picture tube. Test points are usually provided for this purpose. Test points in RCA receivers are found by tracing the red, green, or blue leads from the picture-tube socket back to their respective tie points on the chassis.

Some thought must be given as to which of the three color-difference waveforms to observe first. The choice depends on the make and age of the receiver. Specifically, the choice is determined by the way in which signals are coupled from the 3.58-mc oscillator to the demodulators. When you adjust TINT or phase you adjust the phase of the 3.58-mc oscillator. To check for correct results, you should look at the signal produced by the demodulator that is driven directly from the 3.58-mc oscillator. Consider Fig. 5-7, which shows the block diagram of the demodulator section of most late-model RCA receivers. Note that the CW feed

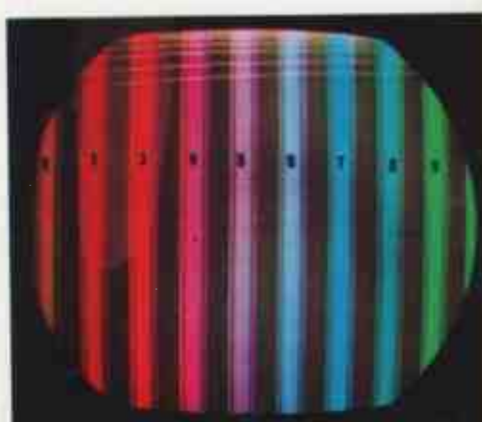


FIG. 5-5. A normal correctly-phased color-bar display. The eighth bar should be cyan; however, this hue is difficult to photograph accurately.

to the X demodulator comes directly from the oscillator; the CW feed for the Z demodulator passes through an additional phase-shift network. In this case you should set phase by checking the output of the X demodulator. However, the +(R-Y) signal is easier to identify and is obtained primarily from the X signal. Thus phase is checked in this case by observing the +(R-Y) signal at the picture tube grid. Keep this idea in mind: *Check master phase by observing the color-difference signal that is obtained from the demodulator that is driven directly from the 3.58-mc oscillator*. In late-model RCA receivers, check phase by observing the +(R-Y) signal. In other receivers, check the service notes or schematic diagram to determine which of the color-difference signals to observe first.

When phase has been set correctly, you may move the oscilloscope probe to observe the signal that results from the remaining demodulator. This allows us to check or adjust the phase-shift network. In early color receivers, the phase-shift network is adjustable. Late-model receivers employ a fixed phase-shift network.

The procedure that follows applies to late-model RCA receivers and includes models that cover a wide span of years.

Phase Adjustments with the Oscilloscope:

1. Obtain a color-bar pattern as described previously under "quick check."

2. Set the TINT control to mid range.

3. Connect the probe of the oscilloscope to the control grid of the red electron gun, +(R-Y) signal.

4. Adjust the oscilloscope to produce a stationary pattern, as shown in Fig. 5-8. (Horizontal timebase at 7875 or 5250 cps.)

5. Adjust the burst-phase transformer until the center of the sixth bar (B-Y) goes through the zero-reference line as shown in Fig. 5-8. The zero-reference line is

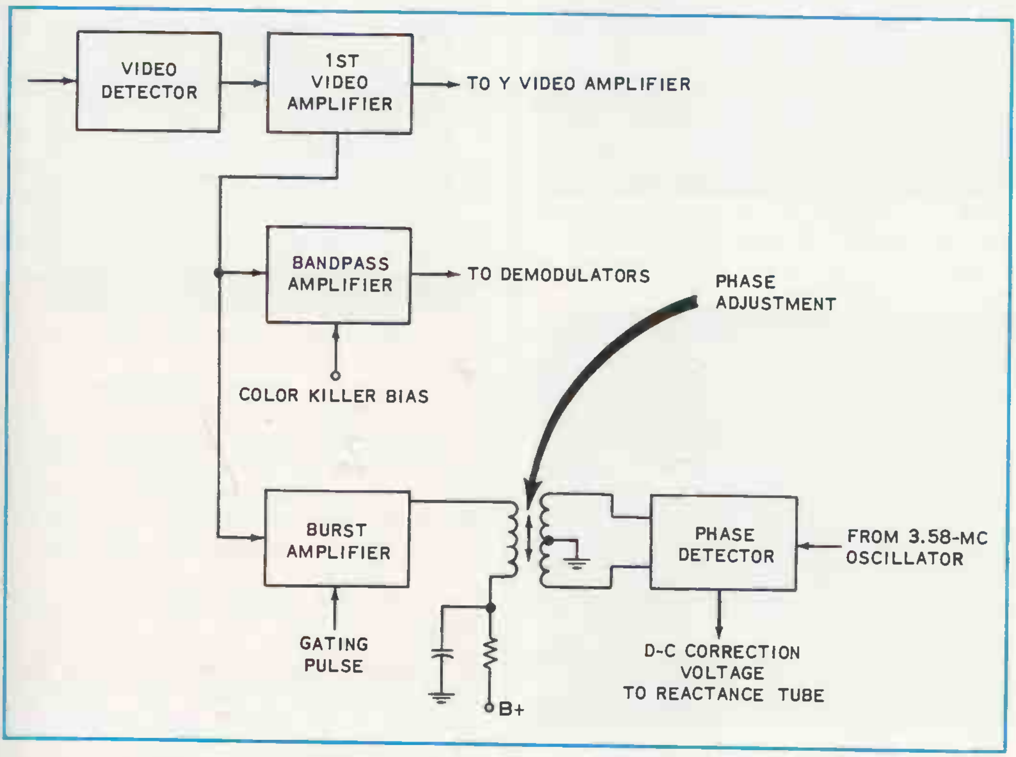


FIG. 5-6. The "service" phase adjustment in many receivers is made at the transformer that couples the burst amplifier to the phase detector.

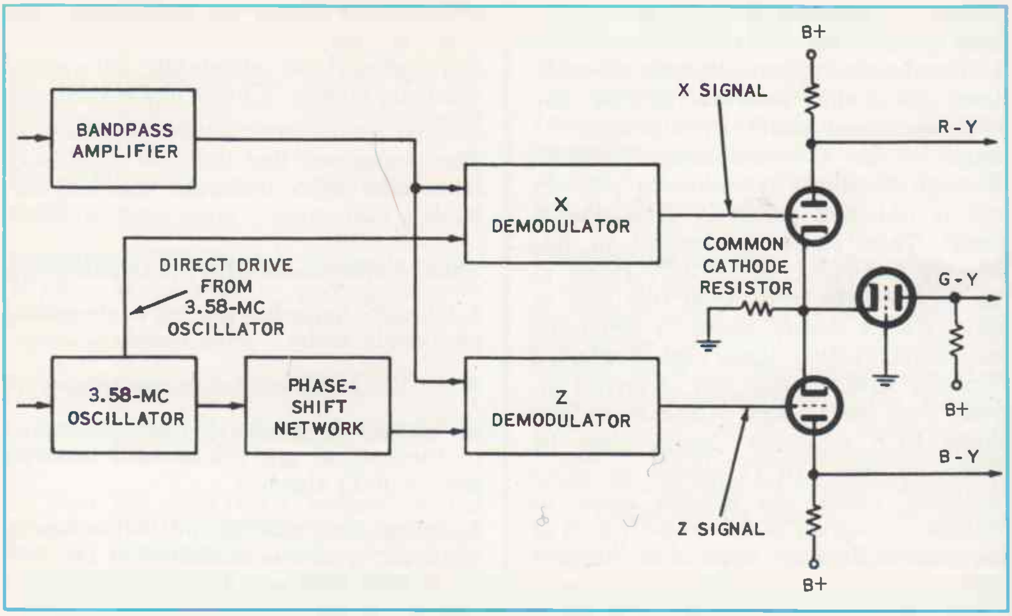


FIG. 5-7. Chrominance circuits of late-model RCA receivers.

established by the spaces between the color bars.

6. Now, move the oscilloscope probe to the control grid of the blue gun and check the +(B-Y) signal. As Fig. 5-9 shows, the *third* and *ninth* bars, which represent +(R-Y) and −(R-Y) respectively, should pass through zero, (The *sixth* bar should be at maximum positive amplitude). If they do not, a fault is indicated in the phase-shift network or the matrix amplifier.

7. Now move the oscilloscope probe to the control grid of the green electron gun and check the +(G-Y) signal. As shown in Fig. 5-10 the first and the seventh bars should pass through zero. Oscilloscope vertical gain was turned up in making Fig. 5-10, and the blanking pulse extends off the screen in this waveform.

Here are the key factors to remember in checking each of the color difference signals:

+(R-Y) signal — *sixth* bar passes through zero.

+(B-Y) signal — *third* and *ninth* bar pass through zero.

+(G-Y) signal — *seventh* bar passes through zero.

Precise checks without an oscilloscope. Fortunately, the conditions noted in the previous paragraphs can be observed on the screen of the picture tube. The only additional equipment needed is a Grid Shunt Switch.

To observe the +(R-Y) signal, bias off the blue and green guns using the grid shunt switch. A properly-phased pattern appears as shown in Fig. 5-11. Advance the brightness control on the receiver until the spaces between the color bars are lighted dimly. Remember that the sixth bar should pass through zero on the grid waveform. Thus, the sixth bar should be the same brightness as the spaces between the bars. The fifth bar is brighter and the seventh bar is darker than the spaces. As you turn the TINT (phase) control back and forth, the sixth bar should become alternately brighter and darker than the spaces between the bars. To set phase accurately, make the sixth bar the same brightness as the spaces between the bars.

It is sometimes difficult to tell the bars from the spaces between the bars when only one of the electron guns is operating. To avoid confusion, locate the bar or bars in question by looking at the full color-bar pattern before you switch off

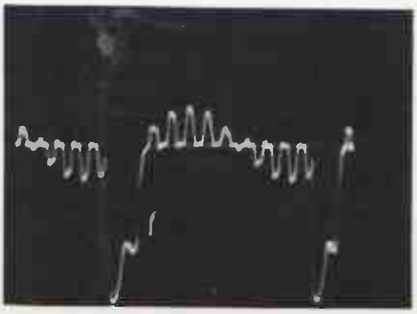


FIG. 5-8. R-Y waveform.

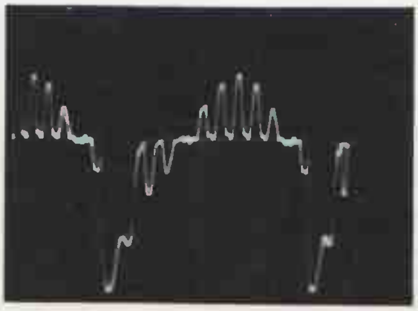


FIG. 5-9. B-Y waveform.

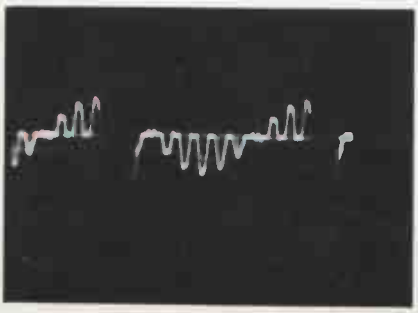


FIG. 5-10. G-Y waveform.

the appropriate guns. It might help to mark temporarily the bars you wish to observe with a grease pencil before you make any adjustments with two of the electron guns cut off.

The +(B-Y) and +(G-Y) signals can be checked in the same way. To observe +(B-Y), bias off the red and green guns. The pattern should appear as shown in Fig. 5-12. The third and ninth bars are the same brightness as the spaces between the bars. Figure 5-13 shows the correctly-phased green pattern, obtained

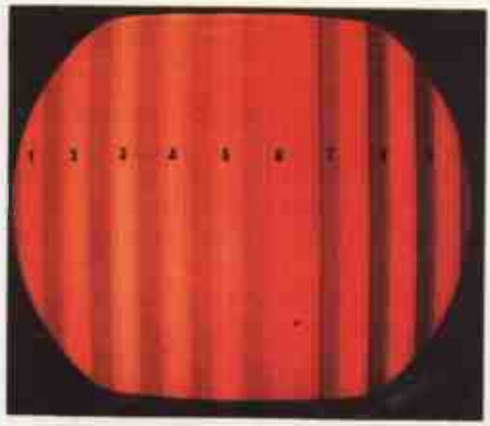


FIG. 5-11. Correctly phased color-bar pattern; blue and green guns cut off.

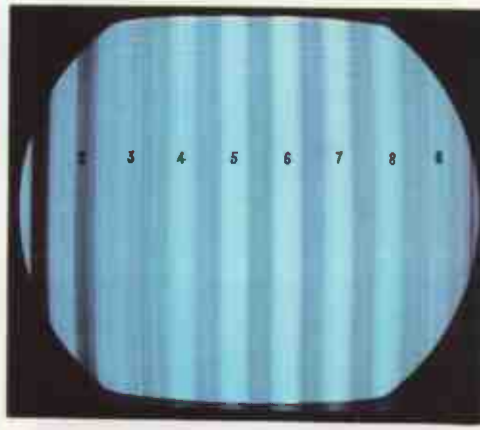


FIG. 5-12. Correctly phased color-bar pattern; red and green guns cut off.

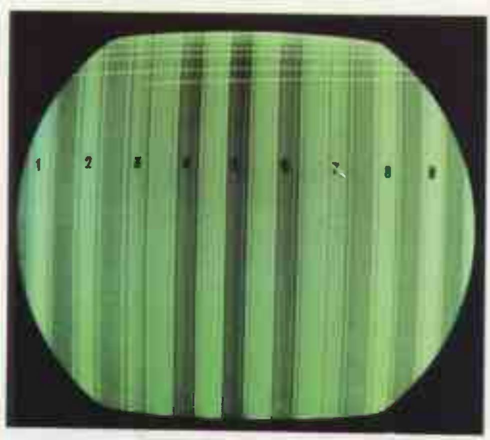


FIG. 5-13. Correctly phased color-bar pattern; red and blue guns cut off.

by biassing off the red and blue guns. Notice that the seventh bar is the same brightness as the background.

Checking the Range of the TINT Control. The front-panel TINT or hue control should permit the viewer to alter the phase of the 3.58-mc oscillator signal by about 60° (±30°). This range is more than adequate to compensate for slight phase differences between channels.

A change of phase of 30° is noted when a particular hue in the bar pattern shifts to the left or right by one bar position. For example, the eighth bar should be cyan when the receiver is properly phased. A 30° phase shift is indicated when the TINT (phase) control is turned far enough to make either *seventh* or *ninth* bars appear cyan. A range of 60° is indicated when the cyan hue can be made to move from the seventh to the

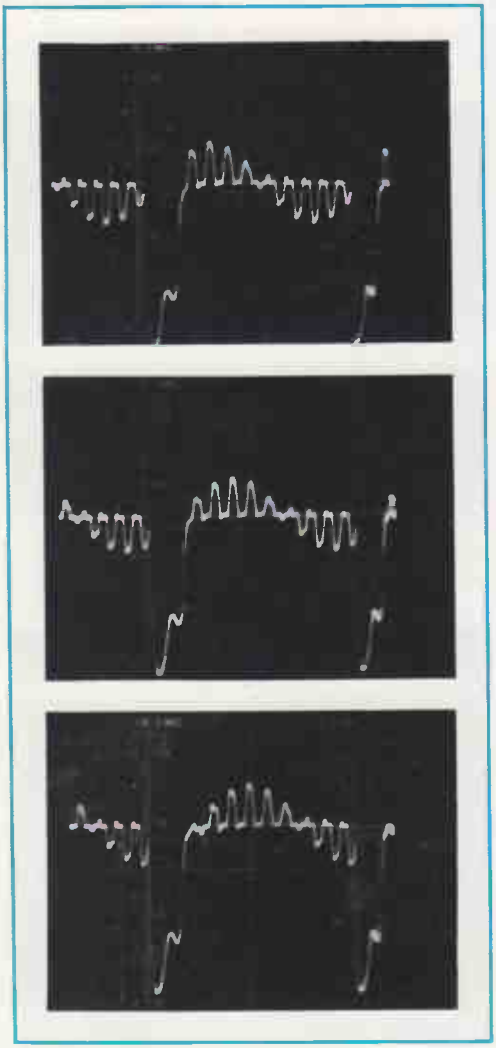


FIG. 5-14. Waveforms at the control grid of the red gun, showing the range of the TINT control.

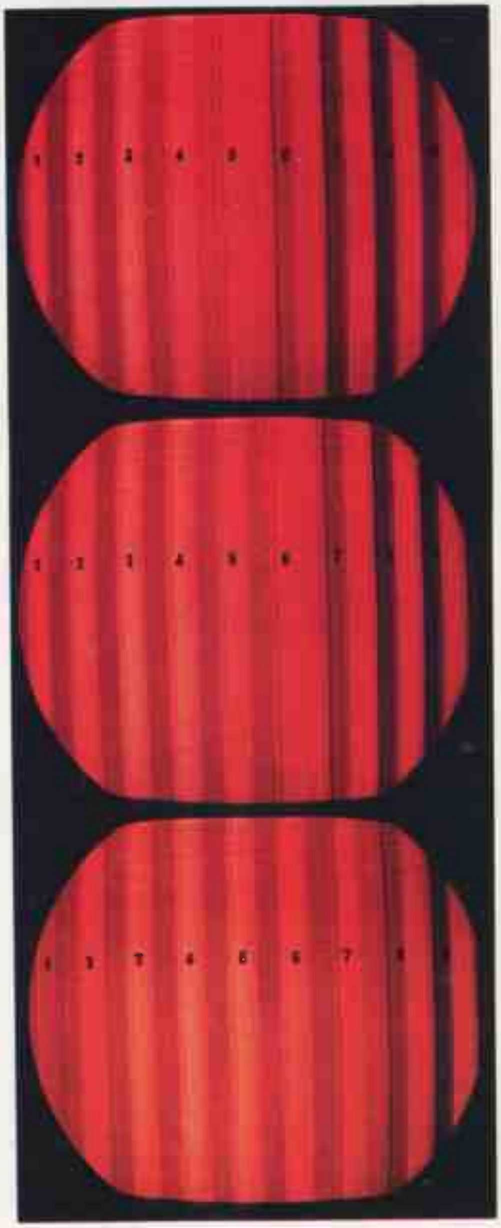


FIG. 5-15. Checking the range of the TINT control with the color-bar display (blue and green guns cut off).

ninth bar position while turning the TINT control through its entire mechanical range. Insufficient range points to a fault in the AFPC system.

Figures 5-14 and 5-15 show how to check the range of the TINT control using the oscilloscope and the single-color display discussed earlier. Correct phase is indicated at the red control grid (Fig. 5-14) when the sixth bar passes through zero. A 30° phase shift in either direction causes the fifth or seventh bars to pass through zero. The same conditions are noted in the pictures of the picture-tube screen in Fig. 5-15. Notice that the bar that has the same brightness as the spaces between the bars shifts from the fifth to the seventh position.

Checking Receiver Matrix. It was mentioned earlier that the color-difference signals undergo different amounts of relative attenuation in the TV studio in order to keep the composite video signal from overmodulating the transmitter. These signals are restored to their proper relative amplitudes in the receiver by the circuits that process the demodulated color-difference signals (the matrix circuits). Additional corrections are made in the receiver to compensate for the different video drive requirements of the three guns of the picture tube. The drive requirements are different because of differences in phosphor efficiency.

You need not concern yourself with the mathematics involved in determining the relative gains of the B-Y, R-Y and G-Y channels. All you need to know is what the results should be and how to check them.

At the transmitter, B-Y receives the most attenuation. Therefore the B-Y channel in the receiver must have the highest gain. The G-Y signal has the highest amplitude at the transmitter. Thus the G-Y channel in the receiver has the lowest gain.

Accurate matrix checks can be made with an oscilloscope and the color-bar generator. The procedure is to pick one of the color-difference signals as a reference and then compare the amplitudes of the remaining color difference signals with the reference. It is important to remember that the color-bar generator has no built-in amplitude corrections; all color-difference signals provided by the generator have equal amplitudes. Therefore the relative amplitudes of the color-difference signals produced by the receiver are an indication of the relative gains of the R-Y, B-Y and G-Y channels.

You must have the service notes for the receiver before you can make matrix checks. Figure 5-16 shows how matrix information is given in the service notes for a current receiver. These are idealized waveforms drawn for maximum clarity. Note that the R-Y signal is chosen as a reference. The peak-to-peak amplitude of the color signal *Not including the blanking pulse,* is chosen to be 100%.

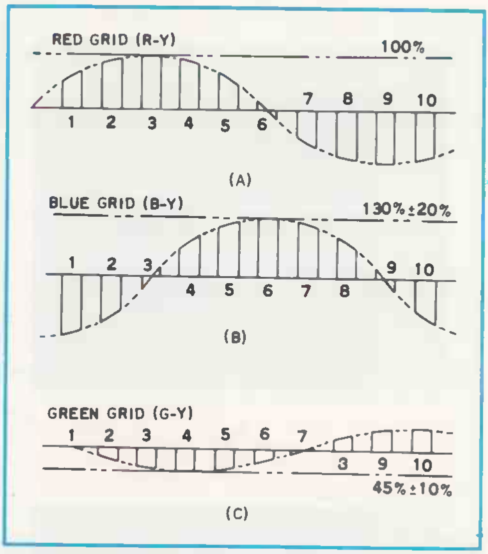
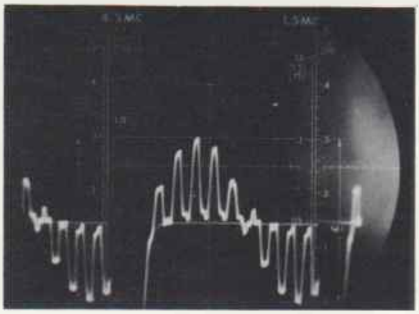
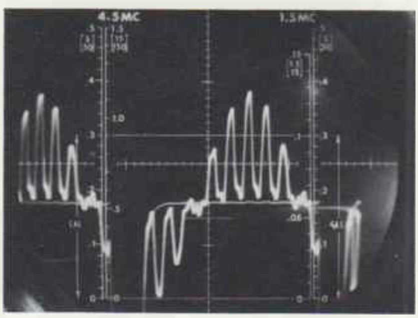


FIG. 5-16. Idealized waveforms of the three color-difference signals showing the designated relative amplitudes for a late-model receiver.

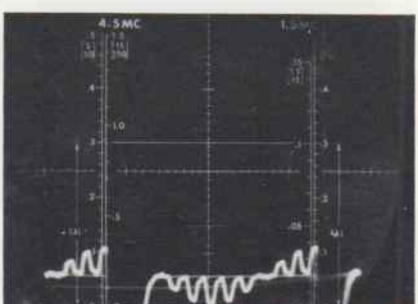
To make the check, proceed as follows. Set the gain controls on your oscilloscope so that the peak-to-peak amplitude of the R-Y signal (at the red control grid) covers some convenient value on the graph scale. Figure 5-17*a* shows an actual waveform. Gain controls have been set so that the R-Y waveform lies between 0 and 1 on the scale at the right. Without changing the setting of the gain controls on the oscilloscope, move the probe to the blue control grid. Reset the centering control so that the negative peak of the signal rests on the zero line as shown in Fig. 5-17*b*. The positive peak of the signal reaches about 1.28 on the graph scale, representing 128%. The correct reading for B-Y, given in Fig. 5-16, is 130% ± 20%. Hence, this reading of 1.28 is within tolerance.



a.



b.



c.

FIG. 5-17. Waveforms at the control grids of the picture tube showing correct relative amplitudes. (Oscilloscope gain settings held constant.)

Move the oscilloscope probe to the green control grid and check the G-Y signal. Figure 5-17*c* shows the waveform. Reset the centering control as before, and read off the relative amplitude of the signal — about 40%. The tolerance, as given in Fig. 5-16 is 45% ± 10%.

A large error in relative amplitudes of the color-difference signals points to a malfunction in the adder stages (matrix), or the demodulators, or the CW drives to the demodulators.

Rough Check of Receiver Matrix. To make a rough check of receiver matrix, simply observe the properly phased color-bar pattern on the picture-tube screen and turn down the BRIGHTNESS gradually. Since the G-Y signal has the lowest amplitude, greens will become extinguished first. Continued rotation of the brightness control causes reds to fade out, leaving blues lighted. This sequence of events is shown in Fig. 5-18. If hues do not become extinguished in this sequence a fault exists in the demodulator/matrix sections.

Checking the Time Delay in the Brightness Channel. The chrominance signals pass through relatively narrow-band filters before they are applied to the picture tube. The filters introduce a time delay which tends to make the color-difference signals arrive late at the picture tube. To restore the correct time relationship, the brightness signal passes through a delay line in the video amplifier. When the delay is correct the brightness and color signals register or "fit" together correctly. Since the picture is scanned from left to right, any error in relative time delays causes the colors in the picture to be displayed to the left or right of the monochrome picture.

The RCA WR-64A provides a means of checking relative time delays by placing marker pips at the beginning and end (left and right) of each color bar. Figure 5-19 shows the waveform produced in the brightness amplifier (picture tube cathodes) by the bar pattern. Note the pips that mark the left and right edges of each bar. The appearance of these marks on the picture tube screen is shown in Fig. 5-20. When the delays are correct the colors of the bars fit between the pips. Look closely at the normal color bar pattern in Fig. 5-5. Note that the colors "fit" between the narrow vertical stripes that mark the left and right edges of the color bars.

FIG. 5-18. A rough check of receiver matrix made by reducing brightness gradually.

A large error in time delay is shown in Fig. 5-21. To make this photo, a wire jumper was substituted for the delay line. Thus, there is no time delay in the brightness amplifier, and therefore brightness signal arrives early. Note the thin white line at the leading (left) edge of each color bar. In addition, the colors spill over into the spaces between the bars.

Checking Color Sync Performance. The subcarrier amplitude control, labeled CHROMA on the WR-64A, provides a way of checking the ability of the AFPC system to lock-up on a burst signal. Normally, this control is set at 100%, which gives the proper relative amplitudes of color and sync signals.

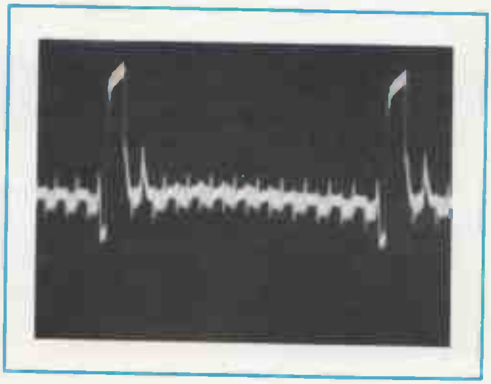


FIG. 5-19. Brightness-signal waveform at the picture tube cathodes produced by the color-bar signal. The "pips" identify the leading and trailing edges of the color bars.

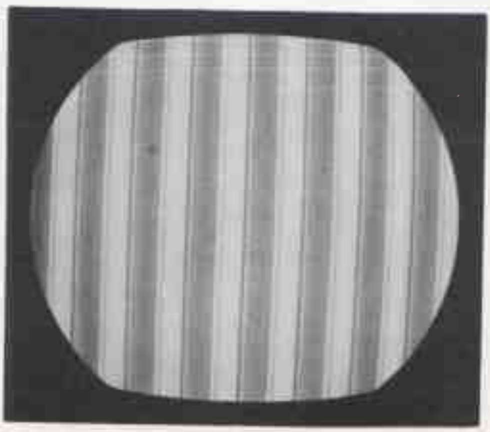


FIG. 5-20. Brightness signal part of the color-bar pattern. (Color turned off at the receiver.)

FIG. 5-21. Effect of incorrect time delay in the brightness amplifier (delay line bypassed).

As the CHROMA control is turned down, the amplitude of the 3.58-mc signal (including the color bar that the receiver "sees" as burst) decreases. The color bars become less saturated (pale) as the control is turned down. If the AFPC system is working correctly, color lock will be maintained until all color disappears, or until the color bars become very pale. Poor sync-lock action is indicated if the colors fall out of lock when the color bars still show appreciable color in the bars. Loss of synchronization is indicated when the colors run and break up into bands within the color bars. When this happens, the color bars look like "barber poles."

USING THE GREEN STRIPE TEST SIGNAL

Most stations that broadcast a regular color schedule provide a "green stripe" test signal during the periods of black-and-white transmissions. The green stripe signal provides a broadcast color test signal for the use of TV technicians.

To eliminate interference with regular telecasts, the green stripe signal is normally invisible on color and black-and-white sets alike. It consists of a two short bursts of 3.58-mc signal that occur just before and just after the horizontal blanking pulse, as shown in Fig. 6-1. This signal is invisible in the black-and-white telecast. If the color receiver is made to reproduce the hue represented by the signal, the display appears as vertical yellowish green bars at the extreme left and right edges of the picture.

Color Set Must be Adjusted to Reproduce the Stripe. Since the green-stripe signal does not occur during the normal burst interval, the color killer system in the receiver does not sense the presence of

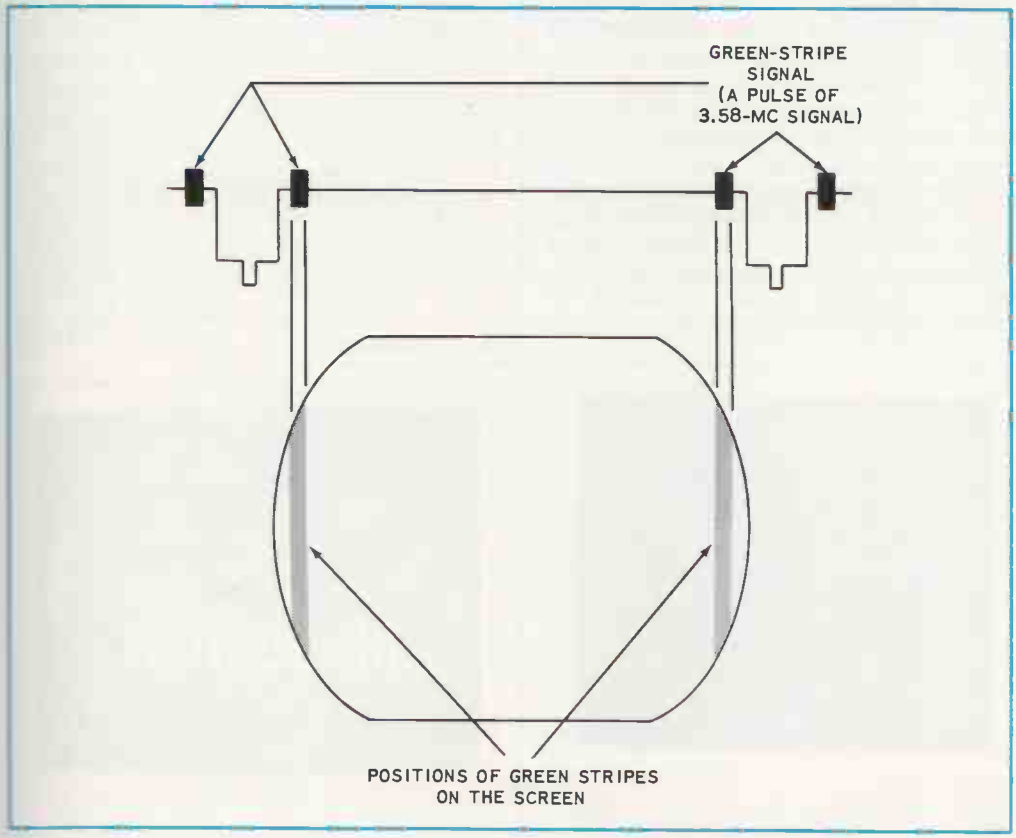


FIG. 6-1. Positions of the green-stripe signals in the composite signal waveform and on the screen of the picture tube.

a color signal. Thus, the bandpass amplifier remains cutoff and no color can be seen. To display the color stripe, the color killer must be disabled and the gate signal for the burst amplifier must be delayed sufficiently so that the burst amplifier will accept the left stripe as the burst signal.

What Can the Green Stripe Tell You? Although the green-stripe signal cannot be used for extensive receiver adjustments, the signal can yield important information. When used properly the green-stripe test signal can establish:

1. The ability of the receiver to make color,

2. Whether or not the color sync section is working properly,

3. The approximate setting and range of the TINT (hue, phase) control.

When is the Green Stripe Transmitted? Many stations that handle color telecasts transmit the green stripe during all black-and-white telecasts. (It is not transmitted during color telecasts, when the picture itself is the best test pattern.) It is a simple matter to detect the presence of the signal. Simply rotate the fine tuning control in the direction that will produce sound bars in the picture. Before sound bars appear, the 920-kc sound beat pattern will show up at the position of the stripes. Figure 6-2 shows a close up of the pattern that appears at the right edge of the picture when fine tuning is adjusted to produce the beat pattern.

FIG. 6-2. Close up of the right edge of the screen showing the sound beat in the green-stripe signal (fine tuning misadjusted to produce the beat).

Quick Checks Using the Green Stripe. To check the receiver's ability to make color, first tune the receiver properly. Adjust fine tuning until the sound beat becomes visible; then reverse rotation and tune slowly until the sound beat just disappears. This is an important step. The receiver might be working normally, but if mistuned it cannot reproduce color. Set the TINT and COLOR controls to midrange.

Disable the *color killer* stage by turning the color killer control fully CCW. If the set can make color, the stripes will appear in color at the left and right edge of the picture. However, the AFPC system cannot function (there is no burst signal) and the stripe will show evidence of loss of color synchronization. The stripe may appear as shown in Fig. 6-3. If the 3.58-mc oscillator in the receiver runs free at very nearly the correct frequency, the stripe will appear as a solid color that shifts slowly through all the hues in the rainbow. A larger frequency error results in the colors being broken up into bands. The stripe then looks like "a barber pole." The larger the frequency error, the narrower the vertical bands of color become. Thus this observation gives you a clue as to the free-running frequency of the 3.58-mc oscillator in the receiver. A large

FIG. 6-3. Disabling the color killer makes the stripe signal appear in color. Color appears out of sync in this case as there is no burst signal.

frequency error points to a need for re-alignment of the AFPC section of the receiver.

It is sometimes possible to make a rough check of the receiver's color lock ability by adjusting the horizontal hold control until the picture goes out of sync horizontally. Steady the picture carefully with the hold control until two or three slanting blanking bars (slanting upwards to the right) can be seen. This permits some of the green-stripe signal to pass through the burst amplifier and the AFPC system will lock up. You will then see a solid diagonal stripe of color in the blanking bar as shown in Fig. 6-4.

Direct Observation of the Green Stripe. Maximum use is made of the green stripe by shifting the phase of the horizontal oscillator in the receiver so that the left stripe signal passes through the burst amplifier. If the phase of the deflection oscillator can be shifted far enough, the burst gate occurs during the time that the left stripe appears. You see this sort of phase delay when you rotate the horizontal hold control. The change in phase between the video information and the start of the horizontal trace results in the shift in horizontal centering. Normally, sufficient phase delay cannot be achieved with the horizontal hold control; the picture slips out of sync first. However, by introducing an artificial delay into the feed between sync separator and the horizontal oscillator, the phase can be altered enough without loss of sync. To insert sufficient delay into the horizontal sync section, simply place a 0.005-μf capacitor between the plate of the sync output stage (or sync separator if only one sync separator tube is used) and the chassis as shown in Fig. 6-5. The added capacitance "rounds off" the leading edge

FIG. 6-4. By throwing the picture out of sync horizontally, you may see the green stripe signal in color lock. (Some green-stripe signal gets through the burst amplifier in this case.)

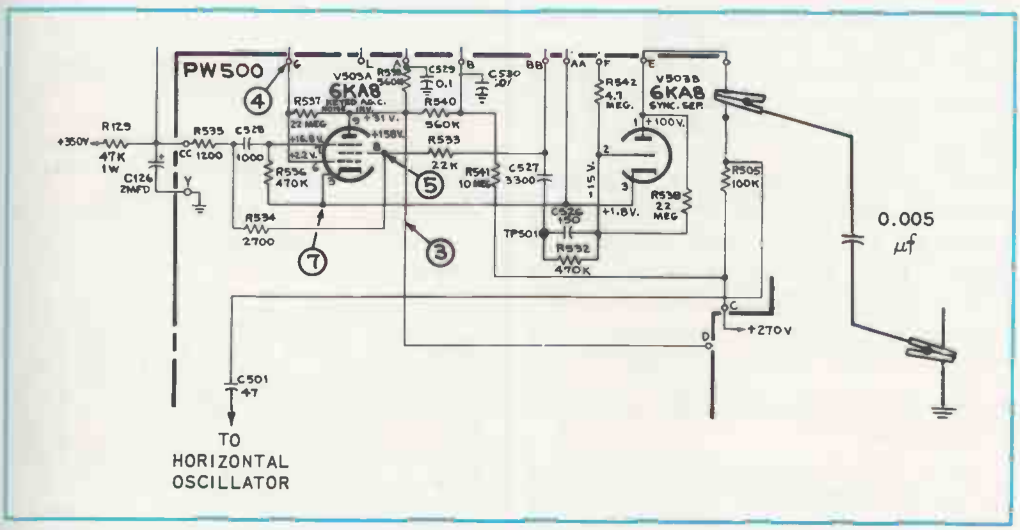


FIG. 6-5. The 0.005-μf capacitor "delays" the horizontal sync pulse with respect to the picture information. This permits the left stripe signal to act as burst.

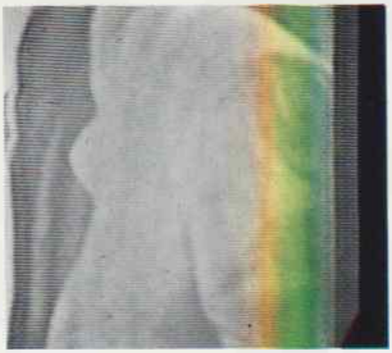


FIG. 6-6. The green-stripe display obtained by delaying the horizontal sync pulse as shown in Fig. 6-5.

of the horizontal sync pulse. This time delay introduced in this fashion causes an increase in the phase lag between the video information and the deflection signal. The burst gate is also delayed and occurs at the time that the left stripe arrives. The capacitor may be installed from the top of the chassis by wrapping one lead around the appropriate pin of the sync separator tube and then replacing the tube in its socket. Ground the free lead of the capacitor to the chassis.

Figure 6-6 shows how the green stripe signal appears when the receiver is properly set up. Note that the entire picture is shifted to the left, due to the artificial phase delay in horizontal synchronization. The deflection signal lags behind the picture information somewhat so that the entire picture is shifted to the left. At the right edge of the picture, the stripe appears. If the receiver is phased properly, the stripe is yellowish-green.

Figure 6-7 shows the range of hues produced by the green stripe signal as the TINT control is rotated through its range.

Remember these steps for setting up the receiver to view the green stripe.

1. Set fine tuning for minimum sound beat in the stripe.

2. Turn color killer control (rear apron of chassis) fully CCW. (Some receivers may require CW rotation of the control to disable the killer. Check the service notes).

3. Set TINT and COLOR controls to midrange.

4. (Install a 0.005-μf capacitor between the plate of the sync output stage and chassis.

5. Readjust horizontal hold, if necessary, to sync the picture and obtain the colored stripe.

While the stripe signal gives you a good indication of the receiver's ability to reproduce color, including a rough check of phase and AFPC action, this signal should not be used for phase or AFPC adjustments. Use the color-bar signal from a generator such as the RCA WR-64A for all adjustments.

FIG. 6-7. Range of the TINT control using the green-stripe signal.

TROUBLESHOOTING BLACK-AND WHITE DEFECTS UNIQUE TO COLOR RECEIVERS

Since most of the television circuits in the color receiver are similar to that in a black-and-white receiver, many trouble symptoms are familiar to the practicing TV technician. Troubles involving faults in sync, tuner tracking, receiver sensitivity, AGC, deflection, and so on are handled in the same way in color and monochrome receivers alike. However, color receivers are subject to troubles in the black-and-white picture that have no counterpart in the black-and-white receiver. These faults involve troubles in the specialized circuits of the color receiver. Examples are faults in the regulated high-voltage supply, delay-line faults, troubles in the two or three stage direct-coupled video amplifier, and convergence-circuit troubles.

Another source of trouble is "color" in the black-and-white picture. An important *first step* in diagnosing any defect in a color receiver is to examine the black-and-white picture closely. There should be no evidence of a predominant hue in the whites or grays of the picture. Any color in the black-and-white picture upsets accurate color reproduction. Therefore, you should make sure that there is no color in the black-and-white picture before you consider troubles in the color-reproducing circuits.

Unwanted color can be introduced into the black-and-white picture in several ways. Faulty gray-scale tracking (black-and-white setup), bad purity, and poor convergence are examples. Faulty color circuits can also cause color in the monochrome picture. An inoperative color killer, for example, can result in monochrome signals and noise signals (whose frequencies are around 3.58-mc) being processed as color signals. The result is rainbows in those parts of the picture that display fine or grainy patterns.

Troubles in the color circuits can also result in extraneous signals, such as hum signals, reaching one or more of the picture-tube control grids. This results in colored hum bars or various forms of color shading in the picture. In this section, these forms of troubles are covered in detail.

High-Voltage Troubles. The high-voltage supply in a color receiver must maintain a nearly constant high voltage, despite a comparatively wide range of load current. Part of the load current in the color set is the total beam current for all three electron guns. Unless high voltage is held constant, picture size (height and width) varies considerably as average scene brightness changes.

Figure 7-1 shows a simplified schematic diagram of the shunt regulator employed in the high-voltage supply of color sets.

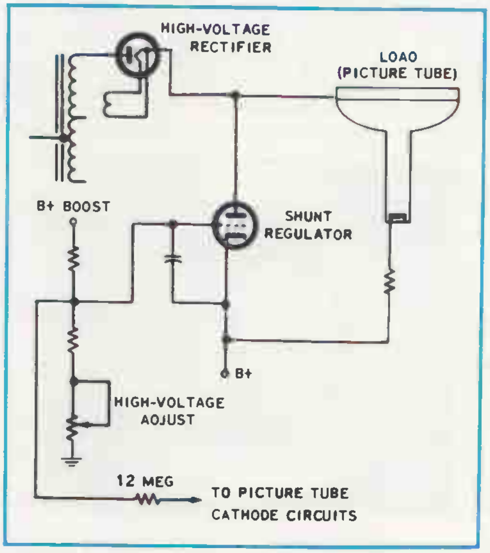


FIG. 7-1. Simplified diagram of the high-voltage supply of a color receiver.

It is called a shunt regulator because the variable path for current is placed in parallel or shunt with the load (picture tube). The regulator triode acts to maintain a *constant load* on the high-voltage supply. If picture-tube beam current increases, due to an increase in scene brightness, the plate current of the regulator decreases automatically. In this way, the total load current remains constant, and high-voltage does not change.

Control for the shunt regulator is obtained in the following way. The cathode is held at the fixed, B+ voltage. Grid voltage is obtained from a voltage divider on the B+ boost supply. The control is adjusted to bias the regulator tube properly. Bias is adjusted so that the regulator tube passes enough current to assume the normal current load of the supply when the picture tube is cutoff (black). If high voltage tends to decrease due to an increase in beam current, the B+ boost voltage also drops and the grid of the triode swings less positive. Regulator tube plate current decreases to make up for the initial increase in picture tube beam current. In some late-model receivers an additional voltage, taken from the cathode circuit of the picture tube, increases the effectiveness of regulation. An increase in picture-tube beam current results from negative-going video signal. To help compensate for this current increase, the same video signal is coupled through a large resistor to the control grid of the regulator tube to increase the bias in the regulator and equalize the load on the supply.

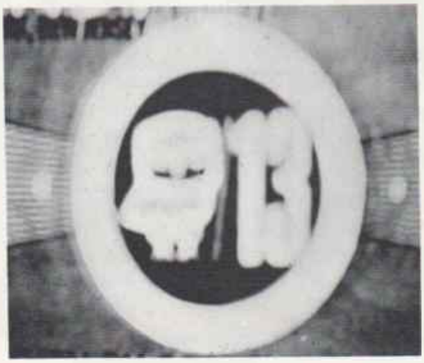


FIG. 7-2. Blooming caused by an excessive load on the high-voltage supply.

Blooming. Blooming describes a symptom of poor high-voltage regulation. At very high brightness levels, a drop in high voltage results in an increase in picture size and loss of focus. The picture seems to grow or "bloom" towards the viewer. Blooming can be seen in black-and-white sets operated at very high brightness levels. Picture size changes gradually as the brightness control is rotated. In color receivers, blooming does not occur until a specific amount of beam current is drawn. As you turn up the brightness control the picture blooms abruptly (if it blooms at all) when you reach a certain brightness setting. At this setting the regulator tube is cut off and the regulating action stops. Figure 7-2 shows how blooming looks. Often one of the electron beams will defocus more than the others. The result is a bigger "spot" of one primary color. This results in a symptom similar to misconvergence, but the color in question forms a fringe that completely surrounds the white areas of the picture.

If blooming occurs at all brightness levels, or if the picture blooms at brightness levels that seem to be too low, a fault is indicated in the regulator system. Any fault that causes the regulator tube to be cut off, or lose bias altogether, causes a complete loss of regulation. A fault that alters the operating point of the regulator tube may cause premature blooming — blooming at relatively low brightness levels. Here are some of the things to look for:

Excessive High Voltage — No Regulation. A nonconducting regulator tube (open heater, open cathode or plate circuit, excessive bias) results in no high-voltage regulation. Picture size changes greatly when the brightness control is turned. The only load on the high-voltage supply is the picture tube. This load is removed altogether when brightness is turned down to cutoff (black). High voltage then rises to 27 kv or more. This might be noted by evidence of arcing and the odor of corona discharge when brightness is turned down.

Insufficient High Voltage — No Regulation. Grid-to-cathode leakage or heater-to-cathode leakage in the regulator tube can result in grid bias on the regulator tube that is either zero or positive. In this case, the regulator conducts excessively and places a heavy load on the high-voltage supply. Symptoms are excessive picture size, poor focus, and no regulation.

In cases where regulation is poor or seems to cease functioning at lower-than-normal brightness levels, the best troubleshooting approach is to make direct checks of the d-c operating point of the regulator tube. Measure plate voltage with a VTVM equipped with a high-voltage probe. In many receivers high-voltage is measured easily by touching the high voltage probe to the anode button (high-voltage terminal) on the picture tube as shown in Fig. 7-3. Regulator tube plate current is measured by inserting a milliammeter (0-1 ma preferably) into the cathode circuit of the regulator tube. Removable links are usually provided at the socket of the regulator tube to permit easy insertion of the milliammeter.

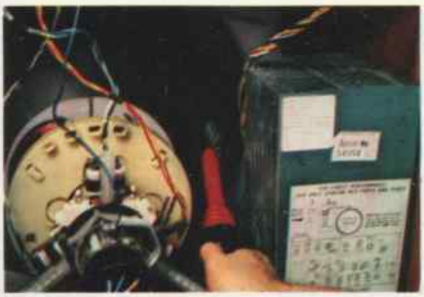


FIG. 7-3. Measuring high voltage at the picture-tube anode connection.

Late-model receivers have a resistor in the cathode circuit of the regulator tube (a typical value is 1000 ohms). You may find cathode current easily, in this case, by measuring the *voltage* across the cathode resistor. Calculate current by dividing the voltage reading by the value of the cathode resistor. A 1000-ohm resistor will develop 0.1 volts for every 100 microamperes. Thus, 850 μa develops 0.85 volts across 1000 ohms.

The operating condition is noted by turning the brightness control to minimum (dark screen) and noting plate voltage and cathode current of the regulator tube. Under this condition the regulator assumes the total current. The high-voltage control, which is the bias control on the regulator tube, is adjusted until the high voltage is as specified by the service manual of the receiver (24 kv in RCA CTC-11, 12 and 15 chassis). Inability to reduce the high-voltage to the specified amount points to a weak regulator tube or a defect in the bias network.

If high voltage can be adjusted to the specified value, the next job is to check the cathode current of the regulator tube. Check the service notes for the correct value. A typical *minimum* value is 850 μa. Note, make sure that the picture tube is at cutoff (dark) when making this measurement. If regulator tube cathode current is below the specified minimum when the correct high-voltage is obtained, the high-voltage input to the regulator system is probably low. Adjustment of the horizontal efficiency control (linearity coil) can correct a small error in high-voltage input. If this adjustment does not correct the condition, check the horizontal output tube, the damper, and the drive to the horizontal output tube.

When making any adjustments in the horizontal deflection circuits, make sure that the average cathode current of the horizontal output tube remains below the specified maximum (typically 210 ma, but check the service notes on each individual receiver model). A removable wire link is usually provided in the cathode circuit of the horizontal output tube for current monitoring purposes.

Check Gray-Scale Tracking. Problems with blooming can sometimes be traced to faulty setup of the picture tube. Excessive screen-grid voltage can cause the initial beam current of the picture tube to be too high for adequate compensation by the regulator. Go over the gray-scale tracking procedure and make sure that screen settings are correct. In modern receivers, screens are set to produce a *barely visible* horizontal line of each hue with the NORMAL/SERVICE switch in the *service* position.

Gassy Regulator Tube. A gassy voltage regulator tube can sometimes bring about an action similar to that of a gas-tube relaxation oscillator, causing pulsating high voltage. The symptom is a picture that oscillates in size, *both* vertically and horizontally, and the brightness pulses at a slow rate. The fault can be easily identified as regulator trouble by turning the brightness up until the picture blooms. The regulator is cut off at this point and the pulsating action stops. Gassy regulator tubes are easily spotted by looking for the telltale purple glow inside the tube. Do not mistake the blue glass-fluorescence as evidence of gas. Remove the necessary panels on the high-voltage cage to observe the regulator tube.

Focus Problems. Color picture tubes are focused electrostatically. Focus voltage is variable and is 16.8%-20% of the voltage between the picture-tube cathodes and the high voltage terminal. A typical value is 5000 volts (measured to ground).

Figure 7-4 shows the basic focus circuit employed in late-model color receivers. The circuit is a simple half-wave rectifier, fed from a tap on the horizontal output transformer. Focus control is provided by the special transformer. This transformer is constructed so that coupling between the coils can be varied by the movable core. The coils are placed so that the total pulse input to the rectified cathode either aids or opposes the pulse applied to the plate.

Semiconductor rectifiers have replaced vacuum diodes as focus-voltage rectifiers in late-model receivers. This results in reduction of the total load on the horizontal output stage, as no heater power need be supplied for the focus rectifier.

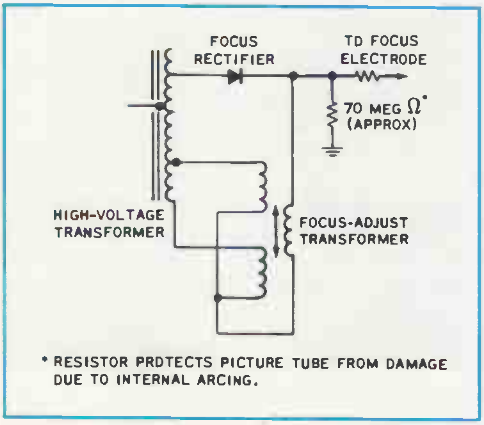


FIG. 7-4. Simplified diagram of a focus-voltage supply.

Loss of Focus Voltage Results in a No-Raster Condition. The focus anode serves as one of the accelerating anodes in the picture tube. Loss of focus voltage has the same effect as loss of the first anode voltage on black-and-white picture tube.

Older receivers employ a potentiometer in a voltage divider network to provide variable focus voltage. A pitted or noisy potentiometer results in erratic or intermittent changes in focus. This type of control does not respond to conventional cleaning and lubricating techniques; control replacement is recommended. If the focus control requires frequent replacement, look for an intermittent short in the output of the focus circuit. The transformer type of variable focus control, shown in Fig. 7-4 gives very little trouble.

Troubles in the Y Video Amplifier. The monochrome Y video section of the color receiver differs in several respects from that of the black-and-white receiver. The monochrome video section of a color receiver is a two-or three-stage amplifier employing direct coupling throughout. It must supply video drive to all three cathodes of the color picture tube. The time-delay line, inserted to make the Y signal time delay equal to the time delay of the chrominance circuits, is placed in the Y video amplifier. In addition, the brightness control in many receivers actually controls picture-tube bias by controlling the bias on the direct-coupled video output stage.

Symptoms of a Faulty Delay Line. The delay line causes the brightness and chrominance (color) signals to reach the picture-tube control elements in the correct time relation. Correct time delay results in color that "fits" or registers with the black-and-white picture. Incorrect time delay results in color that is displaced to the left or right of the black-and-white components of the picture. However, faults in the delay line usually *do not* result in mere errors in timing. Timing errors, but with no other visible defects, can come about when the delay line cable is too long or too short, but is otherwise undamaged — an unlikely fault. Possible faults in the delay line are an open, or an internal short. External faults can be caused by open connections or incorrect termination.

An *open delay line* interrupts the signal path in the Y channel. The symptoms are loss of picture accompanied in some instances by loss of brightness (no raster), or low brightness. The latter two effects result from a change in the d-c operating point of the video output stage. Loss of the positive voltage that accompanies the video signal through the delay line causes the video output stage to approach the cutoff condition. When this happens, the plate of this stage, and hence the cathodes of the picture tube, swing more positive. Whether or not the picture tube cuts off as a result of this bias change is determined by the picture-tube screen-grid voltages.

An *improperly terminated* delay line results in the reflection of energy back and forth from the ends of the delay line. A poor termination can result from an internal short to ground (center conductor to shield); or from an open terminating network at the output end of the line; or from an ungrounded shield on the delay line. The symptoms are multiple, *evenly spaced* ghosts or reflections in the picture. Figure 7-5 shows the effects of an open ground lead on a crosshatch pattern and program material. Note that the condition looks exactly like ghosts. But the clue to delay line trouble is that there are several ghosts — all *evenly spaced*. The distance between two adjacent vertical lines in the crosshatch pattern of Fig. 7-5*a* represents the "round trip" (back-and-forth) time delay of the line. While on the subject of the delay line, it should be mentioned that time-delay errors can be introduced due to improper time delay in the *chrominance* channel. A change in the bandwidth of the chrominance channel results in a change in over-all time delay. Severe misalignment might be the cause. One of the symptoms might be an error in time delay, which appears as a right or left shift in color information with respect to the monochrome components of the picture. Other symptoms will accompany this condition, however. These are poor color resolution (color does not "fill in" small colored objects in the picture) and crosstalk between the color-difference signals. Crosstalk appears as incorrect colors at the vertical edges of colored objects.

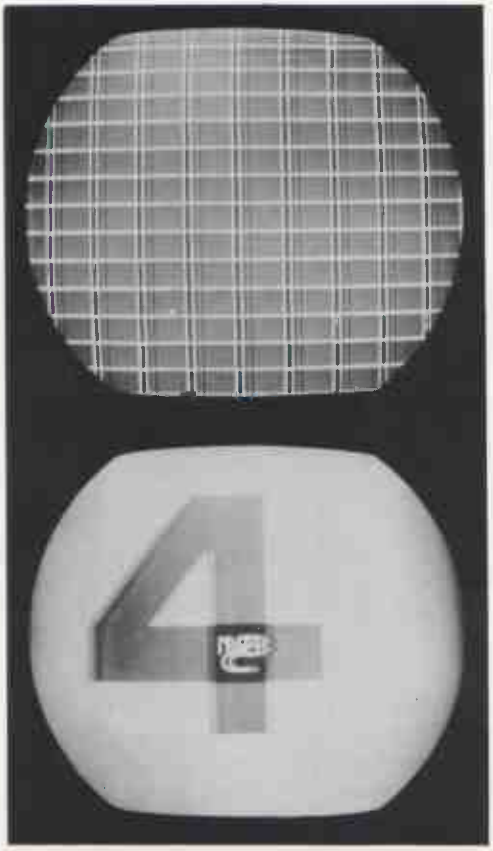


FIG. 7-5. Effects of an open ground connection to the shield of the delay line.

Brightness Defects. Since the Y video amplifier is direct coupled, a change in the d-c operating point in any of the amplifiers affects the bias on the picture tube. Study the simplified picture-tube drive circuits shown in Fig. 7-6 and consider the following faults.

No Raster. All picture-tube guns are affected so you must look for trouble in those circuits which are common to all guns. A routine check of this condition should be made to see if high voltage (anode voltage), focus voltage, and screen-grid voltages are present and within tolerance. The presence of high voltage is very easy to detect in a color receiver, as you can usually hear a slight crackling noise as the high voltage "comes up"

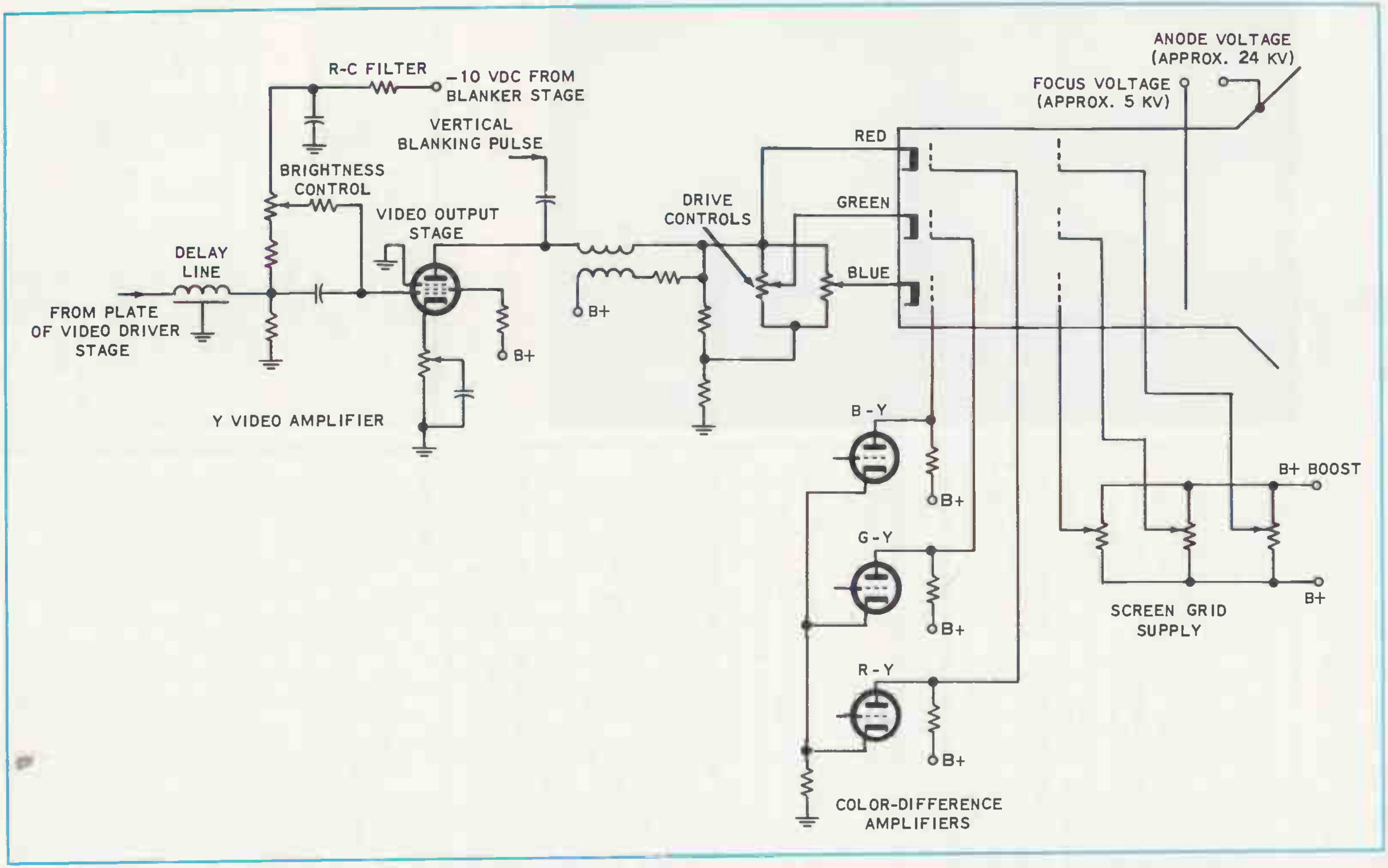


FIG. 7-6. Circuits that supply the signals and voltages required by picture tube.

after you turn on the set. Anode, focus, and screen-grid voltages being correct, the next check should be of the control grid-cathode bias. This is best measured by connecting the voltmeter leads directly to the control grid and cathode pins of one of the guns. Negative 200 volts from control grid to cathode is sufficient to cut the gun off in most cases.

Excessive picture-tube bias can be caused by loss of positive voltage at the control grids, or excessive positive voltage at the cathodes (control grid and cathode voltages measured to chassis). Let's consider the control-grid circuits. The control grids are fed from three separate amplifiers. For all guns to be affected, a fault would have to exist in all three amplifiers at once. This is very unlikely. One amplifier might have a fault, but then only one gun would be affected; the picture would have an excess or deficiency of one primary color. Of course, loss of B+ to all the amplifiers, caused by a break in the B+ feed, could cause the control grids of all three guns to be at zero volts with respect to chassis, however. This would cause raster cutoff.

A more likely cause of excessive picture-tube bias is a fault in the video output stage. A nonconducting video output stage for example, results in high plate voltage and consequently high cathode voltage on all three cathodes of the picture tube. An open heater, open cathode circuit, or loss of screen voltage could cause this condition. In addition, excessive bias on the video output stage can cause this stage to cut off. Bias for this stage is determined by a negative d-c voltage applied from the blanker stage and a positive d-c voltage obtained from the plate circuit of the preceding video amplifier. Loss of the positive component (mentioned earlier in connection with an open delay line) can cause excessive bias on the video output stage.

Excessive Brightness. This condition results from a lowering of picture-tube bias. It might not be possible to turn off the picture by adjusting the brightness control. If there is no marked shift in color balance (the raster remains nearly white) you should assume that the trouble is common to all three picture-tube guns. Loss of bias can result from excessive positive voltage at the picture-tube control grids or insufficient positive voltage at the cathodes (measured with respect to chassis).

Let's look at the control-grid circuit first. The grids of all three picture-tube guns will be at the B+ voltage if *all* three color-difference amplifiers are nonconducting (no voltage drop across the plate resistors). In this particular circuit, all three amplifiers share a common cathode resistor. If this resistor opens, therefore, a condition of excessive brightness will result. Brightness may be so high that the picture "blooms out" and disappears due to excessive loading of the high-voltage supply.

Consider the picture-tube cathode circuit. A lower-than-normal positive voltage at the picture-tube cathodes results in excessive brightness. A likely cause is heavy conduction of the video output stage. One possible cause of excessive conduction is a control grid-to-cathode short in this stage. The symptoms are: bright raster, no picture, and the brightness control has no effect.

Another cause of heavier-than-normal conduction of the video output stage is loss of the negative voltage supplied to the brightness control by the blanker stage. Grid leak bias, developed by the pulse-driven blanker stage, serves as the source of this voltage. A long time-constant RC filter removes the pulse component of the signal at the grid of the blanker, and supplies a steady negative d-c voltage to the brightness control. A shorted capacitor in this filter results in loss of the negative voltage, and a change in the bias on the video output stage. The result is an increase in brightness, but in this case the brightness control still has some effect. In many cases a normal picture can be obtained, but it is impossible to turn the picture off with the brightness control.

Color in the Monochrome Picture. The most common cause of "color" in the monochrome picture is faulty setup — misadjustments of purity, convergence, and black-and-white setup. You will learn to recognize faulty setup quickly after you have gained some experience in setup procedures. However, the components and circuits that contribute to good purity, convergence, and setup are subject to failure, and you must learn to tell the difference between faulty adjustments and an actual malfunction. In this section you will look into some of the common difficulties that result in poor setup. In addition, you will learn how severe changes in black-and-white color balance can result from failures in circuits that are *not* common to all three electron guns in the picture tube.

Purity Problems. Good purity is easy to obtain in late-model receivers, and purity is not subject to change over a long period of time. About the only thing that can alter purity, following a correct setup, is a change in the magnetic field in the vicinity of the receiver. A very common purity fault results from repositioning the receiver (changing the direction in which the receiver faces) after it has been set up. Degaussing compensates for the earth's magnetic field, but if the receiver is turned after degaussing, the compensation is no longer correct. Figure 7-7 shows the effect on purity of rotating the receiver after degaussing about 90° in the horizontal plane. Degaussing the receiver in its new position usually clears up this trouble.

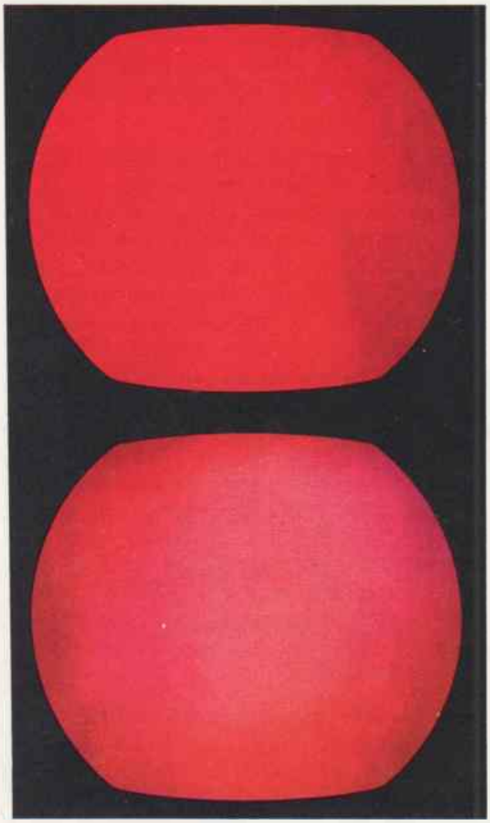


FIG. 7-7. Purity may be altered by facing the receiver in a different direction after setup has been completed.

The steel parts of the picture tube and its supporting members may become magnetized by exposure to a strong local magnetic field. Toys equipped with permanent magnets may cause this trouble if they are left on the top of the receiver for some time. Another cause is the passage of a very heavy current in conductors near the receiver. There have been isolated reports of local lightning discharges affecting receiver purity. All of these faults can be corrected by removing the source of the local magnetizing field and degaussing the receiver. When degaussing does not correct impurity, you may assume that adjustments have been disturbed somehow. A common fault is a loose and misplaced deflection yoke. Repeat the purity setup procedure.

Static Convergence Faults. Static convergence adjustments employ permanent magnets, are extremely stable, and are not subject to change unless physically disturbed. Occasionally, some trouble is experienced during setup, where it is found that the static convergence adjustments lack sufficient range. The fault, in this case, is poor magnetic coupling between the convergence magnets and the internal pole pieces in the picture tube. Check to see if the convergence yoke is placed properly on the neck of the picture tube. The pole faces of the electromagnets must fit over the internal pole pieces mounted on the focus-anode assembly. Figure 7-8 shows how the fully-exposed gun assembly appears. If you look carefully into the neck of the picture tube, by sighting along the electron guns toward the screen, you can see the rear disk that forms part of the support for the internal pole pieces. The pole pieces themselves are hidden from view by the internal coating that extends into the neck of the picture tube. Figure 7-9 shows the correct position of the convergence yoke.

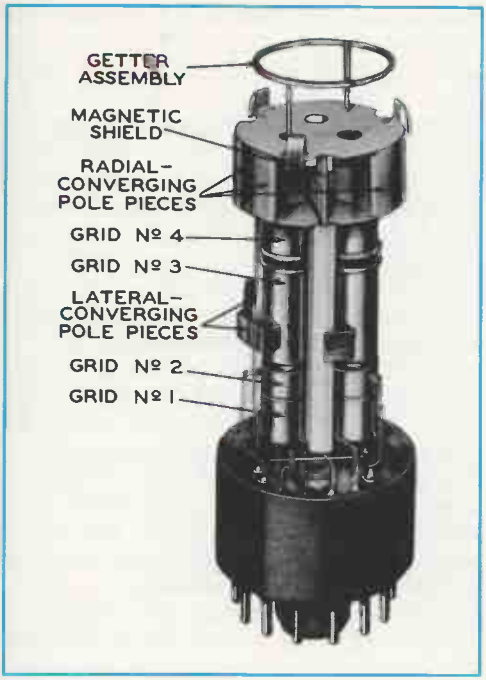


FIG. 7-8. The electron-gun assembly of a color picture tube.

The internal pole pieces for the blue-lateral convergence magnet are easier to see. Figure 7-10 shows the correct positions of several types of blue-lateral convergence magnets.

Dynamic Convergence Faults. Circuit failures can result in dynamic convergence errors that show up after the receiver has been set up properly. The most powerful help in troubleshooting defects in the convergence circuits is the convergence

FIG. 7-9. Position of the convergence yoke on the neck of the picture tube.

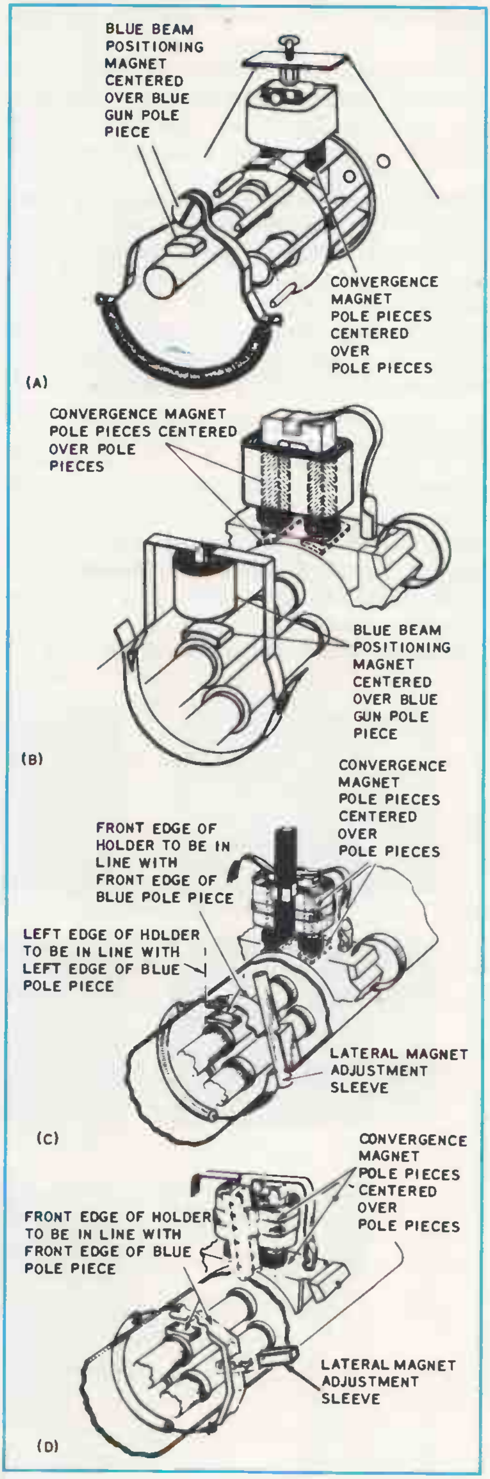


FIG. 7-10. Positions of four types of blue-lateral convergence magnets.

procedure itself. Faults are quickly pinpointed when adjustment of a particular convergence control does not produce the expected results. Certain observations of the picture-tube screen also help to indicate the nature of the convergence fault.

Check Size, Linearity and Centering First. Before you tackle any trouble whose symptoms indicate dynamic convergence errors, make sure that picture size, linearity and *centering* are correct. All of these factors affect dynamic convergence, and corrections in picture size, linearity, or centering should be made *before* any of the convergence adjustments are touched.

Convergence Circuits. Figure 7-11 shows the schematic diagram of a representative dynamic convergence board. This circuit board, with minor changes, has been standard equipment on RCA receivers since about 1960 (CTC-10 chassis). Separate coils are used on each of the three dynamic convergence electromagnets for the vertical and horizontal convergence signals. To aid in understanding these circuits, the vertical and horizontal sections are shown separately in the simplified drawings of Fig. 7-12 and Fig. 7-13.

Let's examine the vertical circuits first (Fig. 7-12). A parabolic-shaped waveform is needed in the convergence coils. This parabolic waveform is formed in the following way. A sawtoothed-shaped voltage waveform is obtained from the cathode circuit of the vertical output stage. Part of this waveform is tapped off by potentiometer R_{808} and applied to the vertical winding of the "blue" electromagnet. The inductance of this winding is such that the circuit behaves as an integrator (all rapid changes of current are suppressed) and the current flowing in the coil is parabolic in shape. (Actually, some integration takes place in the cathode circuit of the vertical-output tube as well.) The amplitude of this parabolic waveform is controlled by R_{808}. Additional correction is needed to correct for the fact that the electron beams do not travel along the central axis of the picture tube. For example, the "blue" electron gun is mounted above the center axis of the picture tube. Since the blue gun is high, additional convergence correction is needed to secure convergence at the bottom of the screen (electrons travel farthest from the blue gun to the screen when the scanning beam is at the bottom). Additional correction is added by "tilting" the parabolic waveform. This is accomplished by adding a sawtooth component of current to the parabolic waveform. Signals for the tilt correction are obtained from one of the extra sets of windings on the vertical output transformer. The voltage waveshapes at points 5 and 6 are sawtooth signals with large rectangular-wave components. Integration

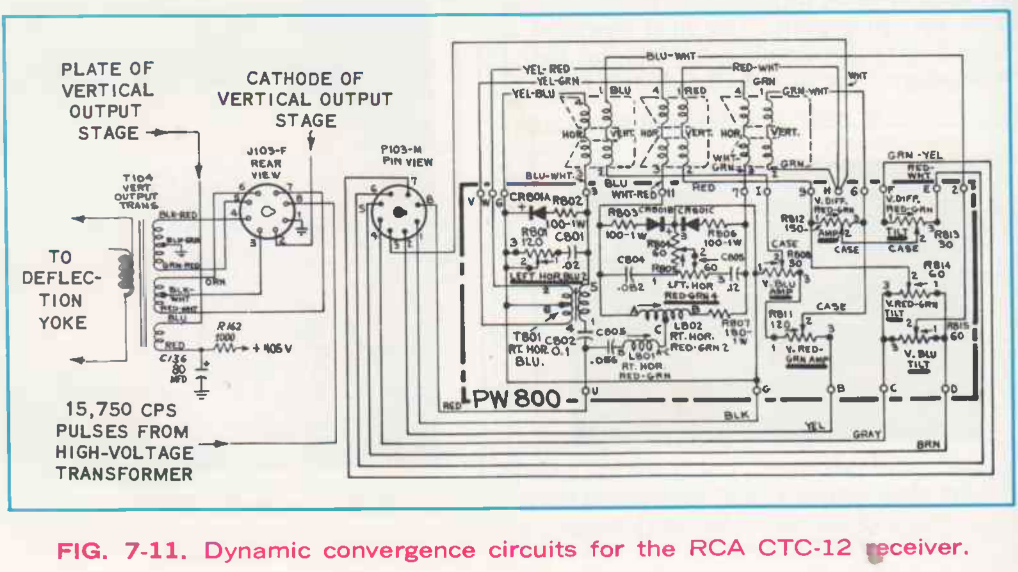


FIG. 7-11. Dynamic convergence circuits for the RCA CTC-12 receiver.

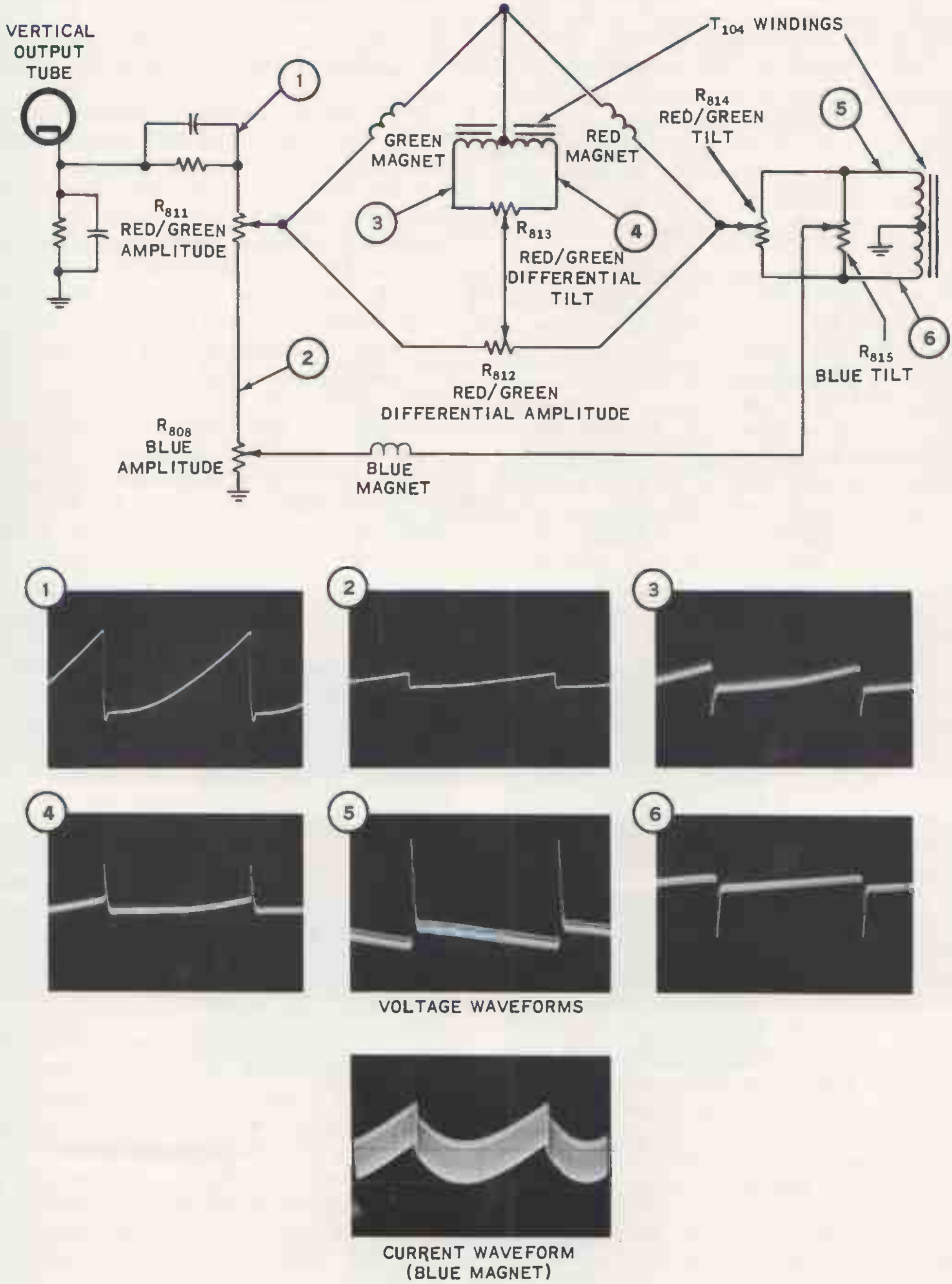


FIG. 7-12. Simplified drawing of the vertical dynamic convergence circuits.

of the voltage waveform (points 5 and 6) by the coil yields a sawtooth-shaped current waveform. The blue tilt control, R_{815}, controls the amplitude of the sawtooth component of current in the winding of the electromagnet. Note that the voltage applied to this potentiometer is obtained from a centertapped transformer. Thus, sawtooth components of either polarity are obtained by moving the slider of the potentiometer to either side of the center setting. At the center setting there is no tilt correction.

Circuits for the "red" and "green" electromagnets are similar to that of the "blue" electromagnet, except that the action of the red/green controls is coordinated. To simplify understanding of the circuit, consider first that controls R_{812} and R_{813} are set to their midpositions. In that case, a balanced bridge circuit is formed between the two halves of R_{812} and the series-connected red and green electromagnets. Another balanced bridge circuit is formed between the two halves of R_{813} and the centertapped winding of T_{104}. Under balanced conditions, no current flows between the arms of R_{812} and the point where the red and green electromagnets join. Since no current flows, the circuitry between these two points may be ignored for the moment.

A voltage sawtooth is picked off at the arm of R_{811} and applied to the red and green coils in *series*. The red electromagnet returns to ground through R_{814}. A parabolic current waveshape results from the integrating action of the coils. Since the coils are in series, turning R_{811} clockwise results in an equal increase in the current flowing in both the red and green coils. The sawtooth component of the total current waveform is formed from the waveform of voltage picked off at R_{814} — the *master* red/green *tilt* control. Rotation of R_{814} causes an equal change in the sawtooth components of current in both the red and green coils.

The *differential* controls, R_{812} and R_{813}, function by unbalancing the bridge circuits mentioned in the previous paragraphs. By turning R_{812} clockwise from center, the green electromagnet coil is nearly shorted and most of the parabolic current flows in the red electromagnet coil. Thus, the differential controls increase the current in the red coil and decrease current in the green coil, or vice versa. Similarly, adjustment of the red/green differential tilt control R_{818} unbalances the tilt (sawtooth) component of current in the red and green coils.

The 15,750-kc parabolic current waveforms in the horizontal-convergence windings are formed in a different way. Consider the circuit for the "blue" electromagnet shown in Fig. 7-13. The input signal is a positive pulse obtained from a winding on the horizontal output transformer. The signal is coupled through a large inductance, the primary of T_{801}, to the blue electromagnet. In parallel with the blue electromagnet are two shunt paths formed by the diode-resistor combination, and the capacitor-rheostat combination. The series inductance (primary of T_{801}) has a large impedance compared to the impedance formed by the blue electromagnet and its two shunt paths. Since the inductance predominates, the total I_T has a sawtooth waveshape. (A rectangular voltage pulse impressed across an inductance causes a sawtooth of current to flow). To get a photograph of the *current* waveform in the primary of T_{801}, we placed a 10-ohm resistor in series with the primary of T_{801}. The oscilloscope's vertical input leads were placed across this 10-ohm resistor. To see how the parabolic current waveshape is developed in the convergence-magnet winding, it is easier to see how the total current, I_T, splits up in the three parallel branches to the right of T_{801}. *Current* waveshapes for each of the three branches are shown in the diagram. These were made by inserting small resistors in series with each branch, and monitoring the voltage developed across the resistance. Current I_1, in the diode branch, flows only during the positive half cycle of the waveform. The diode blocks current flow in the opposite direction. Current in the branch that contains the tilt control is shown by waveform I_2. The capacitor *integrates* (smooths out) the sawtooth waveshape, so that the current flowing in this branch is roughly parabolic in shape. The current in the windings of the blue electromagnet is really what's left over after subtracting the current that flows in

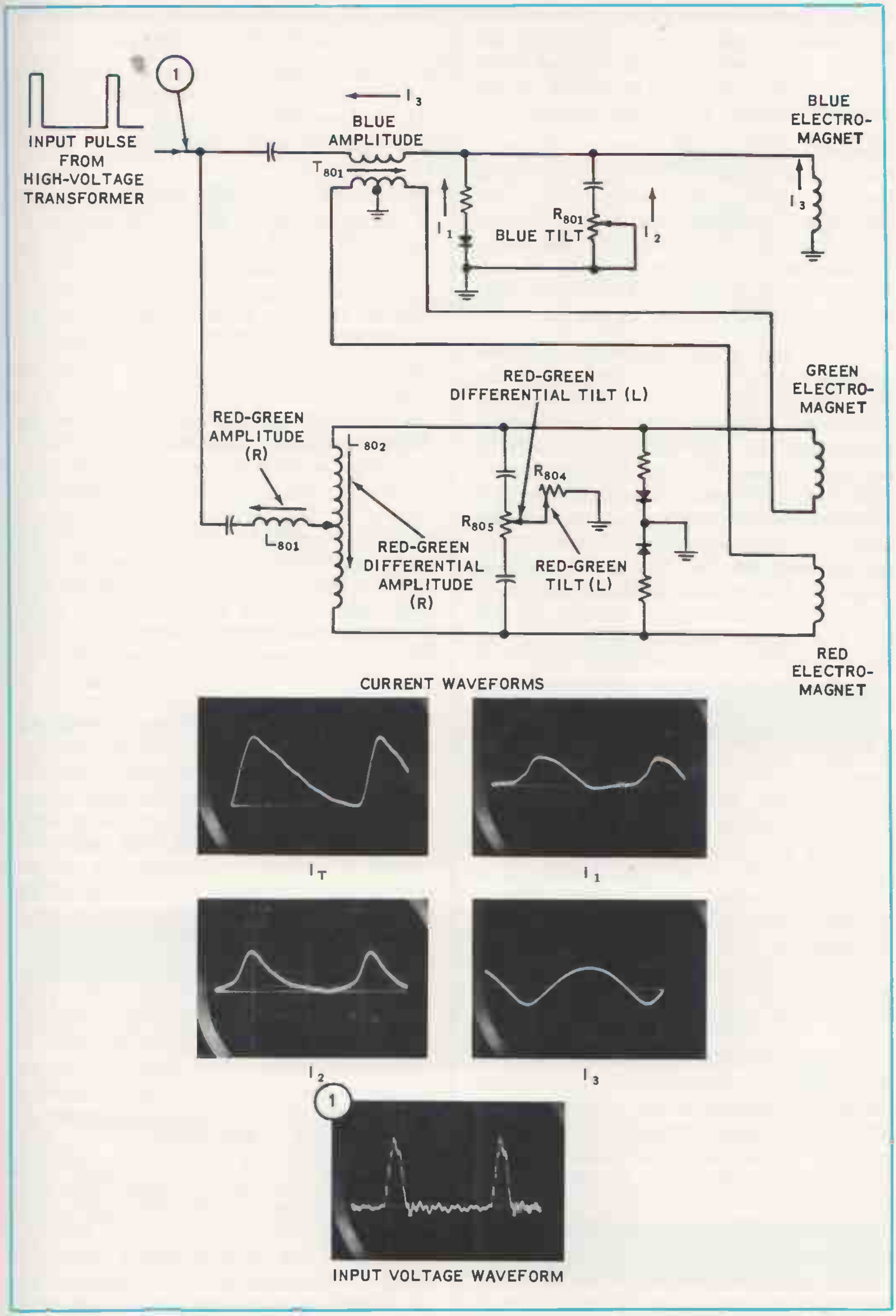


FIG. 7-13. Simplified drawing of the horizontal dynamic convergence circuits.

the parallel branches. (Subtraction can be performed graphically by inverting the I_1 and I_2 waveforms and adding them to the I_T waveform.) The result is the parabolic current waveshape shown at I_3.

The total amplitude of current in the convergence winding is adjusted by changing the inductance of the primary of T_{801}. The tilt control has most effect on the amount of current that flows during the early part of the trace. (Note the peak of current at I_2.) Thus the *tilt control* has most effect upon the *left side* of the screen.

The red and green horizontal convergence circuits are basically the same as the blue convergence circuit, except that the red/green controls have been coordinated. Inductance L_{801} controls the total current flowing in both the red and green circuits. It is the "master" red/green amplitude control. Inductance L_{802} controls the way in which the total current splits up between the red and green electromagnets. Since L_{802} controls the *proportion* of total current flowing in the red and green electromagnets, L_{802} is called the differential red/green amplitude control. Similarly R_{804} controls "master" tilt correction current in both the red and green windings, and hence is the *master* red/green tilt control. R_{805} perform a proportioning action for the tilt correction, and is called the *differential* red/green tilt control. Note that the red and green windings are not returned directly to ground, but return to ground through a secondary winding on T_{801}. This adds an additional correction to the red and green convergence fields. Without this added correction, red and green horizontal lines tend to be tilted in opposite directions, and cross at center screen.

Localizing Failures in Dynamic Convergence Circuits. When confronted with a situation where dynamic convergence is obviously in error, determine first if the error is due to misadjustments or some circuit defect. This is not as difficult as it sounds because outright failures, such as those due to broken leads, open coils, open or shorted diodes or capacitors, usually produce severe changes in the convergence conditions. Where there is some doubt, follow the convergence procedure. Faulty circuits are easily spotted when adjustment of particular controls do not give the desired results.

In general, however, large dynamic convergence errors point to circuit failures. Also intermittent changes in dynamic convergence point definitely to circuit troubles.

To localize the trouble, first check to see if the condition is in the horizontal or vertical circuitry. Misconvergence at the sides of the picture indicate trouble in the horizontal circuits. Failures in the vertical circuits show up as miconvergence errors at the top and bottom of the picture.

Next localize the fault to a particular primary color. Usually, the color that "hangs out" the farthest identifies the defective circuit. Trouble in the "blue" convergence circuitry is particularly easy to spot as there is little interaction between the blue circuits and the red/green circuits. Faults in the circuits of the green convergence magnet usually have some effect upon red convergence and vice versa. (Older receivers with independent convergence controls do not have this interaction between red and green.)

Underconvergence and Overconvergence. It sometimes helps to size up misconvergence in a particular area of the picture as insufficient or excessive convergence correction. An open blue horizontal convergence coil, for example, results in excessive convergence correction of the blue beam at the sides of the picture. Let's see how we can predict how this would look.

When properly converged, the three electron beams converge or cross at the phosphor screen. The result, when viewing the dot pattern, is a white dot, free of fringing. If there is no correction at all, the three electron beams remain parallel to one another and strike the screen as shown in Fig. 7-14*a*. Note that the illuminated spots are in the same relative positions as the electron guns. This condition is termed *underconverged* since there is no convergence (or not enough) correction. An *overconverged* condition occurs when correction is excessive. Here the beams cross behind the shadow mask and produce the pattern shown in Fig. 7-14*c*. If the proper amount of conver-

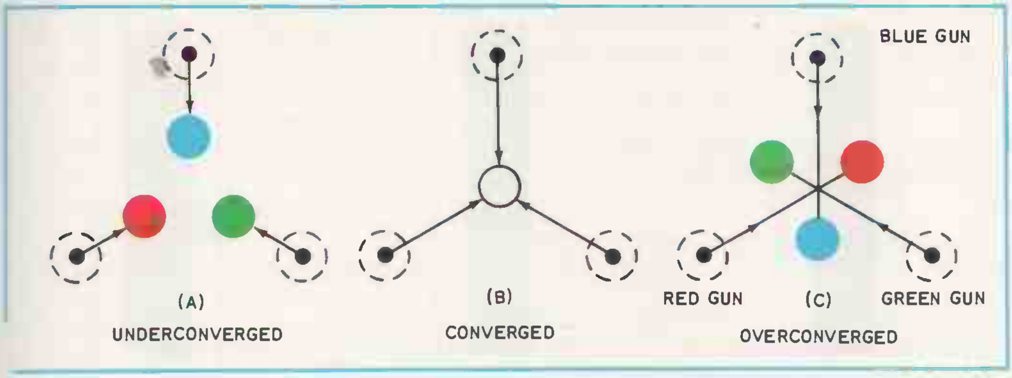


FIG. 7-14. Convergence conditions.

gence correction is applied, the three beams cross at the phosphor screen and the white dot shown in Fig. 7-14*b* is obtained.

Now let's get back to that open blue horizontal convergence coil. An open coil will have little effect on center convergence so that the picture remains converged near center screen. However, loss of dynamic correction means that the blue convergence field is not reduced sufficiently at the screen edges. (Remember that dynamic correction acts to *reduce* the field at the screen edges). Thus there is excessive convergence at the screen edges and blue appears low (overconverged) at the sides of the picture, as shown in Fig. 7-15.

FIG. 7-15.* Open blue horizontal convergence coil.

Let us summarize the effects of too much or too little convergence-coil current as follows: Too *little* convergence-coil current produces an *overconverged* condition; too much convergence-coil current produces an *underconverged* condition.

Misconvergence due to open green or red horizontal convergence coils is more difficult to diagnose. Figure 7-16 shows the symptoms of an open red horizontal dynamic convergence coil. Note the peculiar dot arrangement at the right edge of the picture. There is excessive convergence of the red beam, so that the red spot is overconverged (high and to the right). An open *red* coil, however, causes excessive convergence current to flow in the *green* coil. As a result the green spot is *underconverged* (low and to the right).

FIG. 7-16.* Open red horizontal convergence coil.

The opposite condition, green overconverged and red underconverged results from an open green horizontal convergence coil. The symptoms are shown in Fig. 7-17.

The effects produced by open vertical convergence coils are shown in Figures 7-18, 7-19 and 7-20. Note that there appears to be less interaction between red and green in the vertical circuits. An open red coil is easily spotted as overconverged red.

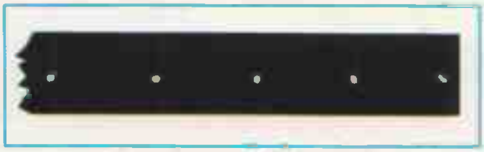


FIG. 7-17.* Open green horizontal convergence coil.

*Figs. 7-15, 7-16, and 7-17 show the right center portion of the screen.

FIG. 7-18.* Open red vertical dynamic convergence coil.

FIG. 7-19.* Open green vertical dynamic convergence coil.

FIG. 7-20.* Open blue vertical dynamic convergence coil.

Open and Shorted Diodes. The horizontal dynamic convergence signals are obtained from a rectangular wave (pulse) that reverses polarity (swings positive and negative). The resulting parabolic waveforms would also swing above and below zero were it not for the "clamping" action of the diodes. The diodes effectively "clamp" the midpoint (center screen) of the parabolic waveform at zero. Since there is zero current when the beams are at center screen, the horizontal dynamic adjustments affect only the sides of the picture. If the diodes are defective, this clamping action is lost. The clue to this condition is severe misconvergence in the *center* of the screen. Figures 7-21*a* and *b* illustrate the effect of an open and shorted diode in the blue horizontal convergence circuit. Note the severe convergence error at the center of the screen.

Clamps are not needed in the vertical dynamic circuits as the signal obtained from the cathode of the vertical amplifier is not an a-c signal. (This voltage, though varying, is always positive with respect to ground.)

FIG. 7-21a.* Shorted diode in the blue horizontal convergence circuit.

b. Open diode in the blue horizontal convergence circuit.

If trouble with dynamic convergence cannot be localized with visual checks of the screen, make a direct continuity and component check of the convergence board. Fortunately, there are not too many components. Start with voltage waveform checks at the points on the convergence board where the signals from the deflection circuits are applied. These are shown by the *voltage* waveforms in Figs. 7-12 and 7-13. If the input signals are correct, make continuity and component checks on the convergence board. Missing or distorted input signals should be checked back to their sources in the deflection circuits.

Faulty Color Balance. A uniform tint in the black-and-white picture is caused by some factor that upsets the black-and-white tracking adjustments. The entire picture then appears dominated by one of the primary or complementary hues. In some cases the dominant hue becomes more pronounced at different settings of the brightness control.

Changes in the color balance result from a change in the relative conduction of the three electron guns in the picture tube or a change in the cutoff voltage for the guns. Correct relative beam currents are set up during the black-and-white tracking procedure. It is then that screen-grid voltages, bias voltages, and video drives to the three guns are adjusted to produce

*Figs. 7-18, 7-19, and 7-20 show the bottom center portion of the screen. Fig. 7-21 shows the right center portion of the screen.

neutral whites and grays. Changes that alter the *relative conduction* of the guns, after the receiver has been set up properly, cause a shift in color balance. Any change that alters gun conduction by the same factor (if beam current should double for each gun, for example) results in a change in brightness or contrast, but not in color balance.

Small changes in color balance, that show up months after the receiver has been set up properly, are the result of normal component aging. This condition is easily corrected by following the setup procedure for black-and-white tracking. Our concern in this section is with changes in color balance that result from circuit failure. In many cases this type of trouble cannot be corrected by adjusting the setup controls.

Circuits Involved in Color-Balance Faults. There are four general sections of the receiver where a circuit failure can alter color balance. These are:

1. the picture tube itself
2. the picture-tube screen-grid circuits
3. the picture-tube cathode circuits
4. the control-grid circuits of the picture tube (including the color circuits that supply the control-grid signals)

Figure 7-22 shows the general area where circuit defects can affect color balance.

The Picture Tube. Low emission in one or more of the electron guns of the picture tube is one cause of poor color balance. One of the familiar clues to low emission in a black-and-white picture tube is the "silvery" effect in the picture as contrast and brightness is advanced. Low emission causes the electron gun to reach the saturated condition when the peak-white parts of the picture demand high beam currents. The result is the "silvery" effect and loss of detail in the bright parts of the picture. This same indication can be applied to color picture

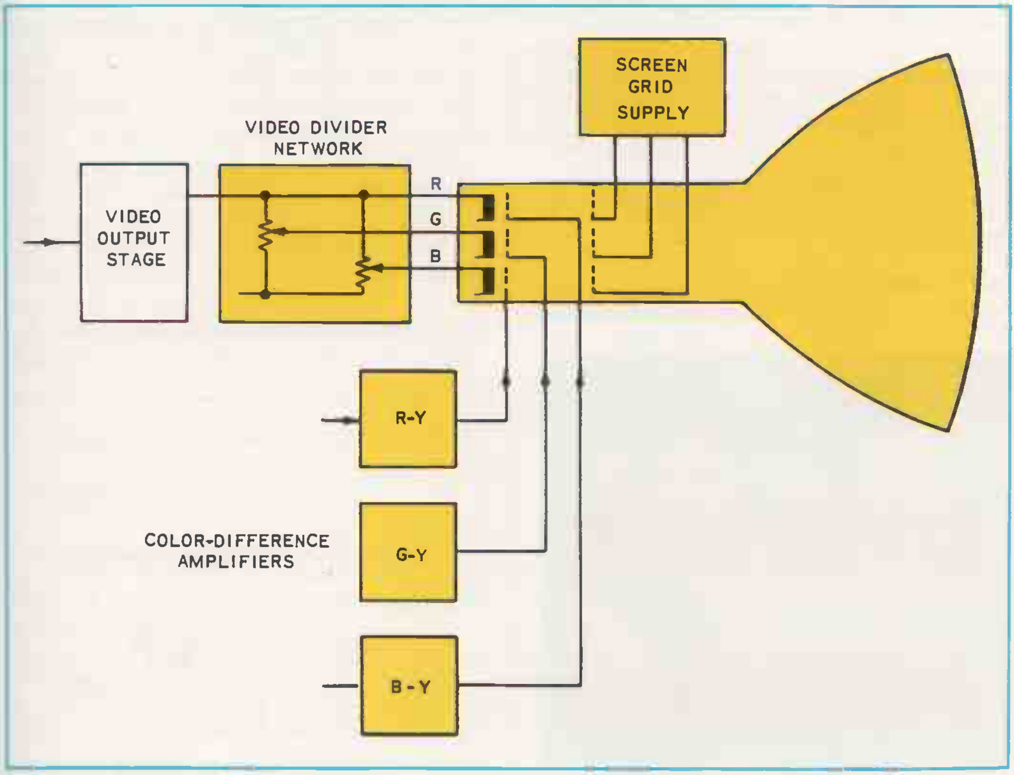


FIG. 7-22. Circuits that affect color balance.

tubes if you examine the picture produced by the suspected electron gun separately. For example, suppose that the picture has a definite cyan tint, indicating insufficient red light output. Since the red gun is suspect, the blue and green guns are biassed off so that the red picture can be examined by itself. Figure 7-23 shows how low emission in the red gun might look. Other picture-tube failures, such as a control grid to cathode short, are also pinpointed by examining the three primary-color pictures separately.

Another picture-tube fault that can affect color balance is a change in the cutoff voltage for one or more of the guns. The cause is a change in the spacing between elements of the picture tube with time. Although this condition alters black-and-white setup, and requires the screen-grid controls to be reset, the change can always be corrected within the normal range of the setup controls.

Sometimes a change in cutoff voltage is mistaken for loss of emission. However, in sets equipped with a NORMAL/SERVICE switch, it is easy to tell the difference: If cutoff can be set (screen-grid controls set for dim line of each primary hue) but it is impossible to get the correct white highlights by adjusting the drive controls, the fault is low emission. The faulty gun is identified by the primary hue that appears to be missing in the highlights.

The Screen-Grid Circuits. Low screen voltage on one or more of the guns of the picture tube can cause a tracking error. However, the screen-grid supply circuit is quite simple and is easy to check out. In nearly all receivers the screen grids of the picture tube are fed from simple voltage-divider potentiometers connected between the boosted-B supply and the B+ supply, as shown in Fig. 7-24. Defects in the controls or the bypass capacitors are the only troubles that can affect conduction of one or two of the electron guns in the picture tube. A quick check of each screen-grid supply can be made by measuring the screen-grid voltage between chassis and pin 3 (red gun), pin 7 (green gun) and pin 11 (blue gun). Rotate the appropriate screen-grid control through its entire range and note the high and low readings. At each screen grid, the low reading should be near the B+ voltage (390 to 420 volts). The high reading should be equal to the boosted B voltage (700 to 1100 volts, depending upon the receiver model). Check the service notes for the correct supply voltages for each receiver model.

The Cathode Circuit. One amplifier drives all three cathodes of the picture tube. Usually any defect in the video output stage affects conduction on all three guns *simultaneously* and no change in color balance occurs. Any fault that affects the *relative* cathode voltages must exist in the network where the individual cathode voltages are branched off. Figure 7-25 shows two representative cathode-drive circuits. The shading in each diagram shows those components that could be responsible for a change in color balance

FIG. 7-23. Effect of low emission (red gun).

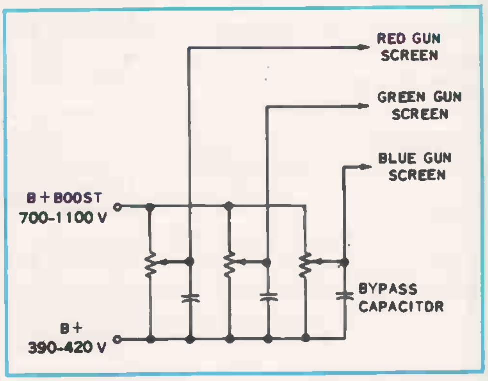


FIG. 7-24. Typical screen-grid supply circuit.

if there is a marked change in the values of the components in the circuit.

Cathode voltages are easily checked. In older receivers, those employing the fixed type of divider network shown in Fig. 7-25*a*, normal cathode voltages are given in the service notes. Newer receivers, with adjustable blue and green drive controls, should have nearly equal d-c voltages at all three cathodes. When measuring cathode voltages with respect to ground, the voltage reading is not effected very much by the d-c levels of the video signals. In these receivers, the video signal amplitude should be checked at each cathode with a calibrated oscilloscope.

The Control-Grid Circuits. The control grids are fed from separate direct-coupled amplifier chains. The plate voltages for the output tubes form the control-grid voltages (with respect to ground) for the associated electron guns in the picture tube. Bias for each gun is the actual voltage between control grid and cathode. Both elements are positive with respect to ground. The control grids are at the same voltages as the plates of the color-difference amplifiers; the cathodes are at a higher positive potential. Since the control grids are less positive than the cathodes, the control grids are negative with respect to the cathodes.

A fault that alters the d-c plate voltage of any *one* of the amplifiers driving the picture-tube control grids causes a change in the bias on the associated electron gun. An increase in plate voltage results in the associated picture-tube control grid

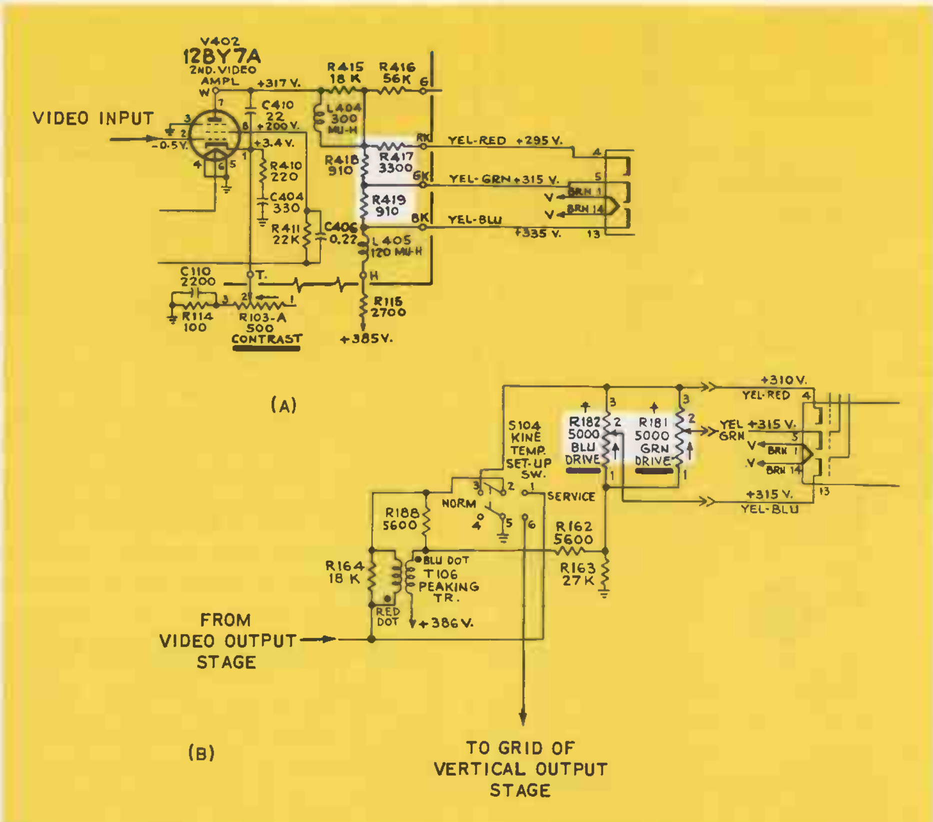


FIG. 7-25. Cathode drive circuits.

becoming more positive with respect to ground, that is, the bias on the electron gun decreases. A drop in plate voltage causes the associated picture-tube control grid to become less positive, that is, the bias on the gun increases.

Consider the simplified schematic diagram of the color circuits of a typical receiver, shown in Fig. 7-26. Suppose that the plate current of V_6, the R-Y amplifier, is low. Its plate voltage will rise towards the B+ value. Since the V_6 plate is directly coupled to the control grid of the red gun, the grid voltage for the red gun will become more positive with respect to ground. The resulting increase in conduction of the red gun causes the black-and-white picture to show a decided excess of red. Figure 7-27 shows the effects of a weak tube in the R-Y amplifier.

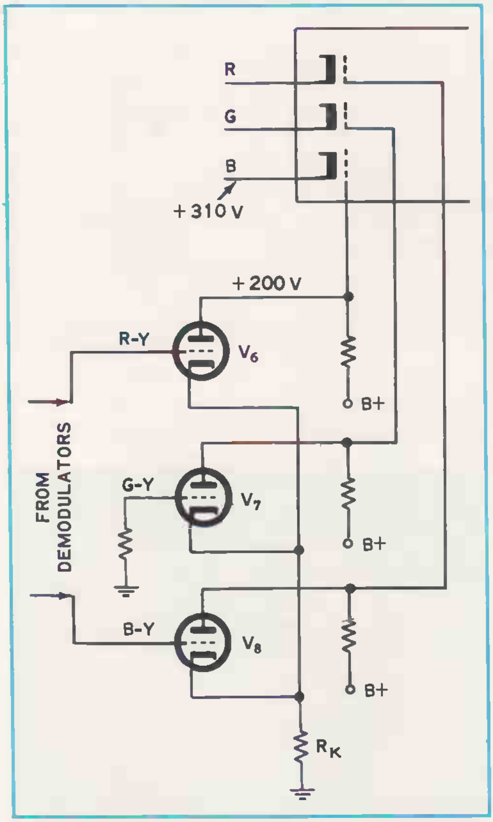


FIG. 7-26. Changes in the d-c operating conditions of the color-difference amplifiers are coupled directly to the control grids of the picture tube.

FIG. 7-27. Effect of a weak R-Y amplifier.

A completely dead or nonconducting color-difference amplifier can produce more serious symptoms. Picture tube gun conduction may rise to the point where the current load on the high-voltage supply is excessive. High voltage may drop to 2 or 3 kv. The symptoms then are no raster and low high-voltage. The high voltage returns to normal when the high-voltage lead is removed from the picture tube, or the picture tube socket is disconnected.

A drop in plate voltage in one of the color-difference amplifiers has the opposite effect. In this case, the picture is deficient in one of the primary colors. A lowering of plate voltage can result from an increase in the value of the plate-load resistor or an increase in tube conduction. Figure 7-28 shows an example of this fault. The picture has a definite yellow cast, indicating a deficiency of blue light. The cause, in this case, is low plate voltage on the B-Y amplifier resulting from excessive tube conduction. A control grid-cathode short in V_8 is responsible for the fault.

Excessive conduction can also be caused by a leaky coupling capacitor (from the demodulator to the color-difference amplifier). A shorted coupling capacitor, in this particular system, produces entirely different results. Tube conduction increases to the point where the common cathode resistor burns open. As a result, all color-difference amplifiers stop conducting, and the voltage at the grids of

FIG. 7-28. Effect of control-grid-to-cathode leakage in the B-Y amplifier.

all three electron guns increases to the B+ value. Severe blooming, and possibly loss of raster due to heavy loading of the high-voltage supply, may result.

Changes in the d-c operating point of one or more of the color difference amplifiers can also result from a change in the level of the signals found at the inputs to these amplifiers. A nonconducting demodulator, for example, can affect the conduction of one of the color-difference amplifiers. However, in the type of circuit shown in Fig. 7-26, the change in black-and-white setup resulting from an inoperative demodulator is very small and is easily corrected with the setup controls. The major symptom in this case is faulty color reproduction.

High-Level Demodulators. Many early RCA receivers, and some late models of other manufacturers, employ high-level demodulators whose outputs are coupled directly to the control grids of the picture tube. The color-difference signals are produced directly by these demodulators; there is no need for additional amplification. In receivers that use this type of chrominance circuits, there are several additional factors that can cause a shift in black-and-white setup. The d-c plate voltage for the demodulators depends upon the average conduction of the demodulators. If you refer to Fig. 2-13 you will see that average plate voltage is determined, in part, by the amplitude of the 3.58-mc CW signal supplied by the local oscillator. (This is true even when no chrominance signals are applied.) Loss of the CW drive to either of the demodulators produces a change in plate voltage which is coupled directly to the control grid of the associated electron gun in the picture tube. The result is a shift in black-and-white setup. In some cases, loss of CW drive to both demodulators, resulting from failure of the 3.58-mc oscillator, can produce a decided tint in the black-and-white picture. This can come about because when the CW drive signals to both demodulators are lost, the plate voltages for the demodulators become equal. The *change* in *relative control-grid voltages* at the picture tube results in a shift in black-and-white color balance.

Keep this in mind when working on receivers in which the demodulators are directly coupled to the control grids of the picture tube. Failure of the 3.58-mc oscillators can upset black-and-white color balance. You might waste time tracking down the cause of a slight tint in the black-and-white picture, when a more obvious symptom — failure to make color — is present. Either color-bar generator, or the green-stripe signal, may be used to determine if the receiver can reproduce color when there are no color telecasts being transmitted.

Hum and Shading. Another cause of color in the black-and-white picture is extraneous signals, such as hum signals, that originate in the chrominance circuits. The causes of colored hum bars or other types of shading (to be shown), can always be traced to the chrominance circuits or the picture tube itself. Hum signals that originate elsewhere, in the Y video amplifier for instance, have the same effect on all three primary colors. The result is the more familiar "black-and-white" type of symptom.

Signals are not processed by the chrominance circuits during black-and-white telecasts because the input to the system — the bandpass amplifier — is cut off by the action of the color killer. However, all the remaining color circuits remain active, and any signal that is injected between the bandpass amplifier and the picture-tube control grids causes some form of color to appear on the screen.

FIG. 7-29. Effect of 60-cps hum injected at the cathode of the X demodulator.

FIG. 7-30. Effect of 60-cps hum injected at the cathode of the Z demodulator.

FIG. 7-31. Hum in the R-Y amplifier.

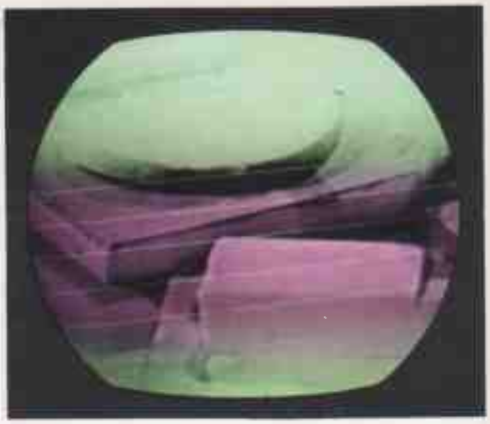


FIG. 7-32. Hum in the G-Y amplifier.

FIG. 7-33. Hum in the B-Y amplifier.

Figures 7-29 through 7-33 show the effects produced by 60-cps hum signals injected at various points in the chrominance circuits. Shorts or leakage between cathode and heater can cause these symptoms.

Horizontal color shading can result from distortion of the horizontal blanking signals that are normally applied to the control grids of the picture tube. In most late-model RCA receivers, horizontal blanking signals are applied to the common cathode resistor of the three color-difference amplifiers. The negative pulse applied at this point has two functions. First, it drives each color-difference amplifier heavily into conduction so that grid current is drawn. For an instant the grid-cathode circuit behaves somewhat

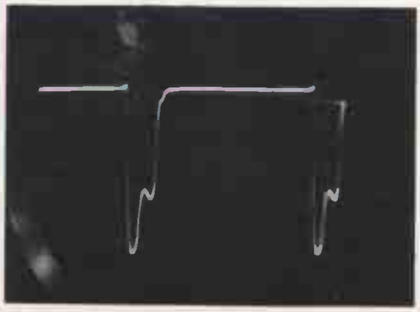


FIG. 7-34. Horizontal blanking waveform at one of the control grids of the picture tube.

like the d-c restorers found in old black-and-white television receivers. This system is called "keyed" d-c restoration. Because of this restoration, the d-c components of the color signals are not lost, even though there is a-c coupling between the demodulators and the color-difference amplifiers. The second effect of the blanking signals is to cut off the guns of the picture tube during horizontal retrace. Negative pulses at the cathodes of the color-difference amplifier are amplified and appear as negative-going pulses at the control grids of the picture tube. Figure 7-34 shows the normal waveform at one of the picture-tube control grids.

A defect that changes the time constant of the coupling circuit between a color-difference amplifier and its associated picture-tube control grid can change the shape of the waveform. An open capacitor, as shown in Fig. 7-35, produces the waveform distortion shown in the accompanying photograph. Notice that the waveform is no longer flat-topped, but remains negative going during the early part of the trace. The signal at the red control grid results in a raster that is predominantly cyan at the left side, as shown in Fig. 7-36. A similar fault, with yellow or magenta shading at the left, occurs if the coupling capacitor opens in the blue or green circuits.

Color-Killer Troubles. The color killer keeps the color circuits from trying to "make color" during black-and-white telecasts. It does so by causing the band-

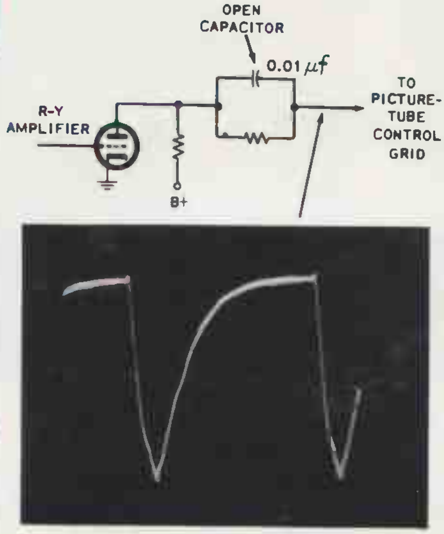


FIG. 7-35. The open capacitor in the coupling circuit to the picture-tube control grid distorts the blanking waveform as shown.

pass amplifier, which is the input to the color circuits, to be cut off. If the band-pass amplifier is permitted to function during black-and-white telecasts, the video information and noise in the vicinity of the 3.58-mc will be processed by the color circuits. The result is random signals that produce rainbow-like patches of color at the edges of those areas of the picture that contain small details. Figure 7-37 shows how this form of "color" in the black-and-white picture

FIG. 7-36. The effect of the open capacitor shown in Fig. 7-35.

FIG. 7-37. Color in the black-and-white picture resulting from an inoperative color killer.

appears. The cause is a failure in the color-killer circuit.

Threshold Adjustment. The color killer functions by sensing the presence or absence of the burst signal. If burst is absent, as it is during black-and-white programs, the color killer develops the bias voltage used to cut off the bandpass amplifier. A KILLER THRESHOLD adjustment is usually provided to adjust the sensitivity of the killer circuit. If sensitivity is too high, noise and other extraneous signals are mistaken for burst and the bandpass amplifier remains conducting at all times. If sensitivity is too low, burst signals are ignored and the bandpass amplifier remains cut off at all times. In the latter case the receiver will not produce color on a color telecast.

Color killer sensitivity on late-model receivers is adjusted while looking at a snowy raster (with the receiver switched to an unused channel). Turn the KILLER THRESHOLD control fully clockwise. If the killer is working you will see the familiar black-and-white effect of a snowy raster. Turn the threshold control counterclockwise slowly while looking at the screen. At one point there will be evidence of color in the snowy raster. The snow looks multicolored and appears coarser than "ordinary" snow (due to the narrow bandwidth of the color circuits). Turn the threshold control clockwise until the color just disappears and a plain black-and-white snowy picture is obtained. This is the correct setting of the color killer threshold adjustment.

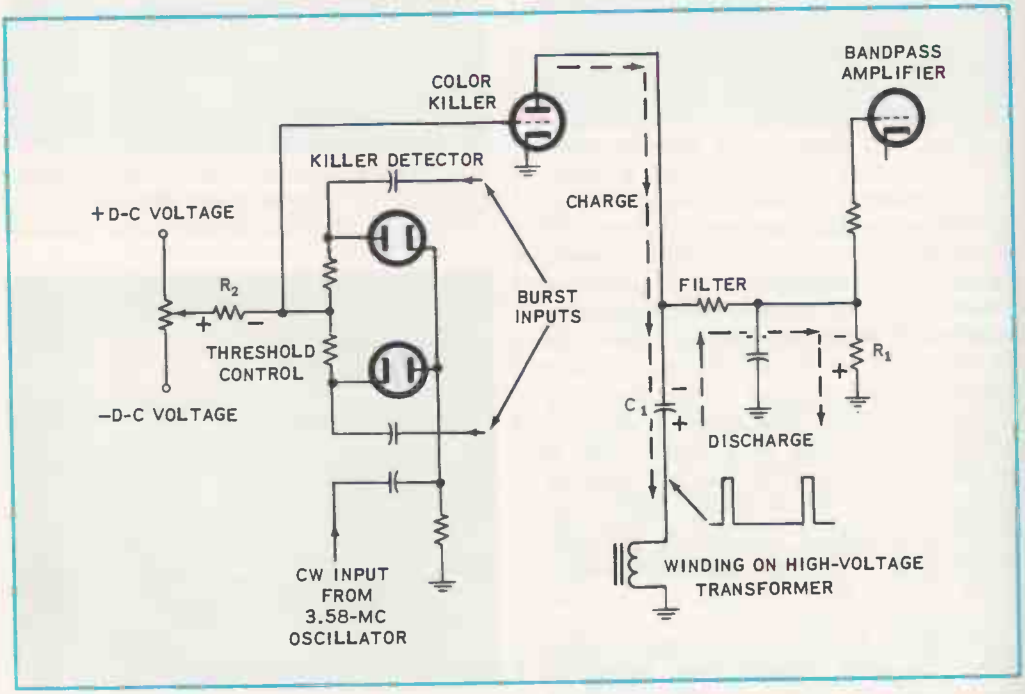


FIG. 7-38. Basic noise-immune color killer system.

If there is evidence of color in a snowy raster at all settings of the killer threshold control, the color killer circuit is defective. If there is no evidence of color at any setting, the color circuits are probably defective (to be covered later).

Figure 7-38 is a simplified block diagram of a killer circuit that is representative of those found in late-model receivers. The killer does its job as follows. During black-and-white telecasts, when there is no burst signal in the composite signal, the killer tube develops a negative bias voltage in its plate circuit. This bias is applied to the grid of the bandpass amplifier to cut off the bandpass amplifier. Bias is generated in the same way that the familiar keyed AGC tube develops the AGC bias. A positive pulse signal, obtained from a winding on a high-voltage transformer, is applied to the plate of the killer through capacitor C_1. The tube conducts during the pulse interval, charging the capacitor. Between pulses, C_1 discharges through R_1 developing the negative bias for the bandpass amplifier. The killer tube can conduct during black-and-white telecasts because the output of the killer detector is zero. The only bias on the killer tube is that picked off at the threshold control.

During color telecasts, burst signals appear at the input to the killer detector. This stage is like the phase detector, but it is arranged to have the burst signals and the CW input signals in phase. When burst is present, a large negative voltage is developed across R_2, and the color-killer is biased beyond cutoff. Since the tube cannot conduct, the negative d-c voltage developed in the plate circuit falls to zero, and the bandpass amplifier is brought out of cutoff.

Notice that the killer tube must be conducting in order to develop the bias that cuts off the bandpass amplifier during black-and-white telecasts. Failure of the killer, as evidenced by the symptoms of Fig. 7-37 at all settings of the threshold control, points to some fault that prevents tube conduction. An inoperative killer tube and loss of the pulse drive to the plate circuit are examples of possible faults. A circuit defect that permits the killer to conduct at all times, such as a grid-cathode short in the killer tube, or an inoperative killer detector, results in a no-color condition.

TROUBLESHOOTING THE COLOR SECTIONS OF THE RECEIVER

In this section, we deal with the troubles that prevent the receiver from reproducing the colors of a color telecast. You have already taken the first and most important step in localizing the trouble if you have examined the black-and-white picture and found it to be normal and correct. In a receiver that produces a perfectly normal black-and-white picture, but cannot reproduce color, the trouble is definitely localized to those circuits that reproduce and process the color-difference signals. The fault lies somewhere between the input to the bandpass amplifier and the control grids of the picture tube. This section of the receiver is shown in the block diagram of Fig. 8-1. Fortunately, the chrominance section of the receiver is physically quite small. It is usually all located on one printed circuit board or one subassembly of the receiver. The chrominance section is one of the easiest sections of the receiver to troubleshoot.

Trouble Symptoms. Common circuit troubles in the chrominance section result in the following symptoms:

1. *No color* — (Normal black-and-white picture during a color telecast).
2. *Weak color* — Color present but low in saturation. The colors appear as light tints.
3. *Incorrect color reproduction* — Saturated colors are produced, but colors are incorrect. Flesh tones appear too green or too purple. Some hues appear to be missing.
4. *No color sync* — Objects change color rapidly. Colors appear to break up into horizontal bands that "run" or change across the picture.
5. *Distorted color* — Color appears only in large blotches. Incorrect colors appear at the edge of vertical lines in the picture. Colors smear into one another.

Preliminary Considerations. In any problem concerning color reproduction, remember to make a routine check of the operating controls. Most important of all, check the setting of the fine-tuning control. Accurate tuning is extremely important for correct color reproduction. The response curve of the i-f amplifier is designed so that when combined with the response curve of the bandpass amplifier, the sidebands of the color subcarrier are amplified uniformly. For this system to work properly, the transmitted color subcarrier must be converted to the correct i-f frequency. This in turn requires precise fine tuning. Errors in fine tuning result in no color, weak color, smear and low color resolution, and 920-kc sound beat in those areas of the picture where color appears.

To tune correctly, rotate the fine-tuning control in the direction that increases resolution (sharpness) of the picture. Continue turning in that direction until sound bars and signs of overshoot (accentuated vertical edges) appear in the picture. At this point, the 920-kc sound beat will appear in the picture if a color telecast is being received. On black-and-white telecasts you may see the sound beat in the green stripes at the edges of the picture. Now, reverse the direction of turning, and tune carefully until all signs of the sound beat just disappear. (Sound bars will have disappeared at this point as well).

No Color. This condition is found when the receiver produces a normal black-and white picture, but there is no sign of color (the picture remains black-and-white) during color telecasts. If you encounter this symptom, do not forget to make a quick check of fine tuning and make sure the COLOR (saturation, chroma) control is turned fully clockwise.

As an added preliminary check, disable the color killer by turning the color killer threshold control fully counterclockwise.

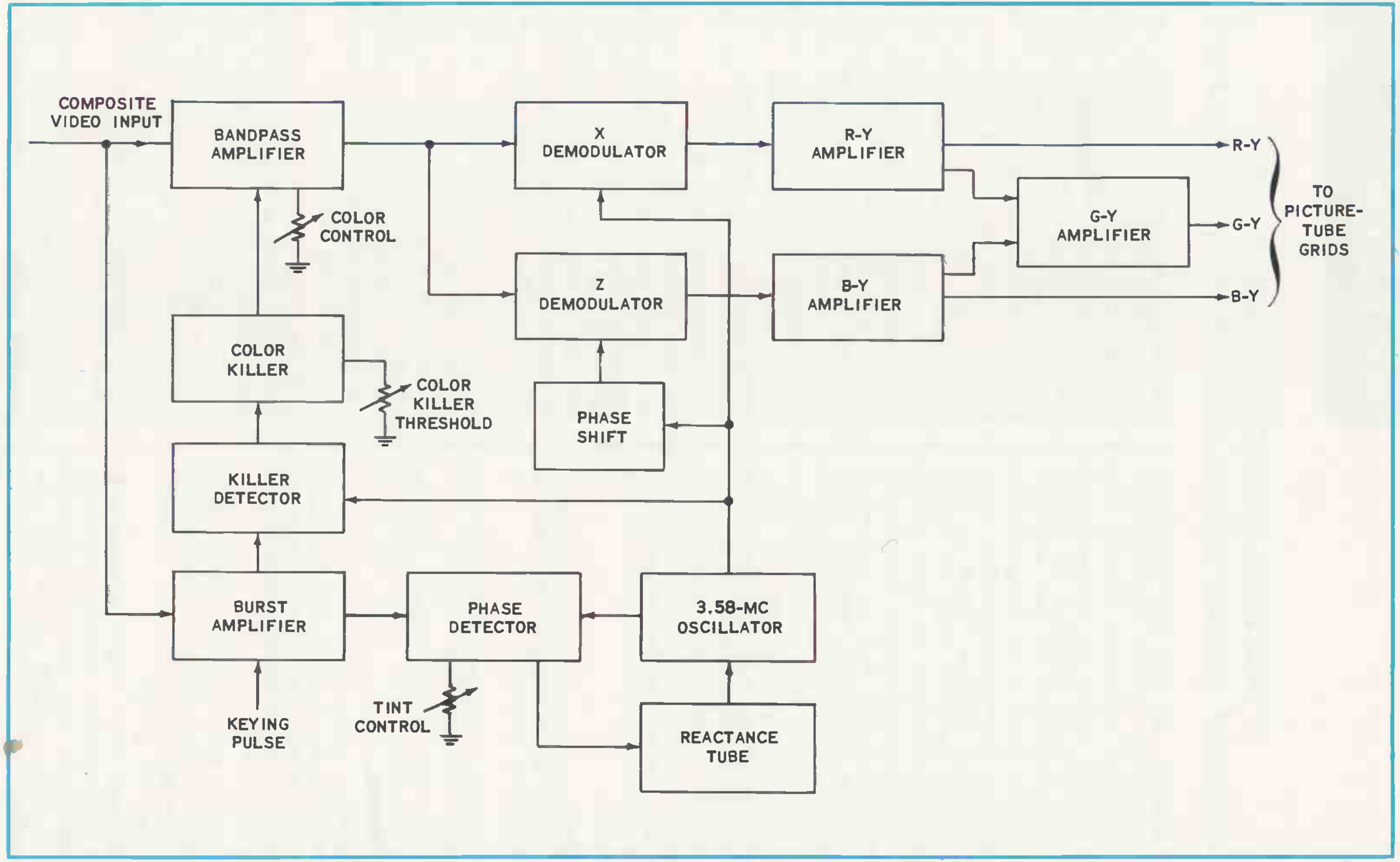


FIG. 8-1. Block diagram of the chrominance circuits of a late-model RCA receiver.

Loss of color is sometimes caused by faulty setting of the color killer threshold control. If color appears with this control turned fully counterclockwise, the sensitivity of the killer circuit was originally too low. Reset the killer circuit as discussed earlier. [**Note.** *Check the manufacturer's service data for proper color killer adjustments. Some receivers may require clockwise rotation of the threshold adjustment to disable the color killer.*]

Disabling the color killer may reveal a new symptom. Color may appear in the picture but it may lack color synchronization. The real problem in this case is the loss of color sync. The original symptom — no color — may result from the action of the color killer system. Remember that the color killer allows the bandpass amplifier to conduct only if the burst signal is present in the composite signal. As shown in Fig. 8-1, the burst signal input to the color killer is taken from the burst amplifier. Therefore, failure of the burst amplifier is interpreted as absence of burst by the color killer system. In receivers with noise-immune color killers, burst must be present *and* the AFPC system must be operating normally before the color killer bias is removed from the bandpass amplifier. Therefore, if out-of-sync color appears when the color killer is disabled, the primary trouble is loss of color sync (to be covered shortly). If no color appears at all when the color killer threshold control is turned fully counterclockwise, proceed as follows:

Localize the Trouble to a Major Section. The color signal passes through the antenna system, the tuner, the i-f amplifier, and the video detector as part of the composite signal. In the bandpass amplifier the color signal is *separated* from the composite signal for processing. (Actually, the color signal is not completely separated from the composite signal by the bandpass amplifier, as the high-frequency components of the video signal also pass through the bandpass amplifier. However, for troubleshooting purposes, it is convenient to think of the bandpass amplifier as the point where chrominance and monochrome signals are separated.) Complete loss of color can result from a failure in the circuits that process the separated color signal. These are shown in Fig. 8-1. However, color can also be lost in the stages that handle the composite signal before separation. In this case, since there is a black-and-white picture, those stages have not failed completely, but are discriminating against the band of frequencies which carry the color signal. Misalignment of the i-f amplifier, for example, such that frequencies in the region around 42.17 mc (the color subcarrier frequency in the i-f section) receive little amplification, can cause loss of color. A sharp "suckout" or trap effect in the antenna system, caused by a poorly terminated transmission line, may also cause attenuation of the r-f frequencies near the color subcarrier. These faults should also produce a noticeable effect, such as loss of resolution, in the black-and-white picture.

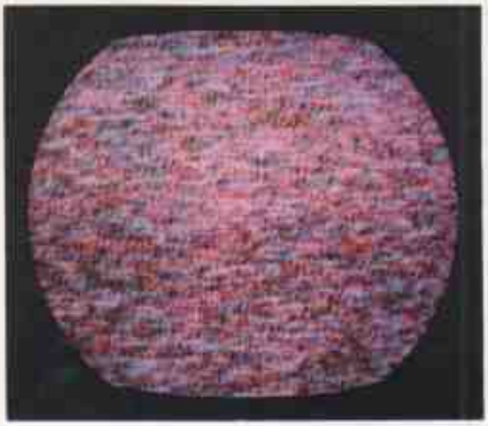
Your first job, then, is to localize the cause of loss of color to either the circuits that handle the *composite* signal (antenna to the input of the bandpass amplifier), or the circuits that handle the *separated* color signal (Fig. 8-1).

Try Another Channel. If you are in an area where more than one channel transmits color, switch to the other channels and look for color (look for the green stripe if a black-and-white telecast is in progress).

If normal color is found on one channel, the color circuits are functioning normally and the fault must lie in those circuits that are not common to all channels — the tuner, and possibly the antenna. If the antenna system is suspected, try an indoor antenna. A faulty antenna system is indicated if color is seen, even if the picture is snowy, using an indoor ("rabbit-ear") antenna.

Snow check. A very useful check can be made by observing a snowy raster. Disconnect the antenna and switch to an unused channel to obtain a snowy raster. Turn the COLOR control fully clockwise and look for *colored* snow. To make sure you are seeing "colored" snow, turn the color killer threshold control fully clockwise and then advance the control counterclockwise until an abrupt change in the raster is seen. Figure 8-2 shows this effect. [Check the service notes to find the direction in which the killer threshold control must be turned to disable the color killer.] If the "snow" remains black-and-white throughout the range of the control, the trouble is localized to the chrominance circuits. If "color" can be seen in the snow, as shown in *b* of Fig. 8-2, you can be sure that the color circuits are working. The color circuits are processing the electrical noise signals that appear at frequencies near 3.58 mc at the output of the video detector. The fine-tuning control has little effect upon the amplitude and bandwidth of these signals.

(A)

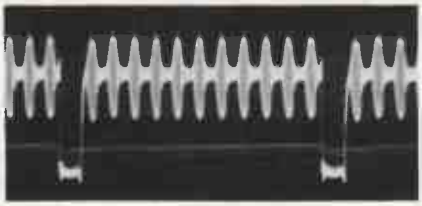


(B)

FIG. 8-2. Colored snow in the raster is a good indication that the color circuits are working.

Signal tracing. A most definite check can be made with a color-bar generator and a wide-band oscilloscope. Connect the color-bar generator to the antenna terminals of the receiver and adjust the generator to produce normal color bars. Tune the receiver, using the sound beat as a guide. Inspect the composite video signal at the output of the video detector with the wide-band oscilloscope. A test point is usually provided at the output of the video detector for this purpose. Figure 8-3*a* shows the normal color-bar signal obtained at the output of the video detector. Note the high-frequency (3.58-mc) signals at each bar position. This waveform tells you that color signals are present at the output of the video detector stage. If the receiver does not make color, the color circuits must be at fault. Figure 8-3*b* shows an abnormal waveform. No 3.58-mc information is visible. This photo was obtained by detuning the receiver.

Localizing No-Color Faults in the Chrominance Section. If the preceding checks indicate that the cause of a no-color condition is in the chrominance section, your next step is to localize the fault to a particular stage. Refer to Fig. 8-1. Since *all* color is missing the fault must be located at some point that prevents signals from appearing at *all three* control grids of the picture tube. A fault in *one* of the color-difference amplifiers or *one* of the demodulators cannot cause this condition. Color-difference signals cannot be



(A)

(B)

FIG. 8-3. Output of the video detector; signal source is the color-bar generator.

produced by either demodulator, however, if the signals from the bandpass amplifier *or* the 3.58-mc oscillator are missing. No color troubles, therefore, are localized to the bandpass amplifier, including the color killer, which controls the bandpass amplifier, and the 3.58-mc oscillator. A dead 3.58-mc oscillator causes complete loss of color, but a large error in frequency may cause a very similar symptom. You will learn how to check and adjust oscillator frequency in the next section. Tube substitution should be the next step to be taken. A voltage check can be made to see if the 3.58-mc oscillator is working. Grid leak bias, a negative d-c voltage measured at the grid of the oscillator tube, is evidence of oscillation. Pin voltage checks can be made from the top of the chassis, due to the type of tube socket employed on printed circuit boards, as shown in Fig. 8-4. Remember to count pins counterclockwise from the gap when identifying tube pins from the top of the socket.

FIG. 8-4. Pin-voltage measurements can be made from the top of the chassis in most printed circuit boards.

An inoperative bandpass amplifier can result from a trouble in the bandpass amplifier itself, or it may be cut off due to the action of the color killer. Although one of the first steps taken in checking a no-color condition involves disabling the color killer by adjustment of the threshold control, a fault may exist in the killer stage itself. For example, a grid-cathode short in the killer tube will hold the killer in the conducting state regardless of the setting of the threshold adjustment. The bias developed by the conducting killer holds the bandpass amplifier in the cutoff state. Check the control grid voltage of the bandpass amplifier. A negative d-c voltage of −10 volts or more indicates the presence of sufficient color-killer bias to cut off the bandpass amplifier.

Signal Tracing. The foregoing discussion shows how to localize a no-color condition to a stage or group of stages. Once the inoperative stage is found, voltage checks usually reveal the fault. However, "tough" cases occur when the fault does not alter the d-c operating voltages of the stages involved. An open coupling capacitor is an example of this type of fault. In these cases, signal tracing provides a foolproof method of tracking down the fault. Signal tracing with a calibrated oscilloscope is extremely helpful in finding the causes of weak (low saturation) color. In that case you should be looking for a drop in signal amplitude rather than a complete break in the signal path. Figure 8-5 shows how the chrominance signal may be traced from the video circuits, through the bandpass amplifier, to the inputs of the color demodulators.

Weak or Unsaturated Color. The symptoms of this condition are weak or tinted colors even when the receiver is tuned properly and the COLOR control is turned fully clockwise. The trouble is attacked in the same way as a no-color condition except that here you are looking for a loss of signal amplitude and not a complete break in the signal path.

Signal tracing provides the surest approach to the problem. Again, the first job is to localize the fault to the r-f, i-f sections, or the chrominance circuits. This can be done by inspecting the waveform produced by the color-bar generator at the output of the video detector. By comparing the amplitude of the 3.58-mc bursts that form the color bars with the amplitude of the sync signal, you can see if the color subcarrier receives too little or too much amplification in the r-f, i-f sections. Figure 8-6*a* shows how the color-bar signal looks at the modulator of the RCA WR-64A generator when the CHROMA control is set to 100%. Note that the peak-to-peak amplitudes of the 3.58-mc signals in the "bars" just about equals the peak-to-peak amplitude of the sync pulse.

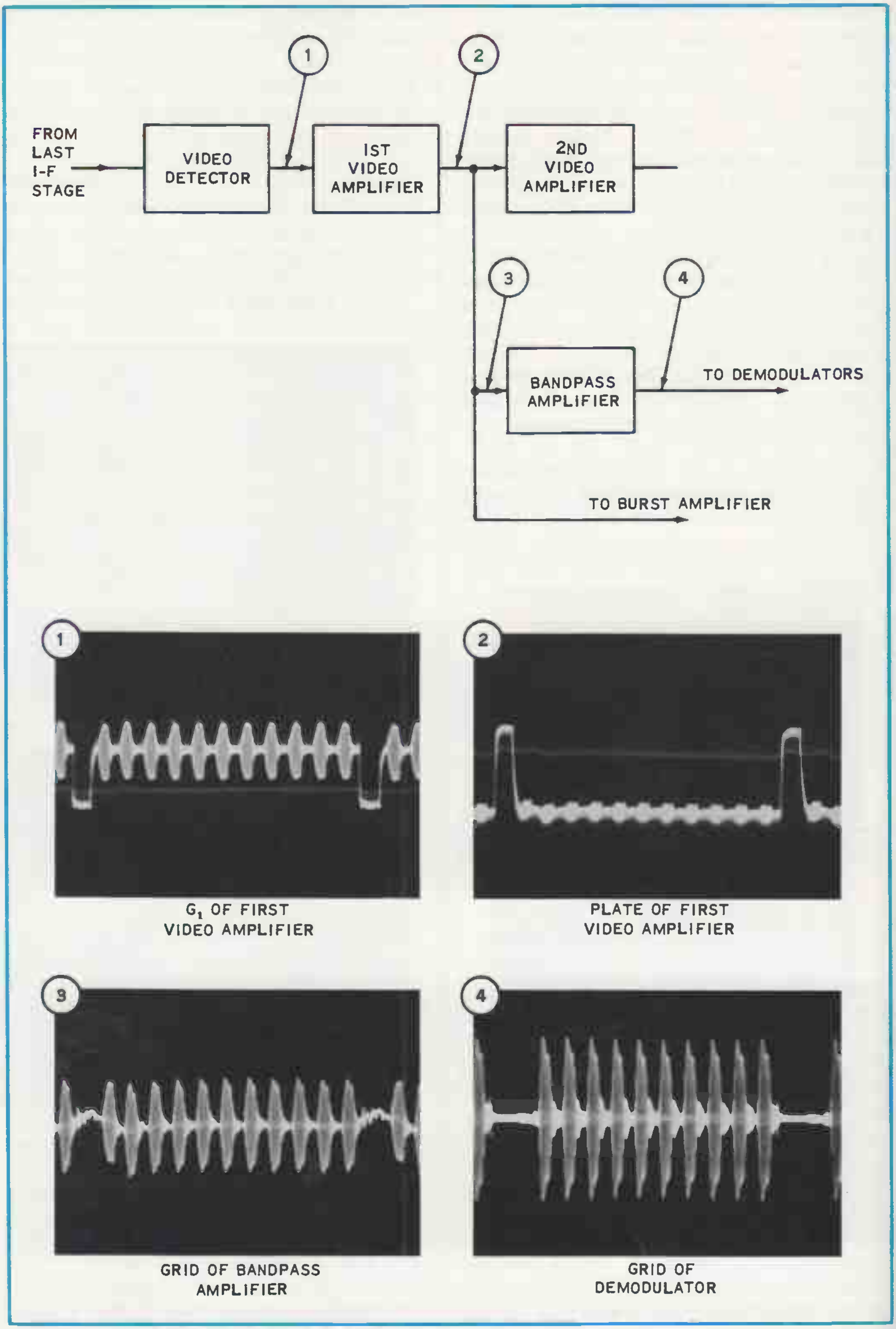
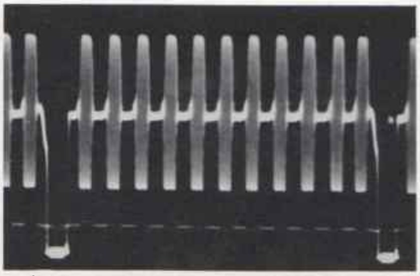


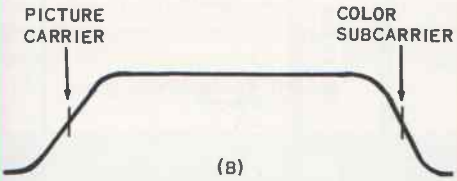
FIG. 8-5. Tracing color-bar signals from the video detector to the demodulators.

The i-f response curve of the color receiver is as shown in *b* of Fig. 8-6. Note that the color subcarrier is at the 50% point of the slope. Therefore, the waveform at the output of the video detector should appear as shown in Fig. 8-6*c*. The amplitude of the color bars should be about half that of the sync pulse. (Make sure the set is properly tuned.)

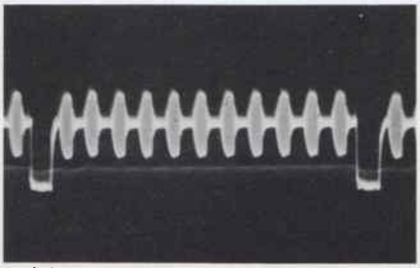
If the color signals at the output of the video detector have the correct relative amplitudes, the next checks are made in the chrominance section. Refer again to Fig. 8-5. Here, the peak-to-peak amplitudes of the waveforms are particularly important, as they permit you to spot the point where the signal is attenuated. Waveform photos, with peak-to-peak amplitudes noted, are found in nearly all service notes.



(A) WAVEFORM – COLOR BAR SIGNAL INPUT TO MODULATOR IN WR-64A



(B)



(C) WAVEFORM – COLOR BAR SIGNAL OUTPUT OF VIDEO DETECTOR

FIG. 8-6.

Incorrect Color Reproduction. Symptoms: the receiver makes a normal black-and-white picture, color is sufficiently saturated (and can be made oversaturated by advancing the COLOR control too far), but colors appear incorrect. Flesh tones appear too yellowish or too purple. Some hues appear to be missing, and the condition cannot be corrected by adjusting the TINT control. Troubles fitting these symptoms are localized to the chrominance section of the receiver. In particular, a fault is indicated in those circuits that produce and amplify the color-difference signals. Figure 8-7 shows the suspected parts of the receiver.

Within the receiver sections designated in Fig. 8-7, incorrect-color troubles fall into two main categories:

1. Phase errors
2. Missing or distorted color-difference signals.

Phase errors result when the phase of the 3.58-mc CW signals applied to the demodulators is incorrect. A large phase error, one that cannot be corrected with the TINT control, results in the following symptoms: All colors and hues appear in the picture, but all colored objects are shown with incorrect hues. In other words, you can see reds, greens, blues, magentas, yellows, and so forth, in the picture, but flesh appears green, or purple, or blue, or some other unnatural hue. Figure 8-8 shows how a large phase error looks using the color-bar pattern. Note that all hues are shown in the picture, but they occur at the wrong bar positions. The *fourth* bar should be magenta; however, the sixth bar is magenta in this figure. The color-bar pattern is especially useful in detecting phase errors.

Missing color-difference signals produce a slightly different set of symptoms. Usually, the color picture appears to lack one of the primary colors regardless of the setting of the hue control. Figure 8-9 shows the result of an inoperative X demodulator. The outstanding effect of this trouble is the absence of the R-Y signal. As Fig. 8-7 shows, the X demodulator drives the grid of the R-Y amplifier.

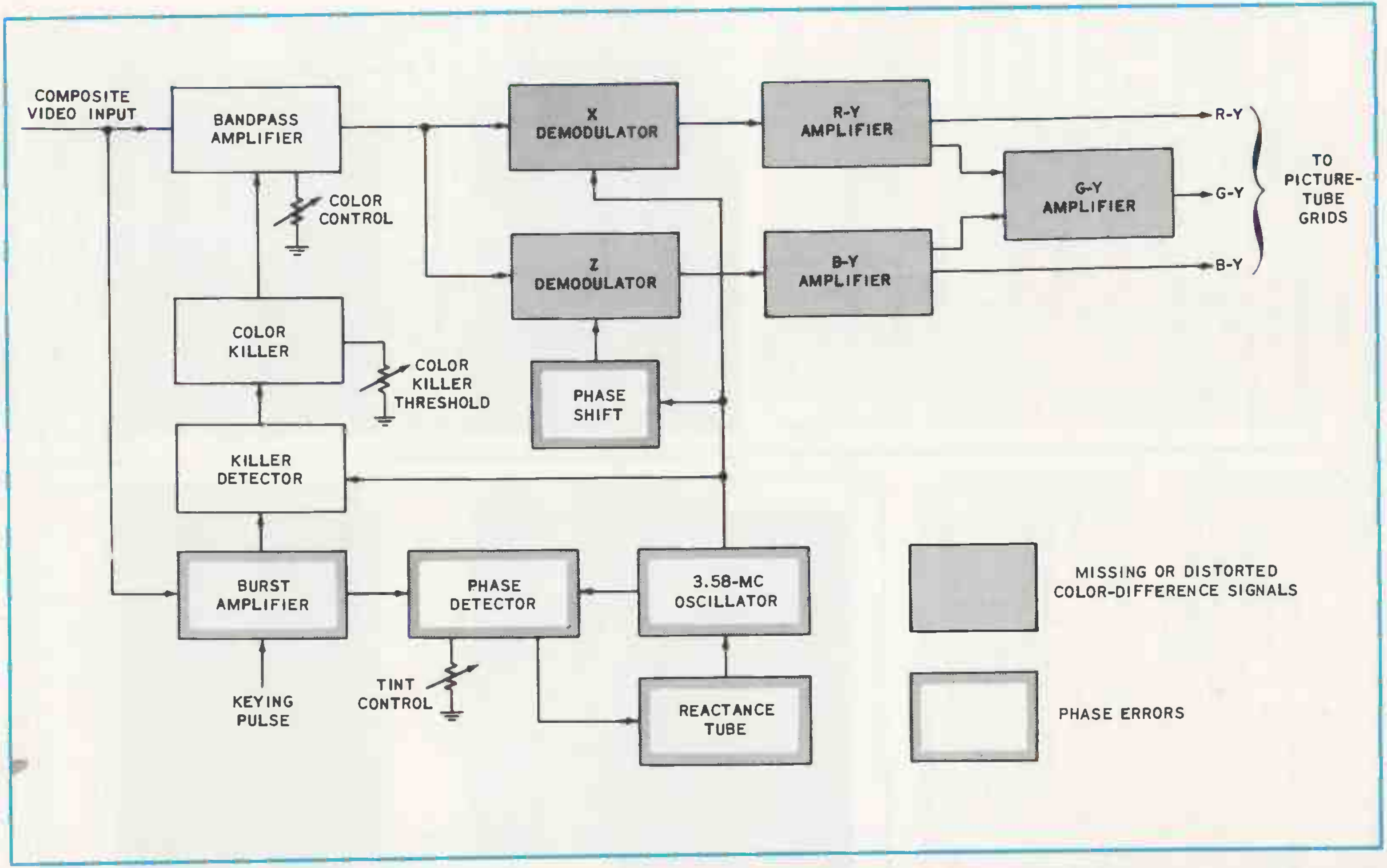


FIG. 8-7. Shaded blocks show the circuits that can be responsible for missing or incorrect colors.

FIG. 8-8. Effect of a large phase error.

Actually, an inoperative X demodulator does not result in the complete loss of signal at the output of the R-Y amplifier. Some of the Z signal, which resembles a —(B-Y) signal, appears at the R-Y amplifier's plate due to the action of the common-cathode resistor. However, for trouble-shooting purposes it is not too inaccurate to say that the R-Y signal is absent. Note that there are no reds in the picture of Fig. 8-9, — only blues and greens. Fig. 8-10 shows the result of an inoperative Z demodulator. The most outstanding effect of this trouble is that blue (B-Y) appears to be missing from the color picture. This condition is quite obvious from examination of the color-bar pattern. However, color telecasts look almost normal on some scenes and flesh tones look nearly natural at times.

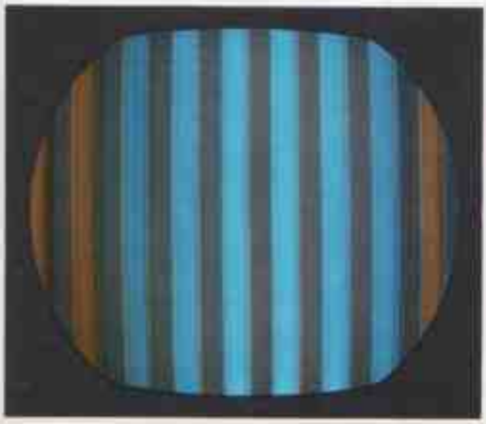


FIG. 8-9. Effect of an inoperative X demodulator.

FIG. 8-10. Effect of an inoperative Z demodulator.

Localize the fault. As a first step in localizing a color fault, inspect the color-bar pattern with all guns turned on. If one of the primary colors appears to be missing, check the demodulator tubes by substitution. You may also interchange the demodulator tubes and look for a *change* in the pattern to help identify the fault. A faulty demodulator tube is indicated if the pattern changes from that shown in Fig. 8-9 to that shown in Fig. 8-10 when you swap demodulator tubes. It is also possible for the color-difference amplifiers (adder stages) to be responsible for an attenuated or missing color-difference signal. However, nearly all severe troubles in the color-difference amplifiers result in a change in the d-c voltages of the stages involved, and a noticeable change in black-and-white color balance. The fault was treated earlier in this book.

If all of the primary and complemetary hues can be observed in the color-bar pattern, but the various hues occupy the wrong bar positions, the fault is probably a phase error in the AFPC system. Refer to the section entitled AFPC *Checks and Adjustments* for a complete discussion of the ways of setting up correct phase.

Signal Tracing in the Chrominance Section. Signal tracing, using the color-bar generator as a signal source and an oscilloscope as an indicator, is the best way to localize hard-to-find faults in the chrominance section. A wide-band oscilloscope is needed only to check the 3.58-mc CW signal inputs to the demodulators.

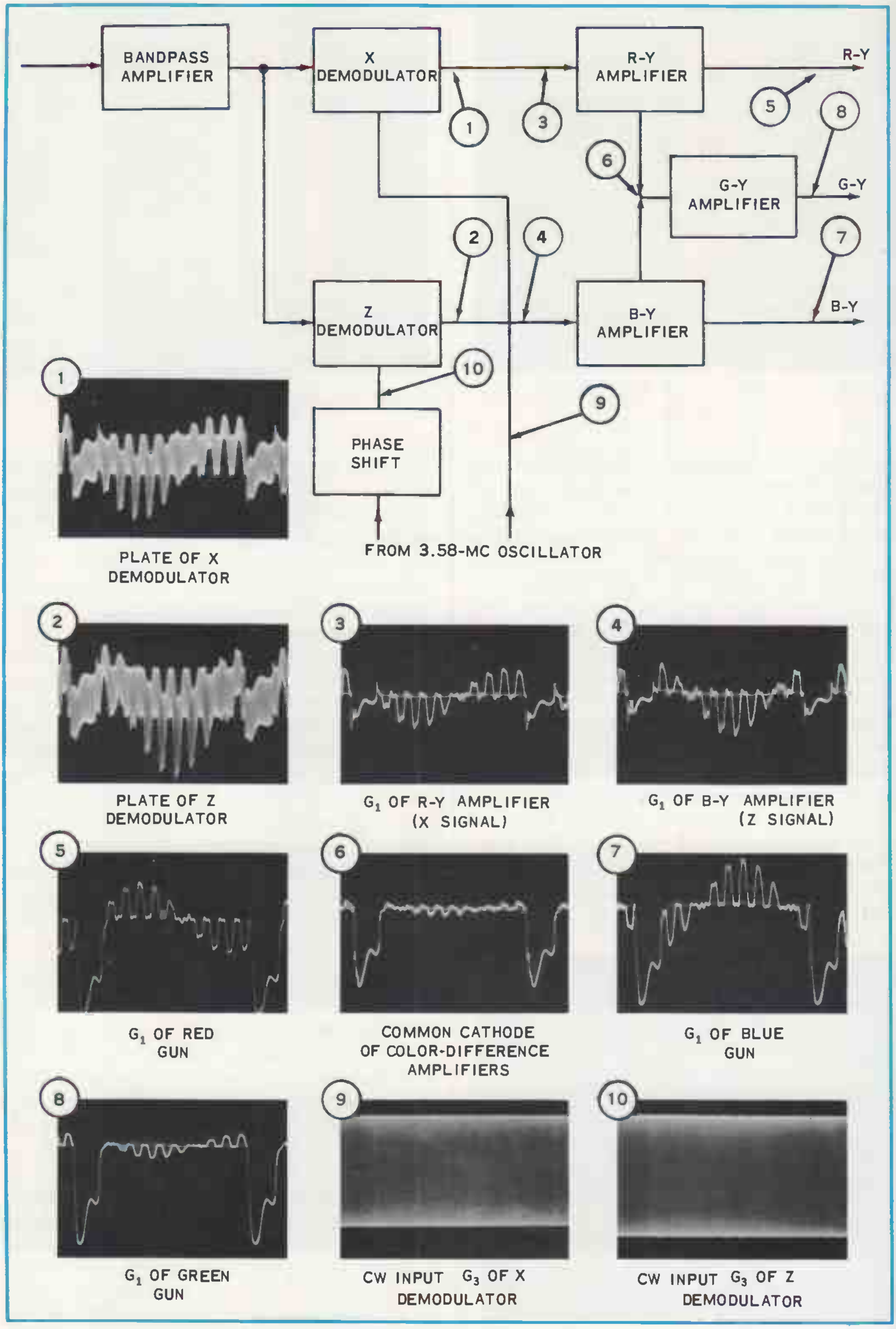


FIG. 8-11. Signal tracing in the chrominance circuits.

Waveforms at the outputs of the demodulators, and those in the color-difference amplifiers, may be observed with a narrow-band oscilloscope.

Figure 8-11 shows the key waveforms in the chrominance section of a typical receiver. A similar set of waveforms is found in the service manuals for most receivers. A good place to start looking is at the outputs of the color demodulators where the color-difference signals originate. Start by inspecting the signal produced by that demodulator which is driven directly from the 3.58-mc oscillator. If the correct signal can be identified at this point, you can be sure that the AFPC system is working correctly. Rotate the TINT (hue, phase) control to produce the correct waveform. If the correct signal cannot be identified, the AFPC system probably requires alignment.

The clue to identifying the correct waveform at the output of the demodulator is to note the bar position at which the signal goes through zero. In receivers that demodulate the color difference-signals directly, correct waveforms can be identified as follows:

R-Y waveform — sixth bar passes through zero

B-Y waveform — third and ninth bars pass through zero

G-Y waveform — seventh bar passes through zero

Late-model RCA receivers demodulate a set of chrominance signals designated X and Z. These resemble *minus* (inverted) R-Y and *minus* B-Y respectively. Note the waveform at the output of the X demodulator in Fig. 8-11. This waveform looks very much like the R-Y signal at the red control grid except that it is inverted (turned upside down). In both cases the *sixth* bar goes through zero. Start to count from the bar to the right of the "spike" that is formed by a blanking pulse. In the X signal, however, the sixth bar is not quite at zero. For troubleshooting purposes, you may consider the phase of the signal fed to the X demodulator to be very nearly correct if the sixth bar goes through zero. The range of the TINT control allows ample correction to make a precise phase adjustment. (Correct phase adjustment is made when observing the R-Y signal at the red control grid).

If the output of the demodulator that is driven directly from the 3.58-mc oscillator is correct, check the output of the remaining demodulator. If a correctly phased signal cannot be observed at this point, the phase-shift network is suspect. Look at the Z signal waveform in Fig. 8-11. The Z signal resembles an inverted B-Y signal; the third and ninth bars pass through zero.

Check Amplitudes. The relative amplitudes of the signals produced by the demodulators are important to proper reconstruction of the color-difference signals. It is customary to find peak-to-peak amplitudes given along with the waveforms in the service notes. To make use of these voltages given by the manufacturer, you must duplicate the operating conditions used by the manufacturer when the voltages were measured. Check the service notes for any setup instructions. In particular, set the COLOR control to the correct value. You may do this by observing the waveform at the output of one of the demodulators and adjusting the COLOR control until the peak-to-peak voltage is as specified in the service notes. The remaining voltages should then fall within tolerance. Unless voltage tolerances are given, assume a tolerance of $\pm 20\%$.

If correctly phased signals, of the correct relative amplitudes, are found at the outputs of both demodulators, check the signals at each picture tube grid. Incorrect signals at the picture tube grids, such as clipped or distorted waveforms, or incorrect relative amplitudes, point to signal distortion in the color-difference amplifiers.

No Color Sync. Trouble in the AFPC section of the receiver results in color that breaks up into horizontal bands, or in objects that change in hue as you look at them. This problem is attacked in much the same way as when servicing the horizontal AFC section of any television receiver.

Quite a bit must be said in connection with color sync problems. The next section in the book is devoted entirely to this topic.

Distorted Colors. Misalignment of the i-f and bandpass amplifiers can result in non-uniform amplification of the 3.58-mc sideband signals that carry the color information. This type of trouble is quite rare as alignment very rarely changes by itself, and most TV technicians have learned that alignment adjustments should not be disturbed unless the proper equipment is at hand. The symptoms of misalignment are as follows:

Color definition may be low. In this case color appears only in large areas of the picture, and little color is seen in the details. The condition is noted in colored titles, and in letters such as *E* etc. Color appears in the long horizontal portions of the letter but not in the narrow vertical portions. However, this situation is normal if the letter is small, and you must study the picture on a few color receivers and look at much program material before you can judge when color definition is adequate. There is a variation in color definition between live, filmed, and taped color programs.

Another symptom of faulty alignment is wrong colors at the vertical edges of objects. A red block, for example may have blue lines at the leading and trailing (left and right) edges. Figure 8-12 shows an exaggerated example of this form of distortion. This form of distortion comes about when sideband signals above the color subcarrier frequency are amplified more or less than the sideband signals below the subcarrier frequency. The result is a shift in the phase of the resultant subcarrier signal and a change in hue. If this form of distortion occurs only for sideband signals greater than about 500 kc above and below the carrier, then the shift in phase occurs only in color video signals that represent small areas in the picture and the *edges* of vertical objects. Sideband distortion does not occur if amplification is uniform throughout the range of sideband signals. The techniques for obtaining uniform amplification of the color signals is shown in the *alignment* section of this book.

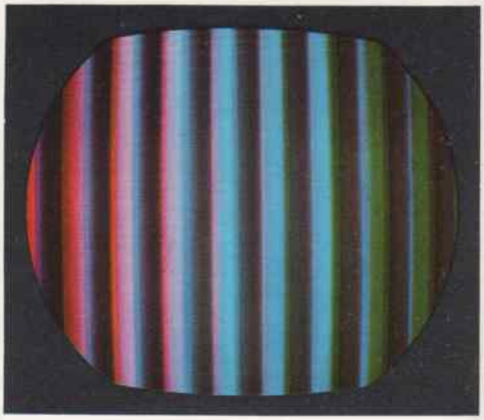


FIG. 8-12. Distorted color-bar signal caused by detuning the receiver and advancing the COLOR control.

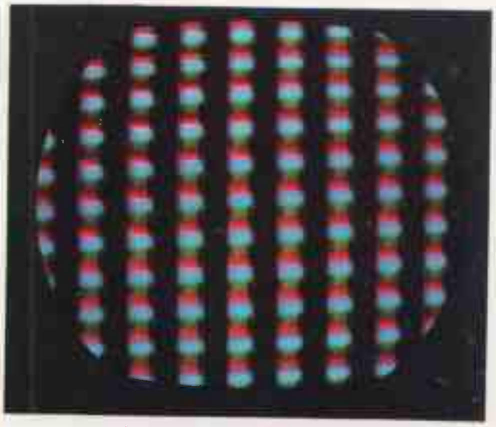
AFPC CHECKS AND ADJUSTMENTS

Trouble in the AFPC system usually shows up as a loss of color sync. The symptoms are shown in Fig. 9-1, as they might appear in a color telecast and on the color-bar pattern. In both cases, the 3.58-mc oscillator is operating at the wrong frequency. Other symptoms of trouble in the AFPC system are the inability to obtain a correct color picture (correct phase) by adjusting the TINT control, and a narrow range of phase adjustment with the TINT control. Faulty AFPC action is also indicated if color locks well on strong channels but slips out of lock on weaker channels.

FIG. 9-1. Examples of the effects of no color-synchronization.

Estimating Frequency Errors. You can make rough estimates of the frequency error of the scanning oscillators by observing the picture. For example, you can tell the difference between a large and a small frequency error in the horizontal scanning oscillator by counting the number of horizontal bands into which the picture is broken. You can judge errors in the frequency of the color subcarrier oscillator in the same way. To illustrate, if color is solid throughout the length of the color bars but changes slowly, about twice each second, the frequency error is 2 cps. The subcarrier oscillator is thus

(A) SMALL FREQUENCY ERROR



(B) LARGE FREQUENCY ERROR

FIG. 9-2. Frequency errors

above or below 3.58-mc by 2 cps. If the bars are not uniform from top to bottom, but are broken into 2 rainbows, stacked one above the other, then the subcarrier oscillator is off by 2 x 60 cps or 120 cps. At larger frequency errors, the color bars break up into still more horizontal bands. The amount of frequency error is proportional to the number of horizontal bands, as shown in Fig. 9-2. Hence, when making corrections to the subcarrier oscillator frequency, you tune to reduce the number of horizontal colored bands.

Troubleshooting the AFPC Section. Faults in the AFPC section are easily localized by following the alignment procedure. In this case, the alignment procedure is the most powerful troubleshooting aid that you can use. Therefore, this section shows a general alignment procedure that can be applied to nearly all color receivers. Each step will be analyzed to show you how to interpret results and spot circuit failures.

AFPC Alignment. No special alignment equipment is needed for the job. It can be done with a VTVM and a few clip leads if a color telecast is in progress. If no color signals are available, use the color-bar signal from a generator such as the RCA WR-64A. The green-stripe signal may also be used.

Tune in a color telecast or attach the color-bar generator to the antenna terminals, and set the channel selector and fine-tuning controls to produce a correct picture with no sound beat. Turn the COLOR control fully clockwise. Turn the TINT control to the center of its range. Set the COLOR KILLER THRESHOLD control fully counterclockwise, to turn the bandpass amplifier on.

The next few steps are adjustments made in the alignment procedure. They apply to all receivers using reactance-tube-controlled crystal oscillators. This applies to the majority of color receivers in the field today.

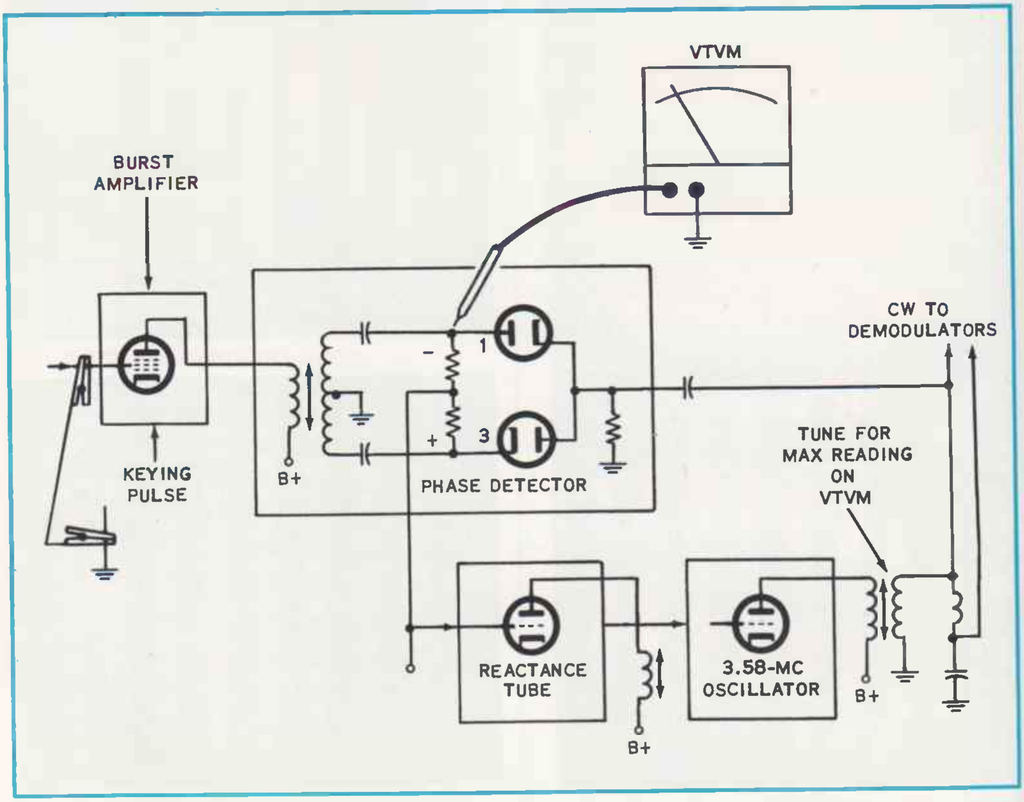


FIG. 9-3. Step 1 of the AFPC alignment procedure.

Step 1. Tune the 3.58-mc oscillator transformer.

Equipment connections

a. Short the grid of the burst amplifier to ground with a very short clip lead.

b. Connect the probe of the VTVM to the cathode of the phase detector diode that is coupled to one side of the burst transformer.

These connections are shown in Fig. 9-3. In late-model RCA receivers, the VTVM is connected to pin 1 of the phase detector diode.

Adjustment

Tune the core of the transformer in the plate circuit of the oscillator to produce maximum negative voltage reading on the VTVM. A typical reading is —45 volts. (About +45 volts is developed at the other side of the phase detector, at pin 3.)

Observations

In this step you adjust the 3.58-mc oscillator for maximum output. Your indicator is the rectified signal appearing at one side of the phase detector. Note that the burst signal is shorted out, so that the only signal fed to the phase detector is from the 3.58-mc oscillator. If there is no d-c voltage developed at the phase detector at this step, the oscillator, or its coupling circuit to the phase detector is suspect. (An inoperative oscillator results in a no-color symptom.) Check the oscillator to see if it is operating. A negative d-c voltage at the oscillator control grid (about —6 volts) indicates an operating oscillator. If the oscillator is working, but no d-c voltage is developed at the phase detector, check the phase detector tube. An oscilloscope check (wide-band oscilloscope) may be used to see if the 3.58-mc signals are reaching the phase detector.

Step 2. Tune the burst-phase transformer.

Equipment connections

a. Remove the short from the grid of the burst amplifier.

b. Leave the VTVM connected as in Step 1.

Tune the core of the burst-phase transformer for maximum reading on the VTVM. Refer to Fig. 9-4.

Observations

At the moment that the clip lead is removed from the grid of the burst amplifier, the VTVM should show a sharp increase in deflection. If the VTVM reading does not increase, and the adjustment of the burst-phase transformer has no effect on the meter deflection, then burst signals are not arriving at the phase detector. Burst signals are present at the input to the burst amplifier if the receiver is making color (even though color is out of sync), so that a fault is localized to the burst amplifier itself. The next thing to do is to check the burst amplifier tube, followed by pin voltage checks to determine d-c operating conditions. Use an oscilloscope to check for the presence of horizontal keying pulses at the burst amplifier (pin 1, the control grid, in late-model RCA receivers.) Remember that the burst amplifier is normally cut off and is keyed into conduction during the burst intervals. Loss of the keying pulses renders the burst amplifier inoperative. Errors in the *timing* of the keying pulse at the burst amplifier sometimes cause complete or partial loss of the burst signal. In this case the keying pulse arrives too early or too late with respect to the burst signal. Faulty adjustment of the horizontal AFC system (misadjusted sine-wave coil) can cause this condition. Make a routine check of the alignment of the horizontal AFC circuits. In a few cases an open 27-$\mu\mu$f capacitor, that couples a pulse from the high-voltage transformer to the horizontal phase detector, has been the cause of a large phase error in the horizontal AFC system and a resulting malfunction of proper keying.

To check for proper keying action in the burst amplifier with an oscilloscope, observe the burst signal at the plate of the burst amplifier. Clip the ground lead of the oscilloscope to the cathode of the burst amplifier (not to the chassis) when observing this waveform.

Step 3. Tune the reactance coil.

Equipment connections

a. Ground the output of the phase detector with a clip lead as shown in

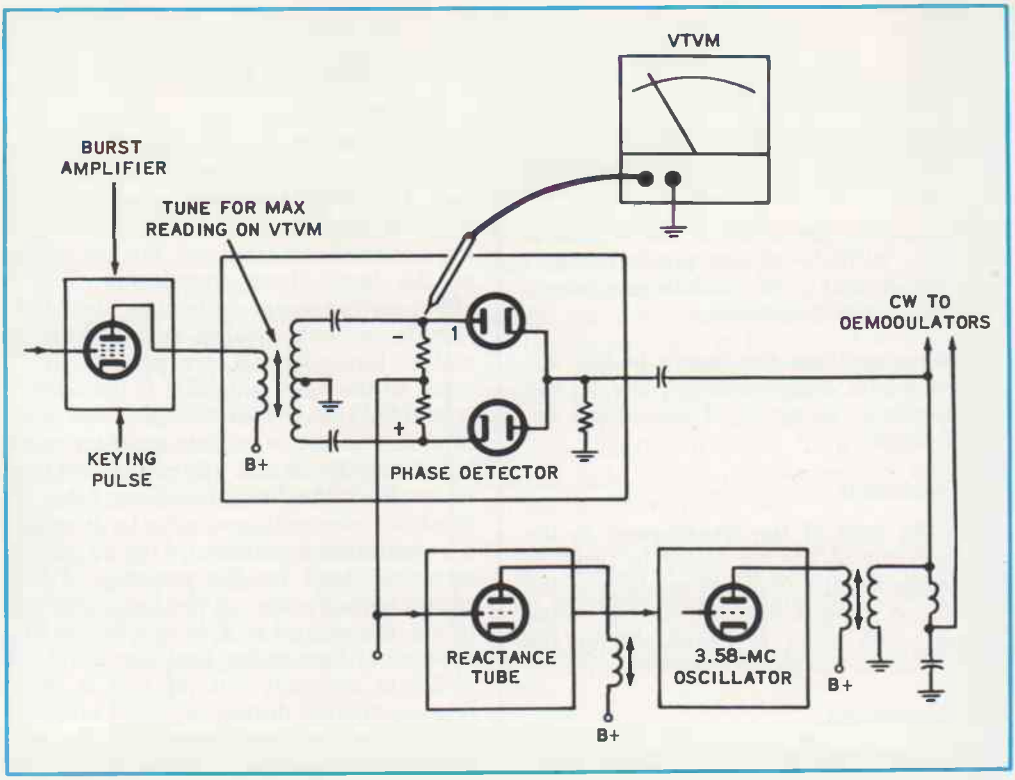


FIG. 9-4. Step 2 of the AFPC alignment procedure.

Fig. 9-5. A test point is usually provided in the circuit for this purpose.

Adjustment

Look at the picture and adjust the core of the plate coil of the reactance tube to make the oscillator free-run at the correct frequency. Tune in the direction that reduces the number of horizontal bands of color. As the correct setting is approached, colors become uniform but change hue slowly. When looking at the color-bar pattern, the bars are a uniform hue throughout their length, but change hue slowly. Technicians sometimes refer to the condition where the oscillator frequency is very near the correct frequency as the "zero beat" condition.

Observations

In this step you find out if the local subcarrier oscillator can run at 3.58-mc. Correction voltage is reduced to zero by shorting the output of the phase detector to ground. Hence, the system will not try to correct the oscillator frequency, and you can see what the oscillator can do all by itself. If it is not possible to obtain the "zero beat", mentioned under *adjustment*, the frequency-determining components of the oscillator are defective. Included in these frequency-determining components are the 3.58-mc crystal, the plate circuit of the reactance tube, and the rest of the reactance tube circuit.

Step 4.

Remove the jumper from the output of the phase detector. Color should now lock solidly. If there is no change, that is, if the zero-beat condition set up in Step 3 does not change, the reactance tube circuit is suspect. If a large frequency error (many colored bands) occurs when the jumper is removed, the phase detector is unbalanced. Imbalance may occur if only one diode of the phase detector is conducting. Imbalance causes a steady d-c error voltage to be developed by the phase detector, even when there is no frequency error. This d-c voltage, applied

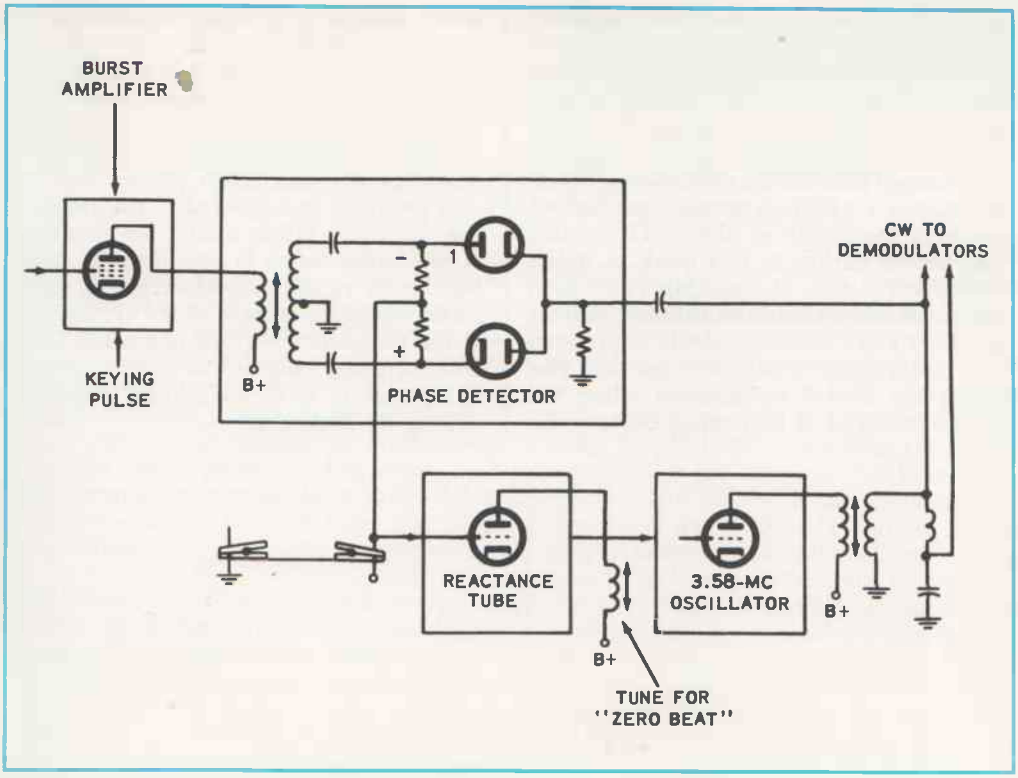


FIG. 9-5. Step 3 of the AFPC alignment procedure.

to the reactance tube, shifts the frequency of the oscillator. Hence, if removing the jumper at the output of the phase detector causes an increase in frequency error, check the components of the phase detector.

Phase Adjustment. The final step in alignment of the AFPC system is adjustment of master phase. This is accomplished by a readjustment of the core of the burst-phase transformer. Correct adjustment is obtained when correct R-Y, B-Y, and G-Y signals are produced at the picture-tube control grids. Methods of checking phase were shown earlier in this book.

Performance Checks of the AFPC System. The RCA WR-64A generator provides a unique way of checking the sensitivity of the AFPC system. The CHROMA control on the generator makes it possible to adjust the amplitude of the 3.58-mc color-bar signal with respect to the Y components (sync) of the signal. Normally, the CHROMA control is set at 100%, which gives the correct relative amplitudes for the chrominance and Y signals. As this control is turned counterclockwise from the 100% position, the amplitude of the 3.58-mc color-bar signal drops. Since the first color-bar is used as burst by the receiver, the generator CHROMA control effectively varies the burst amplitude as well as color saturation in the visible bars.

The effect of turning down generator CHROMA is the same as turning down the COLOR control on the receiver except that burst also drops in amplitude. The color-bars show reduced color saturation and finally color disappears. If the AFPC system is working correctly, color remains locked in sync until the point where color just about disappears. The exact CHROMA setting at which colors run diagonally or break up varies somewhat with receiver models. However, poor color-sync action is indicated if colors fall out of sync when the CHROMA control is turned down slightly from the 100% position.

Check the Range of the TINT Control. Another way of checking the performance of the AFPC section is by observing the results of turning the TINT (hue or phase) control through its entire range. The TINT control should provide a total change in the phase of the 3.58-mc oscillator of about 60 degrees ($\pm 30°$). A precise method of checking the range of the TINT control was shown earlier in this book. A quick and effective way of checking TINT control range can be made as follows: Adjust the TINT and COLOR controls to produce a normal, full-color color-bar pattern. The fourth bar should be magenta when the TINT control is at mid range. Rotate the TINT control fully counterclockwise and then fully clockwise. All hues will shift laterally. The magenta bar should move to the third bar position and then to the fifth bar position. Each time a particular hue moves one bar position, a change in phase of 30° has taken place. Improper AFPC action is indicated if the range of the control is either limited or excessive. A minimum range is specified as $\pm 30°$. Maximum range is seldom given, but a phase change in excess of 90° is too large. If the range of the TINT control is incorrect, or color falls out of sync when the TINT control is turned, AFPC alignment should be rechecked.

WHEN TO INSTALL A NEW TRICOLOR PICTURE TUBE

The decision to replace a color picture tube is not made lightly. The picture tube represents a substantial investment for your customer, and replacement requires quite a bit of your time. You'll want to make sure the picture tube is indeed at fault before you change it. Fortunately, modern color picture tubes have been engineered to provide long, trouble-free service and you will not meet this problem often.

No "New" Troubles. You might expect all sorts of unfamiliar trouble symptoms with color picture tubes. However, color picture tubes fail for the same reasons as black-and-white picture tubes. Common faults are the familiar conditions caused by low emission and leakage and shorts between control elements.

Examine Each "Picture Tube" Separately. For troubleshooting purposes, the color picture tube may be thought of as three independent picture tubes in one envelope. You can look at the picture produced by any one of the tube "sections" by biasing off the electron guns of the two remaining sections. Familiar conditions, such as low emission, can then be recognized. The Convergence Grid Shunt Switch is used to examine each picture-tube section separately.

Identify the Faulty Section. It is extremely unlikely for some fault to occur in all three guns of the picture tube at the same time. In most cases one of the guns is at fault. Failure of one gun always upsets color balance, and the black-and-white picture displays an excess or deficiency of one primary color. For example, a picture with a red, or green, or blue "cast" points to excessive beam current in one of the guns. A picture with a yellow, or cyan or magenta "cast" suggests low beam current in the blue, red, or green guns respectively.

Check Black-and-White Setup. Make a routine check of the black-and-white setup adjustments whenever you are faced with hue imbalance in the black-and-white picture. Many picture tube and picture-tube circuit failures are localized in this way. In addition to localizing the fault to a particular electron gun, you may be able to spot the nature of the fault. For example, a gun which cannot be cut off might have a grid-cathode short. When you have localized the fault to a particular gun, and the trouble cannot be corrected with the setup controls, bias off the remaining guns and examine the picture produced by the faulty gun. The next step is to decide whether the picture tube or its controlling circuit is at fault.

The next few paragraphs describe the troubleshooting approaches. The problem is divided into two general conditions: lack of one primary hue (low gun-emission), and an excess of one primary (excessive gun-emission.)

Emission and Cutoff Troubles. Low emission and changes in the cutoff voltage in one of the electron guns can result in similar trouble symptoms. Low emission results from deterioration of the cathode surface. Changes in cutoff occur when the mechanical positioning of the control elements of the gun changes. It is easy to localize the fault to an emission or cutoff trouble in those receivers equipped with NORMAL/SERVICE switch (RCA CTC-10 and later.) Follow the regular setup procedure given earlier in this book. Low emission is indicated if the following conditions arise: (1) Cutoff can be set correctly (dim horizontal line of each primary hue with NORMAL/SERVICE switch in the service position.) (2) Picture lacks one primary color in highlights (switch in normal position) even if drive control associated with the hue that appears to be lacking is set to maximum.

A change in cutoff is indicated if you can get any light at all from each primary hue, but it is impossible to set cutoffs accurately (switch in the service position). It seldom happens that cutoff changes so much that you cannot adjust cutoff correctly within the normal range of the screen-grid controls and the picture-tube bias controls. [Leakage problems can affect the operation of the setup controls. A test for leakage will be shown later in this book.]

Circuit troubles can also cause the symptoms noted in the previous paragraphs. Make a routine check of screen grid voltages and control grid-to-cathode voltages for each gun. In late-model receivers, check the video drives to each gun with a calibrated oscilloscope. Drives should be about equal with all drive controls set to maximum. A VOM set to the *output* position to read a-c voltage can be used to get a rough video drive reading. The actual voltage read in this fashion is unimportant, but you should get the same reading at all three cathodes when all drive controls are set to maximum.

Other Symptoms of Low Emission. You have no doubt replaced many black-and-white picture tubes that have had low cathode emission. The symptoms are familiar: (1) dull picture; (2) highlight areas of the picture turn "silvery" (display a metallic sheen) when brightness or contrast is advanced beyond a certain point; (3) detail is lost in the bright parts of the picture as brightness or contrast is turned up (faces become gray "blobs"); (4) the conditions noted in 1, 2, and 3 improve slowly as the picture tube warms up. The picture may be almost normal after about one-half hour of operation.

Point 4 is useful in spotting low emission. For example, suppose that the black-and-white picture is cyan in the highlights at first (indicating loss of red), but becomes almost normal after the set is on for twenty minutes or so. Low emission in the red gun is indicated. However, you should check for the other symptoms of low gun-emission before drawing any conclusions. Allow the set to cool off for a half hour or more and then bias off the remaining guns and look at the suspected primary-color image (red in this example.) Advance the brightness control and look for signs of the metallic-sheen effect and evidence of limiting in the brightest parts of the picture. Limiting causes the peak white parts of the picture to be clipped or compressed.

The effects of loss of emission in the green and blue guns can sometimes be corrected by rearranging the cathode circuits of the picture tube. For example, loss of emission in the green gun might be noted when the picture lacks green in the highlights and the condition cannot be corrected with the setup controls. By interchanging the cathode leads to the green and red guns, the highest-amplitude drive signal (usually applied to the red gun) is applied to the green gun. This circuit change permits you to extend the useful life of the picture tube. The same considerations apply for loss of emission in the blue gun. Severe loss of emission, in which limiting occurs (causing metallic sheen), can be corrected only by replacing the picture tube. Limiting is caused by saturation of the suspected gun. If these symptoms of low emission are observed, the picture tube should be replaced.

Picture tube brighteners, or boosters, are impractical for color picture tubes. The heaters are not independent, so you cannot boost the output of one gun without also boosting the outputs of the remaining guns.

High Output-One Primary. In this case the black-and-white picture shows a general excess of one primary hue. The condition may change radically as the brightness control is rotated. Here again, many types of circuit faults can cause this condition. However, the most common picture tube fault is shorts, or leakage between control elements. Leakage between grid and cathode, for example, causes a reduction in bias and an increase in gun conduction. The symptom of this type of fault is an excess of one primary hue in the monochrome picture. In addition, the affected gun remains conducting when brightness is turned all the way down.

A simple test localizes the cause of incorrect bias to either the picture tube or its controlling circuits. Simply measure the control grid-to-cathode bias as shown in Fig. 10-1. The voltmeter is connected di-

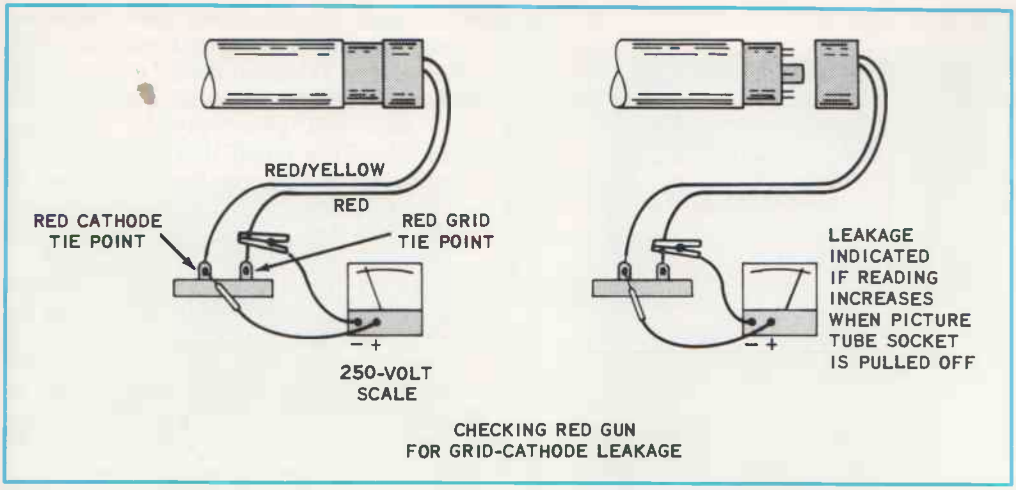


FIG. 10-1. A way of spotting control grid-to-cathode leakage in the picture tube.

rectly across the grid-cathode leads of the picture tube socket (not between grid or cathode and ground. Turn the brightness control fully counterclockwise and note the voltage reading. Keep the voltmeter connected as shown in Fig. 10-1 and pull the socket off the base of the picture tube. Hold the plastic part of the socket carefully as you pull off the socket, and do not allow your finger to touch the base pins. If the reading of the voltmeter *changes* when the socket is pulled off, there must be some internal leakage between control grid and cathode (or between cathode and heater) in the picture tube. If bias does *not* change when the socket is pulled off, the fault must be somewhere in the control grid or cathode circuits.

Picture tubes with shorted or leaky elements should be replaced. Various systems for clearing shorts have been used in the field, but the cure is usually temporary and results in an early callback.

Picture Tube Testers. A suitable picture-tube tester is a valuable tool for localizing a spent electron gun. In addition, a good emission tester is a great aid to customer relations, as you can demonstrate to the customer that his picture tube should or should not be replaced. However, choose a picture tube tester with great care. Many commercial testers do not do an adequate job on color picture tubes. Some make emission tests with lower-than-normal heater voltage. Tests made with low heater voltage often make good picture tubes, or even brand-new tubes, appear to be bad. Many picture-tube testers do not incorporate provisions for setting the cutoff bias for each gun. Such testers often indicate that one gun may be weak when the actual emission for all three guns may be perfectly normal. Correct adjustment of cutoff bias is vital for making accurate emission tests.

The RCA WT-115A Color Picture Tube Tester. This new instrument, shown in Fig. 10-2, satisfies the requirements of the picture-tube manufacturer and performs a conclusive test of tube performance. It checks leakage between control elements, and checks emission properly — after the correct cutoff condition has been set. Tests are performed in time sequence. One test is made two minutes after a cold start (after power is initially applied). The test is then repeated four minutes after power is applied. The results of these tests give a clear and definite picture of electron gun performance.

Other Picture Tube Troubles. It is possible for misalignment of the electron guns to make it impossible to produce good purity. A warped or buckled shadow mask can have a similar effect. However, these conditions are exceedingly rare, and you should make sure that you have care-

FIG. 10-2. The RCA WT-115A Color Picture Tube Tester.

fully followed the degaussing and purity setup procedures before you consider changing the picture tube.

Replacement Picture Tubes. Color picture tubes are not interchangeable. Mechanical considerations, such as faceplate dimensions and mounting methods, account for significant differences between picture tubes of different types. Hence, in most cases you must use exact replacements. In a few instances, the production of a particular type may be discontinued. In these cases, the manufacturer makes provisions for a substitution. An example is the discontinued type 21AXP22 (metal cone). This picture tube is now replaced with type 21CYP22. A mounting kit, containing the necessary mounting hardware, is available from distributors.

Video Drive Considerations for Replacement Picture Tubes. The cathode circuits of most color receivers are arranged so that the red electron gun receives maximum video drive. However, it is possible that some picture tubes, when new, require that the green gun have maximum video drive. Unless some provision is made in the drive circuits, a new picture tube will lack green (appear magenta) even when the green drive control is at maximum. To remedy this situation, interchange the red and green cathode leads at the tie points on the chassis.

Replacing the Picture Tube. Detailed, step-by-step procedures for replacing the picture tube are found in the instruction manuals for all receivers. Wherever possible, you should have a copy of the instruction book handy when you change a picture tube. However, the job can be done without the instruction book if you take careful note of the way in which parts are assembled on the old picture tube, and make sure all parts, shields, and other assemblies are installed on the new one in exactly the same way. A very general procedure and some helpful hints are given in the next few paragraphs.

Chassis Removal. The first step in replacing a picture tube is removal of the chassis. Disconnect all leads that connect from the chassis to the tube—yoke leads, socket, high-voltage lead. The high-voltage connects to the ultor button in the same way as high-voltage connections are made to black-and-white glass picture tubes. In older receivers, high-voltage connections to the picture tube are made under a special plastic shield. The high-voltage lead in these older receivers is unplugged at the high-voltage cage.

Disconnect or unplug cables that lead to the convergence board, the speakers, and the tuner and remote-control chassis (if necessary). Remove the tuner from the cabinet if necessary. Remove the knobs and chassis mounting bolts and lift the chassis out of the cabinet.

Remove Picture Tube Components. Remove the blue-lateral magnet, the purity magnet, the convergence yoke and the deflection yoke. Take careful note of the positions of all these components so that you can replace them at the correct positions on the new tube.

Position the Cabinet for Picture Tube Removal. The cabinet should be positioned so that it is face-down on the floor when you remove the tube. Use a thick blanket or other suitable pad to cushion the cabinet. A rolled pad, as shown in Fig. 10-3, protects the cabinet from damage.

FIG. 10-3. Position of the cabinet for removal of the picture tube.

Remove the Picture Tube. In late-model receivers (those with the conventional type of high-voltage connection at the picture tube) the tube and its mounting harness are lifted out of the cabinet as one piece. In older receivers the mounting harness must be removed first, and then the tube can be lifted out. Remove the bolts or screws that secure the harness to the cabinet. To remove the picture tube, stand near the top of the cabinet and brace your feet in a wide stance. The color picture tube is quite heavy (the 21FJP22 weighs **43** lbs.) and you should stand so that the weight of the tube will not throw you off balance. *Caution*— wear protective goggles and keep other people out of the room when you handle the picture tube.

Reach down into the cabinet and grasp the harness or the rim of the picture tube with both hands. Lift the tube straight up out of the cabinet, tilting if necessary to clear the cabinet rails, as shown in Fig. **10-4**. Place the tube face down on a padded surface. At this point, unpack the new picture tube and stand it face down on a padded surface.

Identify the Blue Electron Gun. Before you transfer the mounting harness and other assemblies, such as high-voltage leads and shields (on older tubes), identify the blue guns in both old and new picture tubes. Position the tubes so that both

FIG. 10-4. Lifting the color picture tube out of the cabinet.

blue guns are in the same relative positions. Figure 10-5 shows how to spot the blue gun by noting the position of the key on the picture tube base. The small pole piece for the blue-lateral magnet also identifies the blue gun. Small glass bumps are found on the rim of newer color picture tubes to identify the gun positions. Figure 10-6 shows the position of the blue gun and the glass bump that identifies the "top" of the color picture tube. This glass bump is useful in positioning the color picture tube in the cabinet.

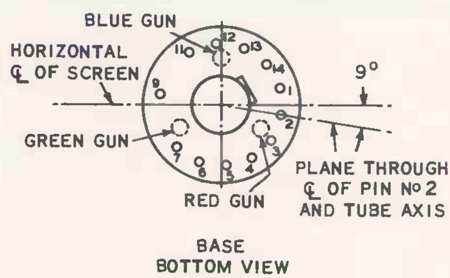


FIG. 10-5. Electron gun positions with respect to the pins on the picture-tube base.

FIG. 10-6. Note the relative positions of the blue electron gun, the anode connection, and the glass bump on the rim of the color picture tube.

Transfer the Harness. Remove the harness from the old picture tube, noting its position on the old tube, and place it on the new tube. Tighten the harness strap bolts to secure the harness in place. Correct positioning of the harness is indicated when a small hole in the top-center of the harness strap is over a U-shaped mark embossed on the glass rim of the glass envelope as shown in Fig. 10-7. On older color picture tubes the high-voltage lead and various plastic shields are transferred from the old tube to the new one at this point. Make sure that you note how these parts were mounted on the old tube.

FIG. 10-7. Correct placement of the mounting harness on the color picture tube.

Replace the Color Picture Tube. Position the picture tube so that the blue gun is towards the cabinet top. Lower the tube into the cabinet and position the tube so that the blue gun is uppermost. Use the glass bump that shows the relative position of the blue gun as a guide.

The bump should be positioned so that it is directly over the centerline of the tube. Install and tighten the bolts that secure the harness to the cabinet. In older receivers the shields and pull-up ring are installed and tightened so that the picture tube is held securely against the mask.

Replace Picture Tube Components and the Chassis. The cabinet can now be returned to the upright position. Replace the components on the neck of the picture tube (yoke, convergence yoke, purity magnet, blue-lateral magnet). Replace the chassis and other components that may have had to be removed.

SERVICING TECHNIQUES

The way in which you will handle color service calls will depend largely upon the bench facilities in your shop. Many large service organizations do little "under-the-chassis" troubleshooting in the home, but provide the test setups needed to work on the customer's chassis in the shop. A complete color bench setup includes a color picture tube, deflection yoke, and other components needed to allow full operation with only the customer's chassis. Unless your shop has these facilities, you must be prepared to do nearly all service work in the home. As a last resort, the entire receiver may be taken to the shop. But this is poor business, as two men are required to transport a complete receiver, and the cabinet is subject to damage.

Troubleshooting in the Home. In addition to routine tube substitution, a great deal of work can be performed in the home. A very large part of the necessary voltage, resistance, and waveform checks can be made from the *top* of the chassis. Thus, faults can be localized without pulling the chassis out of the cabinet. This is especially true of late-model RCA receivers, which have a narrow, horizontally-mounted chassis in which all circuits are within short reach of the rear of the cabinet.

The types of sockets used in the printed circuits allow all pin voltages to be measured from the top of the chassis, as was shown earlier in Fig. 8-4. Remember to count pins counterclockwise from the index space when counting from the top of the socket.

Printed circuit components are also located atop the printed circuit board, so that nearly all circuit tie points are available from the top of the chassis. Components and key tie points are identified by schematic symbol numbers printed on top of the printed circuit boards. It is possible, and advisable, to replace defective components on the top of a printed-circuit board, as shown in Fig. 11-1. This method of repair does no damage to the printed conductors. One printed circuit board, the video i-f board, is mounted below the chassis and is less accessible than the others. Tube pin voltages in the i-f board can be measured with the aid of test-socket adaptors. Figure 11-2 shows

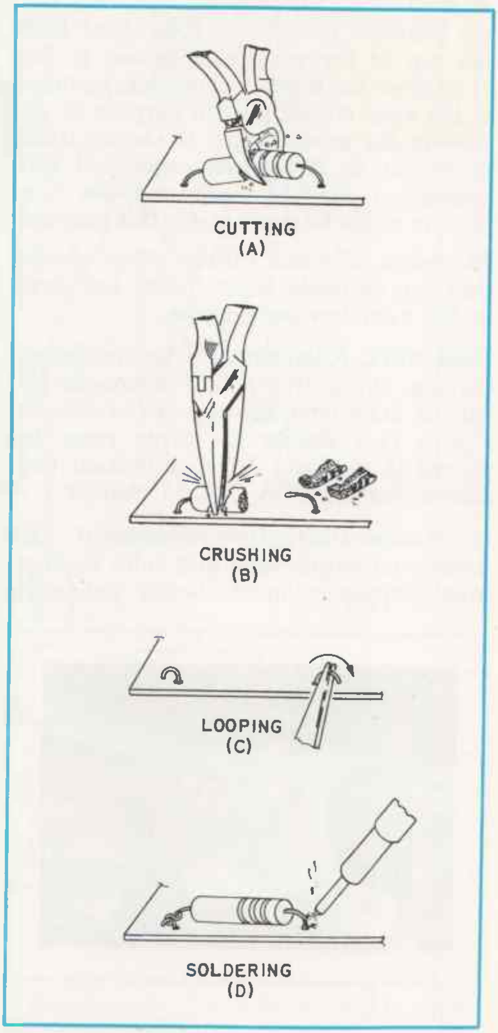


FIG. 11-1. Steps in making repairs on printed circuit boards.

FIG. 11-2. Test socket adapters.

the type of test-socket adaptor that can be used for this purpose.

An example of what can be done from the top of the chassis is shown in Fig. 11-3. Here the 0.005μf capacitor, installed in the sync circuit for the purpose of observing the green stripe, is shown (refer to Section 6). A capacitor equipped with permanent flexible leads and pin connectors might be made up for this purpose.

Examples of some of the other checks that can be made in the home are given in the next few paragraphs.

Field AFPC Alignment. In late-model receivers, the entire AFPC alignment job can be done from the top of the chassis. Figure 11-4 shows the three steps involved in the field AFPC alignment procedure for the RCA CTC-15 chassis.

Horizontal Deflection Alignment. The horizontal output tube in a color receiver must supply a much larger deflection

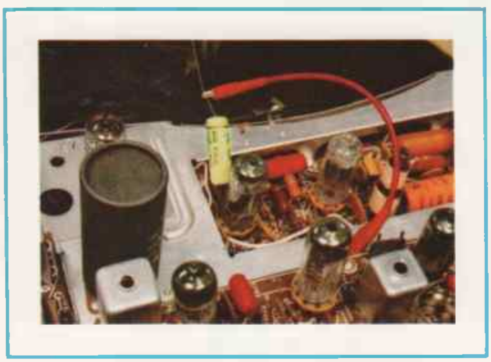


FIG. 11-3. Temporary connection of the 0.005-μf capacitor to observe the green stripe can be made from the top of the chassis.

power than the horizontal output tube in a black-and-white receiver. Deflection power requirement is greater due to the lower deflection sensitivity of the large-necked color picture tube. In addition, the horizontal output tube supplies the higher power requirements of the focus and regulated high-voltage supplies. For these reasons, the horizontal output circuit in a color receiver must be adjusted for a maximum in power efficiency. Careless adjustment of the horizontal circuit can result in excessive power dissipation in the horizontal output tube and decreased tube life.

When any service work or adjustments are required in the horizontal deflection or high-voltage circuits, it is a good idea to go through the short steps of the *horizontal-deflection alignment* procedure. Check the instruction manual for the exact procedure. The job is done in three stages. The first step is to set up horizontal AFC system. This procedure differs from model to model depending on the type of horizontal oscillator circuit. The second step is to monitor the cathode current of the horizontal output tube, and adjust the *horizontal-efficiency* coil for minimum cathode current. This is an important step, as you are adjusting the circuit so that the tube operates within its power dissipation ratings.

The horizontal efficiency coil in the color receiver controls the decay of current in the damper tube and affects the "crossover point" where deflection current is taken over by the horizontal output tube. This control is adjusted to produce maximum efficiency in the deflection system (maximum deflection with minimum power input). Horizontal efficiency is adjusted to produce minimum d-c cathode current in the horizontal output tube. Best horizontal linearity occurs at, or very near, this point. Slight changes in the setting of this control may be made to secure horizontal linearity, but the cathode current of the horizontal output tube should never be permitted to go above its designated maximum value. A typical maximum cathode current is 210 ma. If cathode current is high at all settings of the horizontal efficiency control, check the drive at the grid of the output tube with a calibrated oscilloscope. Low

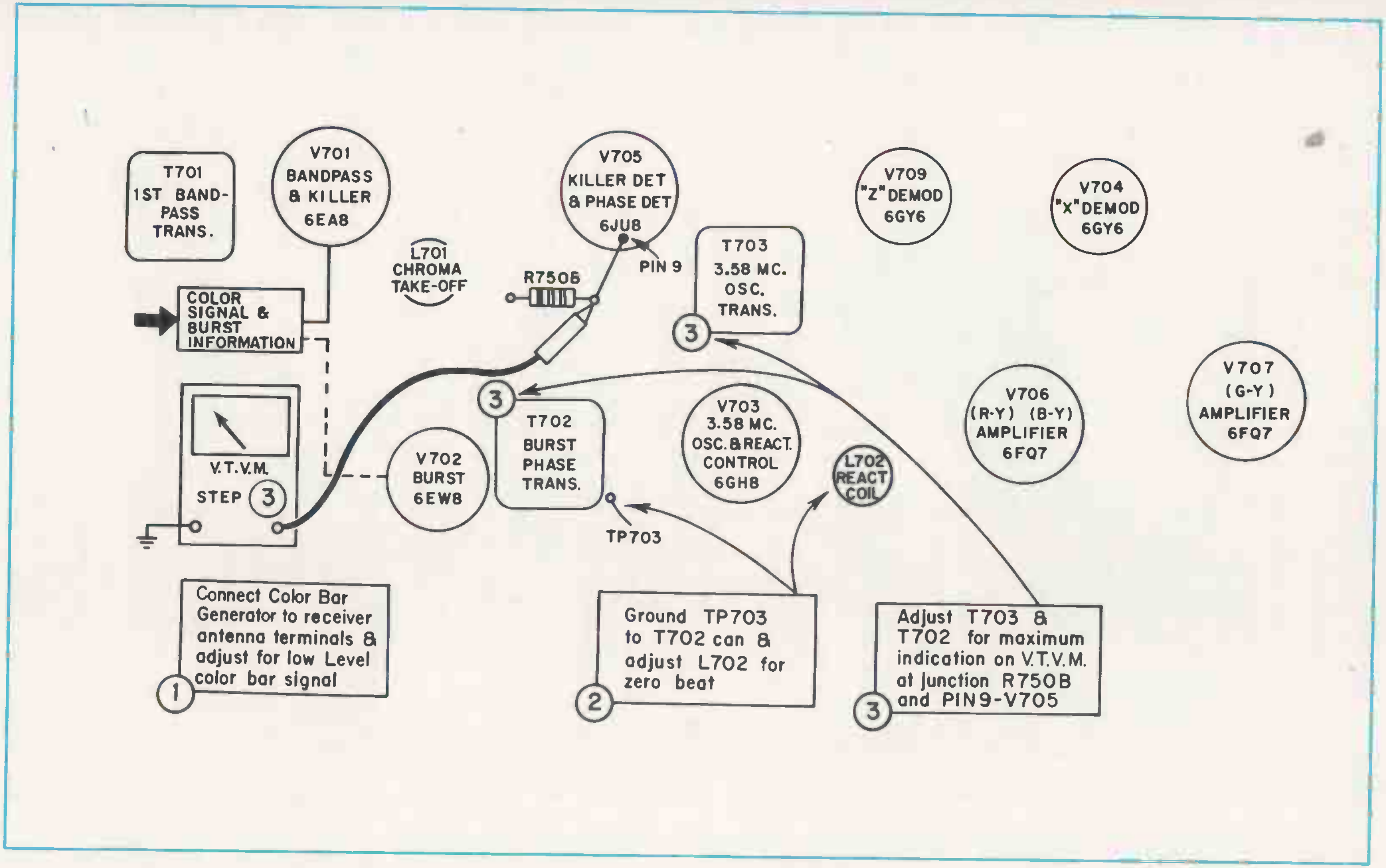


FIG. 11-4. Alignment of the AFPC system can be performed from the top of the chassis.

drive, caused by a weak horizontal oscillator, is a frequent cause of excessive cathode current in the output tube.

The third and final step of the horizontal alignment procedure is adjustment of the regulated high-voltage supply. This job is done while monitoring both the high-voltage at the picture tube and the cathode current of the high-voltage regulator. The high-voltage control is adjusted to produce the designated high-voltage (typically 24 kv). To check for proper regulator action, the brightness control is turned down to minimum so that the regulator tube assumes the entire load. Cathode current of the regulator should be above a specified minimum (typically 850 μa) at this time. If cathode current is too low, the horizontal efficiency coil may be readjusted slightly to secure the designated minimum regulator cathode current. (Monitor the horizontal output tube cathode current when readjusting the efficiency coil to make sure that the horizontal output tube cathode current does not exceed 210 ma.)

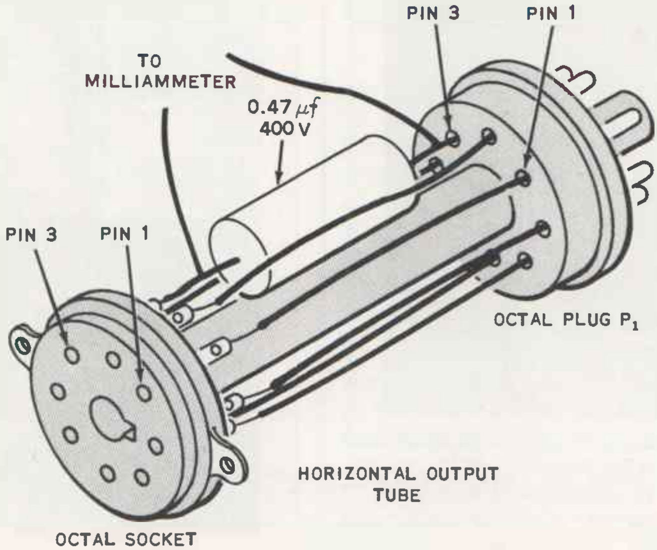
The horizontal-deflection alignment job requires current meters to be inserted into the cathode circuits of both the horizontal output tube (a 0 to 500-ma meter) and the high-voltage regulator (a 0 to 10-ma meter). Removable wire links are provided at or near the sockets of these tubes for the purpose of inserting the milliameters. Fortunately, it is seldom necessary to remove the chassis from the cabinet in order to insert the meters. Most chassis (RCA receivers since the CTC-7) have the horizontal output tube and shunt regulator mounted near the rear apron of the chassis. It is only necessary to pull the chassis out part way. The chassis can be pulled out far enough, without disconnecting any leads, to allow access to the necessary tube sockets. Install a 0.47-μf capacitor between cathode and chassis at the horizontal output tube when measuring current in this tube.

Test Sockets. You may speed the horizontal alignment job by providing yourself with test-socket adaptors. These can be made from an octal plug and socket as shown in Fig. 11-5. Keep the spacing between plug and socket as short as possible. If the tube stands too high in its socket, you may not be able to connect the plate cap. The entire assembly should be taped or covered with plastic sleeving to eliminate shorts or shock hazard. The bypass capacitor prevents the meter from adding appreciable a-c impedance to the cathode circuit and eliminates radiation from the meter leads. Adaptors of this type can be used with all receivers up to the CTC-12 models. A nine-pin novar type socket and plug is required for the horizontal output tube in CTC-15 and later models. Several types of octal plug-and-socket assemblies, with fixed spacers between the plug and socket, are available commercially.

Chassis Removal. If trouble cannot be localized with top-of-the-chassis checks it will be necessary to operate the receiver with the chassis out of the cabinet. To remove the chassis, it is necessary to disconnect all leads between the chassis and the picture tube. Leads to be disconnected are the high-voltage lead, the picture tube socket, and leads to the deflection and convergence yokes. It is also necessary to unplug the speaker cable, and in some cases to disconnect or remove the tuner.

If the tuner is mounted on the cabinet, it will be necessary to either remove the tuner along with the chassis, or disconnect the tuner. In late-model RCA receivers, the tuner may be removed from its mount on the cabinet and transferred to temporary mounting screws at the rear apron of the receiver. This allows the tuner and chassis to be removed as one unit, and all connections between tuner and chassis remain intact. Figure 11-6 shows the tuner in the "service" position on a CTC-15 chassis.

To operate the chassis outside the cabinet, it is necessary to reconnect all leads to the picture tube. A complete set of extension cables allows maximum flexibility, and allows the chassis to be mounted in any convenient position. Figure 11-7 shows one way of mounting the chassis that provides easy access to all parts and permits you to stand erect while troubleshooting. A *thick* pad is needed on the cabinet top to prevent any possibility of cabinet damage.



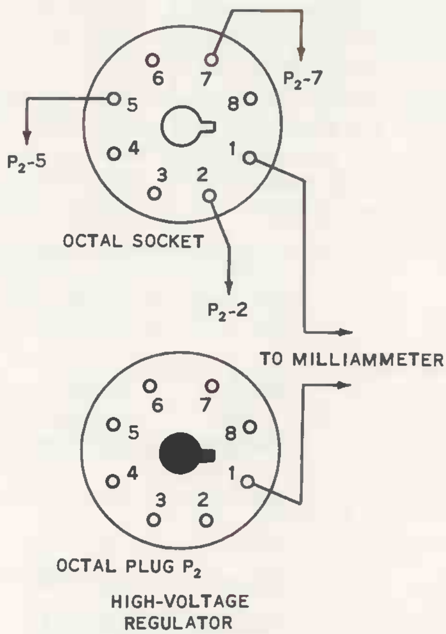


FIG. 11-5. Test adapters allow convenient checks of the cathode currents of the horizontal output tube and the high-voltage regulator.

FIG. 11-6. Tuner in the service position on the RCA CTC-15 chassis.

FIG. 11-7. One way of positioning the chassis for easy troubleshooting. A thick rug or pad is needed to protect the cabinet top. Extension cables are needed for the picture tube socket, the deflection yoke, and the high-voltage lead.

Extension cables are needed for the picture tube socket, the deflection yoke, the convergence assembly, and the high-voltage lead. Table 11-1 gives a list of extension cables by RCA part number for a large number of receivers. For complete freedom of action, on all RCA receivers, a total of seven cables is needed. No special cable is needed for the high-voltage lead in late-model receivers. An ordinary clip lead, dressed so that it is positioned away from metal parts, does the job.

Although extension cables are helpful, a complete set is not absolutely necessary. You can do an adequate job with a few leads. First of all, you may dispense with dynamic convergence correction in most

RCA Extension Cables
RCA Chassis Number

Extension Cable	CTC-4 (600 Series)	CTC-5 (700 Series)	CTC-7, 9, 10	CTC-11, 12, 15
Picture Tube Socket	220X1	220X1	220X1	220X1
High-Voltage Lead	223X1	225X1	225X1	*
Deflection Yoke	221X1	221X1	228X1	228X1
Convergence Assembly	222X1	224X1	221X1	221X1

*insulated clip lead

TABLE 11-1

cases. If you are working on a problem of sync, deflection, AGC, color, etc., you will not need a perfectly converged picture in order to see the trouble symptoms. Thus, you may leave the lead between the chassis and the dynamic-convergence assembly disconnected. However, in many receivers, if the lead between the chassis and the convergence assembly is disconnected, the cathode circuit of the vertical output tube is not completed to ground (hence no vertical deflection). This is true of all RCA receivers that employ the separate dynamic convergence control board (all sets since the CTC-7). Proper operation of the vertical circuit can be restored in receivers of this type by shorting pins 1 and 2 on the octal convergence socket together. Refer to Fig. 11-8. An octal plug with pins 1 and 2 jumped together can take the place of the plug on the convergence cable, and permits near normal operation of the vertical circuit.

By placing the chassis on a low stool, or a box, behind the cabinet, it is sometimes possible to make some of the remaining picture tube-chassis connections without the use of extension cables. Figure 11-9 shows how the chassis may be arranged so that all but the high-voltage connection can be made without the use of extension cables. A clip lead, dressed so that it is not close to the chassis or any metal parts, completes the high-voltage connection to the picture tube.

If it is necessary to extend one or all of the deflection-yoke leads, it is possible to use ordinary clip leads. The newer deflection yokes employ tab connectors that are plugged into sockets on the rear rim of the yoke. An ordinary alligator clip can be used to connect to the small metal (male) tab on the yoke sockets, and to the female tab connectors on the ends of the yoke leads.

The Shop Setup. At least one bench in the shop should be set up for color work. A mock-up or test jig containing all the components of the receiver, *with the exception of the chassis,* is required. Figure 11-10 shows the RCA color test jig, available from the RCA Electronic Parts distributor. It contains a deflection yoke, purity and convergence components, and all the cables needed to make connections with the chassis. Some shops use more than one test jig. An extra test jig is almost a necessity when color sets must be "cooked" in order to reveal intermittent troubles.

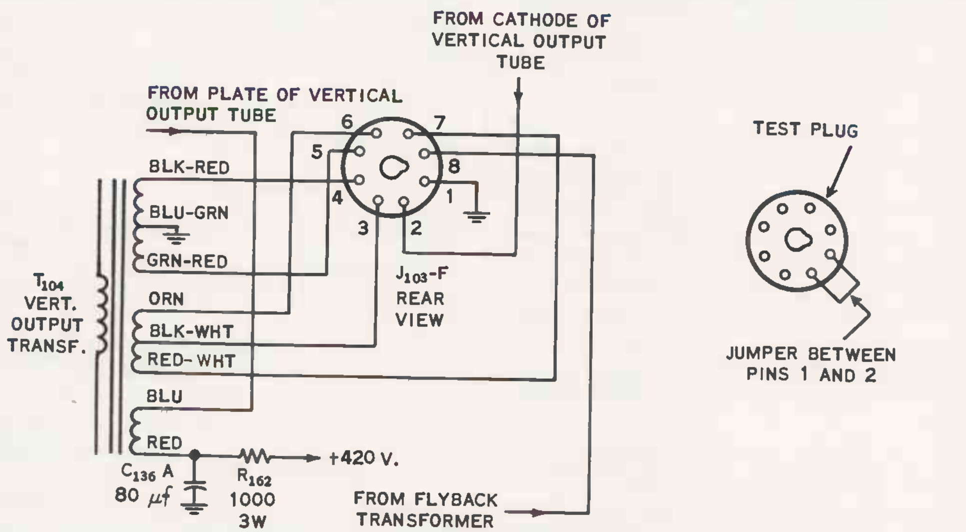


FIG. 11-8. To operate the receiver with the dynamic convergence board disconnected, jump pins 1 and 2 of the convergence socket together (on late-model RCA chassis).

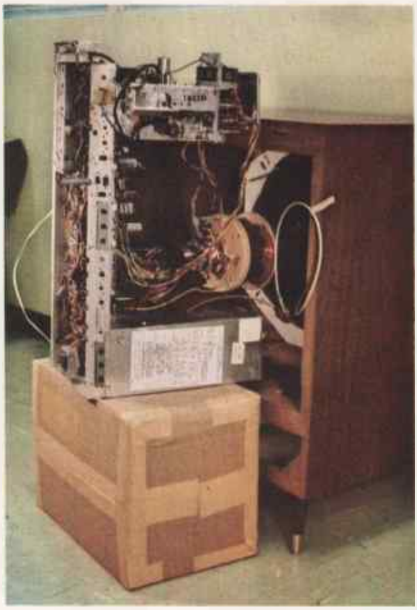


FIG. 11-9. This arrangement allows full operation of the chassis outside the cabinet with a minimum of extension cables.

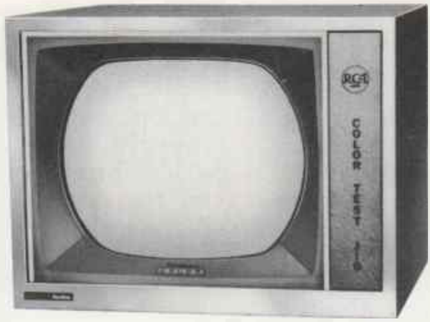


FIG. 11-10. RCA Color Test Jig.

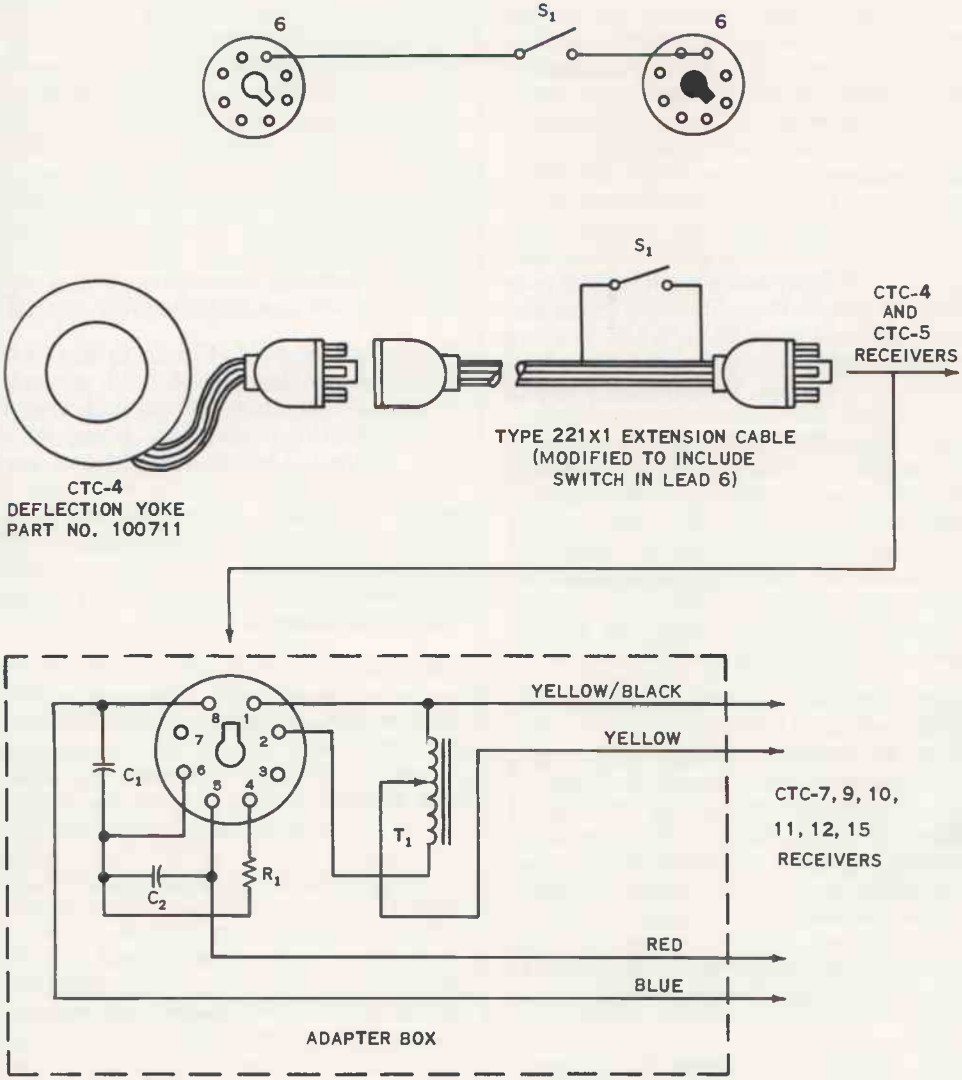
Universal Test Jigs. A small shop will require at least one "universal" test jig. This single test unit should accommodate as many different receiver models as possible. Larger shops may use several test jigs — each one adapted for use with a particular group of receiver models.

A valuable "universal" test jig is not too complicated electrically; connections need only be made between the chassis and the picture tube socket, the deflection yoke, and the high-voltage anode connection on the picture tube. Perhaps the toughest job is providing mechanical support and housing for the picture tube. The ready-made test jig of Fig. 11-10 is particularly attractive in this regard as it can save you a lot of carpentry headaches.

Let's see what sort of electrical connectors are needed in the test jig. One cable is needed to extend the leads from the picture tube socket. Nearly all color picture tube have the same base connections (an exception is the old 15″ picture tube) so that one cable will accommodate the base socket connections for a wide range of receivers. Deflection yoke connections differ from model to model. Older receivers employ an octal plug and socket while newer receivers (nearly all makes) employ individual leads that connect to single-terminal connectors on or near the yoke housing. Figure 11-11 shows how yoke connections can be adapted to accommodate a wide range of receivers. As each new model comes out, you will have to adapt the deflection yoke connections to the new chassis.

When using the universal test jig you cannot evaluate problems connected with deflection size, linearity, or yoke ringing. The test jig itself introduces faults in these areas. However, if you bring a customer's chassis to the shop with a deflection problem, make sure that you bring the deflection yoke as well. It is a simple matter to install the customer's yoke on the test jig.

High-voltage connections are easily arranged. A heavily-insulated lead from the anode connection on the test jig can be terminated in an ordinary alligator clip. This clip can be made to mate with the high-voltage connections on most chassis. You might have to install a paper clip, or some such device, into the jaws of the alligator clip at times to make connections with some of the different types of high-voltage terminals. Take particular care in arranging high-voltage connections. Make sure that the leads are dressed so that you will not come near exposed metal parts that carry the high voltage. Use a piece of heavy plastic sleeving to cover these exposed metal parts.



PARTS FOR ADAPTER BOX
T_1 - AUTOTRANSFORMER 120V INPUT, 0-120V OUTPUT, 0.15 KVA
C_1, C_2 - 470$\mu\mu f$, 2KV
R_1 - 4700Ω, 2W
OCTAL SOCKET
YOKE EXTENSION CABLE, TYPE 228X1, WITH FEMALE ENDS CUT OFF

NOTES
1. S_1 CLOSED FOR CTC-4 (600-SERIES) RECEIVERS, OPEN FOR ALL OTHER MODELS.
2. ADJUST T_1 FOR BEST VERTICAL LINEARITY AND READJUST VERTICAL HOLD TO STOP PICTURE.

FIG. 11-11. Deflection yoke connections for a universal test jig.

The test jig should be equipped with a convergence assembly that uses permanent magnets for static convergence. A PM purity magnet is also needed. This allows purity and center-convergence to be adjusted independently of the chassis under test. Dynamic convergence connections are unnecessary since you can observe nearly all trouble symptoms without the help of convergence correction at the screen edges. You might pick the dynamic convergence yoke that will match the receiver type that you are most likely to encounter (perhaps the present line). This will allow you to provide edge correction on at least some models. The only time that you will really need dynamic-convergence correction is when you are troubleshooting a fault in the dynamic-convergence system. In that case you will have to pull the customer's convergence yoke, along with his chassis, to the shop. If connections between the chassis and the convergence yoke are omitted, remember that the cathode circuit of the vertical output tube should be completed to ground. On all late-model RCA receivers, pins 1 and 2 of the convergence socket on the chassis should be shorted together for this purpose.

Routine Checks to Eliminate Call-Backs. When service is completed, or a color chassis is returned from the shop, it is a good idea to make a thorough check of receiver performance. A lot of time is wasted if you return a receiver after servicing the color circuits and are called back because the tuner needs tracking. Provide yourself with a check list and you will be less likely to forget the minor adjustment that might have had little to do with the original reason for the service call.

Before you have completed a color service call, make an inspection of the following aspects of receiver performance.

1. *Picture size and centering.* Check height, width, linearity and centering. A quick look at several different forms of program material will tell you whether linearity needs attention. Insufficient or excessive picture size, that cannot be corrected with normal service adjustments, might be caused by deflection circuit trouble. Incorrect high voltage can also cause abnormal picture size. Check high voltage with a VTVM equipped with a high-voltage probe. Consult the service notes for the correct value.

2. *AGC.* Switch to the strongest channel in your area and look for signs of overload (bends or weaving near the top of the picture). To adjust the AGC control, turn the control clockwise until the picture shows signs of bending at the top, then turn the control counterclockwise until all signs of picture bending just disappear. Similar symptoms are caused by misadjustment of the noise-inverter threshold control (in RCA CTC-9 and earlier models). Check the service notes for the correct way to set this control.

3. *Horizontal hold.* Check to see if the range of the horizontal hold control is normal. The picture should lock near the center of the mechanical range of the hold control. Change channels to see if the picture locks properly when the signal is interrupted. Rotate the hold control and look for signs of "squegging" — the rhythmic break-up or collapse of deflection that results from a misadjusted sine-wave stabilizing coil.

The picture should fall out of sync and go to at least three horizontal slanting bars before squegging is noticed. If the picture breaks directly into the squegging condition from the synced condition as you rotate the hold control, the horizontal AFC system requires adjustment. Consult the service notes for correct adjustment methods for each particular receiver model.

4. *Focus.* Raster lines should be clean and sharp. Adjust the focus control for sharp raster lines. Make sure, when adjusting focus, that brightness is not turned up so high that the picture is on the verge of blooming.

5. *Tuner tracking.* Check all active channels in the area and make sure that correct fine tuning is obtained near the center of the mechanical range of the control. If tracking adjustments are needed, make sure that you start with the highest-frequency channel when working with switch-type or incremental-inductance tuners, and work down to the lowest-frequency channel in sequence. No particular sequence is required in tracking

turret-type tuners. (Most RCA color receivers use the switch-type tuner.)

6. *Black-and-white tracking*. Rotate the brightness control and check for a neutral gray scale throughout the range of the control. If tracking is unsatisfactory, repeat the tracking procedure. On the newer receivers, those equipped with the NORMAL-SERVICE switch, the tracking procedure can be performed in a few seconds. On older receivers, note whether highlights or lowlights are off. In general, the *screen* controls are used to set color balance in the lowlights and the *background* controls are used to set color balance in the highlights.

Remember that adjustment of a screen control necessitates readjustment of the corresponding background control to maintain proper tracking throughout the range of the brightness control.

7. *Static convergence*. Check convergence in the center of the screen and readjust if necessary. With a little practice you can learn to set static convergence while looking at regular program material, using a black-and-white picture.

8. *Check purity*. Examine the black-and-white picture and look for an excess or deficiency of a primary hue at the screen edges. If purity is poor, try degaussing the receiver before you attempt to readjust the purity controls.

9. *Dynamic convergence*. Look for convergence errors at the top and bottom and sides of the picture. Confine your attention to the areas near the outer arms of an imaginary "cross" that is centered on the screen of the picture tube. If these areas are correct, convergence is set correctly. If errors show up only at the corners of the picture, there is less of a chance that you can make a worthwhile improvement by going over the dynamic convergence adjustments. If picture size, linearity, or centering were changed during the service call, you should touch up dynamic convergence.

10. *Color saturation control*. Make sure that you can "oversaturate" the colors of a color telecast by turning the COLOR control all the way up. Use a color telecast, the color-bar display from a portable generator, or the green stripe to make this check.

11. *Tint (hue, phase) control*. Make sure that proper phase (correct flesh tones) are obtained when this control is set near midrange. Check the range of the control by rotating the control fully clockwise and then fully counterclockwise. It should be possible to make flesh tones change from a yellowish green to purple. If you use a color-bar generator follow the instructions given earlier in this book.

12. *Color lock*. Generally, the locking action of the AFPC system is satisfactory if color remains in lock throughout the range of the TINT control, and a ± 30 degrees shift in phase can be obtained by rotating the TINT control. As an added check, you may couple the antenna lead loosely to the antenna terminals of the receiver to obtain a weak and snowy picture. Color synchronization should remain even though the picture is quite snowy. You may perform a better check by using the WR-64A color-bar generator. Turn the CHROMA control counterclockwise and note the action. Colors should remain locked in sync until the colors in the bars become quite pale.

13. *Color killer threshold*. Switch to an unused channel to obtain a snowy raster and look for signs of "colored snow" (COLOR control at mid range.) Adjust the COLOR KILLER THRESHOLD control until the color just disappears. (Receivers with non noise-immune color killers require a different setup procedure.)

Antennas and Installations. In most cases, an antenna installation that gives good reception for black-and-white receivers works equally well for color receivers. However, trouble with color reception is sometimes traced to the antenna and you should learn to recognize the effects of poor antenna response.

The important requirement of the antenna is that response be uniform over the bandwidth of each channel. Figure 11-12*a* shows the ideal response. A tilted response, as shown in *b* and *c* of the figure, can cause degradation of color reproduction. Remember that the AGC system in the receiver sets up on the amplitude of the picture carrier (AGC actually sets up a sync amplitude but most of the energy in the sync signal is in a band of frequencies near the picture carrier frequency). Hence, the gain of the receiver is determined primarily by picture-carrier amplitude. If the relative color subcarrier amplitude is raised or lowered in the antenna system, the amplitude of the chrominance signals in the receiver will be higher or lower than normal.

The COLOR control allows the viewer to compensate for changes in the relative amplitude of the picture and color signals. There is enough "reserve gain" in the bandpass amplifier to make up for some attenuation of the color signal, and gain can be lowered if the color signal is too large. However, a severe "tilt" in the antenna response can bring about the following symptoms:

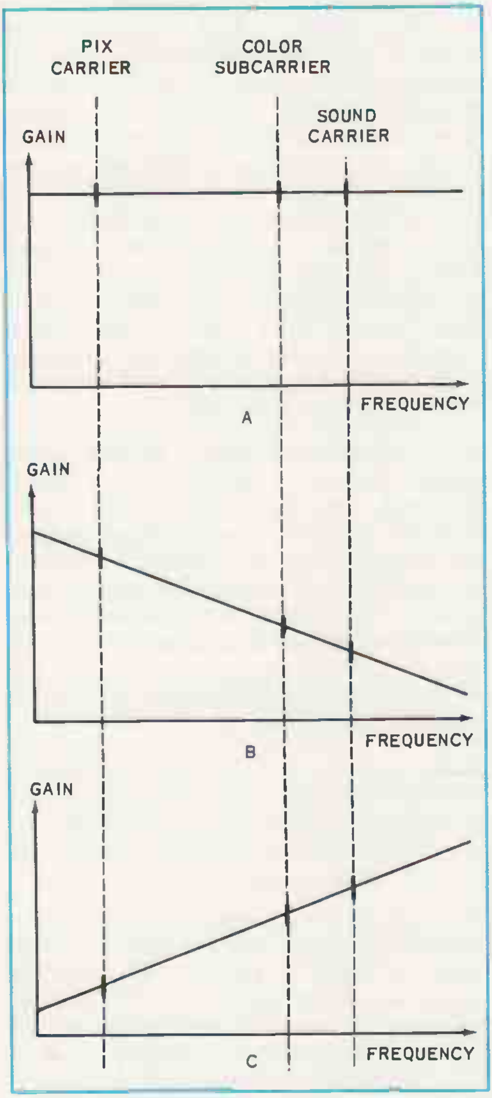


FIG. 11-12. Antenna response curves.

Weak color caused by the response of Fig. 11-12*b* can result in unsaturated or pale colors even if the COLOR control is turned up fully. In some cases normal saturation can be obtained, but the color picture appears "noisy". Snow appears in colors, especially blue, but does not appear in the black-and-white picture. Noise appears in the colors since the chrominance circuits operate at maximum gain. Since gain is highest in the B-Y channel, noise is most noticeable in blue areas of the picture.

Strong color resulting from the response curve of Fig. 11-12*c*, results in a different set of symptoms. Since color signal amplitude is excessive, it is necessary to operate the bandpass amplifier with lower-than-normal gain. Color saturation then appears normal. However, the large chrominance signals may overload some stage ahead of the bandpass amplifier. If the color signal is clipped or compressed due to overload, the color picture is degraded. You might see evidence of "crosstalk" at the edges of colored objects, or bright areas of the picture (faces) may appear pale or unnaturally white.

Try Another Antenna. If the symptoms mentioned in the previous paragraphs suggest a fault in the antenna system, substitute another antenna. An ordinary indoor antenna of the "rabbit-ear" type will suffice in many locations. If the conditions noted when the regular antenna is connected disappear when the indoor antenna is connected, the antenna installation needs attention.

Inspect the Antenna Installation. Replace antennas that are broken, have missing elements, or deteriorated lead-in connections. Look for breaks in the transmission line, poorly-connected lightning arrestors, and branches to other receivers. Poor antenna response can be caused by improper termination of the transmission line. Avoid taps in the transmission line to feed other receivers. Transformers or inductive couplers are also to be avoided. If one antenna is to feed more than one receiver, resistance type couplers are recommended. They are less likely to cause the transmission line to become misterminated.

New Installations. When installing a new antenna, or replacing an old one, select an antenna that has proven to give satisfactory results with color. Several antenna manufacturers have antenna types that they recommend for color reception.

Orientation is Important. Multipath reception can produce other trouble symptoms in addition to the familiar ghosts. A reflected signal may not have sufficient time delay to cause a ghost to appear, but frequency components of the reflected signal are delayed in phase as compared with the direct signal. When two such signals add in the antenna system, the over-all effect is a series of humps and dips where frequency components happen to be either in phase or out of phase. Since multipath reception can affect response, it is a good idea to check antenna orientation and positioning in cases where the color picture appears degraded.

Antenna Distribution Systems. Antenna distribution systems that are functioning normally offer no problems to color reception. The entire system, including the amplifiers and the individual branches, must provide uniform response for the local channels that transmit color. If you suspect poor response in the distribution system, use a test (indoor) antenna to see if normal color can be obtained from another signal source. Antenna distribution amplifiers that are overloaded (too much input signal) give the following symptom: Sound beat appears in the color picture which cannot be removed by careful fine tuning. Suspect overload in the distribution amplifiers if sound beat can be tuned out when the set is connected to an indoor antenna.

IF THE RECEIVER NEEDS ALIGNMENT

Receiver alignment is definitely more critical in color receivers than it is in black-and-white receivers. The color receiver is subject to the same symptoms of non-uniform frequency response as the black-and-white receiver, such as loss of definition, smear, streaking, overshoot, ringing, regeneration, and tunable ghosts. In addition, poor alignment can result in insufficient, noisy, or distorted color. The average viewer may not notice a loss of definition in a black-and-white set caused by insufficient frequency response in the high-video-frequency range. However, he will certainly notice the loss or distortion of color produced by the same condition in a color set.

When is Alignment Needed? Receiver alignment seldom changes by itself. The most common cause of misalignment is the incorrect settings that result when inexperienced or amateur technicians tamper with or "diddle" the alignment screws while looking at the picture. Experienced technicians have learned to leave these adjustments alone unless they are doing the job the right way — with suitable alignment equipment. Alignment can also be upset when r-f or i-f coils become damaged. Damage may result from overheating due to a short circuit somewhere in the receiver. Coil damage sometimes results from accidents that occur when the chassis is brought back to the shop. Whenever coils or transformers are replaced it might be necessary to check alignment.

Things to Check Before Alignment is Attempted. A few quick observations may help to minimize or even eliminate the alignment job. First, make a visual check of antenna connections and the r-f and i-f sections of the receiver. Make sure that there are no missing shields. On the printed boards, tube shields are grounded by means of a metal pin that sticks up from the tube socket. Make sure that the shields contact this pin and that the pin is indeed grounded. Check the shields by looking at the picture and grounding each shield to the chassis with a screwdriver. If the picture changes when a shield is grounded, inspect the grounding pin on that tube socket.

Check reception on all active channels. If the trouble symptoms appear on only one, or possibly two channels, your job may be reduced to just checking tuner alignment.

Switch to an unused channel and look for snow in the raster. This allows you to make a rough check of i-f gain. A weak i-f amplifier results in little or no snow in the raster. A weak or dead i-f stage may not only cause a severe change in the receiver's response curve, but it may also cause a marked reduction in over-all gain. The loss of gain might not be noticed when looking at a picture produced by a strong local signal, but lack of snow on an unused channel definitely points to a weak i-f amplifier. A weak tube might be the cause of trouble.

Alignment as a Troubleshooting Aid. Many experienced technicians rely on alignment checks to localize troubles. The response curves provide an extremely powerful troubleshooting tool, as you can make independent checks on the performance of the tuner, the i-f section and even individual stages in the i-f section. Troubles, especially the "tough" troubles such as smear and loss of resolution, are easily localized in this way. Take the time to become proficient at receiver alignment and you will find that you will spend a lot less time on those "tough dogs." Some shops have the alignment gear mounted permanently on a movable table or dolly so that the gear can be easily moved from bench to bench. This greatly minimizes the setup time.

Special Alignment Technique For Color Receivers. The bulk of the alignment job in a color receiver is similar to that performed on black-and-white receivers. Tuner alignment and i-f amplifier alignment are done in the same way and we shall not rehash that subject here. The one part of the job that is different is the alignment of the bandpass amplifier. The response of the bandpass amplifier must match the response of the i-f amplifier in such a way that uniform response is obtained throughout the frequency range of the color sideband signals. Figure 12-1*a* shows the i-f response curve of a color receiver. Note that the color subcarrier is located at the 50% point near the sound carrier side of the curve. Due to this arrangement the lower sideband signals of the color subcarrier receive more amplification than the upper sidebands. To obtain uniform over-all amplification, the response of the bandpass amplifier is arranged as shown in Fig. 12-1*b*. In the bandpass amplifier the color subcarrier is also at the 50% point, but the slope of the curve is reversed. Here the upper sidebands receive greater amplification than the lower sidebands. The result is shown by the over-all response curve in *c* of the figure.

The job of getting the i-f and bandpass-amplifier response curves to match as shown in Fig. 12-1 involves an entirely new alignment setup. You might think that it would be possible to align the i-f amplifier and the bandpass separately. However, the slopes of both curves must be accurately matched and evaluating the slopes individually would be a difficult process. In addition, the response of the video detector enters the picture. Since this circuit supplies signals to the bandpass amplifier, the response of the video detector to signals in the 0-4 mc range affects the over-all response of the system. It is not possible, by conventional means, to obtain a response curve that shows the response of the video detector to video frequencies. (You cannot feed a video sweep signal (0-4 mc) in at the video detector, as the detector will rectify this signal. Feeding in a sweep signal in the i-f range (40-47 mc) *does not* produce a curve that displays the response of the detector to frequencies in the 0-4 mc range.)

What is needed is a method of obtaining an over-all frequency response curve for

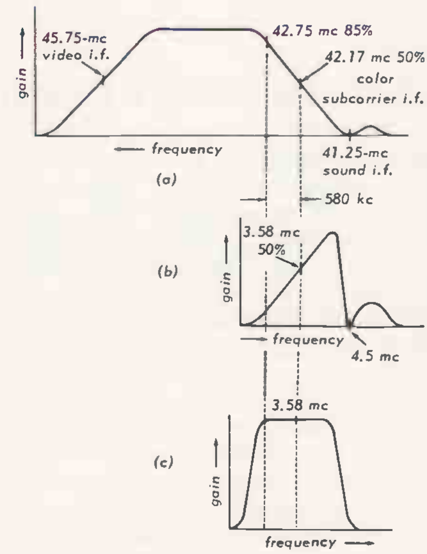
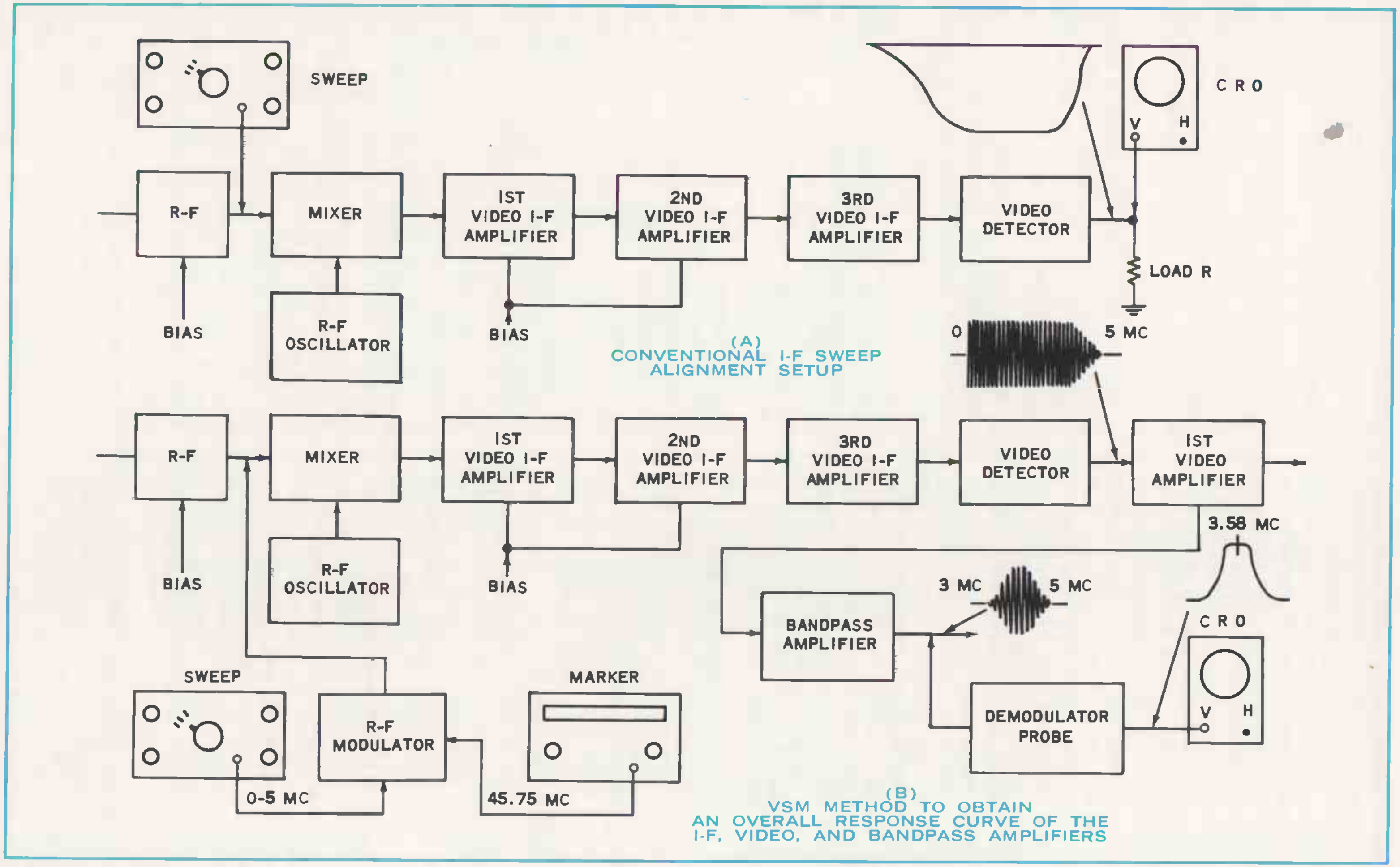


FIG. 12-1. Response curves of the i-f and bandpass amplifiers combine to produce uniform amplification of the 3.58-mc sideband signals.

all the circuits between the input to the i-f amplifier and the output of the bandpass amplifier.

The VSM method. VSM stands for Video Sweep Modulation. This method yields a response curve that shows the over-all effect of i-f and video circuits. Consider a conventional i-f sweep setup as shown in Fig. 12-2*a*. The sweep generator sweeps the i-f range of about 40-47 mc. At the output of the detector there is a varying d-c signal whose amplitude is determined by the response of the i-f system. The waveform at the video detector repeats at the sweep rate of 60 cps. Thus, the output circuit of the video detector need only pass 60 cps in order to show the response curve of the i-f section. The video response of the detector does not enter the picture at all.

In the VSM system shown in *b* of the figure, the sweep generator is set to sweep the video range (0-5 mc). This signal is applied to a modulator where the 0-5 mc signal modulates a carrier at the inter-



(A)
CONVENTIONAL I-F SWEEP ALIGNMENT SETUP

(B)
VSM METHOD TO OBTAIN AN OVERALL RESPONSE CURVE OF THE I-F, VIDEO, AND BANDPASS AMPLIFIERS

FIGURE 12-2

mediate frequency of 45.75 mc. The effect is the same as would be obtained by applying the 0 to 5-mc sweep signal to the modulator in the transmitter. The sweep signal goes through the i-f amplifier as modulation of a carrier. At the detector, the original modulating signal is recovered. A 0 to 5-mc sweep signal appears at the detector output and is passed on to the bandpass amplifier. Note that the signal at the output of the detector is not a response curve, but is a video sweep signal which varies from 0 to 5 mc at a 60-cps rate. The signal has been shaped by the response of the i-f amplifier as shown in the figure. It is shaped further by the bandpass amplifier. Here both sidebands are restored to their correct relative amplitudes, and the signals below about 3 mc are rejected. Signals at the output of the bandpass amplifier are still video signals, varying between 3 and 5 mc at a 60-cps rate. To obtain an over-all response curve, it is necessary to detect the sweep signal. A demodulator probe, at the output of the bandpass amplifier is used for this purpose.

Setup for Bandpass Alignment. The equipment connections for VSM alignment of the bandpass amplifier are shown in Fig. 12-3. A preliminary requirement is that the i-f amplifier be aligned first, in the conventional way. The correct i-f response curve for a late-model receiver is as specified in Fig. 12-4.

A number of circuit conditions must be set up so that the amplifiers to be aligned are biased properly and there is a minimum of interference on the oscilloscope trace. These conditions are as follows:

1. *Disable the horizontal deflection circuit.* The lead between the cathode of the horizontal output tube and ground is opened. By disabling this circuit, interference from flyback pulses is eliminated. In addition, the horizontal blanking pulses normally supplied to the bandpass amplifier disappear. These blanking pulses would interfere with the alignment display.

Disabling the horizontal output tube removes a considerable load from the power supply. To restore correct supply voltage, a dummy load, designed to draw as much current as the horizontal output stage, is connected to the B+ supply. A 2000-ohm 100-watt resistor connected between the B+ supply and the chassis serves as the dummy load.

2. *Bias off the r-f amplifier.* Since the sweep signal is fed in at the mixer, you should bias off the r-f amplifier to prevent channel signals from interfering with the display. A —15 volts is applied to the tuner AGC line.

3. *Bias off the killer.* The killer is biased off to allow the bandpass amplifier to conduct. A —15 volts is applied to the threshold control as shown.

4. *Apply normal operating bias to the bandpass amplifier.* Correct bias (about —2 volts) is applied to the bottom of the grid resistor of the bandpass amplifier.

5. Set the COLOR control to the designated position. Frequently, the COLOR control is set fully clockwise during alignment. Check the service notes for the correct setting of this control for each receiver model.

Signal Source. Sweep signals are obtained from a sweep generator capable of providing a flat and clean sweep signal in the video range. Sweep output is adjusted to produce a 3-5 mc sweep width, centered at 3.58 mc. (Since the video frequencies below 3 mc are rejected by the bandpass amplifier there is no point in supplying them.) An RCA WR-69A sweep generator or equivalent is recommended.

The sweep signal is fed through an absorption-type marker box, as shown in Fig. 12-5. The marker box extracts energy from the sweep signal at key marker frequencies. This produces tiny dips in the response curve at frequencies of interest. A marker box made specifically for this purpose is the RCA WG-295C. Individual marker frequencies are identified by touching small buttons on the marker box. This causes one of the tuned circuits to be loaded, and the marker pip associated with that particular frequency changes in amplitude.

Video sweep signals at the output of the video marker box are coupled to an r-f modulator. This is a relatively new piece of alignment equipment. It contains a crystal-diode modulator circuit, and ac-

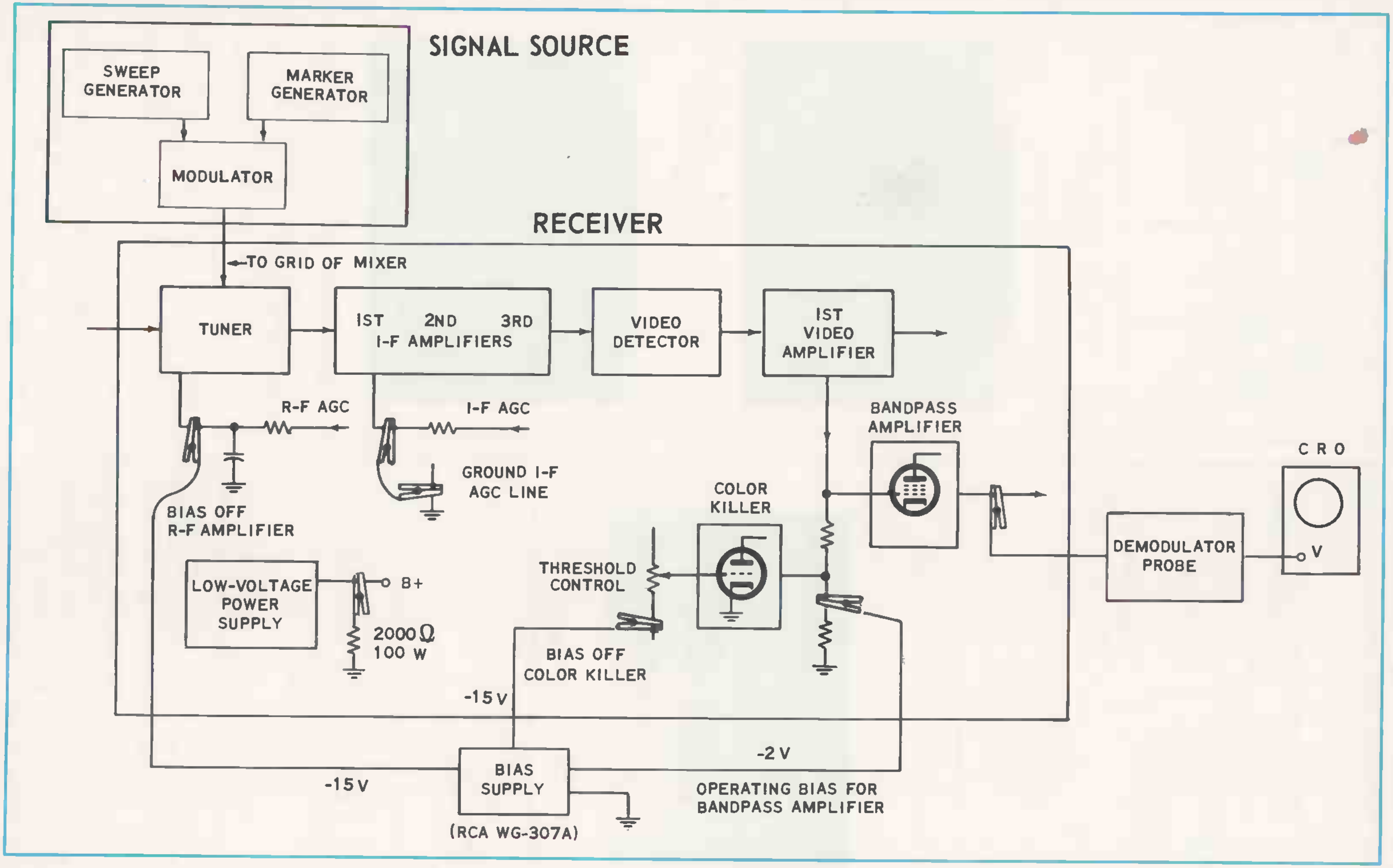


FIG. 12-3. Basic equipment connections for VSM alignment of the bandpass amplifier.

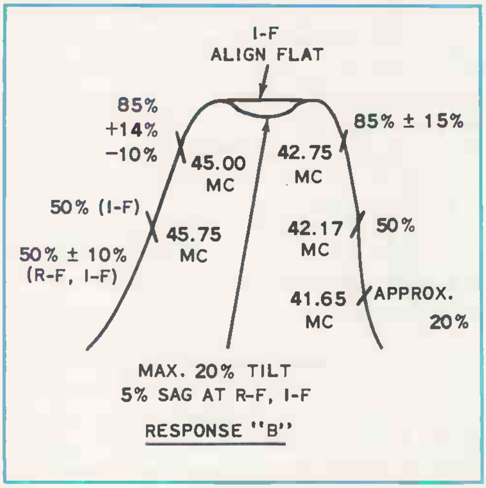


FIG. 12-4. I-f response curve of the RCA CTC-15 receiver.

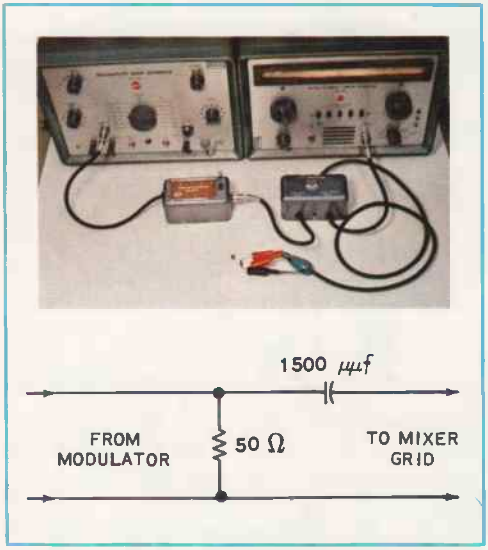


FIG. 12-5. The signal source for VSM alignment. The matching pad shown in the detail connects the output of the modulator to the grid of the mixer stage.

cepts a video and an r-f input. The output signal is a conventional amplitude modulated signal (both upper and lower sidebands are produced). The r-f modulator shown in Fig. 12-5 is an RCA WG-304B.

The carrier signal for the r-f modulator must be at the receiver's picture i-f frequency of 45.75 mc. Output amplitude must be adjustable and at least 0.1 volts at maximum. A signal source, such as the

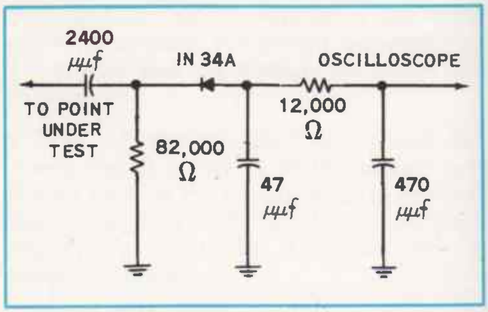
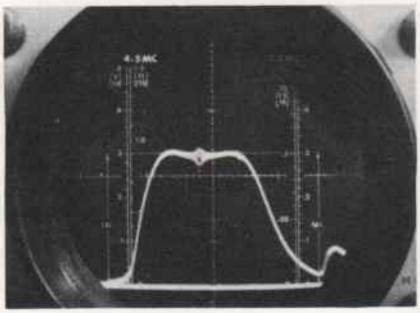
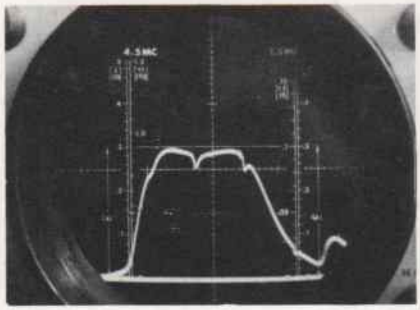


FIG. 12-6. Detector probe used in VSM alignment.



(A)
3.58-MC MARKER OBTAINED FROM LOCAL SUBCARRIER OSCILLATOR



(B)
ABSORPTION MARKERS PROVIDED BY THE RCA WG-295C VIDEO MULTIMARKER. MARKERS NEAR THE TOP OF THE CURVE (LEFT TO RIGHT) ARE 4.08 MC, 3.58 MC, AND 3.08 MC.

FIG. 12-7. Over-all response curve of the i-f, video, and bandpass amplifiers using the VSM alignment system.

RCA WR-99A crystal-controlled marker generator is ideal for this purpose.

A matching pad couples the modulated

45.75-mc signal to the grid of the mixer stage in the receiver. The pad shown in Fig. 12-5 terminates the cable of the modulator and swamps out the tuned circuits in the grid circuit of the mixer stage.

Oscilloscope connections. The vertical input to the oscilloscope is connected to the output of the bandpass amplifier. A convenient tie point is the grid of either of the demodulators. Signals at this point are video signals that sweep through the range of 3 to 5 mc. A detector is needed to form a response curve at this point. Figure 12-6 shows the type of detector that should be used.

Figure 12-7 shows the correct over-all i-f/bandpass response curve obtained by the VSM method.

RCA COLOR TV Troubleshooting PICT-O-GUIDE