

COLOR TV-IV



Techni-talk

on AM, FM, TV Servicing

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In this issue the production of various colors by mixing the three basic colors used in color television will be described in conjunction with the "color box." Information describing the construction of this color box was given in the Vol. 6 No. 2 issue. Unfortunately the wiring diagram Fig. 5 on page 5 of the Vol. 6 No. 2 issue indicated that the green and the blue lamps were wired in series instead of in parallel. A corrected wiring diagram is shown in Fig. 2 on page 2 of this issue. We apologize for this error and regret any inconvenience it may have caused.

It has also been noticed that some of the colored Christmas tree bulbs required for use in the color box may not be completely coated with the coloring material. This leaves some clear bulb area near the base. If bulbs of this type are used the clear area should be covered with either black paint or tape to prevent color contamination with white light.

COLOR PROPERTIES

A color is ordinarily identified by three properties which define its component characteristics, namely: hue, saturation and luminosity. Hue defines the actual color and may be expressed in terms of red, green, blue, etc. Saturation describes the purity of a color and may be expressed in terms of deep, vivid, pale, pastel, etc. Luminosity describes the degree of brightness or the brightness level displayed by the color. Each of these will be discussed in relation to a color receiver or the color box.

The chromaticity diagram in Fig. 1 indicates the various spectral and nonspectral colors. Each segment of color should be visualized as very vivid or fully saturated at the outside rim. These colors become lighter and lighter as they approach the center area marked white which is pure white only at the center. The outside portion of this white section is tinged slightly with the color of the adjacent area. The colored areas within the triangle represent the gamut of colors which can be reproduced by the phosphors used in the color picture tube. This diagram will be referred to at various times when discussing the reproduction of colors either with the color box or a color picture tube.

HUE

Hue describes the actual color and may be specified as a color of a specific wavelength. Each of the colors shown in Fig. 1 is a definite hue. It was previously mentioned that each color phosphor in a color picture tube has been carefully chosen to produce a specific wavelength of color, or in other words, a specific hue. The hue of each phosphor used in the color picture tube can be observed individually by adjusting the proper color controls on a color receiver. Each color may also be individually controlled in the color box. In order to simplify this discussion it

will be assumed that the colors in the color box and those in a color picture tube have the same hue.

If the color box is used, both the blue and green controls should be turned off and the red control turned on. The color which appears on the opal glass window will have a specific hue which is assumed as point R on Fig. 1. If it were possible to compare this color with the red on the television picture tube, it would be found that the hue is different but both are within the range of wavelengths which are called red. Now slowly rotate the green control to the maximum leaving the red at the maximum setting. The color will change from a red to a reddish-orange and then to an orange as shown along the right slope of the triangle in Fig. 1. Now, slowly rotate the red control toward the minimum setting. The color will change from orange to yellowish-orange then yellow, greenish-yellow, yellow-green, yellowish-green and then green as shown along the balance of the right slope of the triangle in Fig. 1. If the blue is slowly turned to the maximum setting and then the green slowly turned toward the minimum setting, the colors will change to the colors shown on the left slope of the triangle. If the same procedure is now followed by first increasing the red control to its maximum setting and then decreasing the blue control to its minimum setting, the

color will change as is indicated by those colors along the base line of the triangle from left to right. This demonstrates the change in hues as shown by the colors along the outer edges of the triangle in Fig. 1. It should be kept in mind that only two colors have been mixed at any one time. Therefore, the colors produced were only those on the outside edge of the triangle.

Before discussing saturation it is important to observe that a white light can be produced by the proper mixture of the three primary colors. Since, as previously stated, white light is composed of more green than red or blue, the green control should be turned to the maximum position. The red control should now be turned up to the point where the color yellow is produced. Now slowly turn up the blue control to the point where the color becomes a reasonable shade of white. The shade of white can be varied over a considerable range as shown by the egg-shaped area near the center of Fig. 1. These shades may be obtained by slightly adjusting the proportions of the primary colors. The white may be tinged slightly with either red, green, blue or some other color depending on the color mixture.

SATURATION

Saturation describes the vividness of a color. The amount of white light which is added dilutes the hue and reduces the degree

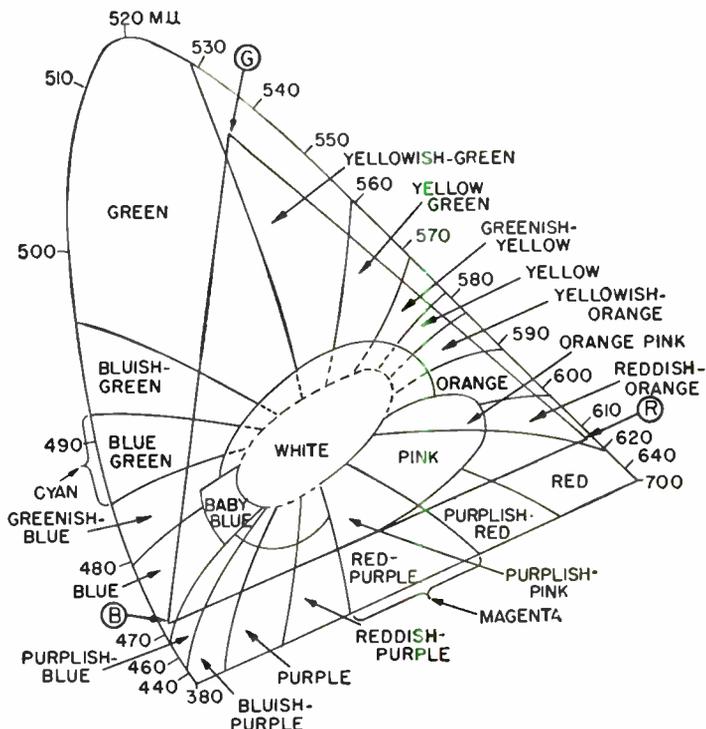


Fig. 1. Chromaticity diagram showing the various spectral and non-spectral colors. The area within the large triangle represents the gamut of colors reproducible by color television.

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of saturation. A zero saturation of a red hue would appear as white light whereas a 100% or total saturation would appear as a true vivid red hue not containing any white light. Saturation can also be demonstrated with the color box. Since the degree of saturation depends upon the dilution of a hue with white light, and white light is composed of all three primary colors, any color which appears on the color box screen will become less saturated if the correct proportions of all three primary colors are added. If Fig. 1 is referred to again and the curved line followed from the 620m μ point toward the center it will be noticed that the color changes from red to pink to white. These colors represent varying degrees of saturation for a hue with a wavelength of 620m μ . It will be slightly more difficult to demonstrate saturation with the color box since rather accurate amounts of the colors which produce white would be required so that the hue would not be changed. As an example, if the red control is set at the maximum position and a slight amount of the other two primary colors are added in the correct proportions so that the basic hue remains the same, the result will be a less saturated red. As more white is added to the hue the amount of saturation will change from red to pink to a pastel and then to white. This change may be visualized as starting at some point in the red area of Fig. 1 such as the 620m μ point and then following an arc through the pink to the white area. All of the wedge-shaped areas on Fig. 1 should be visualized as becoming more saturated as they approach the outer edge of the drawing and less saturated as they approach the center.

It should be kept in mind that the same method of obtaining various degrees of saturation is used in color TV as is used in the color box. A saturated red can only become less saturated by the addition of correct amounts of green and blue since white as a separate color cannot be added. The mixture in a color receiver is made electronically and is therefore much more accurate than can be produced manually with the color box. A description of the color signal voltages will be described at a later point in this issue.

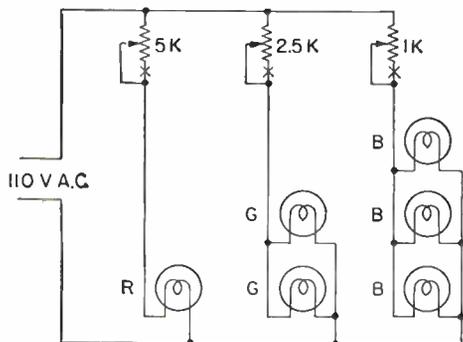


Fig. 2. Revised diagram of the color box indicating the green and blue lamp wired in parallel instead of series.

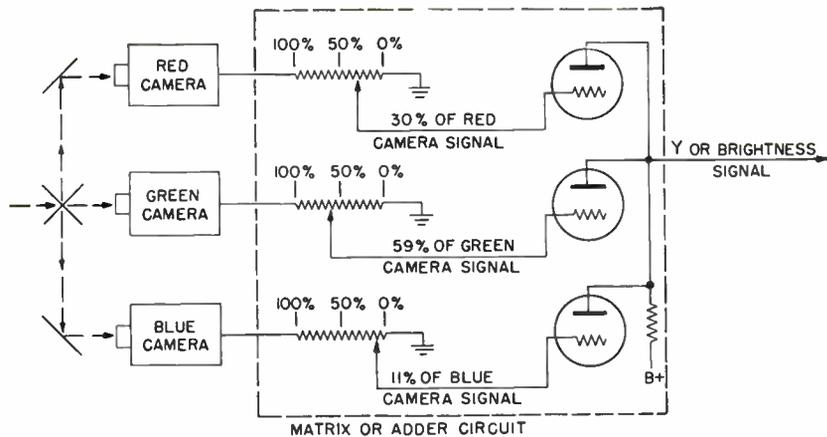


Fig. 3. A simplified matrixing circuit showing a method which could be used to obtain the Y signal from three color cameras.

BRIGHTNESS

Brightness describes the amount of energy in a color. A specific hue such as red with a wavelength of 620m μ will change somewhat in appearance at very low brightness levels. At a low level of brightness all colors appear gray. Colors such as violet or blue will appear gray before green or yellow due to the color response of the human eye (Vol. 6 No. 2 Fig. 3). If brightness is eliminated entirely all colors lose their identity and appear black. The brightness of each primary color can be demonstrated with the color box by varying any one control when the other controls are in the minimum or "off" position.

One method of producing various colors has been described using the color box. These same colors can be produced on a color TV screen by manually controlling the quantities of the three primary colors. When a color program is televised these colors must be combined very rapidly if the program is to be reproduced in full color on the receiver.

One of the basic requirements for a compatible color TV system is that a color telecast should produce satisfactory black and white pictures on normal unmodified black and white receivers. A black and white or monochrome picture is produced by rapid variations in the brightness level only. The studio scene for a monochrome program is in many instances quite colorful. The black and white camera changes these colors to various shades of gray or in other words to various brightness levels. The monochrome requirement for color telecasting is fulfilled in the NTSC system by transmitting a brightness signal which is essentially the same as that used for black and white transmission. This brightness signal is known as the "Y" signal. The Y signal represents the brightness level for color TV reception and at the same time the complete video signal for monochrome reception.

THE R, R - Y AND B - Y SIGNALS

The NTSC system has established a standard for the brightness or Y signal. This Y signal is composed of a specific mixture of the outputs of the three color cameras. The Y signal represents 0.299 red plus 0.587 green plus 0.114 blue. This is generally simplified and shown as $Y = .30R + .59G + .11B$. Fig. 3 is an illustration of mixing the outputs of three color cameras to obtain a brightness signal. The output of each color camera goes to a matrix or adder circuit which combines a part of the output from each camera.

Since the Y voltage is composed of specific proportions of the three camera output volt-

ages, it is used both as the brightness signal and as a color reference signal. Fig. 3 shows only the development of the Y signal in a simplified matrix circuit, however, color signals are also developed in the matrix unit. The discussion at this point can be simplified if the color signals are considered only as $R - Y$ (R minus Y) and $B - Y$ (B minus Y). These color signals are transmitted on separate color subcarriers which will be described in the next issue.

As previously explained, the Y signal represents exact percentages of the output signal from each color camera, therefore, it is only necessary to transmit two color signals. If $Y = 30\% (R) + 59\% (G) + 11\% (B)$ then $Y = 100\%$.

If any one of these percentages were removed its value could be determined from the remaining percentages. This can be illustrated with simple algebraic equations.

$$100\% (Y) = 30\% (R) + 59\% (G) + 11\% (B) \text{ or}$$

$$1.0 Y = .30R + .59G + .11B$$

If the red signal is removed from the right side the equation becomes:

$$1.0 Y - .30 R = .59 G + .11 B$$

(Continued on page 5)

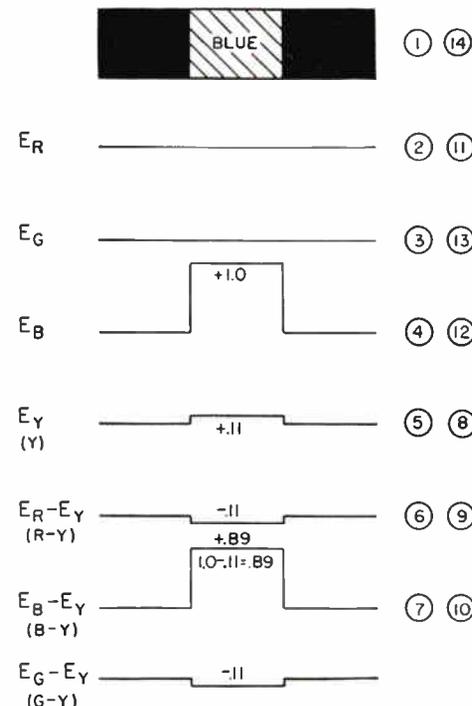


Fig. 4. Signal voltages developed when a blue bar is scanned by color cameras.

UHF ANTENNA INSTALLATIONS

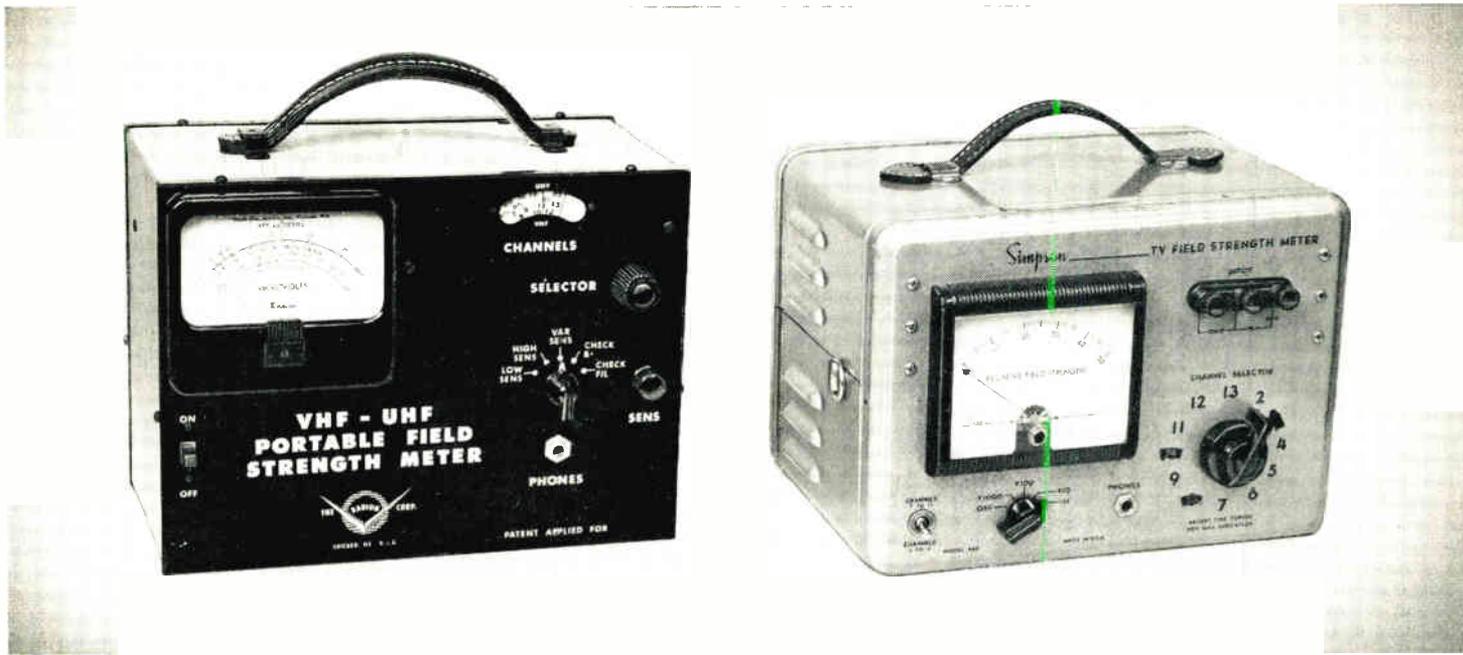


Fig. 1. Two typical Field Strength Meters, which can be used for VHF or UHF antenna installations. The one on the left is battery-operated and the one on the right is AC-operated.

There have been altogether too many reports regarding UHF antenna installations which are not producing satisfactory TV pictures. This has probably resulted in a reduced number of UHF installations and a loss of income for the service technician. This is the start of a vicious circle because the number of viewers have a direct relation to the quality of the programs which are available to any TV station. The number of viewers also determines the advertising revenue, and therefore whether a station makes money or loses money. Very few stations can lose money continuously and stay on the air. The service technician, therefore, has a responsibility not only to himself but to his customers and to the UHF station to provide the best UHF reception obtainable.

A field strength meter will be practically invaluable when installing a UHF antenna. It can also be used to check the gain of different types of antennas and transmission line losses. The efficiency of the completed installation can also be checked with this type of instrument. All of these different uses will be described in this article.

Obviously, in areas where the signal level is very high it is relatively unimportant whether the antenna is positioned for optimum performance or not, since the loss of even a large percentage of the signal may not affect the picture quality. In other areas where "snow" is visible in the picture it is important that the antenna be positioned so that every available microvolt of signal is delivered to the receiver. It is practically impossible to accomplish this without some type of field strength indicator.

If the maximum signal is to be obtained,

the UHF antenna must not only be rotated in the proper direction but it must be positioned at the optimum point both horizontally and vertically. In view of this there is very little chance that the antenna can be positioned at this point without some indicating instrument. The quality of the picture which appears on a TV receiver does not ordinarily provide an accurate indication of signal level because of the action of the AGC (automatic gain control) circuit. Field strength meters *do not* have AGC circuits and provide a direct indication of the signal level.

A field strength meter can be used more effectively and economically than other methods such as communication between a person viewing the receiver and a person at the antenna because the indication is instantaneous. In this way most installations can be made by one man. Field strength meters such as those shown in Fig. 1 are typical of a number of instruments which are available from General Electric Tube and Parts Distributors. Each type of instrument has advantages.

The instrument on the left of Fig. 1 is operated from self-contained batteries and covers the complete UHF-VHF range. The one on the right is a-c operated and was designed for the VHF range only, but since it uses a strip-type tuner, UHF strips may be substituted in any unused VHF position. Any field strength meter with a strip-type tuner can be converted to UHF at a small cost. Other VHF field strength meters may be converted by fastening a UHF converter to the case, although this will result in higher cost and a more bulky instrument.

It was previously mentioned that each

of the instruments shown in Fig. 1 has advantages as well as disadvantages. Batteries are expensive but due to the intermittent type of service, replacement is rather infrequent unless the switch is accidentally left "on" for a long period of time. The a-c operated instrument will require an extension lead. Usually a fifty- or seventy-five-foot lead will be sufficient but the lead length will depend upon the type of structures in the service area. The a-c instrument has a large meter which may be easily read from a considerable distance.

The battery-operated instrument uses a continuous type tuner. This type of tuner may pick up harmonics of other UHF stations. It may also pick up either the fundamental or harmonics of the oscillator in nearby TV receivers or UHF converters. This may also happen on the a-c operated instrument, but due to the limited range of the fine tuning control, the problem is not as great. Both instruments have an earphone jack which will help in the identification of spurious meter indications. Sync pulse buzz will be present on harmonics of a UHF station but will not be heard on frequencies originating in nearby oscillators.

When a field strength meter is used for the first time on a UHF antenna installation, the variations in the signal level will probably be a revelation to even the most experienced UHF technician. It will be found that the signal will vary considerably as the UHF antenna is moved just a few inches either horizontally or vertically.

It will also be found that the signal level may be increased by tipping the mast a few degrees either toward the

ground or toward the sky. This will be more noticeable when high gain antennas are used. This is true because signal lobes such as those shown in Fig. 2 actually have three dimensions instead of two. In other words a signal lobe should be visualized in the same form as a drop of heavy oil. Therefore, an antenna with a signal lobe similar to that shown on the left of Fig. 2 will receive a signal over a wider horizontal and vertical range than an antenna with the signal lobe shown on the right of Fig. 2. The same horizontal reception lobes shown in Fig. 2 are illustrated as vertical reception lobes for a typical low and high gain antenna in Fig. 3. It will be found that particularly in UHF fringe areas the angle of reception may deviate somewhat from the normal horizontal plane. Probably the greatest change in signal level will be noticed as the UHF antenna is raised or lowered. It will be found that the signal level changes very rapidly from maximum to minimum every few inches. This is illustrated by the size of the dotted lobes in Fig. 4. A similar change in signal level will occur if the antenna is moved horizontally. These changes in signal level will occur as the antenna is moved just a few inches without changing either the rotation or the vertical angle. In addition to the changes in signal level already mentioned it will be found that by probing all areas suitable for an antenna installation, one or more spots will be located where the signal level will be somewhat higher. The meter reading should be recorded for comparison with a reading at the receiver after the installation is completed.

In view of all the possible variations in signal due to positioning the antenna, the value of an instrument which gives a positive indication of the available signal just can't be underestimated. Too many installations have been made where the customer was not satisfied but the technician either didn't know how to improve the reception or didn't have an instrument such as a field strength meter to aid him in locating the maximum reception position.

OTHER USES

A field strength meter can be used to check the gain of different types of antennas. This can be accomplished by positioning each antenna for the maximum signal and recording the reading. The increase obtainable by stacking two or more antennas can also be recorded.

The losses in different types of transmission line can be checked by using a standard length such as fifty or one hundred feet of each type of line. The line should be reasonably straight and fastened to stand-off insulators. The line does not have to be connected directly to the antenna, but can be connected to the receiver end of a completed

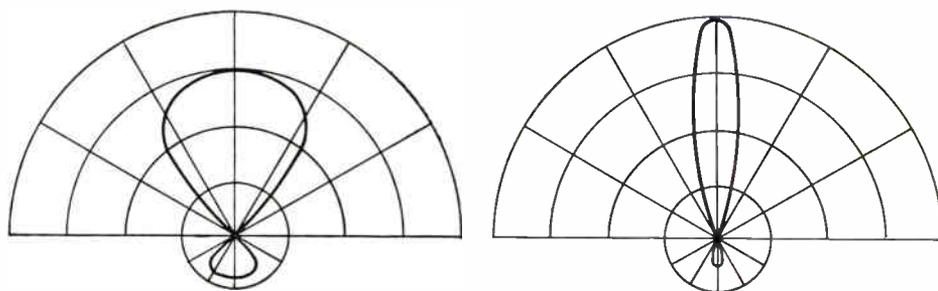


Fig. 2. Typical radiation patterns for a low gain antenna on the left and high gain antenna on the right.

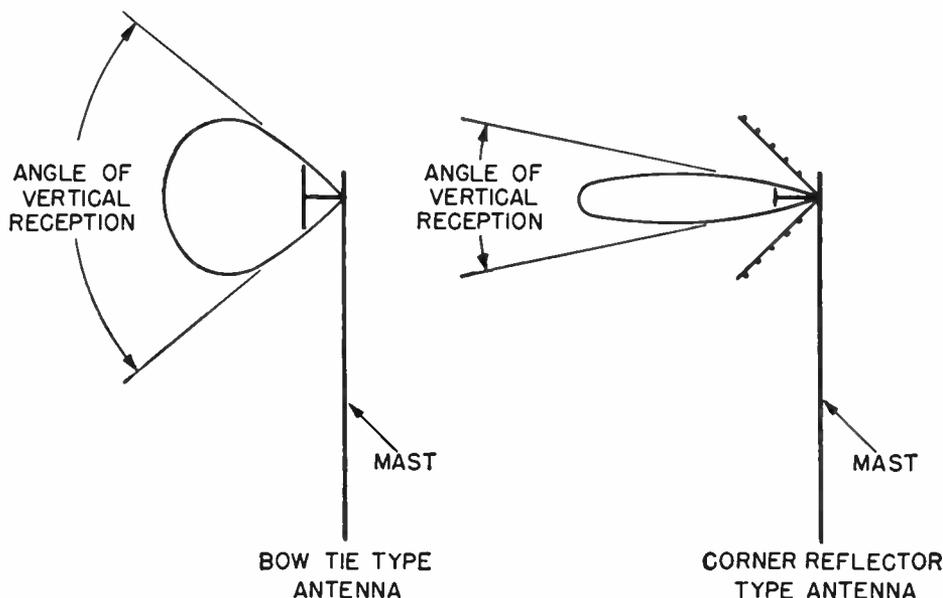


Fig. 3. Radiation pattern for a typical UHF bow-tie antenna is shown at the left and for typical UHF corner reflector is on the right.

installation. A record should be made of the readings for each type of line. The signal loss when wet can also be recorded by soaking a certain length with either a wet sponge or a hose.

The efficiency of the completed installation can be determined by comparing the reading taken at the antenna during the probing operation with one taken at the receiver when the installation is completed. If the loss is higher than expected a check should be made of the line. It may be necessary to add more stand-off insulators or to reposition the line to avoid or reduce contact with metal or wood. In some cases it may be found that a lower loss transmission line will have to be substituted.

If the antenna is installed in accordance with the instructions given in this article, and a converter with a good signal to noise ratio is used (see Tele-Clues 0-171 to 0-180), you can be sure that your customer has the best UHF reception obtainable in that location. Also he will probably feel that you are well qualified to do this work since the use of any instrument is impressive. This is important because anyone who can climb a ladder can put up an antenna, but the use of a field strength meter is an indication that equipment and "know-how" are also required.

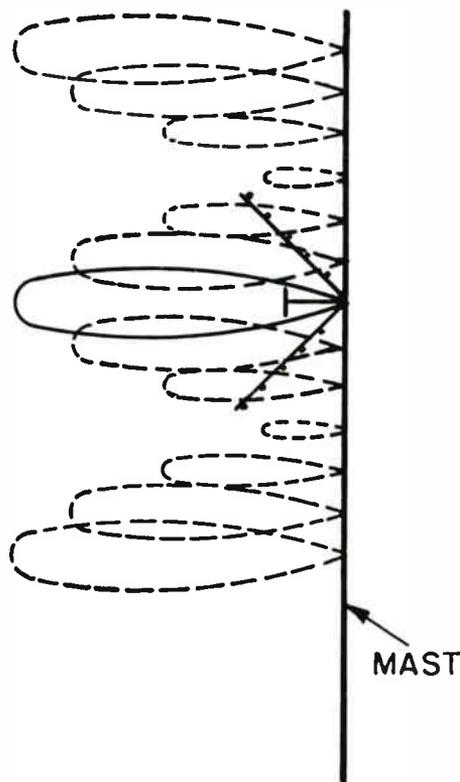


Fig. 4. Illustration of the change in signal as a UHF antenna is raised or lowered.

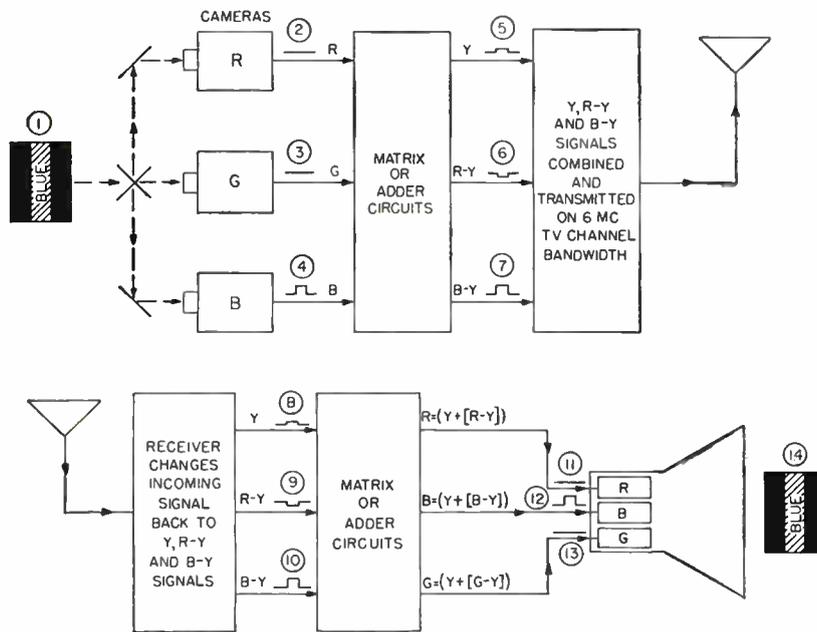


Fig. 5. Block diagram of a color transmitter and receiver indicating the location of the signal voltages shown in Fig. 4.

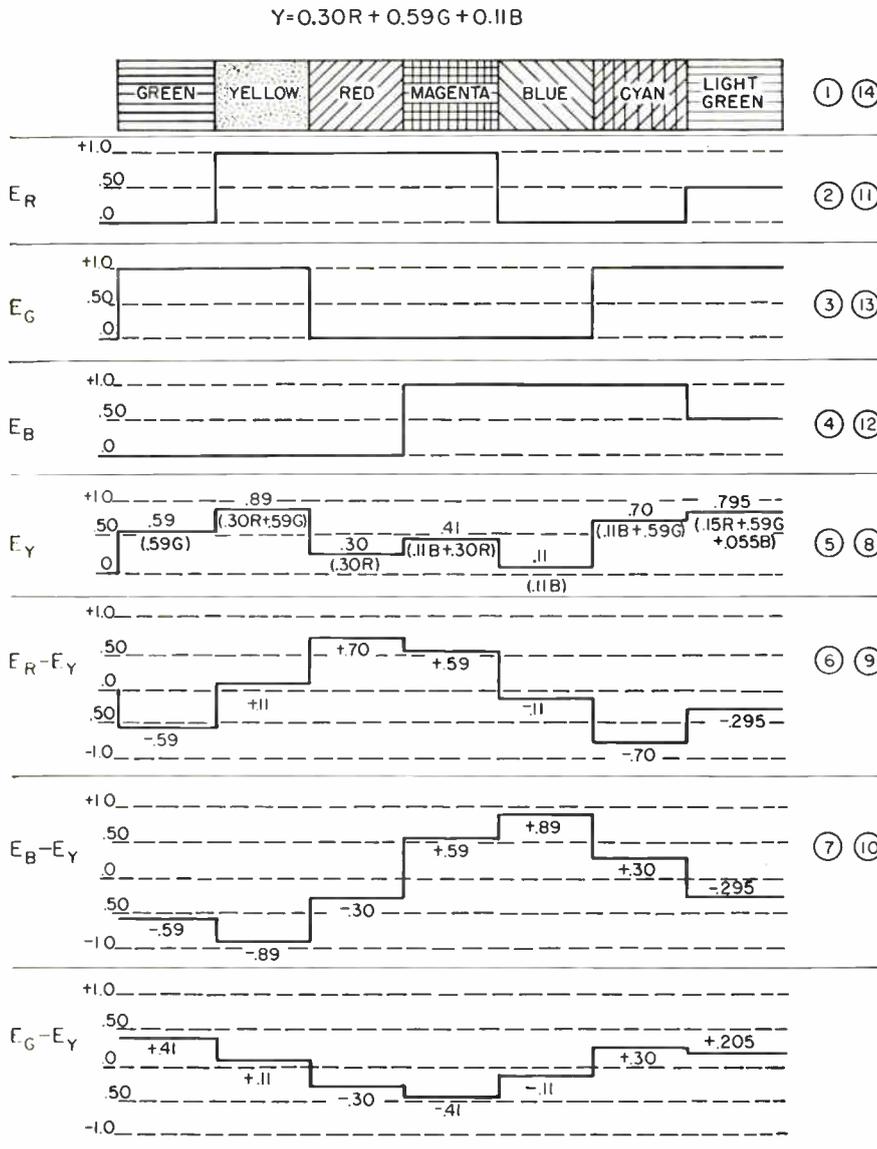


Fig. 6. Signal voltages developed when seven different colors are scanned by color cameras.

If both the red and blue signals are removed from the right side the equation becomes:

$$1.0 Y - .30 R - .11 B = .59 G$$

If the three signals Y, R and B are known and their mathematical relationship is also known the fourth signal G can be eliminated. Therefore, only two color subcarriers and the Y signal are used in color television.

In the equations shown above, Y-R was used whereas the actual color signal is known as R-Y. In color TV the Y signal is subtracted from the R signal instead of R from the Y signal. The same is true of the blue signal. This will be easier to understand if we observe the signals which would appear if a blue bar on a black background were scanned.

The development of the color signal voltages is illustrated in Figs. 4 and 5. Fig. 4 shows the different signal voltages which would be developed at four points on the block diagram in Fig. 5 as a result of scanning the blue bar (1).

The signal will be followed through the four points shown in Fig. 5. The numbers shown on the right of Fig. 4 tie in with the same members in Fig. 5. It will be assumed that the blue bar (1) is a saturated blue and does not contain any white. Therefore the red and green cameras would not develop any E_R (2) or E_G (3) signal voltages. The blue camera would develop the maximum signal which is indicated as 1.0 volt E_B (4). The matrix circuit in Fig. 5 would change the blue camera signal to Y, R-Y and B-Y signals. Since blue has a brightness level of only 11% the Y signal (5) would have an amplitude of 0.11 volt. The R-Y signal (6) would be negative by 0.11 volt ($E_R - E_Y$). The B-Y signal (7) would be positive by 0.89 volt ($E_B - E_Y$). These three signals Y, R-Y and B-Y are combined and transmitted on a 6 mc TV channel.

The receiver changes the transmitted signal back to the Y, R-Y and B-Y signals (8), (9) and (10) which are applied to the receiver matrix circuits. The matrix circuits in the receiver perform a function which is the reverse of the matrix circuit in the transmitter. In the receiver the Y signal is added to the R-Y and B-Y signals. In addition the G-Y signal is developed as shown at the bottom of Fig. 4 and also added to the Y signal. The signal applied to each gun in the picture tube becomes the same as that originally developed by each color camera.

The blue bar type of color signal would seldom be used at a transmitter. It is somewhat easier to follow than the multicolor bar pattern shown in Fig. 6. This shows seven color bars with saturated green at one end and light green at the other. The signal voltages developed as a result of these various colors are coded the same as those shown in Fig. 4. Any single color can be followed through the points shown in Fig. 5. Notice that the light green hue on the right of Fig. 6 produces both red and blue camera signals in addition to the green signal. The result is the same as adding white light to the saturated green hue on the left. A lighter green color bar would result in higher amplitude E_R and E_B signals and a darker shade would produce lower amplitude E_R and E_B signals.

The various color signals and the way they are developed should be understood since most of these signals can be observed on an oscilloscope connected to various test points on a color receiver. The amplitude of color signals which should appear at various points in the receiver will become very important when troubleshooting color receivers.

(to be continued)

BENCH NOTES

Contributions to this column are solicited. For each question, short-cut or chronic-trouble note selected for publication, you will receive \$10.00 worth of electronic tubes. In the event of duplicate or similar items, selection will be made by the editor and his decision will be final. The Company shall have the right without obligation beyond the above to publish and use any suggestion submitted to this column. Send contributions to The Editor, Techni-talk, Tube Department, General Electric Company, Schenectady 5, New York.

INITIAL TUBE STOCK

This contribution is not for the old-timers but is meant to aid those thousands of young fellows who join our ranks each year. As students or recent graduates of technical schools they desire to carry a small inventory of tubes for replacement purposes but usually do not do so for fear of buying types they will seldom use or overstocking other types which they do not desire to do and usually cannot afford to do.

As one young chap pointed out to me, "The school tells us How to Buy and recommends supply houses Where to Buy, but never tells us What to Buy." For instance two years previously he had bought a 6BG6-G, one of the more expensive types which he had never been required to use. He could have purchased two of the faster moving types such as the 6SN7-GT for the same amount of money. By purchasing two new tubes for each tube sold at retail he could have built up a nice little tube inventory in this period from this one investment.

With the interchangeability of the G-E tubes it is no longer necessary to try several tubes of the same type in any one particular circuit to ascertain which tube gives most satisfactory operation. With this in mind I have compiled the following list of tubes which should take care of about ninety percent (90%) of replacements:

For TV replacement you should have on hand:

- *2—6SN7-GTA (6SN7-GT)
- *2—5U4-GA (5U4G)
- 1—6J6
- 1—6AU6
- *1—1B3-GT (1B3-GT)
- 1—12AT7
- *1—6BQ6-GA (6BQ6-GT)

* (New G.E. Service-designed tubes replacing types in parenthesis)

For AC-DC radios using GT tubes:

- 1—12SA7
- 1—12SK7
- 1—12SQ7
- 1—35Z5-GT
- 1—50L6-GT

For AC-DC Radios using 7-pin miniatures:

- 1—12BE6
- 1—12BA6
- 1—12AT6
- 1—50C5
- 1—35W4

For portable receivers:

- 1—1R5
- 1—1U4
- 1—1U5
- 1—3V4

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EDITOR'S NOTE:

The television tubes suggested above may vary in different areas. This is due to the predominance of one manufacturer's receivers in one area and another in some other area. Tube requirements will also be influenced by the length of time TV reception has been available because some tube types will only be found in older receivers. The tubes suggested by Mr. McAllister represent a good initial stock which should be supplemented by the dictates of individual experience.

EASY INTERLOCK REPLACEMENT

I have tried several methods when replacing defective a-c interlocks with new ones, but the one I use now beats them all. I use No. 7375-F Walco trimounts and snap one of these through the chassis and into each hole of the interlock and then reach behind the chassis with a screwdriver and spread the three prongs a little which gives it a good tight fit. I have installed these in the home without pulling the chassis and just snapping the trimounts in will hold the interlock securely.

I have found this method better than nuts and bolts, rivets, soldering, etc.

Andy Condon
Radio & Television Service
176 Crestwood Street
Pontiac, Michigan

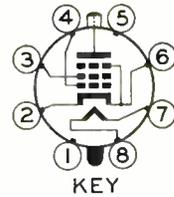
What's new!

6BU5

HIGH-VOLTAGE REGULATOR FOR COLOR TV

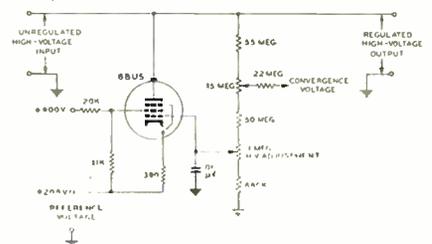
The 6BU5 is a low current, high-voltage beam pentode designed primarily for use as a shunt voltage regulator in the high-voltage power supply of color television receivers. Maximum ratings of the 6BU5 include a plate voltage of 20 kilovolts and a plate dissipation of 20 watts. For isolation of the high voltage, the plate lead is brought out the top cap.

Heater.....	6.3 Volts, 0.15 Amperes
TV H-V REGULATOR SERVICE—DESIGN-CENTER VALUES	
Plate Voltage.....	27000 Volts
Screen Voltage.....	100 Volts
Positive DC G ₁ Voltage.....	0 Volts
Negative DC G ₁ Voltage.....	.50 Volts
Plate Dissipation.....	.25 Watts
Screen Dissipation.....	0.1 Watts
DC Cathode Current.....	2.5 Milliamperes
Heater-Cathode Voltage	
Heater Positive with Respect to Cathode.....	100 Volts
Total DC and Peak.....	200 Volts
Heater Negative with Respect to Cathode.....	
Total DC and Peak.....	200 Volts



TV H-V REGULATOR SERVICE (SEE CIRCUIT DIAGRAM)
Unregulated DC Supply Voltage..... 29900 Volts
Equivalent Resistance of Unregulated

Supply.....	8.5 Megohms
Screen Voltage.....	.70 Volts
DC Reference Voltage.....	200 Volts
DC Load Current.....	0 1.0 Milliamperes
DC Plate Current.....	1.0 0.05 Milliamperes
DC Screen Current.....	0.5 0.03 Milliamperes
Regulated DC Output	
Voltage.....	20000 19600 Volts



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