JUNE—JULY 1954

Vol. 6 No. 3

COLOR TV-III

Electronic TUBES

Techni-talk on AM, FM, TV Servicing

The two previous issues contained a general discussion of the additive process of color reproduction. A "Color Box" which could be built to reproduce a range or gamut of colors similar to those reproducible on a color television receiver was also described. A typical color receiver is the General Electric Model 15CL-100 shown in Fig. 1. The color TV receiver shown in Fig. 1 uses the fifteen-inch tri-color picture tube which produces a twelve and one-half inch picture in either black and white or full color depending upon the type of program transmitted.

In this issue various aspects of color properties and color specifications will be discussed together with the actual operation of the color box.

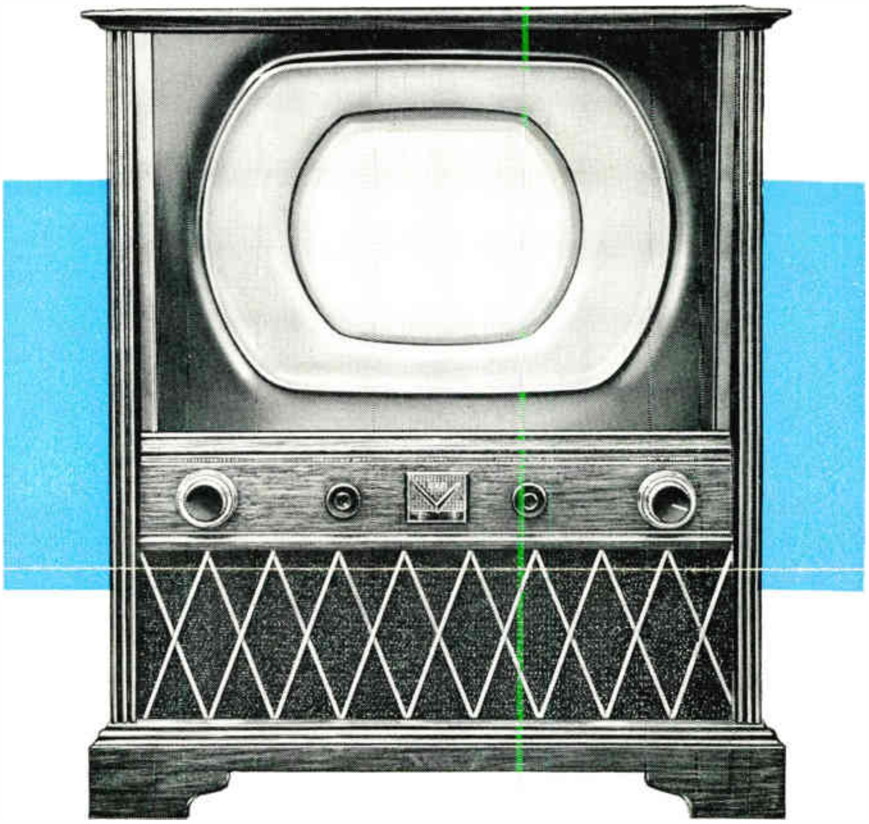

Fig. 1. The General Electric color television receiver Model 15CL100.

THE VISIBLE SPECTRUM

The visible light spectrum shown in Fig. 2 is composed of frequencies between 380 and 700 millimicrons and represents the full range of frequencies visible to the human eye. If a quantity of violet light (380 mμ) is combined with a similar quantity of green light (520 mμ) the resultant color will be in the indigo or blue region which appears about midpoint between these two frequencies in Fig. 2. If the proportions of these two colors (violet and green) are varied, the resultant color will become more green or more violet depending on which color has the largest proportion. The same is true if green (520 mμ) is mixed with red (620 mμ) in different proportions. The resultant colors will have light frequencies which fall in either the green, yellow, orange or red range depending again on the proportion of the two colors.

If a mixture of violet and green light frequencies produces colors which fall between violet and green on the spectrum, and a mixture of green and red light frequencies produces colors which fall between green and red on the spectrum, it would be expected that a mixture of violet and red would produce some color between violet and red on the spectrum. It is found, however, that different proportions of these two colors (violet and red) will produce colors which do not appear at all in the visible spectrum and range from purplish red to reddish purple depending on the proportions.

THE CHROMATICITY DIAGRAM

Because of this phenomenon it is necessary to plot colors not on a straight line but on a horseshoe curve or locus called a chromaticity diagram. This type of diagram, which shows color variations as well as the spectral color frequencies, is shown in Fig. 3. Unfortunately this is not shown in full color. It should be visualized however that the colors indicated are more saturated or vivid at the outer edge and become lighter as they approach the center. It should also be visualized that the colors shown do not change abruptly, but gradually blend from one into the other.

The egg-shaped area in the center would be various shades of white depending upon the color of the adjacent area. The area indicated by dotted lines which surrounds the aforementioned white area represents the various pastel shades of the outside colors. It should be kept in mind that colors on the curved portion or locus of Fig. 3 represent the spectral colors, and those on the straight line at the bottom are nonspectral colors.

THE ICI COLOR PRIMARIES

In order to identify specific colors, certain color standards were established by the ICI (International Commission on

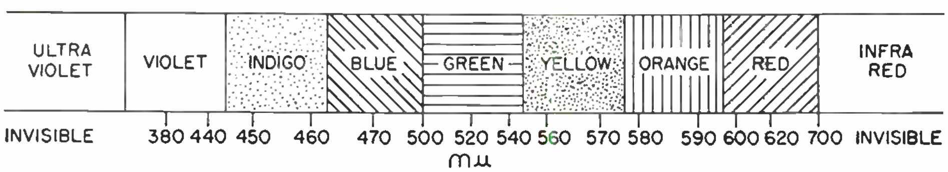

Fig. 2. Visible light spectrum.

Vol. 6 No. 3

TECHNI-TALK

on AM, FM, TV Servicing

Published by
TUBE DEPARTMENT

GENERAL ELECTRIC

SCHENECTADY 5, N. Y.
R. G. KEMPTON—Editor

Illumination). These are known as the ICI color primaries and are defined as monochromatic lights of the wavelengths of 700 mμ for red, 546.1 mμ for green and 435.8 mμ for blue.

These three wavelengths of colored light are used in a colorimeter which is a device used to match an unknown color with a combination of three primary colors. The basic principle of the colorimeter is illustrated in Fig. 4. It was found that *most* of the spectral colors could be matched with combinations of the three ICI color primaries. There were some colors in the range of wavelengths between approximately 450 and 550 mμ which could not be matched unless the red primary was *subtracted* from the other primaries. In other words, it was necessary to *add* some of the red primary to the spectral hue. This color *could* then be matched with a combination of the blue and green primaries. The color mixture curves shown in Fig. 5 have been plotted in terms of power (watts) required to match one watt of any spectral hue.

It should be noted that Fig. 5 covers the range of wavelengths shown in both Figs. 2 and 3. If we would like to obtain yellow which has a wavelength of approximately 580 mμ, Fig. 5 shows that the amounts of the green and red primaries are just about equal at this wavelength.

If a spectral blue-green color in the 490 mμ region in Fig. 3 is to be matched, Fig. 5 shows that a negative amount of red is required. As previously explained this means that the amount of negative power shown must be added to the spectral color. This combination can then be matched with approximately equal amounts of blue and green as shown. It will be also noted that in the 425 mμ region green must be subtracted from a combination of blue and red.

THE X, Y, Z COLOR PRIMARIES

The specification and calculation of colors has been simplified by creating a set of *imaginary* primary colors X, Y, and Z. These three colors *do not exist* but if they could be produced and used in a colorimeter any spectral (or nonspectral) color could be produced without the negative values shown in Fig. 5.

The drawing shown in Fig. 6 is a right triangle based on the three imaginary primaries X, Y and Z. The chromaticity diagram which contains all of the spectral and nonspectral colors has been plotted within the X, Y, Z triangle. The colors which are reproducible by positive combinations of the three ICI primaries are represented by the triangle within the chromaticity diagram. The area between the ICI triangle and the chromaticity diagram represents the colors which cannot be reproduced by the ICI primary colors. Since the chromaticity diagram indicates the full range of visible colors, both spectral and nonspectral, the area between the chromaticity diagram and the X, Y, Z triangle represents imaginary and therefore nonreproducible colors.

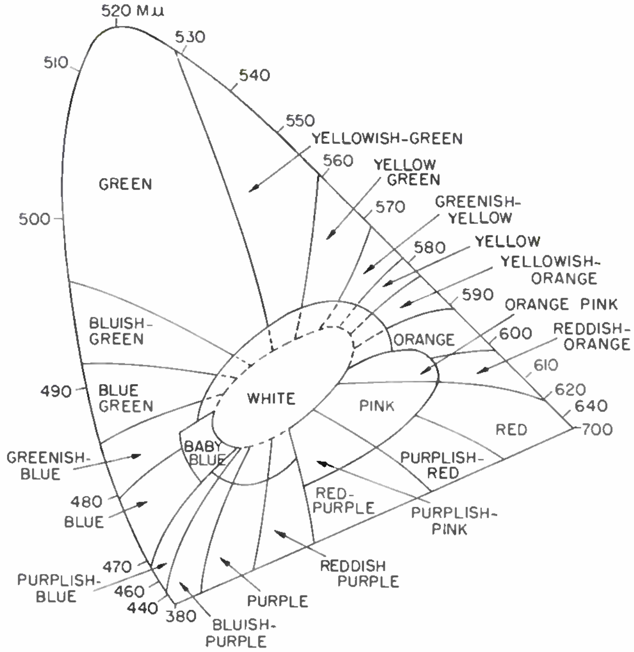

Fig. 3. Chromaticity diagram showing the various spectral and nonspectral colors.

The X, Y, Z diagram is the internationally accepted representation of chromaticity values. Therefore, colors may be specified by stating values of the X and Y co-ordinates. Since X+Y+Z=1 the total of X and Y can never exceed 1. Z is not specified since its value is inferred if X and Y are known. Therefore, the value of X and Y completely describe any color. As an example the primaries used in color television have been specified as follows:

	X	Y
Red	0.67	0.33
Green	0.21	0.71
Blue	0.14	0.08

Dotted lines have been drawn from these points on the X and Y axis as shown in Fig. 7. The points where these lines intersect represent the triangle of colors reproducible by color television. This triangle is slightly smaller than the ICI triangle shown in Fig. 6.

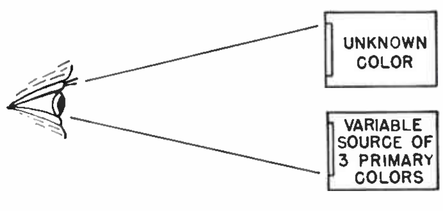

Fig. 4. Basic principle used in a colorimeter to match an unknown color with a combination of the three ICI primary colors.

This illustration may give the impression that a considerable range of colors are not reproducible by color television. It should, however, be pointed out that the colors which cannot be reproduced by color television are saturated colors which seldom occur in nature. Since the colors reproducible by color-printing and color photography are well known, a comparison of the gamut of colors reproducible by each of these systems as well as the color television system is shown in Fig. 8. This illustration will give the reader an idea of the range of colors which can be expected in color television.

The units used in the X, Y, Z, chromaticity diagram were chosen arbitrarily so that negative values could be eliminated. Since these X, Y, Z, units represent imaginary colors, the question may arise as to how these colors may be used to specify actual visible colors. It is possible, whenever desired, to convert these units mathematically to the ICI primary colors.

COLOR PRIMARIES OTHER THAN R, G AND B

It was previously stated that a combination of all colors in the spectrum produced white. If this is true, how can white be produced from only red, green and blue. The answer is that most of the other colors are a combination of either two or three of the primary colors. This was discussed on page one of this issue under the heading "the visible spectrum."

If certain proportions of red and green were mixed, an orange color would be produced with a wavelength in the 590-600 mμ range as indicated in Fig. 3. If certain proportions of blue and green were mixed, a blue-green color would be produced with a wavelength in the 480-490 mμ range. If these two resultant colors were considered as primary colors, a mixture of these primaries would produce colors which would range along a

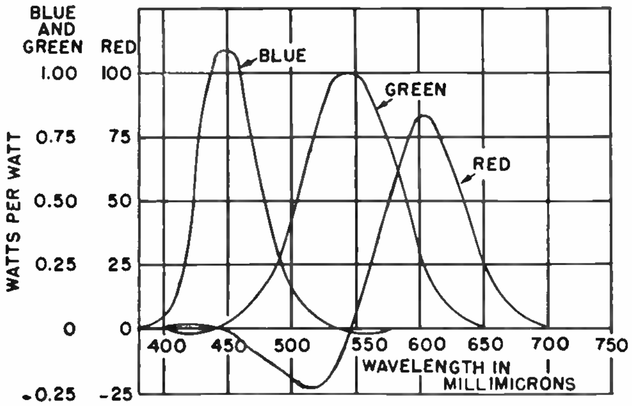

Fig. 5. Color mixture curves which indicate the number of watts of each ICI primary required to match one watt of any spectral hue.

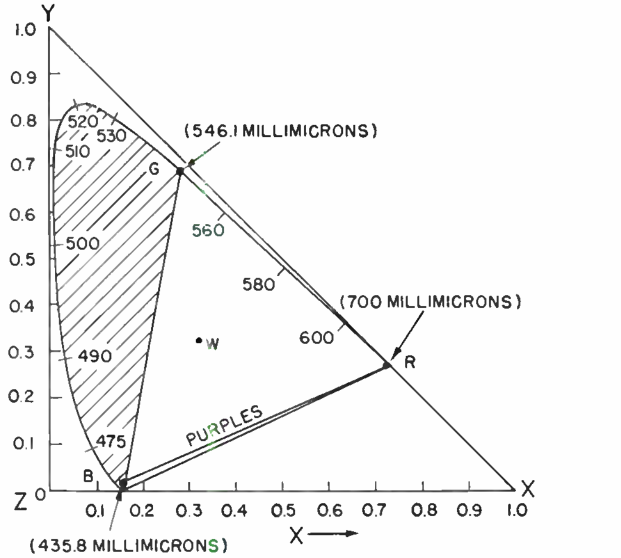

Fig. 6. Right triangle based on three imaginary primaries X, Y and Z. The chromaticity diagram and the ICI color triangle are shown in their relative positions.

line connecting these two colors in Fig. 3. The color produced would depend of course on the proportion of the two primary colors used. It can be seen that these colors would become white near the center. In view of this it is entirely possible that color television receivers may be produced which use only two primary colors. If the two primary colors mentioned above were used, a considerable range of colors including orange, blue-green and the pastel shades of these colors as well as black and white would be produced. Obviously the colors would not cover the same range as those produced with three primary colors but would be similar to some color pictures which use only two primary colors.

In order to understand how the three primary colors can be mixed to produce a number of other colors it would be helpful if a color television receiver were available for experimentation. Since only a few readers will have access to color receivers, the color-box described in the previous issue will materially help in the understanding of color properties and color mixtures. It will be assumed for the sake of simplicity that some means such as a color receiver or a color-box is available to reproduce various color mixtures from the three primary colors. The color demonstrations which will be described in the sections on hue, saturation and brightness are based on the assumption that a color-box is available.

The tri-color tube will be discussed in detail later in this series of articles. At this time it can be visualized as a picture tube with three electron guns, each gun capable of controlling one of the primary colors: red, green and blue. The color-box described in the last issue will also reproduce the three primary colors each of which is individually controlled as it is in a color television receiver. It should be pointed out that the colors used in a color picture tube are carefully chosen to reproduce a particular wave length of color. The colors in the ordinary Christmas tree bulbs used in the color-box do not represent exactly the same colors as these used in color picture tubes, but they are representative of the three primary colors.

The use of the color-box to produce the various colors shown in Fig. 3 will be described in the next issue.

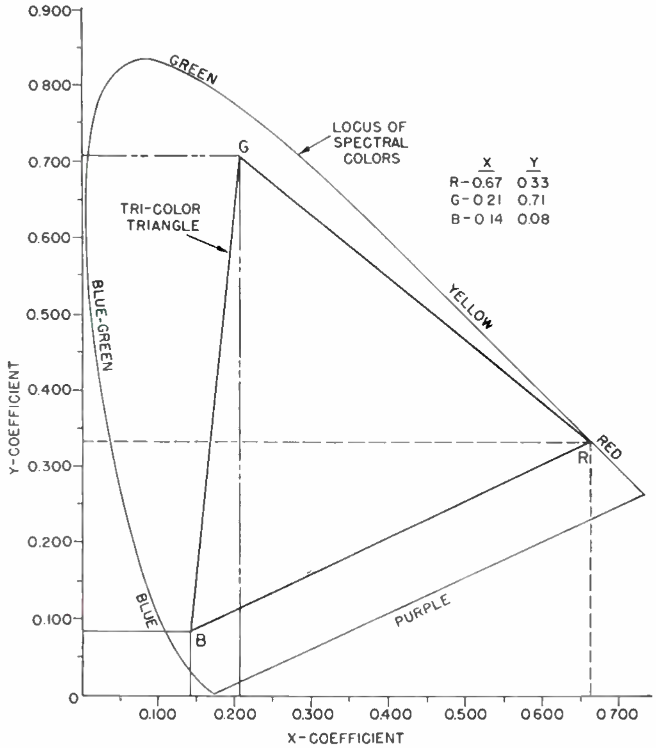

Fig. 7. Trichromatic diagram with the R, G and B color television phosphors plotted on the X and Y axis.

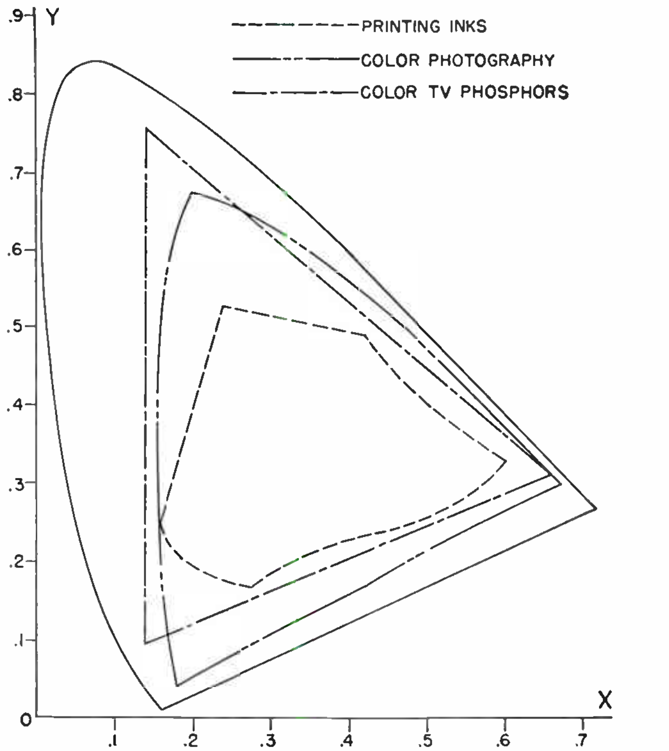

Fig. 8. Range or gamut of three different color-reproduction systems.

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.

PICTURE TUBE DUST SEAL

There are many TV receivers on the market, and in use today which do not have a removable mask for picture tube cleaning purposes. Customers sometimes complain of the frequency with which the tube requires cleaning.

Make a gasket of slightly less circumference than that of the picture tube involved by first purchasing a strip of 1½" sponge rubber from a local rubber products jobber. Cut to the aforementioned length and cement the ends together with rubber cement. After dry, slip this gasket over the tube before placing in the cabinet. When the chassis has been secured in the cabinet, push this gasket forward so that it wedges between the cabinet and the tube itself, thus forming a good seal to resist the dirt-carrying air currents.

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WEAK ION TRAP

When attempting to get as much brightness as possible from a picture tube and after trying everything leaves much to be desired: try replacing the ion trap. A magnet that is too weak or one that is too strong may not be bending all of the cathode-ray electrons the proper amount to send them to the screen.

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SIMPLE SERVICE AIDS

A manicure kit will produce a number of simple radio service aids. Here are a few uses for the aforementioned.

Nail Polish:	Dope or cement for damaged speaker cones, coding replaced components, wiring and polarity.
Polish Remover:	Solvent for some plastics.
Orange Stick:	(Filed to chisel point) To be used as nonconductive screw driver for trimmers or alignment tool.
Emery Boards: and Nail Files:	To clean connections for soldering contacts and condenser plates.
Nail Clippers:	To cut and strip wires.
Tweezers:	For picking up small objects dropping in chassis and for holding small objects in place in cramped quarters.

With a little investigation you will find other uses for the implements I have mentioned.

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TUNABLE HUM

I was working on an RCA 630TS chassis that had a bad sixty-cycle hum, but only when the signal was tuned in sharply. When the set was slightly detuned the hum would disappear. I finally found a 6AU6 sound IF tube that, upon replacement, eliminated the trouble. Apparently the trouble was cathode-to-filament leakage which was not apparent in the speaker until a signal was tuned in and the hum rode on top of it. Upon checking the tube in a tube tester for filament-to-cathode leakage, however, none showed up and the tube checked perfectly although when replaced in the sound IF circuit the same trouble was apparent.

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What's new!

6AR8

SHEET-BEAM TUBE

The 6AR8 is a miniature double-plate sheet-beam tube which incorporates a pair of balanced deflectors to direct the electron beam to either of the two plates and a control grid to vary the intensity of the beam. The resulting unique characteristics of this tube make it especially suited for service as a synchronous detector in color television receivers. In this application, relatively large, balanced output signals of both positive and negative polarities are developed which eliminate the need for phase-inversion functions in the matrix circuits. Other features of the 6AR8 synchronous detector circuit include low oscillator injection power requirements, freedom from the space-charge coupling effects which are present in dual-control pentodes and heptodes, linear output voltages, insensitiveness to variations in oscillator amplitude over a wide range, and a high ratio of plate-to-accelerator current. The 6AR8 is also suitable for service in the burst gate circuit of color TV receivers and a variety of other switching and gating applications.

Heater Voltage, AC or DC	6.3 Volts
Heater Current	0.3 Amperes
MAXIMUM RATINGS, Design-Center Values	
Plate-Number 1 Voltage	300 Volts
Plate-Number 2 Voltage	300 Volts
Accelerator Voltage	300 Volts
Peak Positive Deflector-Number 1 Voltage	150 Volts
Peak Negative Deflector-Number 1 Voltage	150 Volts
Peak Positive Deflector-Number 2 Voltage	150 Volts
Peak Negative Deflector-Number 2 Voltage	150 Volts
Positive DC Grid-Number 1 Voltage	0 Volts

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