This invention relates to a system of color television that is suitable for reception as well as transmission, in which three colors, red, green and blue, or other suitable combinations, may be used. In carrying out the invention, the retentive characteristics of cathode-ray tube screen materials are utilized which exhibit some phosphorescence as well as fluorescence when excited by electrons.

In carrying out this invention, lower repetition rates of the electron beam than usual may be employed, thus making it possible to increase the amount of detail per picture and still remain within a given frequency band allowed for the transmission channel.

While prior attempts to receive color television, it has been found to be detrimental to use a time-delay material for the screen because any hang-over light would show up or be rendered as a false color when the succeeding light filter came into the filtering position.

With the present invention, no moving filter or other mechanical element is used, and therefore any given area of the screen material is required to provide only one color. With this system, the three primary colors are produced frequently enough for the eye to gain the illusion of simultaneity and thus physiologically blend the colors so that all intermediate color shades that appear at the transmitter are rendered at the receiver.

With the usual screens that are used with electron beams, if the rate of color rotation is too low, color break up often occurs, particularly if the pictured objects are in motion or the observer moves or turns his eyes. However, by using retentive screen materials, simultaneous or overlapping transmission of primary colors takes place, since each respective primary color is held on the screen during the subsequent transmission of the other two. The retentivity of the screen material is made to be of such short duration that each color decays to a low intensity in a short enough period to allow rendition of a new picture which may be displaced due to motion of the object.

By the use of this retention or delayed decay of the screen images it is feasible or practicable to reduce the rate of the color cycle, thus allowing more picture elements per color, or better resolution in a given transmission channel.

Illustrative embodiments of the invention are shown in the accompanying drawings, in which:

Fig. 1 is a somewhat diagrammatic longitudinal section through a cathode-ray tube suitable for this invention;

Fig. 2 is an end view of Fig. 1, showing three color field areas;

Fig. 3 shows the sawtooth wave form for the color field frequency;

Fig. 4 shows the stepped positioning wave form for the several fields;

Fig. 5 is a view similar to Fig. 1, partly broken away, showing a modification;

Fig. 6 is a modification using three tubes;

Fig. 7 shows the cathode control signals for the three tubes;

Fig. 8 is a diagram showing how to change the aspect ratio of the pictured objects;

Fig. 9 is a diagram to illustrate how the wave form shown in Fig. 3 can be generated;

Fig. 10 is a diagram to illustrate how the wave form shown in Fig. 4 can be generated; and

Fig. 11 is a diagram showing a potential curve.

In the drawings, reference character 1 indicates a cathode-ray tube having an electron-emitting cathode 2. A grid 3 of the usual sort is shown for controlling the intensity of the electron beam which passes through the aperture 4 of the anode 5. Two scanning fields are provided at right angles to each other by means of the varying potentials imposed in quadrature relations upon the pairs of plates 6 and 7.

A fluorescent screen is provided which is composed of three picture areas 8, 9 and 10 which have applied to them time-delay material of the character indicated above, so that the area 8 will emit red, the area 9 green, and the area 10 blue, respectively, when the electron beam sweeps therewith. Other colors and color sequences may be used. The light from each area will decay gradually after each traverse of the electron beam. Lenses 11, 12 and 13 are employed to focus the images created on the screens 8, 9 and 10 upon any suitable viewing screen, not shown. Three pictures appear upon the three areas 8, 9 and 10. These picture areas contain the intensity modulation characteristic of the colors red, green and blue, respectively. The three areas 8, 9 and 10 may be coated with retentive screen materials of such character that each area radiates directly the desired color for that area. For example, one may use a magnesium salt for the red, a zinc salt for the green, and a calcium salt for the blue. In this way very high efficiency is provided, since no loss is incurred due to absorption by external color filters.

By disposing the three picture areas 8, 9 and 10 vertically, as shown, the horizontal scanning...
can be extended or drawn out to two or three times the normal for aspect ratio of four units horizontally to three units vertically. In this way the round or circular screen cathode-ray tube front surface is considerably more nearly completely utilized and the tendency to burn the screen material is also reduced because of the increased heat radiating area that is provided. This arrangement is also advantageous for permitting increase of horizontal spot size on the screen, which provides an increase in effective horizontal definition for the given 4.26 megacycle vertical channel as compared to the definition that is possible when the usual aspect ratio is used on the cathode-ray tube where the spot size is the same horizontally and vertically as determined by the requirement of just merging the line structure. A cylindrical lens or a cylindrical mirror can, of course, be used to restore the aspect ratio to its proper value of 4 to 3 in the final projected picture. A cylindrical lens of this sort is shown somewhat diagrammatically in Fig. 8 in which the rectangle a—3a represents the screen 8, 9 and 10 focussed by the cylindrical mirror M of the proper curvature so as to provide a suitable viewing screen 4a—3a as described above, thus providing the desired 4 to 3 aspect ratio. Extreme accuracy of linearity for the vertical scan, say 0.5 percent, is required in previous systems when a single vertical scanning sawtooth wave is used at one-third the color field frequency to displace the cathode-ray tube beam. However, the requirement of such accurate linearity of scanning is not necessary when the amount of curvature of the scanning wave form is made the same for three separate color fields. Therefore, in accordance with the present invention we provide a local scanning circuit as shown in Fig. 3 that operates at color field frequency and we displace this scanning raster successively to scan the red area 8, the green area 9, and the blue area 10 of the cathode-ray tube 1 by means of an independent positioning circuit which delivers three levels of control signal as shown in Fig. 4 corresponding to the vertical displacement of the three color areas, the levels being changed at the rate of change of the color field. In Figs. 3 and 4 the wave forms are shown for control voltages for electrostatic deflection or control currents for magnetic deflection. Fig. 3 shows the sawtooth wave form which is at color field frequency, and Fig. 4 shows the stepped positioning control voltage or current for the three fields. Methods of creating these wave forms are already known. The sawtooth wave may be generated as shown on page 456 of "Television," by Zworykin and Morton, published by John Wiley & Sons, Inc., or as shown in Fig. 3 and described on page 3, line 3 et seq., of Patent 2,164,176 of one of the inventors named herein; or as illustrated in Fig. 9 herein in which reference character b indicates a triode to the plate of which a source of positive potential is applied through resistance c with a condenser d connected between resistance c and the plate to ground so that sawtooth voltages are generated. The rectangularly shaped wave shown in Fig. 4 may be generated, for example, as shown in Figs. 2 and 2a of Patent 2,229,506 of one of the inventors named herein, by causing a cathode-ray beam to sweep across substances which yield different amounts of electrons of secondary emission when bombarded by primary electrons as described in said patent and illustrated in Figs. 10 and 11 herein. The highest voltage is generated while the beam is sweeping across the dotted area 40, the next highest while the beam is sweeping across the area 41, and the lowest while the beam is sweeping across the area 42. The proper phasing of these signals is maintained by the synchronizing signals that are supplied by the television transmitter in the well known ways.

In the modification shown in Fig. 5 the three areas 8, 9 and 10 are each coated with the same sort of white light emitting retentive or time-delay material, and filters 14, 15 and 16 that are respectively red, green and blue are placed between the areas 8, 9 and 10 and the lenses 11, 12 and 13, respectively, which focus and blend the thus resulting colors upon the viewing screen. Some loss necessarily occurs by absorption in the filters with this arrangement.

In the modification shown in Fig. 6, three separate cathode-ray tubes 20, 21 and 22 are shown with their retentive or time-delay white light screens 23, 24, and 25. A red filter 26, a green filter 27, and a blue filter 28 are provided for the tubes 20, 21 and 22, respectively, and lenses 29, 30 and 31 are provided to superpose the pictures optically upon the viewing screen 25. The filters 26, 27 and 28 may be omitted and the screens 23, 24 and 25 made of different retentive materials so that screen 23 radiates red under the influence of the electron beam, screen 24 radiates green, and screen 25 radiates blue.

With the three-tube scheme the problem of linearity is less serious than with a single tube because the several tubes can be provided continuously with identical scanning signals, and a locally generated control signal can be used to turn on each tube at the time corresponding to its color modulation signals. These control signals may be applied to the cathodes of the three tubes while the grids are continuously modulated by the incoming video signals.

Fig. 7 shows the wave forms A, B, and C of the cathode control signals for the three tubes 20, 21 and 22, respectively. In each wave form the upper horizontal portions are the cut off voltage levels, and the lower horizontal portions are the operating voltage levels. These keying signals are controlled by the incoming synchronizing pulses in the well known manner.

By the use of retentive screens in accordance with this invention the retention of the screen images for short periods of time enables the rate of the color cycles to be reduced, thus permitting more picture elements per color or better resolution in a given transmission channel. In practice the images on time-delay screen materials rise to maximum brightness very rapidly and gradually fall off in brightness. This gives a decided advantage over a screen having very rapid or practically instantaneous decay, as it permits a reduction of color repetition rate by a factor of two or more, thus enabling improvement of resolution in the picture to be secured both vertically and horizontally by a factor which is the square root of 2 or more.

Where a color picture without retentive screens may require 120 color fields per second with 343 lines per picture in a channel of 4.5 megacycles with a two to one interlace, one with retentive screens as described herein will permit reduction to 60 color fields per second with 450 lines per picture in the same channel. Such a field repetition rate is adequately high for rendering continuity of motion when the retentive screens are used. When the scanning field frequency is de-
creased there is also greater freedom from mag-
netic field difficulties. For example, when 120
cycle sawtooth scanning is used where there is a
60 cycle power circuit, the first 120 cycle field
may be displaced slightly upwardly while the
second 120 cycle field may be displaced slightly
downwardly by the stray magnetic fields from
the transformer, resulting in the pairing of scan-
ing lines which were intended to be interlaced,
thus causing much picture detail to be lost. 10
However, when the field frequency is reduced to
60 cycles any stray fields from the transformer
affect each field equally and do not seriously
injure the resulting picture.

What is claimed is:

1. In a color television system in which the
picture aspect ratio is substantially 4:3, a cath-
ode-ray tube having three fluorescent surfaces of
substantially equal areas which yield three re-
spective colors, each area being rectangularly
shaped and each with a length substantially three
times its height.

2. In a color television system in which the
picture aspect ratio is substantially 4:3, a cath-

do-ray tube having three fluorescent surfaces of
substantially equal areas which yield three re-
spective colors, each area being rectangularly
shaped and each with a length substantially three
times its height.

3. In a color television system, a plurality of
fluorescent surfaces, and means for causing said
surfaces to become fluorescent in succession by
electron scanning, said means comprising a signal
of sawtooth wave form at color field frequency
and a second signal to displace said first named
signal successively to scan said surfaces.

4. In a color television system, a plurality of
cathode-ray tubes all scanned simultaneously
with identical scanning signals, and control sig-

dals to render the beams active in said tubes in
succession corresponding to the colors desired
from said tubes.