Jan. 11, 1949. O. H. SCHADE 2,458,649

COLOR TELEVISION

Filed Jan. 31, 1941 3 Sheets-Sheet 1

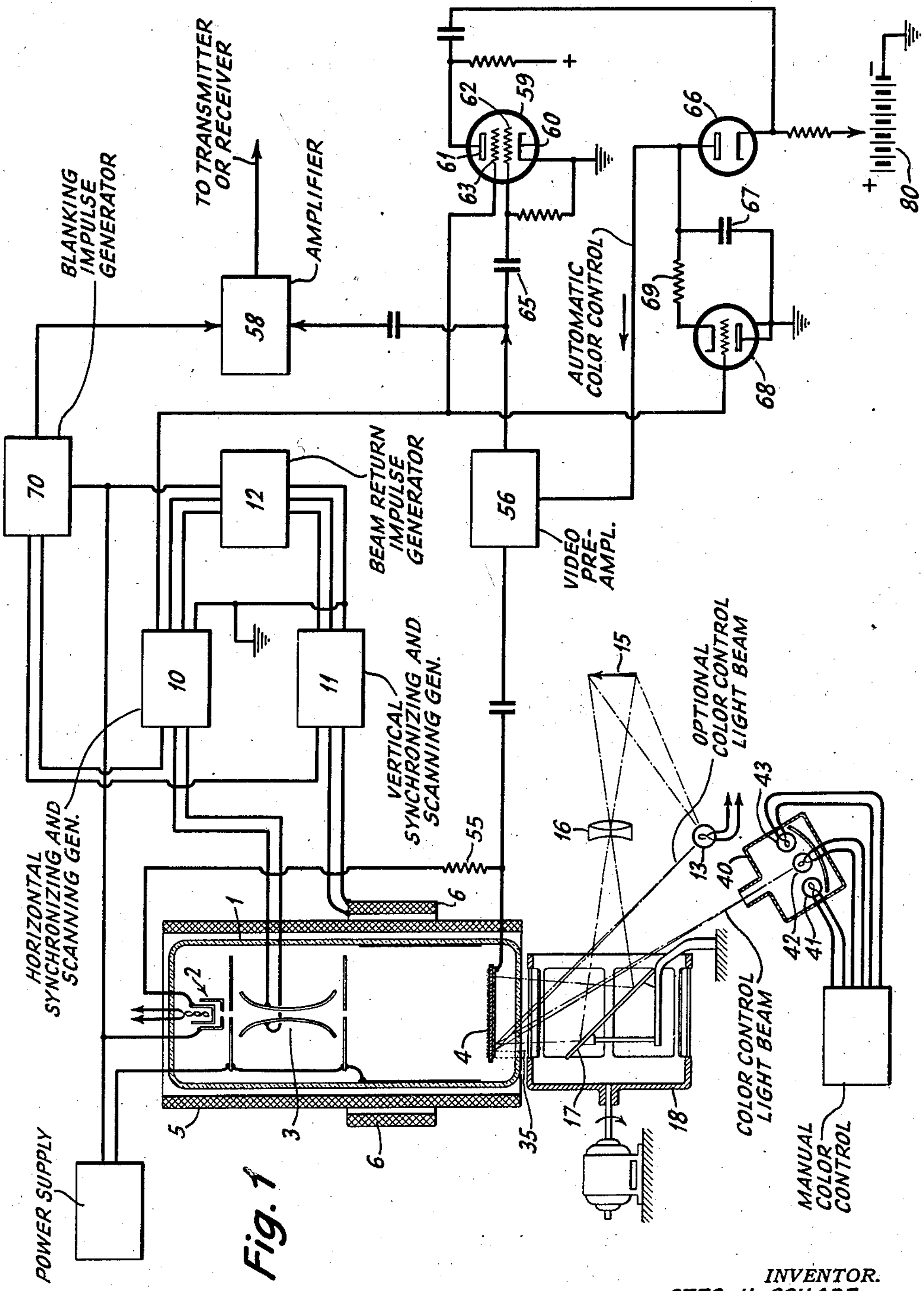

Fig. 1

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Fig. 2

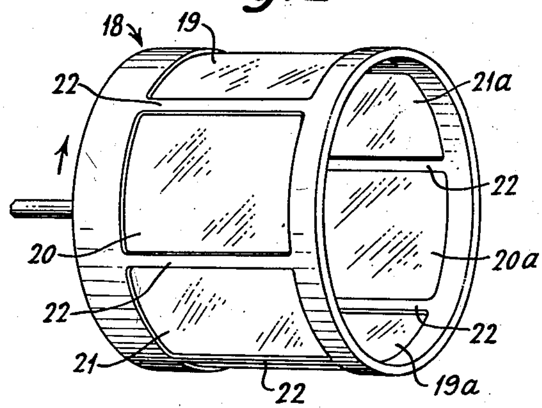
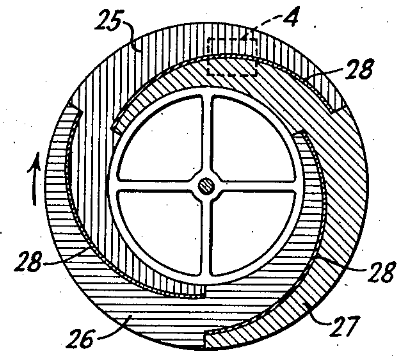


Fig. 3



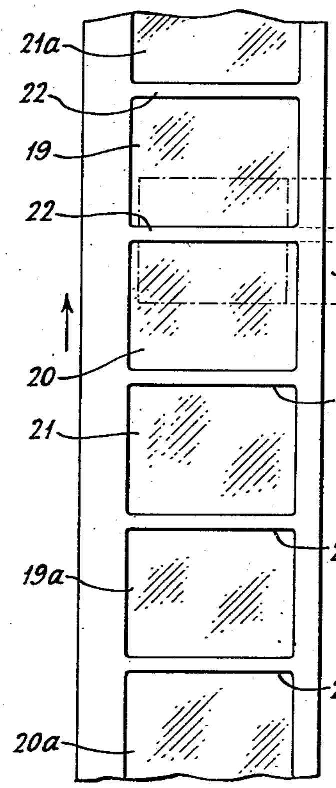


Fig. 4

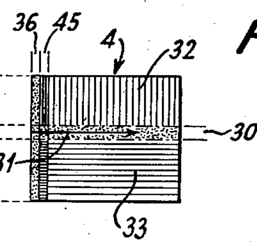


Fig. 5

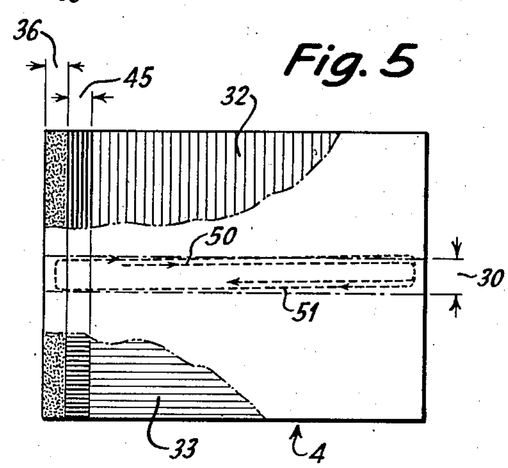


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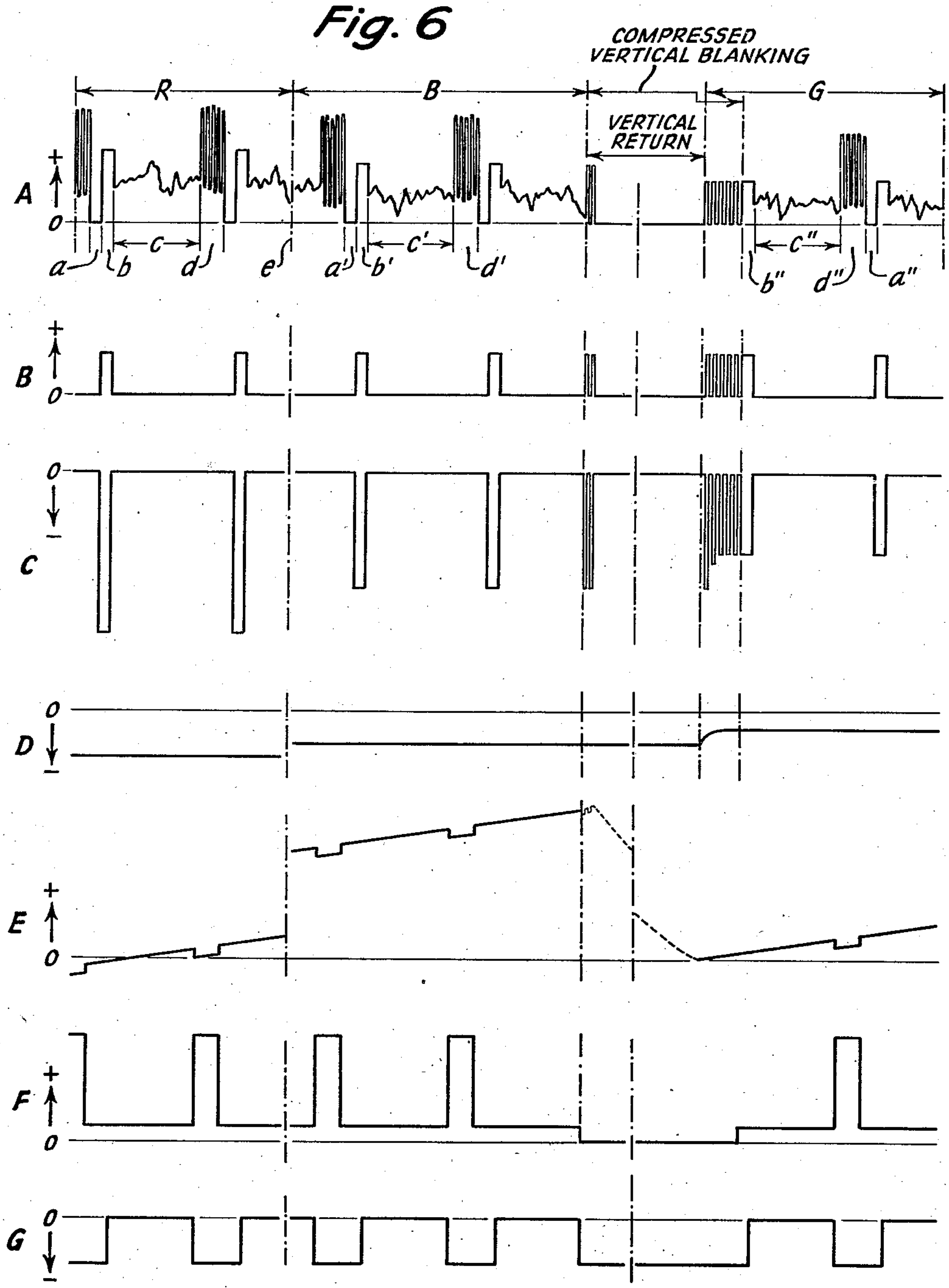
Fig. 6



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2,458,649

COLOR TELEVISION

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Application January 31, 1941, Serial No. 376,770

17 Claims. (Cl. 178—5.2)

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My invention relates to television transmitting and receiving systems and is more particularly concerned with methods and systems utilizing charge storage pickup tubes for producing television pictures in substantially natural colors by means of successive transmission of picture field signals generated by scanning an area on which images in selected primary colors are formed. Thus light from an object may be projected on the area through successively displaced colored filters to develop signals representative of the colored light passing through the filters. The color signals when received produce colored field images which are effectively superimposed so as to produce scanned field patterns which when viewed through corresponding successively displaced filters give to the observer the effect of viewing the original object in substantially its natural colors.

More particularly, my invention relates to the production of television picture images in substantially natural color where the control or modulation signals are transmitted and received over a single channel communication system. In its preferred form the system is so constituted that the signal energy is developed through the utilization of a signal charge storage type of electron beam scanning pickup tube upon which a light image in different selected primary colors is impressed in a predetermined sequence of color exposures to develop signals representative of the individual color fields.

I have found that when utilizing pickup tubes of the charge storage type, such tubes being known in the art as "Iconoscope" or "Orthicon" tubes, the signal resulting from scanning a color field by certain methods is modified by the previous color to which the light sensitive target had been exposed. As a consequence, color mixing may occur so that the desired signals are not representative of a single color but of two or more colors.

In pickup tubes wherein the stored charge image is neutralized by a low velocity electron beam the developed signal is proportional to the charges stored on the target between successive scannings of the same line area. For interlaced scanning this corresponds to the time for scanning two color fields. Thus if the color of the light projected on a photosensitive target is changed every field, and the target is scanned by a low velocity electron beam having sufficient intensity to discharge the scanned areas, an exposure of every line to at least two colors occurs and hence the signal is representative of two successive color fields.

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Television transmitting tubes of the photosensitive type inherently have different photosensitivities to light of different colors. For this reason the signal output is not necessarily proportional to the intensity of the light except in so far as this light is monochromatic. Such tubes are usually highly sensitive to red light, moderately sensitive to the blue and may be even less sensitive to green light. The developed signal accordingly varies for a given amount of light depending upon its color, and consequently it is desirable to provide means to control the sensitivity of a television transmitting system to various colors to develop signals and picture replicas representative of the color values and intensities of the original colored image.

It is an object of my invention to provide a system for color television transmission utilizing a charge storage pickup tube wherein the scanned target is subjected to successive color fields and wherein the effect of persistence of charge due to preceding color fields is minimized or eliminated. Another object is to provide such a system wherein the charge due to a preceding color field is neutralized prior to the generation of signals representative of successive picture fields. It is a further object to provide such a system and of the type described wherein the signals representative of the individual color fields may be controlled or varied in intensity or amplitude by manual semiautomatic or automatic means, and it is a still further object to provide such a system which may be automatically controlled to compensate for variations in spectral response of the pickup tube and variation in the intensity and spectral distribution of the light source utilized to provide illumination of the colored object of which an image is to be transmitted.

In accordance with one teaching of my invention I utilize a charge storage television transmitting tube having a photosensitive target which is subjected to successive differently colored images of a colored object of which a picture is to be transmitted by projecting the light from the object through a rotating light filter having primary color filters such as red, blue and green filters to develop electrostatic charges varying in intensity with the colored light passed by the filter. I so synchronize the scanning beam which neutralizes the charges with respect to the rotation or motion of the filters that the charges resulting from one color are neutralized prior to the development of charges representative of another color. One of the simplest ways to follow this teaching of my invention is to mechanically move primary color filters in synchronized sequence into the path of light between the object and pickup tube and to scan the pickup tube along areas which have been subjected to only one color. A similar combination of primary color filters may be moved in synchronized sequence in the path of light at a receiving location to develop color images corresponding in natural colors to those of the original colored object. The filters at the receiver are moved synchronously but with a phase delay of up to one color field time, inasmuch as the transmitting tube stores the signal due to each color field prior to transmission. Many forms of such filters may be provided, one simple form comprising various sectors of a disc rotating at a suitable and proper speed, another being in the form of a drum or cylinder having various circumferential areas transparent to light of different colors. While I have referred to the use of a corresponding filter arrangement at the receiving location, it is obvious that if the image is to be viewed ultimately as a black and white image, the use of such a corresponding filter at the receiver is unnecessary.

Further in accordance with my invention the signals representative of the individual color fields may be controlled or varied in amplitude or intensity by providing a standard reference level for white light, to which all signals representative of individual colors bear a definite relation and likewise bearing a definite relation to a condition of zero light intensity. In this manner the intensity or amplitude of signals resulting from individual colors may be controlled to obtain signals representative of the original image colors, notwithstanding non-uniformities such as variations in spectral sensitivities of a single pickup tube or between pickup tubes, and even variations in light sources within a time period as short as one line period irradiating the colored object or the spectral distribution of the light source utilized.

These and other objects, features and advantages of my invention will be apparent upon consideration of the following description and the accompanying drawings in which:

Fig. 1 is a schematic diagram of a television pickup tube and an associated circuit suitable for generation of signals representative of colored images;

Figs. 2 and 3 show two types of rotating colored filters for use in the system of Fig. 1;

Fig. 4 shows a portion of the tube and filter structure shown in Fig. 1;

Fig. 5 is an enlarged view of the target of the tube of Fig. 1 showing certain operational phases; and

Fig. 6 is a series of graphs showing relative signal intensities developed by or applied to the transmitting system shown in Fig. 1.

I have referred to two types of charge storage pickup tubes, one of which, known as the "Iconoscope," utilizes an electron scanning beam wherein the electrons have relatively high velocity, being capable of liberating secondary electrons from the photosensitive target electrode. In this type of tube the scanning beam, even in the absence of light projected on the photosensitive target produces a background signal because of non-uniform redistribution of secondary electrons over the surface of the target. Consequently, there is no definite relationship between the incident light and the signal output in so far as the absolute value of signal output is concerned. Thus while the output is modulated in accordance with the intensity of light, a definite reference level to which the amplitude of the signals may be referred is lacking. In the second type of tube, however, wherein the target electrode is scanned by a low velocity electron beam, such as in the so-called "Orthicon" type, the electrons of the beam do not reach the target electrode in the absence of light focused thereon. Consequently, in the absence of light no signal is generated and this feature of the low velocity tube provides a reference level which may be termed the black level of the output signal. Therefore, in accordance with my invention, I provide a system capable of producing a reference black level signal and likewise provide means to generate a reference color signal for each individual color such as red, blue and green. The difference is amplitude between the black reference level and the color reference level is then utilized to control the relative gain or amplification of the system for the various colors. Thus in the low velocity type of charge storage pickup tubes the inherent zero signal with zero illumination provides the zero signal level, whereas with the high velocity charge storage type of tube I provide a dark area on the target which is scanned by the high velocity electron beam, the resulting signal being representative of zero illumination. Furthermore, I provide means to protect light of controllable intensity and of successively varying colors on the target to provide a standard signal value corresponding to the particular colors; and still further in accordance with my invention, I completely neutralize the signal charge on a given area resulting from one color prior to the generation of charges on this area representative of another color. In this manner I am able to avoid the generation of signals representative of two or more colors which would produce a mixture of colors at the point of recreation of the colored picture replica.

The above-mentioned advantages and features of my invention will be understood with reference to Fig. 1 wherein the television pickup tube 1 is of the low velocity beam scanning type, being of the type disclosed by Iams and Rose in their U. S. Patent 2,213,175 and referred to above as of the Orthicon type. It will be appreciated that a tube of the high velocity beam scanning type may be substituted for the tube 1 as shown, especially in view of the description wherein the operational details of these two tube types are contrasted and compared. The tube 1 contains the conventional electron source and control electrode assembly **2**, horizontal line deflection plates **3** and the conventional photosensitive mosaic electrode **4** and is surrounded by a magnetic focusing coil **5** and vertical or frame deflection coils **6**. The electrons from the assembly **2** are focused and directed upon the mosaic electrode **4** and scanned in a horizontal or line direction by the electrostatic deflection plates **3** in combination with the magnetic field produced by the coil **5**, and are likewise scanned over the mosaic electrode in a vertical or frame direction by the magnetic deflection coils **6**. Suitable deflection potentials may be applied to the deflection plates **3** by a horizontal synchronizing and scanning generator **10**, the vertical deflection being produced by currents fed to the deflection coils **6** from a vertical synchronizing and scanning generator **11**. The intensity of the electron beam during discharge of the mosaic electrode is maintained constant, but in accordance with my invention may be changed during the so-called return time by a beam return impulse generator 12, as described in more detail below. A colored image of the object of which an image is to be transmitted such as represented by the object 15 illuminated by a light source 13 is formed on the mosaic electrode 4 in sequentially varying colors. One convenient method of providing sequential color analysis of the image is shown in Fig. 1. I provide a lense system 16 to direct light representative of an optical image upon a mirror 17 located within a cylindrical color filter drum 18; whence the light is projected as an image in proper focus upon the mosaic electrode 4. The filter drum 18, as best shown in Fig. 2, comprises a series of primary color filters such as red, blue and green. I have shown in Fig. 2 a drum including two sets of sequential color filters, the red filter 19 being followed by a blue filter 20 and in turn by a green filter 21, the series being repeated at 19*a*, 20*a* and 21*a*. Obviously, a single or any multiple series of such filters may be used depending upon the desired speed at which the drum is to rotate. Each of the filters 19, 20 and 21 is separated from the other around the circumference of the scanning drum 18 by opaque shutters 22. The opaque shutters 22 may comprise a portion of the scanning drum framework, although the equivalent of such a shutter may be provided by slightly overlapping adjacent filters, since an overlapping red and blue filter would be substantially opaque to red, blue or green light and similarly an overlapping blue and green filter would be substantially opaque to blue, green and red light.

While I have shown in Figs. 1 and 2 the use of a filter drum, an equivalent structure such as shown in Fig. 3 is suitable wherein the filter is of disc formation. Referring to Fig. 3, the filter assembly may comprise a red filter 25, a blue filter 26 and a green filter 27 separated by opaque sections 28 which correspond to the shutters 22 of the drum type of filter assembly. Here likewise the opaque sections 28 may be formed by overlapping the two adjacent color filters as described in connection with Fig. 2. The filter disc may be positioned in a plane parallel and close to the plane of the mosaic electrode, the lateral position of the electrode being shown in Fig. 3 at 4. Obviously, either the drum or disc-type filter assembly may be located at another image plane in the lens system, this arrangement being preferable where there is considerable distance between the mosaic electrode 4 and the envelope of the tube 1.

In accordance with my invention the speed of rotation of the filter is so chosen and the width of the shadow cast by the opaque sections between filters is so proportioned as to cover and darken that portion of the mosaic which is being scanned at any instant of time. Thus I synchronize the vertical or frame deflection of the scanning beam so that that portion of the target which is being scanned at any instant of time is unilluminated. This principle of operation may be further explained by reference to Fig. 4 wherein the filters 19, 20 and 21 are shown projected in a single plane, the mosaic electrode 4 being shown displaced to the right of the filter assembly. Multicolored light such as representative of the object 15 is analyzed by the individual color filters 19—21, a shutter 22 casting a shadow 30 over the entire width of the mosaic electrode 4, the arrow 31 showing a portion of one horizontal scanning line in this shadow 30 of a shutter 22. The electron beam of the tube 1 thus traverses the mosaic electrode 4 and is deflected vertically in synchronism with the rotation or movement of the filter assembly whether it be of the drum type shown in Fig. 2 or of the disc type shown in Fig. 3. It will be obvious that all elemental areas of the mosaic electrode 4 are sequentially subjected to light of the three primary colors, red, blue and green and that any given elemental areas are subject to light of only one color prior to scanning. After the areas are scanned, they are then illuminated by a single different color of light. Furthermore, it will be noted that the time to which any elemental areas of the mosaic are subject to light of a given color is the same for all colors so that the charges developed on elemental areas of the mosaic will be representative of the intensity value of the single color. Thus while the area 32 above the shadow portion 30 is being charged in response to light of one color such as red, the area 33 below the shadow portion 30 (which has just been discharged by the electron beam within the shadow portion) is being charged by light representative of another color such as blue. In this manner the effect of a mixture of charges is avoided, the signal developed by the scanning electron beam being representative of only one color at any particular instant.

In conventional television transmitting systems it is customary to use what is referred to as interlaced scanning, that is, the electron beam during one portion of the frame time is caused to scan the target in a vertical direction over one distinct raster. During another portion of the frame time the beam is scanned over a second distinct raster whose lines are intermediate those of the first raster. Thus the scanning of even-numbered and odd-numbered lines is alternately performed. The vertical frame is thus divided into two portions referred to as fields, the vertical scanning frequency being twice that of normal non-interlaced scanning. It has been considered by those skilled in the art that the application of such an interlaced system of scanning to color television systems is impractical because of the mixing of signals generated by two successive colors. However, it is very desirable to retain interlacing to reduce flicker and transmission band with requirements. Tubes of the charge storage type such as the "Iconoscope" and especially the "Orthicon," referred to above, retain the charge due to light of one color to which is added the charge derived from light of a succeeding color during scanning of the second raster. It is therefore necessary to provide means to discharge the entire mosaic area during the scanning time of one raster to avoid double color exposure. I have found that if the electron beam, instead of being "blanked" during the horizontal return time, is intensified and simultaneously defocused and deflected over the uncharged intervening areas following the vertical progression of the beam, this difficulty may be overcome.

Referring to Fig. 5, the electron beam is assumed to be moving during line scansion from the left to the right across the mosaic electrode 4 and during vertical deflection from bottom to top of the mosaic electrode. The electron beam trace 50 shown in Fig. 5 which corresponds to one horizontal scanning line is shown as being in the shadow 30 of the shutter 22. Following each horizontal trace of the electron beam, it is deflected in a direction opposite to the normal vertical deflection, that is, downward in Fig. 5, and follows the path 51. Over this path 51 the electron beam is intensified and preferably defocused to discharge the electrostatic charges not previously discharged by the scanning beam during previous horizontal scansions. The amount of deflection in a downward direction is preferably equal to the width of an odd number of frame scanning lines. It will be appreciated that this applies to an interlaced scanning system of the single interlacing type. However, if a four-to-one interlace ratio is utilized, such as where lines 1, 5, 9, etc. are first scanned during one interlacing field, lines 3, 7, 11, etc. during the next interlacing field, then lines 2, 6, 10, etc. and then the remaining lines during the fourth interlacing field, it is necessary to defocus or vibrate the beam sufficiently to discharge all the intervening lines not scanned by the beam during a single raster time. It is not necessary that the return trace 51 as shown in Fig. 5 remain in the shadow of a shutter 22 separating the effective areas of the colored filters.

While I have described the electron beam as returning over an adjacent unscanned interline area, it will be appreciated that the return beam path need not necessarily be over the adjacent unscanned area but over a more distant area. Inasmuch as the electron beam must continue scanning such as at the top of the target shown in Fig. 5 to completely discharge the non-scanned areas adjacent the top, a few horizontal scanning lines and the corresponding time equivalent will be lost adjacent the top of the target. It is therefore desirable to have the return trace of the beam closely adjacent the scanning trace. It is also advantageous to limit the width of the shutters 22 so that the width of the shadows cast by the shutters is less than the vertical space occupied by one to two per cent of the horizontal scanning lines during a single frame period. Thus if the width of the shutter is limited to less than approximately five lines for conventional 441-line frame scanning, the loss of lines at the top of the target is small. I have found a width of the shadow 30 equivalent to three horizontal scanning lines sufficient for good operation.

I have shown the scanning line 50 as being close to the top of the shutter shadow 30. I have found it very desirable, especially in the operation of high velocity beam pickup tubes, to operate in this manner to obtain high sensitivity. I believe this high sensitivity which I have obtained is due to scanning immediately after the light has been removed from the area to be scanned while the charge storage is a maximum. For this condition it is necessary to synchronize the filter and the vertical deflection rather closely and have a sharply defined shadow image of the shutter.

It will be apparent from the above that I have provided means for preventing the generation of signals representative of a mixture of colors. However, in tubes of the type described, the mosaic electrode is usually sensitive to various colors in varying degrees. The red sensitivity of such a mosaic electrode is usually higher than the blue and green sensitivity, and likewise the blue sensitivity is usually higher than the green. To obtain a standard reference level, especially in tubes of the high velocity electron beam scanning type to which the amplitude of the signal generated in response to any color may be referred, I provide means to provide a minimum or zero signal by casting a shadow over a portion of the mosaic surface preferably over an elongated area parallel with the vertical direction of scanning. With reference to Fig. 1 I may provide a mask 35 directly on the wall of the tube to mask a portion of the light projected on the mosaic electrode and form a shadow 36 over a narrow strip of the mosaic as shown in Fig. 4. The area of the shadow 36 when scanned in a horizontal direction by the electron beam will produce a signal which, in the case of the low velocity electron beam tube, is zero, and in the case of the high velocity electron beam tube, is of a finite value. It is not absolutely necessary to provide a mask 35 in combination with the low velocity type of tube inasmuch as the signal in the absence of light or beam current is zero.

By providing this reference value representing zero illumination it is possible to form a relationship between the maximum signal derived from any color with respect to the zero illumination signal. Therefore in accordance with a further teaching of my invention and in order to overcome the disadvantages attendant upon variations in spectral sensitivity of the mosaic electrode and of varying light sources or variations from tube to tube, I provide means to project a controlling amount of light on the mosaic electrode in three synchronized sequential colors. Thus, referring to Fig. 1, I provide a light source such as a color control standard light source or projector 40 to project a narrow band of white light on to the filter assembly 18 and as sequential primary colors upon the mosaic electrode 4, preferably over a narrow section of the mosaic extending in the direction of vertical scanning. The color control standard projector 40 may be provided with three separately controllable light sources 41, 42 and 43, each of the sources developing red, blue and green light respectively which is mixed and focused as white light and then passed through the rotating filter 18 as colored light upon the mosaic electrode 4. As the filter 18 rotates, colored strips of light will be projected on the mosaic electrode so that a red strip of light appears during the time the mosaic is subjected to red light from the object 15 and a blue strip of light when subjected to blue light from the object 15. Similarly, the strip of light will be green during the time the green filter 21 is opposite the mosaic electrode 4. This strip of light from the projector 40 is shown in Figs. 4 and 5 as a narrow band 45 adjacent the shadow portion 36. For purposes of simplicity in explanation, the shadow portion 36 and colored band of light 45 are shown adjacent one another, my system, however, functioning equally as well whether these bands are separated or at one side of the mosaic or the other, it being only desirable that these bands be parallel with the direction of vertical scanning so that the scanning beam passes over an area in shadow and an area illuminated by one color of light during each horizontal beam scansion.

In the operation of my television transmitting system the signal plate is connected to the cathode circuit of the tube 1 through an output impedance 55, the signal across this output impedance being fed to a video pre-amplifier 56 such as through a coupling condenser 57 where the signal strength is increased by amplification, whereupon it may be applied to a further amplifier 58 and to a transmission network, as well known in the art. However, in accordance with my invention I control the gain of the video pre-amplifier **56** in accordance with the intensity of the light projected on the mosaic by the projector **40** which serves as a reference for automatically controlling the color signal intensity. Therefore, in accordance with my invention, I apply a portion of the output of the video pre-amplifier to a metering tube **59**. This metering tube produces an impulse which is proportional to the intensity of light from the projector **40** focused on the mosaic electrode **4** as the narrow band of light **45** during successive color fields. The tube **59** preferably comprises a cathode **60**, an anode **61**, a control grid **62** and a screen or modulating grid **63**. It will be obvious in view of the following description that the metering tube **59** may be either a triode or pentode in place of the tetrode type shown. As mentioned above, a portion of the video output from the amplifier **56** may be applied such as through a condenser **65** to the grid **62** of the tube **59**. To limit the operation of the tube **59** to a period of time simultaneous with the passage of the electron beam over the lighted strip portion **45** shown in Figs. 4 and 5 I connect the grid **63** to the horizontal synchronizing and scanning generator which is so designed as to provide a positive pulse during the time the electron beam is passing over the lighted area **45**. The output, or amplified output if desired, of the metering tube **59** representative of the intensity of the colored light projected on the mosaic electrode is applied to a rectifier such as a diode **66** to rectify the pulsating output which is applied to a condenser **67**. This output is proportional to the colored light intensity projected on the mosaic electrode **4** as a reference and is applied as an automatic color signal control voltage to the video pre-amplifier **56**. This control voltage is utilized in the video pre-amplifier to adjust the gain in much the same manner as automatic volume control potentials in a conventional radio receiver, in fact, conventional methods known in the art may be provided in the video pre-amplifier for automatic color signal control such that the gain of the amplifier is increased for low projected intensities of light from the projector **40** or decreased for high intensities.

The operation of the circuit shown in Fig. 1 may be understood more fully by reference to Fig. 6 which shows in sub-figures A to G the various wave forms produced and utilized in the circuit of Fig. 1. Referring to Fig. 6, the wave form A represents the output signal appearing across the output impedance **55** which is applied to the video pre-amplifier **56** through the condenser **57**, the condenser **57** having the required value to pass the frequency spectrum of the video signal. The wave form A of Fig. 6 is shown in four representative portions, the first, that portion designated R, being a portion of the horizontal video line signal representative of the signal derived in response to red light from the object **15** being projected through a red filter such as the filter **19** and upon the mosaic electrode **4**, it being understood that a portion of the mosaic such as the strip **36** is maintained in shadow. The adjacent strip **45** is illuminated by the red light component of light from the projector **40** likewise passing through the red filter **19**. From an examination of the first portion of the wave form A it will be noted that the signal is zero during the time the electron beam is scanning the portion **36** of the mosaic which is in shadow represented at *a*. The signal then increases over the portion *b* to a value determined in part by the intensity of the red component of light from the projector **40**. The actual amplitude of the portion *b* is determined by a number of factors including the sensitivity to red light of the mosaic electrode, the spectral transmission characteristic of the red filter **19** and the specific characteristics of the transmitting tube **1**. It is assumed for purposes of explanation that the signal derived from the tube **1** for the given intensity of the red component of the light from the projector **40** is higher than a corresponding signal produced by the blue light component and, similarly, still higher than the signal produced by the green light component. The wave form portion *c* shown in Fig. 6A is representative of the red light component from the object **15** and is the true video signal for which transmission is desired. This video signal is followed by a return line signal *d* having considerable amplitude inasmuch as the electron beam is intensified during the horizontal return time for the purpose of discharging areas of the mosaic such as interlacing areas by the method described in connection with Fig. 5. The entire line signal is then repeated for the balance of the horizontal line scannings to complete the red color field scanning. The wave form A is therefore shown discontinuous at *e*. The portion marked B of the wave form of Fig. 6A is representative of the signal across the impedance **55** during a little more than the last two useful horizontal scanning lines prior to the vertical return of the beam for scanning the succeeding field subjected to the green light component from the object **15**. It will be noted that over the portion *a'* the video signal is zero as in the case of over the portion *a* previously described because the electron beam is scanning an unilluminated portion of the mosaic. The amplitude of the video signal over the portion *b'* is constant and representative of the blue component of light from the projector **40** over the area **45** of the mosaic. As mentioned above, it is here assumed for purposes of explanation that the amplitude of this *b'* portion is lower than the corresponding *b* portion representative of the red component in the projected light. The portion *c'* is representative of the blue component of light from the object **15**. The portion *d'* corresponds to the signal generated during the horizontal beam return and, naturally, is of high amplitude because of the electron beam intensification during the horizontal return time. As noted above, the portion of the wave form B representative of substantially the last two useful lines of the blue field is followed by the vertical return of the electron beam prior to the generation of signals during the blue color field. It will be noted that this portion of the wave form has been compressed, it being understood that the vertical return time of the pickup tube beam is equivalent to the time occupied by a number of line scannings, this time in practice being approximately five per cent of the field time. During the vertical return the electron beam intensity is reduced to zero so that no signal is derived during this return. In addition, the video signal of several lines before and after the vertical return is likewise blanked such as for the purpose of obtaining a well-defined top and bottom of the recreated picture replica. Vertical blanking is removed at the beginning of the green field, a portion of which is shown at G, and the portion *b''* is representative of the green component of light from the projector **40**. The portion b'' is followed as before by the true video signal c'' produced by the green light component from the object 15, the signal d'' being representative of the horizontal return line signal.

The wave form shown in Fig. 6B is representative of the keying pulses applied during the red, blue and green color fields to the grid 63 of the metering tube 59 and likewise to the grid of the tube 68, the function of which is described below. Therefore the tube 59 is in operation only during the time the electron beam is traversing the illuminated portion 45 of the mosaic electrode. This keying pulse is of constant amplitude for the red, blue and green fields and merely places the tube 59 in operation so that the output such as in the plate circuit of this tube appears as shown in Fig. 6C. It will be noted that the amplitude of the pulses of Fig. 6C is proportional to the amplitude of the respective portions b, b' and b'' for the three colored fields. This pulse amplitude is therefore proportional to the individual colored components of the light from the projector 40 prior to applying the automatic control voltage, and is therefore a measure of the overall response of the system to a constant value of colored illumination projected on the mosaic. The tube 68 in conjunction with the resistor 69 periodically provides a discharge path for the condenser 67 so that the condenser voltage may instantly be made equal to the metering pulse amplitude within the keying time. The time constant of the condenser 67, tube 68 and resistor 69 combination must therefore be given the proper value to meet this requirement. The rectified wave form of the pulses shown in Fig. 6C is shown in Fig. 6D, this being substantially constant in amplitude and of negative polarity so that when this wave form is applied to the video pre-amplifier 56 an increase in the negative direction reduces the amplification of the pre-amplifier.

The wave forms shown in Figs. 6A, B and C are assumed as being generated in the absence of color signal control fed to the pre-amplifier 56, it being understood that the effect of the applied control will be to decrease proportionally the wave forms for the successive color fields to a level such that all color control pulse amplitudes shown in Fig. 6C are made substantially equal, their value being adjustable by means of the variable potential source 80 which may be referred to as a "delay bias." This automatic control action, therefore, will maintain constant color control pulse amplitude irrespective of changes in spectral response of the pickup tube, transmission of the filters or variations of the standard light from the projector 40. Therefore, if the red light component from the color control light source or projector is decreased, the amplifier gain will be raised automatically to the original level, thereby producing a reciprocal increase in the video signal resulting during the red color field. In this manner the ratio of the various colors may be controlled and maintained automatically by a single adjustment of the color ratios of the color control light source. For linear transmission the color control light source is made pure white.

It is further possible to utilize my system for automatic compensation for variation in color and intensity of the source of illumination used to illuminate the object of which an image is to be transmitted. Thus if a portion of the light directly from the light source 13 used to illuminate the object is diverted, and used in place of the projector 40 as a color control standard, variations in both color of light and intensity of light are automatically and instantly compensated within the time of successive line scannings. The resultant signal is equivalent to that obtained with illumination of the object by a perfectly white light source of exceptionally high stability.

The wave form shown in Fig. 6E is representative of the vertical scanning current applied to the vertical reflection coils 6 of the tube 1. It will be noted that the notches are provided to displace the scanning beam during the horizontal return time in the direction of the previously scanned lines and during the time the electron beam is intensified as shown in Fig. 6F. Instead of applying the notches to the vertical scanning wave form, a separate deflection system may be used to move the beam in a direction opposite to the vertical scanning during the horizontal return time.

It will be obvious that it would be undesirable to transmit a signal corresponding to the wave form shown in Fig. 6A, and portions of this signal are therefore blanked, as well known in the art, such as by pulses shown in Fig. 6G applied to the amplifier 58 from a blanking impulse source such as the generator 70. Suitable synchronizing signals are likewise mixed with the transmitted video signal for purposes of synchronizing the receiver with the transmitter.

While I have described my invention in connection with a circuit wherein automatic color control potentials are applied in a negative polarity to the pre-amplifier, it will be obvious that such control potentials may be applied in either positive or negative polarity to any suitable control point in the system. In some applications it may be desirable to provide additional manual control for color response and shading signals such as by keying a number of amplifiers connected in parallel with the color controlled preamplifier. Thus three amplifiers may be utilized, each having an individual gain and/or shading control and keyed by a sequence switch network controlled by the vertical synchronizing generator in such a manner that only one amplifier is operative at a time, the amplifiers being sequentially switched in accordance with the color fields. Thus one amplifier individually gain controlled may be utilized to control the red response and similar amplifiers for the blue and the green response, the outputs of these amplifiers being applied in parallel to the transmitting network. Similarly, a single amplifier supplied with keyed gain control signals may be used to obtain the additional manual color control. In this arrangement a conventional sequence switching network controlled by vertical synchronizing field impulses may be used to apply to the video amplifier a color control bias from each of three manually controlled potentiometers during successive scanning fields, thereby varying the gain of the amplifier during successive fields. In such a system automatic color control may be applied to the preamplifier, and the following single amplifier or the three amplifiers in parallel may be individually controlled to obtain abnormal accentuation of various colors.

While I have indicated the preferred embodiments of my television transmitting system and my method of controlling the accentuation or attenuation of signals representative of various colors and have indicated only one specified application for which my invention may be employed, namely, the generation of signals for television transmission, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular system used and the purpose for which it is employed without departing from the scope thereof as set forth in the appended claims.

I claim:

1. In a television transmitting system adapted to develop and transmit signals representative of a succession of differently colored optical images comprising a cathode ray tube having a photosensitive target electrode of the charge storage type and electron beam generating means, a light filter assembly associated with said tube including a succession of displaced differently colored light filters, means to move said filter assembly in the path of light from an object intercepted by said target to form a succession of differently colored optical images of said object on said target, means to maintain an area of said target unilluminated between areas subjected to light passing through adjacent filters, means to scan the electron beam of said tube in one direction over said unilluminated area of the said target to develop signals representative of the intensity of light passing through one of said filters, means to displace the electron beam and scan said beam in an opposite direction approximately parallel with said first-mentioned direction and means to intensify said electron beam during scanning in said opposite direction to discharge areas of said target intermediate the areas scanned in said first direction.

2. In a television transmitting system adapted to develop signals representative of a succession of differently colored optical images including a device having a charge storage electrode and means to develop a beam of radiant energy adapted to neutralize charges developed on said electrode in response to light projected thereon, means to progressively expose areas of said electrode to successive differently colored optical images separated one from the other in the direction of progression across said electrode by an unilluminated area, means to scan said beam of radiant energy in one direction over an area of said electrode adjacent the areas of said target illuminated in different colors, means to move said beam in another direction synchronously with the progression of exposure of said electrode to maintain said beam on the said area adjacent the areas in different colors and means to intensify and simultaneously displace said beam in said other direction between scannings in said first-mentioned one direction.

3. In a television transmitting system utilizing interlaced scanning in which successive picture fields are alternately scanned including a tube having an electrode adapted to receive an optical image of an object and electron beam generating means to direct an electron beam on said electrode, means to develop electrostatic charges on said target in response to a succession of primary color components of light from said object, means to scan said electron beam over spaced elongated areas of said electrode following the subjection of said electrode to light of one primary color component and means to discharge elongated areas of said electrode between said spaced elongated areas during the time portions of said electrode are being subjected to light of a primary color different than the said one primary color component.

4. The method of developing signals for television transmission in natural color which comprises the steps of progressively developing over an area a succession of electrostatic charge images representative of three successively different primary color optical images, scanning the area by a cathode ray beam along elemental line areas to produce picture signals sequentially representative of the three successively different primary color optical images by neutralizing at least a portion of the electrostatic charge images, and neutralizing the residual portions of the electrostatic charge images intermediate the portions neutralized to develop the picture signals to thereby prevent instantaneous development of signals representative of more than one of the primary color optical images.

5. The method of developing signals for television transmission in natural color which comprises the steps of progressively developing over an area a succession of electrostatic charge images representative of three successively different primary color optical images, scanning the area by a cathode ray beam along elemental line areas to produce picture signals sequentially representative of the three succesively different primary color optical images by cancellation of at least a portion of the electrostatic charge images, and cancelling the remaining portion of the electrostatic charge images that remain uncancelled after the area is scanned to thereby prevent instantaneous development of signals representative of more than one of the primary color optical images.

6. The method of developing signals for television transmission in natural color which comprises the steps of progressively developing over an area a succession of electrostatic charge images representative of successively different color optical images, producing a series of successive signals representing line elements of each electrostatic charge image by a discharge of at least a portion of the electrostatic charge image, and discharging the residual electrostatic charge image during the interval between the produced successive signals to completely remove the electrostatic charge image prior to the development of the next succeeding charge image representative of a different colored optical image.

7. The method of developing signals for television transmission in natural color which comprises the steps of progressively developing over an area a succession of electrostatic charge images representative of successively different color optical images, producing a series of successive signals representing line elements of the electrostatic charge image by cancellation of at least a portion of the electrostatic charge image, and cancelling the residual electrostatic charge image during the interval between the successively produced signals to completely remove the electrostatic charge image prior to the development of any appreciable charge image representative of a different colored optical image to thereby prevent instantaneous development of signals representative of more than one of the colored optical images.

8. The method of developing color television signals which comprises the steps of forming a succession of electrostatic charge images representative of successively different colored optical images, utilizing portions of the successive electrostatic charge images to intermittently develop image signals by removing at least a portion of each electrostatic charge image, and removing the remaining electrostatic charge image during the time interval between the intermittently devel-

oped image signals so that the entire formed electrostatic charge image is completely removed prior to the formation of the next successive electrostatic charge image.

9. The method of developing color television signals which comprises the steps of forming a succession of electrostatic charge images representative of successively different colored optical images, utilizing portions of the successive electrostatic charge images to intermittently develop image signals by destroying a portion of each electrostatic charge image, and destroying the remaining portion of the electrostatic charge images during the time interval between the intermittent development of image signals so that each electrostatic charge image is completely destroyed prior to the formation of the next successive electrostatic charge image.

10. A television transmitting system for developing signals representative of colored optical images comprising a tube having a light responsive target electrode of the charge storage type, means in said tube to develop a cathode ray beam, means to project a light image of an object onto said target electrode, movable means to intercept light of various colors from the light image to progressively expose areas of said electrode to differently colored components of the light from the object to develop electrostatic charges representative of the colored light intensity, means to scan said target electrode by the developed cathode ray beam in a plurality of line patterns to develop picture signals by discharging a part of the electrostatic charges, and means to displace the cathode ray beam by a predetermined amount in a direction opposite to the scanning direction during the return time interval whereby electrostatic charges on interline areas of the target electrode are discharged following the progression of each colored image across the light responsive target electrode.

11. A television transmitting system for developing signals representative of colored optical images comprising a tube having a light responsive target electrode of the charge storage type, means in said tube to develop a cathode ray beam, means to project an optical image of an object upon said target electrode, movable means to intercept light of various colors from the optical image to progressively expose areas of said electrode to differently colored components of the optical image to develop electrostatic charge images representative of the intensity of the different color components, means to scan said target electrode by the developed cathode ray beam in a plurality of adjacent line patterns to develop signals representative of the electrostatic charges by a release of the charges, means to intensify the developed cathode ray beam following the scanning of each line element and during the beam return time interval, and means to displace the cathode ray beam by a predetermined amount during the return time interval whereby unreleased charges on interline areas of the target electrode are released to completely eliminate each charge image prior to the development of the next succeeding charge image.

12. A color television transmitting system comprising a tube having a light responsive target electrode, means in said tube adapted to developing an electron beam, an object of which an image is to be transmitted, means to progressively expose areas of said light responsive target electrode to successively differently colored optical images of said object to successively develop electrostatic charge images on said target electrode representative of the intensity of the successive colored images, means to scan said target electrode by the developed electron beam in a plurality of line patterns to develop picture signals representative of the light from said object by the discharge of at least a portion of each developed electrostatic charge image, means to intensify the developed electron beam following the scanning of each line element and during the beam return time interval, and means to displace the developed electron beam by a predetermined small amount in a direction opposite the scanning direction during the beam return time interval whereby interline areas of the target electrode are affected by the electron beam to discharge the residual electrostatic charge image prior to the accumulation of any substantial charge representative of the next successive colored optical image, whereby the light responsive target electrode may be completely discharged prior to the development of each successive electrostatic charge image.

13. A color television transmitting system comprising a tube having a light responsive target electrode, means in said tube adapted to developing an electron beam, an object of which an image is to be transmitted, means to progressively expose areas of said light responsive target electrode to successively differently colored optical images of said object to successively develop electrostatic charge images on said target electrode representative of the intensity of the successive colored images, means to scan said target electrode by the developed electron beam in a plurality of line patterns to develop picture signals representative of the light from said object by the discharge of at least a portion of each developed electrostatic charge image, and means to displace the developed electron beam by a predetermined amount in a direction opposite to the scanning direction during the beam return time interval whereby the residual charges on interline areas of the target electrode are discharged prior to the accumulation of any substantial charge representative of the next successive colored optical image, whereby the light responsive target electrode may be completely discharged prior to the development of each successive electrostatic charge image.

14. In a color television system employing a storage scanning device having an image storage surface associated therewith, signals stored on said surface corresponding successively to different color aspects of an object field, the method which comprises scanning said storage surface successively in a plurality of interlaced sets of lines during respective field scansions, successive interlaced field scansions corresponding to different color aspects of an object field, and at least partially removing stored signals corresponding to one color aspect on the scanned portion of the storage surface by traversing the scanned portion with an erasing beam prior to the rescanning of said portion for the succeeding color aspect in the succeeding field scansion, whereby color carryover from one interlaced field scansion to the next may be diminished.

15. In color television, the combination which comprises a storage scanning device having a storage surface associated therewith, color filter means for successively associating said storage surface with filters of different colors, means for scanning said storage surface in a plurality of interlaced sets of lines during respective field

scansions, a source of a beam adapted to at least partially remove stored signals from said surface, and means for progressively deflecting said beam over area of the storage surface between successive scansions thereof, whereby color carry-over from one interlaced field scansion to the next may be diminished.

16. The method of developing signals in successive field scanning intervals for television transmission in natural color, with interlaced scanning, which comprises the steps of progressively developing over an area a succession of electrostatic charge images representative of three successively different primary color optical images, scanning the area by a cathode-ray beam along elemental line areas of an interlaced set of lines during each field scanning interval to produce picture signals sequentially representative of the three successively different primary color optical images by neutralizing at least a portion of the electrostatic charge images, and neutralizing portions of the electrostatic charge images of a set of lines other than the portions neutralized to develop the picture signals during each of said intervals, to thereby substantially prevent instantaneous development of signals representative of more than one of the primary color optical images.

17. In a television transmitting system adapted to develop and transmit signals representative of a succession of differently colored optical images comprising a cathode ray tube having a photosensitive target electrode of the charge storage type and electron beam generating means, a light filter assembly associated with said tube including a succession of displaced differently colored light filters, means to move said filter assembly in the path of light from an object intercepted by said target to form a succession of differently colored optical images of said object on said target, means to maintain an area of said target unilluminated between areas subjected to light passing through adjacent filters, and means to scan the electron beam of said tube over an interlaced line of said target within said unilluminated area during a field scanning interval to develop signals representative substantially of the intensity of light passing through one of said filters, and means comprising said electron beam to at least partially discharge another interlaced line of said target during said interval, to thereby substantially prevent instantaneous development of signals representative of more than one color optical image.

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