

Nov. 18, 1947.

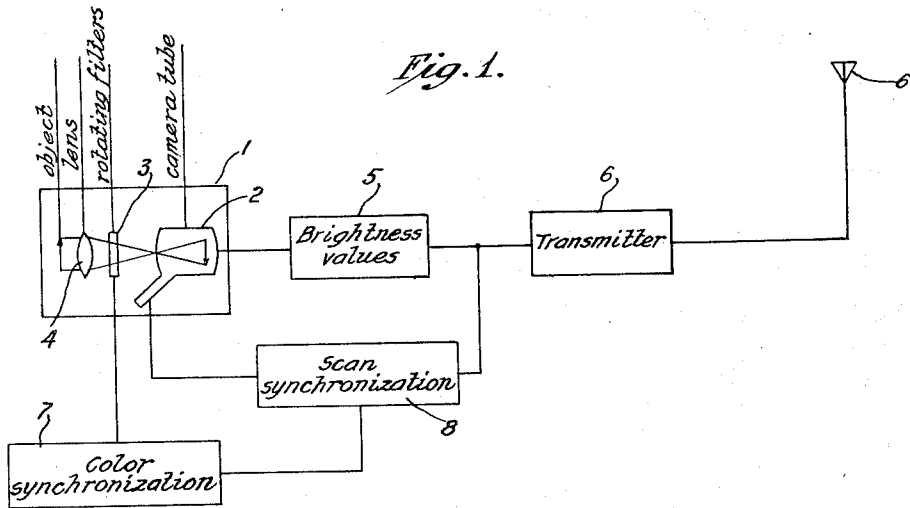
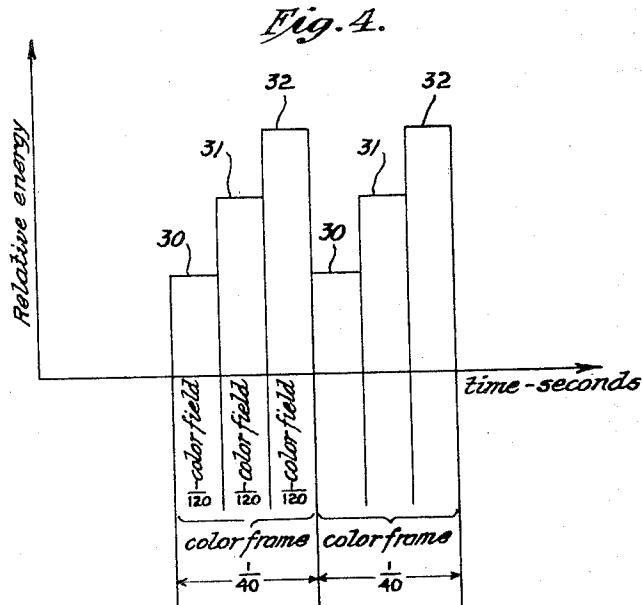
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2,431,088

COLOR TELEVISION

Filed Dec. 3, 1943

2 Sheets-Sheet 1



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Fig. 2.

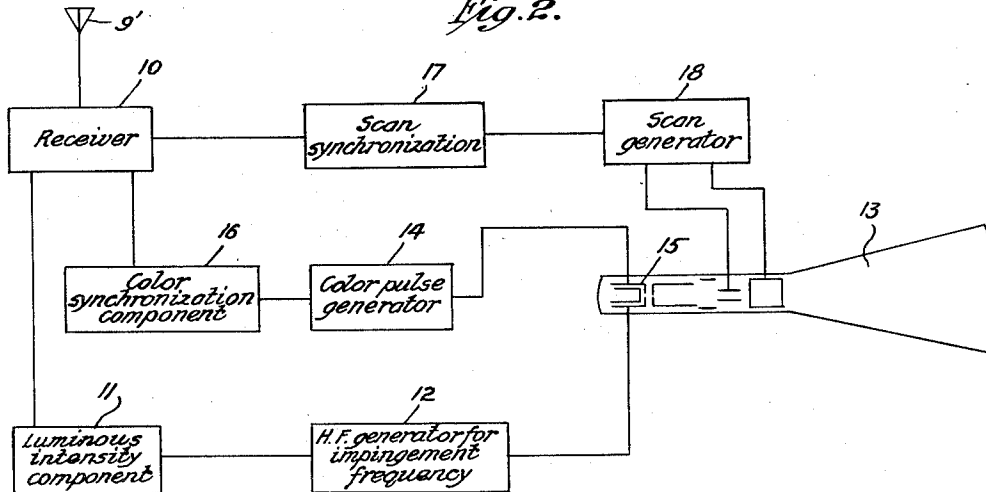
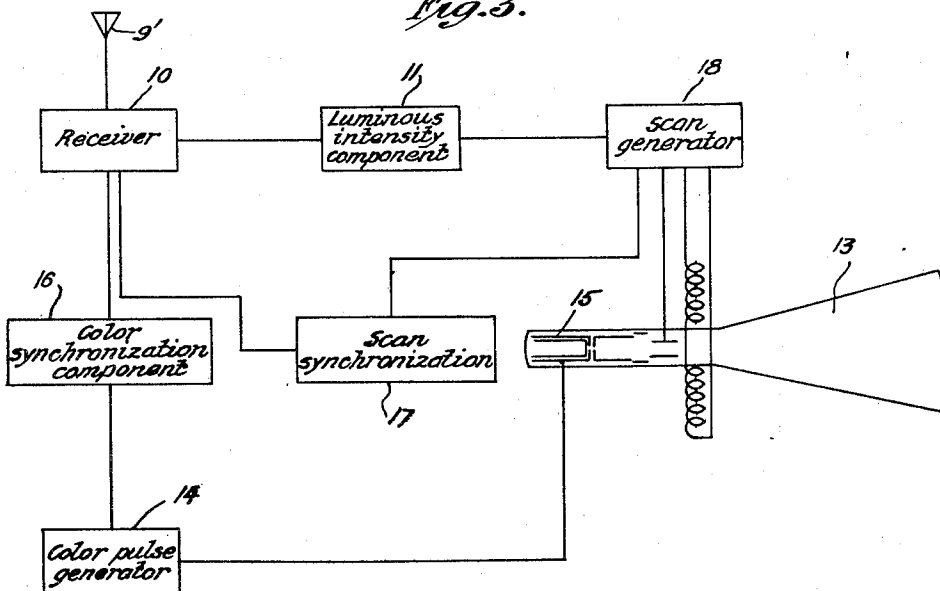


Fig. 3.



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COLOR TELEVISION

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This invention relates to new and useful improvements in color television.

One object of my invention is to avoid in color television the use of any moving parts, such as rotating filters at the receiving station.

Another purpose of my invention is to provide a color television receiver of the cathode ray tube type, wherein changes in beam density produce color changes instead of the changes in luminous intensity usually produced thereby.

Yet another object of my invention is to produce, in a television receiver, changes in luminous intensity by controlling the frequency of beam impingement upon the reproducing screen of a cathode ray tube.

With these objects in view, I provide a cathode ray tube or the like in a television receiver, having a screen including fluorescing materials of more than one type, which saturate at different beam current densities and exhibit different saturation colors. Therefore the screen as a whole will exhibit different dominating or resultant colors, depending on changes in the degree of excitation of the fluorescent material. By varying the current density of the cathode ray beam, different over-all color responses will be obtained from a mixture for use upon a screen, made up of a suitable mixture of fluorescent powders of different types.

In accordance with the present invention, the screen of a cathode ray tube may be made up of a mixture of substances such as cadmium zinc sulphide, which fluoresces with a red hue and saturates easily, and a less saturable beryllium silicate, which latter substance fluoresces with a bluish-green hue. At high current densities of the cathode ray beam, the screen will fluoresce with a blue-green color because the cadmium zinc sulphide saturates at a lower current density. The fact that cadmium zinc sulphide saturates, means that if the current density be increased by decreasing the area of the spot made by the cathode ray beam while keeping a constant total beam current, then the intensity of the fluorescence of the red hue producing component of the screen material will not increase but, quite to the contrary, such component will deliver less light when the current density per unit area transcends a given value. When the area of the spot is increased, then the hue of the red powder will predominate in spite of the constancy of the light intensity of the spot, while at the same time, a flux of the bluish-green light will remain constant, this being due to the fact that under

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these conditions the beam current density per unit area will have decreased.

The current density of the beam can be changed either by varying the area of the spot, keeping constant total current, or by varying the beam current while keeping a constant spot area, or by varying both these factors at the same time. One of these methods of variation has heretofore, in the prior art, been utilized for intensity modulation to reproduce the brightness values transmitted in a television system. According to my invention, not only brightness values but color changes are produced by such variations, and the light intensity variations may be controlled by other methods, such as modulating the sweep velocity or by a novel method hereinafter described. Insofar as intensity modulation is concerned, the modulation of the sweep velocities is produced while keeping a constant current density in the beam. The variation of the current density will, under such conditions, as above stated, allow the reproduction of the color component of the picture elements upon the receiving screen.

Another novel arrangement for reproducing light intensity modulation, makes use of Talbot's law concerning the integrating property of the eye. According to the phenomenon of this well-known law, a series of successive luminous stimuli produce an effect of brightness which increases with the number of stimuli, provided that their frequency of repetition be above a certain critical flicker frequency. In a cathode ray tube it is therefore possible to change the brightness of the luminous spot which the cathode ray beam makes on the fluorescent screen of such tube, by varying the number of interruptions per unit time element, of the cathode ray beam, while it is exciting fluorescence upon the same spot of the screen. In this latter case, the sweep velocity of the beam remains constant, but the cathode ray beam is interrupted a variable number of times while remaining stationary with respect to the reproducing screen. Here also the variation of the current density will cause the reproduction of the color components of the picture elements.

In the foregoing description, it has been assumed that the carrier wave received is modulated both for color and brightness components. The ideal arrangement for deriving color signals from the transmitter would be an arrangement by which a single signal would indicate the color without the latter being split up into its primary components. However, such arrangement would lead to difficulties similar to those which

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are experienced in analyzing the physical meaning of color in relation to the effect the latter produces upon the human eye. Additive color television systems are based on the physiological phenomenon according to which the eye tends to blend into one composite color, two or more (usually three) primary colors, which latter are perceived in rapid succession. The object to be televised may be scanned in succession through three color filters, when the three color system is employed, and for each color filter the light intensities of all the analyzed points of the object are transmitted. Thus the colored object is dissected into its green, blue and red, or other primary color light intensities. At the receiving end, in the prior art, the color synthesis has been effected by successively reproducing the respective green, red, and blue hue components, by means of filters which have been rotated or otherwise moved in front of the pick-up device under the control of suitable synchronization impulses. The transmitting arrangement above described may be adopted, on the other hand, for use with my improved electronic color receiver but certain modifications must be made therein.

Assuming that the color field frequency is 120 per second and that three filters are used at the transmitter, the color frame frequency will be 40 per second. Therefore during an interval of $\frac{1}{40}$ of a second, the object must be scanned for blue, red and green hue components, or similarly for any other primary color combination, and this scanning must be repeated every $\frac{1}{40}$ of a second. A signal will be transmitted, which will be the same in character for each color frame, but of a different energy content for each one of the filters employed. The transmitted or received signals and the corresponding color filters must, of course, be synchronized with each other, and the signals must be applied to the grid of the receiving tube at the proper respective instants and in suitable forms. Each of the signals will thus regulate the density of the electron beam spot, in accordance with the color represented by such signal.

Pulses may be generated at the receiver for controlling the current density locally, in which case only the color synchronization signals need be transmitted.

In the drawings:

Fig. 1 represents diagrammatically a transmitter, according to my invention;

Figs. 2 and 3 represent, respectively, two different embodiments of a receiver, according to my invention; and

Fig. 4 represents one type of signal which is produced by the use of my invention to control the grid of the receiving tube for changing color.

Referring first to Fig. 1, 1 is the conventional recording part of the transmitter comprising a camera tube 2, rotating filters 3, and a suitable optical system 4, all these elements being well-known in the art. The intensity or brightness values of the different elements of the picture, are transformed into corresponding signals at 5 and are sent out through the transmitter 6 and associated antenna 6'. Color synchronization signals are generated at 7 synchronized with the rotating filter system, and signals for synchronizing the scanning at 8, synchronized with the camera tube, elements 7 and 8 being coupled to one another.

Fig. 2 illustrates a receiver operating by impingement frequency variation. Light intensity values derived from antenna 9' and receiver 10, produce at 11 pulses correspondent to the lumi-

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nous intensity component, which pulses control a local high frequency generator 12, which latter, in turn, controls the starting and cut-off of the electron beam, or impingement frequency, in a cathode ray tube 13. The current density variation is obtained by a color pulse generator 14, connected to the control grid 15 of the cathode ray tube 13. The color synchronization signal derived from the receiver 10 by separating element 16 controls the local color pulse generator 14. The scan synchronization signals are derived from generator 17, fed from the receiver 10, and control, through a scan generator 18, the deflecting plates of the tube 13.

Fig. 3 illustrates another form of receiver, using sweep velocity modulation. The elements corresponding to Fig. 2 bear the same reference numerals. As in the previous form of receiver, the beam current density is controlled by a color pulse generator 14, controlled, in turn, by the color synchronization component of the impulses, derived via separating element 16, from the receiver 10. The light intensity signals are derived at filter 11, from the receiver 10 and these, together with the scan synchronization signals, derived at filter 17, control, through scan generator 18, the horizontal sweep scanning.

In the above-described systems, the current densities are changed, while maintaining a constant beam spot size. However, as above stated, the same result can be obtained by varying the size of the beam spot and maintaining constant the beam current. For this purpose the focusing of the cathode ray tube to produce variations of the spot area, are preferably electro-statically controlled, since the focus will vary from one picture point to the next point thereof.

Fig. 4 shows a typical signal transmitted when the color field frequency is 120 per second, and three filters are used. The color frame frequency, therefore, is 40 per second. That means that in an interval of $\frac{1}{40}$ of a second, the object has been scanned for blue, 30, red, 31, and green, 32, light intensities, or any other suitable analytical color combination, the process being repeated in the next $\frac{1}{40}$ of a second, etc. The signal transmitted will then be equal for each color frame and different for each one of the filters. Signals and corresponding color filters are, of course, synchronized. When these signals are applied to the grid of the receiving tube, each of the signals regulates the density of the electron beam spot in accordance to the color it represents.

It is also possible to generate the pulses controlling the current density locally at the receiver and transmit only the color synchronization signal.

What is claimed is:

1. A color television receiver including means for collecting energy from the transmission medium, receiving means proper, filter means separating scan synchronization signals, a scan generator governed by said separated scan synchronization signals, a cathode ray tube having the deflection elements thereof connected to and controlled by the output of said scan generator, filter means separating color synchronization signals, a color pulse generator controlled thereby and connected to said cathode ray tube so as to control current density of the electron beam therein, filter means separating luminous intensity signals, an impingement frequency generator controlled thereby and connected to said tube so as to control the impingement frequency of the electron beam therein, said cathode ray tube

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having upon the screen thereof a coating of material responsive, by the production of differing colors, to variations in the current density per unit area of the electron beam impinging thereupon.

2. Receiver for color television reproduction including means for collecting energy from the transmission medium, receiving means proper, filter means separating scan synchronization signals, a scan generator governed by said separated scan synchronization signals, a cathode ray tube having the deflection elements thereof connected to and controlled by the output of said scan generator, filter means separating color synchronization signals, a color pulse generator controlled thereby and connected to said cathode ray tube so as to control current density of the electron beam therein, filter means separating luminous intensity signals, means connecting said last-mentioned filter means also to said scan generator so as to afford sweep velocity modulation of the sweep scanning in one direction by said cathode ray tube, said cathode ray tube having upon the screen thereof a coating of material responsive, by the production of differing colors, to variations in the current density per unit area of the electron beam impinging thereupon.

3. Method of television reception of the cathode ray tube color reproducing type wherein the tube screen has a coating capable of color variations, including the steps of separating in the received signals components representing respectively luminous intensity, scan synchronization and color synchronization, producing pulses controlled by said luminous intensity components and controlling the impingement frequency of the electron beam in said tube thereby, producing pulses controlled by said color component and controlling current density in said tube thereby, producing scan signals controlled by said scan synchronization component and controlling scanning in said tube thereby.

4. Method of television reception of the cathode ray tube color reproducing type wherein the tube screen has a coating capable of color variations, including the steps of separating in the received signals components representing respectively luminous intensity, scan synchronization and color synchronization, producing pulses controlled by said luminous intensity component and controlling the sweep scanning of said tube thereby so as to yield sweep velocity modulation, producing pulses controlled by said color component and controlling current density in said tube thereby, producing scan signals controlled by said scan synchronization component and controlling scanning in said tube thereby, said scanning being controlled both by said luminous intensity component and said scan synchronization component.

5. In color television receiving apparatus, a cathode ray tube including a gun for producing an electron beam, a screen for translating electronic beam energy of different levels per unit cross-sectional area of the beam into light energy of different values in different complementary colors, means for scanning the screen with the beam, means for generating successive beam control signals corresponding to the different colors and for controlling the beam therewith, a source of luminous intensity video signals, and means for further controlling the beam to vary the electronic beam energy reaching unit areas of the screen in accordance with the video signal.

6. In color television receiving apparatus according to claim 5, wherein the tube includes a

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control grid, said screen comprises a fluorescent substance which translates electronic beam energy of different levels per unit cross-sectional area of the beam into light energy of different values in complementary colors, and the means for generating beam control signals is connected to the control grid to control beam current density and thereby the translations.

7. In color television receiving apparatus as in claim 5, wherein the tube includes a control grid and the means for further controlling the electronic beam comprises an impingement frequency generator connected both to the source of video signals to be controlled thereby, and to the control grid to control beam impingement on the screen in accordance with the video signals.

8. In color television receiving apparatus as in claim 5, which also includes a source of scan synchronizing signals and color synchronizing signals, the means for scanning being connected to and controlled by the source of scan synchronizing signals, and the means for generating successive beam control signals being connected to and controlled by the source of color synchronizing signals.

9. In color television receiving apparatus according to claim 5, wherein the tube includes a control grid; said screen comprises a fluorescent substance which translates electronic beam energy of different levels per unit cross-sectional area of the beam into light energy of different values in complementary colors, the means for generating beam control signals is connected to the control grid to control beam current density and thereby the translations and the fluorescent material is a mixture of at least two substances each of which is excitable by the electron beam at a substantially different value of current density thereof and produces a substantially different color at said level.

10. In color television receiving apparatus according to claim 5, wherein the tube includes a control grid, said screen comprises a fluorescent substance which translates electronic beam energy of different levels per unit cross-sectional area of the beam into light energy of different values in complementary colors, the means for generating beam control signals is connected to the control grid to control beam current density and thereby the translations and the fluorescent material is a mixture of at least two substances each of which is excitable by the electron beam at a substantially different value of current density thereof and produces a substantially different color at said level and each of which is saturable by the beam at a substantially different level of current density thereof.

11. In color television receiving apparatus according to claim 5, wherein the tube includes a control grid said screen comprises a fluorescent substance which translates electronic beam energy of different levels per unit cross-sectional area of the beam into light energy of different values in complementary colors, the means for generating beam control signals is connected to the control grid to control beam current density and thereby the translations and said fluorescent material is a mixture of zinc sulfide and beryllium silicate.

12. In color television receiving apparatus according to claim 5, wherein the tube includes a control grid, the beam control signals comprise a voltage whose wave form includes a number of square waves of different amplitudes having a predetermined order of succession which is cycli-

cally repeated, the number being equal to the number of different complementary colors, and the means for generating these signals is connected to the control grid to vary the electron beam current.

13. In color television apparatus according to claim 5, which includes means for focusing the beam, the means for generating successive beam control signals being connected to the means for focusing to control the transverse cross-sectional area of the beam at its point of impingement on the screen.

14. In color television receiving apparatus, a cathode ray tube including a gun for producing an electron beam, a screen for translating electronic beam energy of different levels per unit cross sectional area of the beam into light energy of different values in different complementary colors, means for scanning the screen with the beam, means for generating successive beam control sig-

nals corresponding to the different colors and for controlling the beam therewith, a source of luminous intensity video signals, and scan velocity control means connected to the source of video signals and to the means for scanning to vary the instantaneous rate of scanning in accordance with the video signals.

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