March 22, 1955 G. C. SZIKLAI 2,704,783

COLOR TELEVISION RECEIVING SYSTEM

Filed Aug. 14, 1948

Fig. 1.

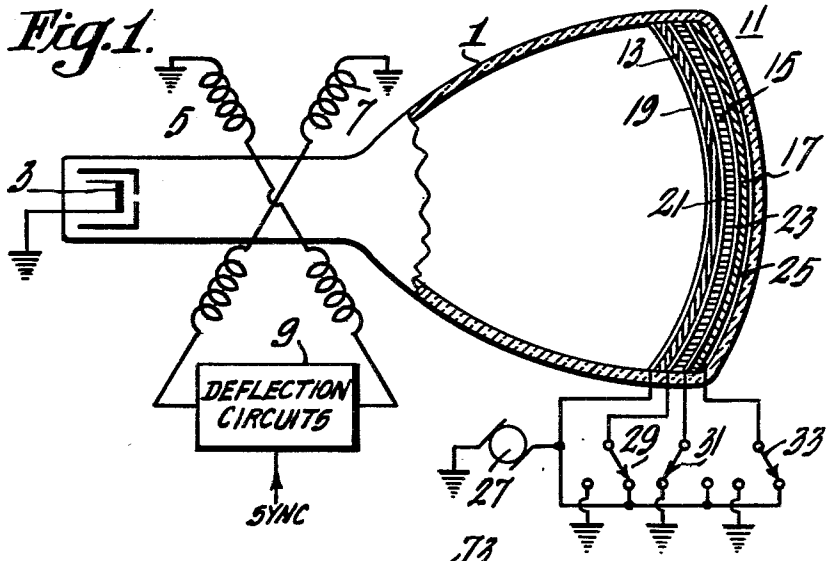


Fig. 2.

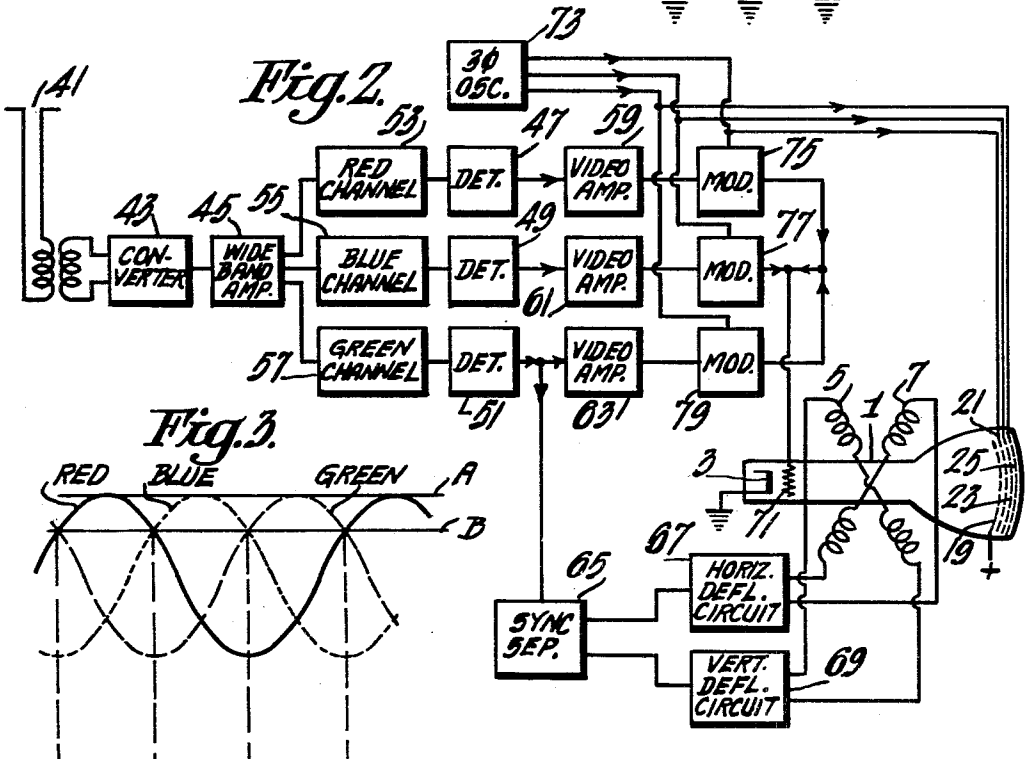


Fig. 3.

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2,704,783

COLOR TELEVISION RECEIVING SYSTEM

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9 Claims. (Cl. 178—5.4)

This invention relates to television, and more particularly to receiving set arrangements for the reception of images in substantially their natural color.

In color television systems wherein image reproduction is accomplished by positioning in registry a group of color component images representative of selected component colors which together add to produce a resultant image in substantially its natural color, the image is broken down not only into its elemental areas but into independent signal trains representative of each of the selected component colors of the image.

Heretofore the formation of images in substantially their natural color has been accomplished by the production of several independent component color images to be optically combined on a projection screen. Such an arrangement is well shown and described in an article entitled "An Experimental Simultaneous Color Television System," beginning on page 861 of the "Proceedings of the Institute of Radio Engineers" for September, 1947. In this article referred to, particular attention is directed to Part III, beginning on page 871, wherein the popular "trinoscope" is shown and described.

Upon an examination of the description and theory of operation of the trinoscope it will be readily understood that mechanical and optical precision is important to insure that the several images are projected in registry on the image projection screen.

In order to overcome the relatively stringent requirements for mechanical and optical registry, there has been proposed a system for the reproduction of images in substantially their natural color wherein colored images are formed sequentially by cyclically altering the effective velocity of the scanning cathode ray beam of a cathode ray image producing tube in the region of the target area of the image producing device. Such an arrangement is shown and described in detail in the copending U. S. application of Vladimir K. Zworykin, Serial No. 739,503, filed April 4, 1947, and entitled "Kinescope for Color Television Reception," now Patent No. 2,566,713 granted September 4, 1951.

In my copending U. S. application entitled "Kinescope for the Reproduction of Color Images," Serial No. 41,294, filed July 29, 1948, now Patent No. 2,543,477 granted February 27, 1951, colored light is obtained by altering the effective velocity of the scanning cathode ray beam of a cathode ray image producing tube in the region of the target area by physically retarding the velocity of the electrons by predetermined amounts by means of mechanical barriers or the like.

The copending applications referred to immediately above depend basically in theory of operation on an electron penetration phenomena covered very thoroughly in an excellent treatise on the subject written by H. Bethe entitled "The Theory of Transmission of Fast Corpuscular Rays Through Materials," which may be found in the "Annalen Der Physik," vol. 5, 1930, beginning on page 325.

In this paper, considering electrons as the particles, the ray equation may be simplified to a form:

$$v_0^4 - v^4 = \frac{16Je^4N}{m^2}BX = K \text{ (a constant)}$$

where

v_0 is the initial velocity of the electron,
v is the velocity after the electron traveled X distance in the material,
e is the charge of the electron 4.77×10^{-10} ESU,

m is the mass of the electron 9.04×10^{-28} gram,
N is the number of atoms per unit volume of the material, and
B is the retardation factor of the material.

Mr. Bethe gives the values for the retardation factor B (Bremsvermogen) for several materials, such as 18.7 for aluminum, 48.4 for gold, etc.; considering that the energy released in the solid is

$$\frac{m(v_0-v)^2}{2}=R$$

it is easily seen that unless v is considerably smaller than v_0, the energy of the electron is going to be released beyond the layer (in this case the energy will be absorbed by the glass support), since

$$R=\frac{m}{2}(v_0^2 \pm 2\sqrt[4]{v_0^8 - v_0^4K} \pm \sqrt{v_0^4 - K})$$

which is a function containing a maximum.

Thus considering a layer of phosphor with a barrier of a given K value bombarded with a beam of increasing velocity, at first the radiation will be zero since the beam does not penetrate the phosphor, then at a value $K=v_0^4$ most of the energy will be absorbed by the phosphor, beyond which the loss of velocity becomes smaller and the energy lost will shift beyond the phosphor.

It will be seen from the above discussion that contrary to the obvious concept, the light radiation does not necessarily increase with the velocity of the impinging electrons but reaches a maximum and then is reduced.

It will be seen, therefore, that differently colored lights may be produced in a stacked or composite screen arrangement wherein the velocity of the electrons traveling through the screen is controlled in such a manner that its most efficient light producing velocity will be at the location of the selected color light producing phosphor or at the phosphor with the properly chosen associated light filter.

This particular principle has, of course, been recognized heretofore for the production of colored light by electron bombardment. An electron sensitive photograph plate may be found well shown and described, for example, in the U. S. patent to E. G. Ramberg, No. 2,442,961, dated June 8, 1948, wherein electrons at controlled velocities are made to impinge upon a layered screen. The velocities are so chosen that the maximum efficiency of each of two velocities produces a maximum of radiation in one of two selected component color light producing mediums.

According to this invention, a novel arrangement is provided for color selection wherein, for example, in a system employing three simultaneous type selected component color image representative signal trains, there is provided a cathode ray tube having an electron gun, an intensity control electrode, and an electron target which includes a color control electrode and an associated color light producing material for each of the selected color components. A three phase oscillator modulates the incoming signal trains and at the same time applies its three phase signal to the color control electrodes. The deceleration of the bombarding electrons in the appropriate color light producing medium may therefore be controlled to produce upon a scanning action an image in substantially its natural color.

A primary object of this invention is to provide an improved system for the production of colored light and colored images.

Another object of this invention is to provide for improved color television image reproduction.

Another object of this invention is to provide a novel electron beam target and associated equipment for color television systems.

Other and incidental objects of the invention will be apparent to those skilled in the art from a reading of the following specification and an inspection of the accompanying drawing in which:

Figure 1 illustrates schematically this invention in one of its forms;

Figure 2 shows by block diagram the operation of this invention; and

Figure 3 is a graphic illustration of the operation of this invention.

Turning now in more detail to Figure 1, there is shown a cathode ray tube **1** including an electron gun **3** for generating a stream of electrons in the usual manner. The cathode ray tube **1** includes horizontal and vertical deflecting coils **5** and **7** together with the associated deflection circuits **9** which receive synchronizing information in the usual manner.

It is not intended to go into detail regarding the construction of tube **1** and its associated beam generating and deflection means because such arrangements are well known to the electrical and television art.

Except for the novel target arrangement of this invention indicated generally by the reference character **11**, the tube may take the form of any conventional kinescope which is well described in the early article entitled "Description of an Experimental Television System and Kinescope" in the "Proceedings of the Institute of Radio Engineers" for December, 1933.

A television receiver arrangement employing a kinescope is shown in U. S. reissue patent to Carlson, No. Re. 20700, granted April 19, 1938. The deflection and control circuits shown and described therein and in a U. S. patent to Tolson et al., No. 2,101,520, granted December 17, 1931, or in the U. S. patent to Vance, No. 2,137,039, granted November 15, 1938, may be employed in connection with the tube **1** of this invention. Synchronization may be maintained in accordance with the arrangement disclosed and claimed in the copending U. S. application of Wright et al. entitled "Beam Deflection Control for Cathode Ray Devices," Serial No. 699,536, filed September 26, 1946, now Patent No. 2,460,112 granted January 25, 1949. The various electrodes of the electron gun **3** (not all shown) of the tube **1** are to be supplied as usual with suitable operating potentials.

In accordance with this invention, screen **11** consists of a plurality of parallel layers of different selected component color light producing materials which, in a three color additive system, may consist of a red light producing phosphor **13**, a blue light producing phosphor **15**, and a green light producing phosphor **17**, enclosed by and separated by electrically independent, conductive and transparent films **19**, **21**, **23** and **25**. Conductive film **19** need not necessarily be transparent and may, for example, take the form of the aluminized backing employed in monochromatic kinescopes for the improvement of light efficiency and reduction of halation.

For the purpose of explanation of the operation of this invention, there is provided a source of potential **27** and switches **29**, **31** and **33**.

By applying a relatively positive potential to the conductive film or layer **19**, it will be seen that the electrons approaching layer **19** will progress through the layer **19** into the red light producing medium **13**. If switch **29** is thrown to the right, as shown, a positive potential will be applied to conductive layer **21**. The electrons will therefore proceed through the red light producing medium without being retarded and therefore lose little or no energy in the red light producing medium **13**. The electrons will therefore proceed through conductive barrier **21** into the blue light producing medium **15**. If the switch **31** is positioned as shown to provide conductive layer **23** with a relatively negative potential, the electrons will be retarded by reason of the electric field in the area between conductor **21** and conductor **23** such that they will lose their energy in the blue light producing layer and thus cause a blue light to be produced. Substantially no electrons will proceed through conductor **23** to the green light producing medium **17** so that no green light will be produced.

It will be seen, therefore, that any of the three selected component color lights may be produced depending upon which of the several color control electrodes **21**, **23** or **25** is made relatively negative to retard the velocity of the electron steam.

Color control may therefore be had in the arrangement shown by applying proper relative potentials to color control electrodes **21**, **23** and **25**.

Figure 2 shows in block diagram one arrangement suitable for employment of this invention for the reception of a simultaneous type color television signal.

In the particular form shown by the example in the drawing, the television receiving antenna **41** is coupled to a converter **43** which provides wide band intermediate frequency amplifier **45** with suitable energy.

The signal energy from the intermediate frequency amplifier **45** is divided in accordance with color component information in the several detectors **47**, **49** and **51**. The separation of the different component color image signals is quite well explained in the color television art and it is not intended here to go into detail regarding such operation, as it is not intended that any specific form should be employed in the practice of this invention.

Thereis, however, an improved arrangement for the separation of image signals in accordance with their color representation in my copending U. S. application entitled "Signal Separator," Serial No. 760,400, filed July 11, 1947, now Patent No. 2,626,323 granted January 20, 1953, wherein an arrangement is disclosed to provide for efficient amplification of independent signal trains representing selected component colors of a composite image signal. The combined signal trains are amplified to a predetermined level before separation, as may be accomplished in wide band IF amplifier **45**, and then are amplified independently of one another such as may be accomplished in the channel amplifiers **53**, **55** and **57**, designated in the drawing as the red, blue and green channel amplifiers.

After being detected in detectors **47**, **49** and **51**, the several component color image representative signals are then amplified in appropriate video amplifiers **59**, **61** and **63**.

In accordance with previously proposed synchronizing arrangements, the synchronizing signal is included in the green signal channel and separated therefrom in sync separator **65** to furnish horizontal deflection circuit **67** and vertical deflection circuit **69** with synchronizing energy.

Tube **1** of Figure 2 contains the deflection coils **5** and **7** and provides for electron beam deflection in the usual manner.

Cathode ray tube **1** is provided with an electron gun **3** which forms an electron beam controllable in intensity by control electrode **71**.

A three-phase oscillator **73** in the presently described form of the invention provides an output signal having three phases of sinusoidal or substantially sinusoidal energy, as illustrated graphically in Figure 3.

One phase of three-phase oscillator **73** is combined with the red image representative signals in modulator **75**. Another phase of the three-phase oscillator **73** is combined with the blue image representative signal in modulator **77**. Likewise, still another phase of the output energy of oscillator **73** is combined with the green image representative signals in modulator **79**.

Electrodes **21**, **23** and **25** of image tube **1** of Figure 2 are also connected to the three-phase oscillator **73**.

In accordance with the explanation given for the operation of cathode ray tube **1** in connection with Figure 1 above, the cathode ray beam produces a red light when electrode **21** is given a relatively negative potential with respect to the potential of electrode **19**. It will be seen, therefore, that by adjusting the bias potentials in modulators **75**, **77** and **79** such that only one of the modulators passes signals at any one time, they all pass signals in a rapidly recurring sequential manner so that energy applied to control electrode **71** is representative of only one selected component color image at a time.

It follows that if color control electrodes **21**, **23** and **25** are connected and properly phased so that the time they receive a relatively negative potential corresponds to the time that their designated color component image representative signal train is being applied to the intensity control electrode **71**, a multiple color image may be formed.

The rate of changing will depend upon the speed of three-phase oscillator **73** which may, of course, be made to operate at elemental sequential frequency.

A further explanation of the operation of this invention may be made by referring briefly to Figure 3, wherein a three-phase signal is applied to both the modulators and their associated color control electrodes. It will be seen that if the bias on the modulators is properly arranged so that the area in the curve of Figure 3 between lines A and B indicates operation of the various modulators, three separate signal trains will be transmitted to

control electrode 71 which take the form of the signals shown graphically at the bottom of Figure 3.

By applying the three-phase energy to the color control electrodes 21, 23 and 25, the time interval of red luminescence will correspond to the time interval when a red representative signal is being applied to control electrode 71. During the time interval that the blue color component electrode is given a relatively negative potential with respect to the other color control electrodes, only the blue representative signal is being applied to the control electrode 71. Likewise, during the time interval that the green color control electrode 25 receives a relatively negative potential, only the green representative signal train is applied to the control electrode 71.

Having thus described the invention, what is claimed is:

1. A color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam, and an electron target including an electrically independent conductive color control electrode and an associated color light producing phosphor for each of the selected color components, a signal channel for each of a plurality of selected component color representative signal trains, an oscillator having a substantially sinusoidal output signal, the oscillator signal also consisting of a number of phases equal in number to the number of different selected component colors, a connection between said oscillator and each of said channels and its similarly color designated color control electrode to apply one different phase to each of said channels and its similarly color designated color control electrode to activate in synchronism each of said channels and its similarly designated color control electrode, said connections to said channels arranged to produce a mixing of the selected color component representative signal and said oscillator output, and a connection between said intensity control electrode and all of said signal channels to develop a natural color image on said target area.

2. In a color television system employing three simultaneous type selected component color image representative signal trains, a color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode and a color control electrode for said electron beam, and an electron target including an associated color light producing phosphor for each of the three selected color components, a signal channel for each of the three selected component color representative signal trains, a three-phase oscillator, a signal mixer in each of said signal channels, a modulating connection between said oscillator and each of said mixers and its similarly color designated color control electrode to apply one different phase to each of said mixers and its similarly color designated color control electrode to simultaneously activate similarly color designated channels and color control electrodes, said connections to said mixers arranged to produce a mixing of the selected color component representative signal and said oscillator output, and a connection between said intensity control electrode and all of said signal channels to control the intensity of said electron beam for developing on said electron target an image in color.

3. In a color television system employing substantially red, blue and green component color image representative signal trains, a color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam, and an electron target, a color control electrode and an associated color light producing phosphor for each of the selected color components, a signal channel for each selected component color representative signal train, a three-phase oscillator, a signal mixer in each of said signal channels, a connection between said oscillator and each of said channels and its similarly color designated color control electrode to apply one different phase to each of said channels and its similarly color designated color control electrode and control similarly color designated channel and color control electrode in synchronism, said connections to said channels arranged to produce a mixing of the selected color component representative signal and said oscillator output, and a connection between said intensity control electrode and all of said signal channels to provide a modulation of said intensity control electrode for the production of a natural color image.

4. A color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam, a luminescent target, a color control electrode and an associated component light producing medium for each of the selected color components, a signal channel for each of a plurality of selected component color representative signal trains, an oscillator having a substantially sinusoidal output signal, the oscillator signal also consisting of a number of phases equal in number to the number of different selected component colors, a signal mixer in each of said signal channels, a connection between said oscillator and each of said channels and its similarly color designated color control electrode to apply simultaneously one different phase to each of said channels and its similarly color designated color control electrode, said connections to said channels arranged to produce a mixing of the selected color component representative signal and said oscillator output, and means to apply to said intensity control electrode signals representative of the brightness of the elemental area under scansion to develop a natural color image on said luminescent target.

5. In a color television system employing a plurality of selected component color representative signal trains, a color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam and an electron target, a color control electrode and an associated color light producing phosphor for each of the selected color components, a signal mixer for each selected component color representative signal train, an oscillator having a substantially sinusoidal output signal, the oscillator signal also consisting of a number of phases equal in number to the number of different selected component colors, a signal mixer in each of said signal channels, a connection between said oscillator and each of said signal mixers and its similarly color designated color control electrode to apply one different phase to each of said channels and its similarly color designated color control electrode, said connections to said channels arranged to produce a mixing of the selected color component representative signal and said oscillator output, and means for applying to said control electrode a combination of said component color representative signal trains to modulate said control electrode and form an image on said target.

6. In a color television system employing a plurality of selected component color representative signal channels, a color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam, an electron target, a color control electrode and an associated color light producing phosphor for each of the selected color components, an oscillator having a substantially sinusoidal output signal, the oscillator signal also consisting of a number of phases equal in number to the number of different selected components colors, a modulating connection between each phase output of said oscillator and a different one of said signal channels to control color selections, and a connection between said intensity control electrode and each of said channels to control image brightness.

7. In a color television system employing a plurality of simultaneous type selected component color representative signal trains, a color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam, and a color producing electron target consisting of transparent conductive layers spaced by different selected component color light producing phosphors, a signal channel for each selected component color representative signal train, an oscillator, the oscillator signal consisting of a number of phases equal in number to the number of different selected component colors, a signal mixer in each of said signal channels, a connection between said oscillator, each of said channels and its similarly color designated color control electrode to apply one different phase to each of said channels and its similarly color designated color control electrode, said connections to said channels ar-

ranged to produce a mixing of the selected color component representative signal and said oscillator output, and a connection between said intensity control electrode and all of said signal channels at a point in said signal channels which includes both the image signals and said oscillator signals.

8. In a color television system employing a plurality of simultaneous type selected component color representative signal trains, a color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam, and a color producing electron target consisting of transparent conductive layers spaced by different selected component color light producing phosphors, a signal channel for each selected component color representative signal train, an oscillator, the oscillator signal consisting of a number of phases equal in number to the number of different selected component colors, means for modulating each of said layers and its corresponding component color representative signal trains with one phase of said oscillator output signal, and a connection between said intensity control electrode and all of said signal channels at a point in said signal channels which includes both the image signals and said oscillator signals.

9. In a color television system employing a plurality of simultaneous type selected component color representative signal trains, a color image reproducing system comprising in combination a cathode ray tube having an electron gun for generating an electron beam, an intensity control electrode for said electron beam, and a color producing electron target, a plurality of parallel layers of different selected component color light

producing materials enclosed by and separated by electrically independent, conductive and transparent films, a signal channel for each selected component color representative signal train, an oscillator having a substantially sinusoidal output signal, the oscillator signal also consisting of a number of phases equal in number to the number of different selected component colors, a signal mixer in each of said signal channels, a connection between said oscillator, each of said channels and its similarly color designated color control electrode to apply one different phase to each of said channels and its similarly color designated color control electrode, said connections to said channels arranged to produce a mixing of the selected color component representative signal and said oscillator output, and a connection between said intensity control electrode and all of said signal channels at a point in said signal channels which includes both the image signals and said oscillator signals.

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