

May 14, 1940.

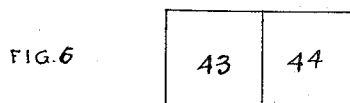
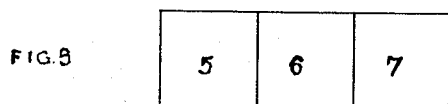
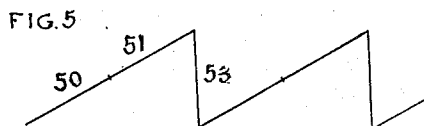
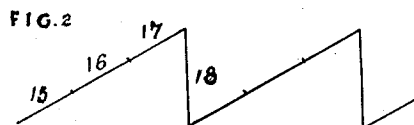
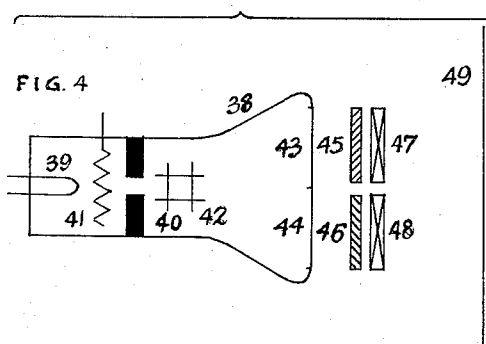
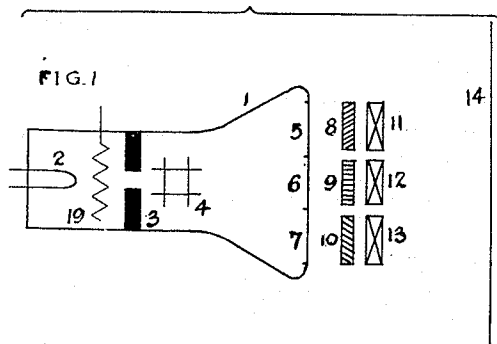
R. LORENZEN

2,200,285

TELEVISION IN NATURAL COLOR

Filed June 22, 1937

3 Sheets-Sheet 1



INVENTOR.  
ROBERT LORENZEN.  
BY *David L. Moore*  
ATTORNEY.

May 14, 1940.

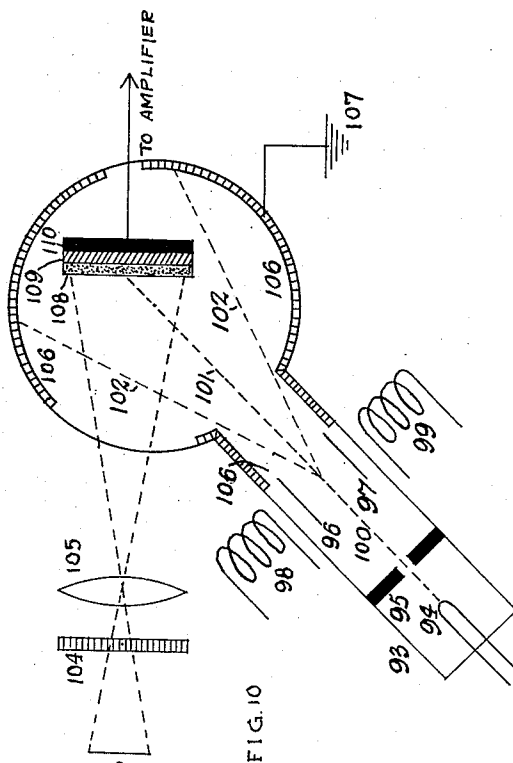
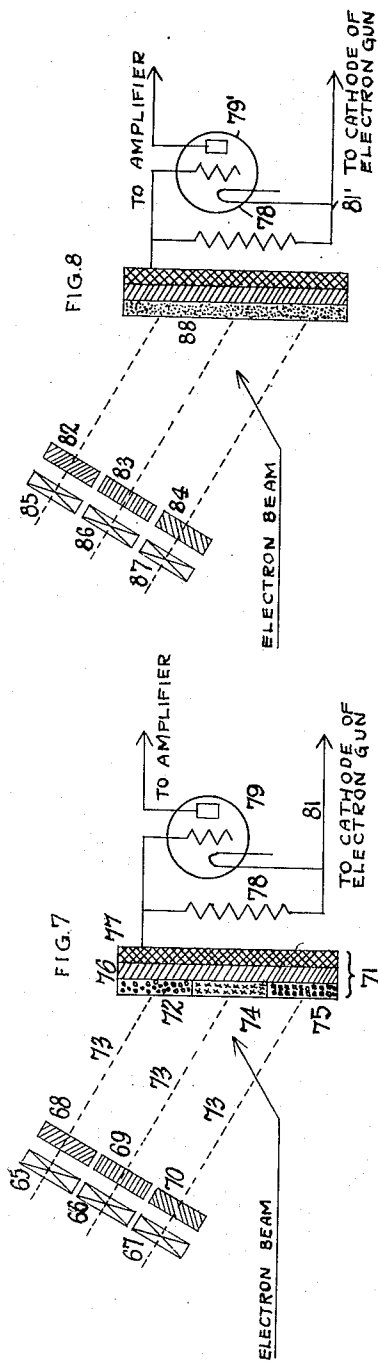
R. LORENZEN

2,200,285

TELEVISION IN NATURAL COLOR

Filed June 22, 1937

3 Sheets-Sheet 2



INVENTOR.  
ROBERT LORENZEN.  
BY *Robert Lorenzen*  
ATTORNEY.

May 14, 1940.

R. LORENZEN

2,200,285

TELEVISION IN NATURAL COLOR

Filed June 22, 1937

3 Sheets-Sheet 3

FIG. 11.

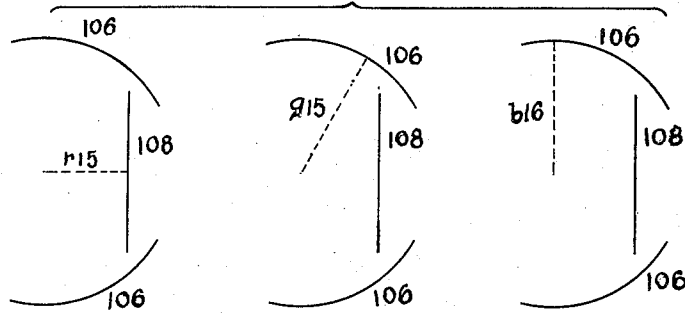


FIG. 12.

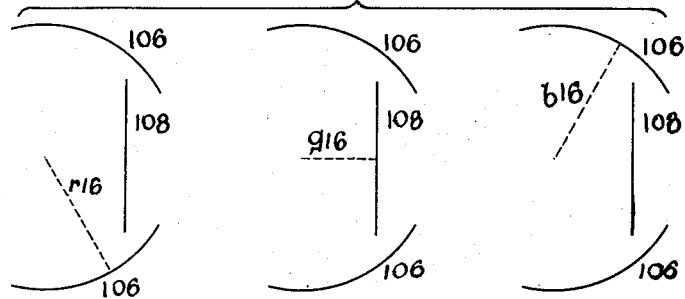
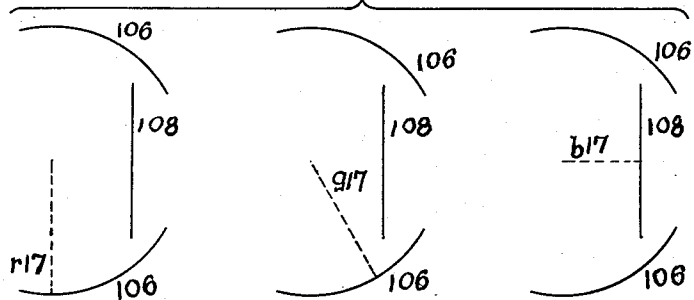


FIG. 13.



INVENTOR.

ROBERT LORENZEN.

BY

*David M. Moore*

ATTORNEY.

## UNITED STATES PATENT OFFICE

2,200,285

## TELEVISION IN NATURAL COLOR

Robert Lorenzen, New York, N. Y., assignor of thirty-three and one-third per cent to George H. Callaghan, thirty-three and one-third per cent to Felix Spiegel, both of New York, N. Y., and thirty-three and one-third per cent to himself

Application June 22, 1937, Serial No. 149,562

12 Claims. (Cl. 178-5.4)

The present invention relates to improvements in television in natural colors.

One of the objects of the invention is the provision of special cathode ray oscillographs for the purpose of receiving colored television images.

Another object of the present invention is the provision of special photoelectric transmitting tubes for the purpose of transmitting colored television images.

Still another object of the present invention is the provision of a cathode ray oscillograph wherein the glass face is colored for the purpose of using it as a color filter, thereby effecting an economy by eliminating separate or external color filters.

Still another object of the present invention is to provide a three color screen in conjunction with a single beam cathode ray tube, so that the three color effect is produced with a single beam.

Fig. 1 represents a longitudinal section through a modified cathode ray tube using only one set (two pairs) of deflecting electrodes, and employing the primary color method.

Fig. 2 represents the shape of the scanning wave employed in the reception of pictures on the cathode ray tube shown in Fig. 1.

Fig. 3 represents the fluorescent screen employed in the cathode ray tube shown in Fig. 1.

Fig. 4 represents a longitudinal section of a modified cathode ray tube wherein deflection is accomplished by one set (two pairs) of deflecting electrodes and using the complementary color method.

Fig. 5 represents the shape of the scanning wave employed in the cathode ray tube shown in Fig. 4.

Fig. 6 represents the fluorescent screen of the tube shown in Fig. 4.

Fig. 7 represents a sectional view of a portion of a photoelectric transmitting tube adapted for the transmission of television pictures in color, in which three kinds of photoelectric materials are used, each being most sensitive to that portion of the spectrum corresponding to each of the three primary colors.

Fig. 8 differs from Fig. 7 mainly insofar as a single photoelectric material is used, this photoelectric material being approximately equal in sensitivity throughout the visible spectrum.

Fig. 9 represents a perspective view of a photoelectric face of a photoelectric transmitting tube whereby the wave forms shown in Fig. 2 and Fig. 5 are obtained when three photoelectric transmitting tubes or two photoelectric transmitting tubes are used respectively.

Fig. 10 represents a longitudinal view of a photoelectric transmitting tube showing how the internal conductive coating can be arranged when three separate photoelectric transmitting tubes are used for the television transmission of colored pictures.

Figs. 11, 12, and 13 show the position of the electron beams for the photoelectric transmitting tubes actuated by red, green, and blue for parts 15, 16, and 17 of the scanning wave of Fig. 2.

Referring to Fig. 1, the cathode ray tube 1 has an electron emitting cathode 2. These electrons are modulated in accordance with the signal intensity in any of a number of methods known to the art, but preferably by means of a grid 19. The electrons pass through the aperture of a centrally apertured anode 3. The electron beam is then subjected to the two scanning fields due to the varying potentials on the two pairs of deflecting plates 4 which are in a relation of quadrature. The electron beam then impinges upon the fluorescent screen or screens 5, 6, 7, which emits light proportional in intensity to the modulating signal.

The novel features of the fluorescent screen 5, 6, 7 can be understood by reference to Fig. 1 and Fig. 3. There are two major methods of utilizing this fluorescent screen for the reception of colored television pictures.

In the first method, the fluorescent screen may be divided into three approximately equal areas such as 5, 6, and 7. Each of these areas is given a coating of fluorescent material such that each area respectively emits a light of each of the three primary colors: red, green, and blue. For example, area 5 may be given a coating of zinc phosphate which emits a red fluorescence, area 6 may be given a coating of zinc silicate which emits a green fluorescence, and area 7 may be coated with calcium tungstate which emits a blue fluorescence. Any other suitable fluorescent materials may be used. The images on screens 5, 6, and 7 are focussed by means of lenses 11, 12, and 13 respectively, or by any other suitable optical system, upon the viewing screen 14 in such a manner that the three images are exactly superimposed. Due to the practical difficulties in obtaining fluorescent materials which fluoresce at exactly the desired spectral frequencies, and also at just the right intensity, it is desirable to interpose a red color filter 8 between screen 5 and lens 11, a green color filter 9 between screen 6 and lens 12, and a blue color filter 10 between screen 7 and lens 13. The interposition of properly designed color filters will result not only

in a delimitation of the frequency of the light to the exact portion of the spectrum desired, but also in a correction of the intensity of the light from each of the three screens so that a proper color and intensity balance is obtained. The phosphorescent afterglow of each fluorescent screen should be as nearly the same as possible in order to avoid distortion of the picture appearing on the viewing screen 14.

In the second method, screens 5, 6, and 7 are coated with the same fluorescent substance. In this case the fluorescent material should be of such a nature as to emit white light, or, at least approximate to this condition by emitting light in each of the spectrum bands corresponding to the three primary colors. This condition can be accomplished by a proper proportioning of the various fluorescent materials. The red color filter 8, the green color filter 9, and the blue color filter 10 serve not only to pass red, green, and blue light respectively, but also serve to compensate for any deviations from the ideal, in other words, properly designed filters will compensate for any deviation both as regards spectral frequency, or intensity of the particular spectral frequency, or both, of the fluorescent screen. After passing through red filter 8, green filter 9, and blue filter 10, the light from the three filters is focussed by means of lenses 11, 12, and 13 respectively, such lenses being so arranged as to superimpose the three images upon the viewing screen 14. What was intended to convey at this point was a well known optical arrangement, where the center picture is projected by means of an ordinary lens to a centrally focused point, while the two outer pictures were focused upon the same focal point through the medium of two prisms, one to each picture. It is thought that this arrangement is so well known as not to need illustration. By this arrangement chromatic dispersion is not of importance since each of the three images are emitting approximately monochromatic light.

Of the various types of scanning waves which might be employed in the operation of the cathode ray tube of Fig. 1, the recommended type is the saw-tooth wave as shown in Fig. 2. Section 15 of the line is operative over section 5 of the fluorescent screen, portion 16 of the line is operative over portion 6 of the screen, and part 17 is operative over part 7 of the screen. Line 18 represents the return of the beam to the beginning of screen 5, the beam now being ready to again sweep the fluorescent screen 5, 6, 7 but a line lower. The method whereby the transmitter produces such a scanning wave will be described in another section of this specification.

Fig. 4 represents a modified cathode ray tube which differs from Fig. 1 only insofar as the fluorescent screen is now divided into two parts instead of three, and that the principle of operation is based upon the use of complementary colors rather than primary colors. The cathode ray tube 38 contains a filament 39 which emits electrons. These electrons are modulated by the incoming signal by means of grid 41, and then pass through an aperture in the anode 40. The electron beam is then subjected to the influence of a set of deflecting plates 42. The electron beam in consequence traces a pattern on fluorescent screens 43 and 44. The operation of the fluorescent screens 43 and 44 will be understood by reference to Fig. 4 and Fig. 6. There are two principal methods of designing the fluorescent

screens 43 and 44 for the reception of colored television pictures.

In the first method the fluorescent screen may be divided into two approximately equal areas such as 43 and 44. Each of these areas is given a coating of fluorescent material such that each area respectively emits a light of one of a pair of complementary colors. For example, area 43 may be given a coating of zinc phosphate which emits a red fluorescence, and area 44 may be given a coating of zinc silicate which emits a green fluorescence. Any other pair of complementary colors may be used as well as any other suitable fluorescent materials. The images on screens 43 and 44 are focussed by means of lenses 47 and 48 respectively, or by any other suitable optical system, upon the viewing screen 49 in such a manner that the two images are exactly superimposed. Due to the practical difficulties in obtaining fluorescent materials which fluoresce at exactly the desired spectral frequencies and also at just the right intensity it is desirable to interpose a red color filter 45 between screen 43 and lens 47, and a green color filter 46 between screen 44 and lens 48. The interposition of properly designed color filters will result not only in a delimitation of the frequency of the light to the exact portion of the spectrum desired but also in a correction of the intensity of the light from each of the two screens so that a proper color and intensity balance is obtained. The phosphorescent afterglow of each fluorescent screen should be as nearly the same as possible to avoid distortion of the picture appearing on the viewing screen 49.

In the second method, screens 43 and 44 are coated with the same fluorescent substance. In this case the fluorescent material should be of such a nature as to emit white light, or else to emit in each of the complementary color spectral bands. The red color filter 45 and the green color filter 46, in the event that these are the pair of complementary colors chosen, serve not only to pass red and green light respectively, but also serve to compensate for deviations both as regards spectral frequency, or intensity of the particular spectral frequencies, or both, of the fluorescent screen. After passing through red filter 45 and green filter 46, the light from the two filters is focussed by means of lenses 47 and 48 respectively, or by any other suitable optical system, upon the viewing screen 49 so that the two images are exactly superimposed.

Of the various types of scanning waves which might be employed in the operation of the cathode ray tube of Fig. 4, the recommended type is the saw-tooth wave shown in Fig. 5. Section 50 of the line is operative over section 43 of the fluorescent screen and portion 51 is operative over portion 44 of the fluorescent screen. Line 53 represents the return of the beam to the beginning of screen 43, the beam now being ready to again sweep the fluorescent screen 43, 44, but a line lower. The method whereby the transmitter produces a scanning wave of this type will be described in another section of this description.

It lies within the scope of this invention to have any number of such colored or uncolored areas and also that regardless of number of areas these areas are not limited either as regards the use of complementary or primary colors but may be of any desired color or combination of colors. Furthermore, the scope of the present invention

is not limited to any particular shape of fluorescent screen or shape of cathode ray tube.

It should be further understood that although deflecting plates have been used as a means of producing the scanning waves, that such limitation is not intended, as any other well known deflecting means may be employed, such as deflecting coils, or a combination of deflecting coils and plates.

Furthermore, the present invention is not limited to use with cathode ray tubes only, but may also be used in conjunction with tubes of any type in which the ray can be electrically deflected.

The viewing screen may be either opaque or translucent and may, in either event, be colored, if it be found that further color correction of the picture is desirable.

Furthermore, for certain applications of the present invention, there is not intended a limitation, where the phrase "primary colors" is used, merely to the physicist's primary colors (red, green, blue), but there is also claimed as within the scope of the invention the use of the painter's primary colors (red, yellow, blue).

In Fig. 7 there is shown part of a special photo-electric transmitting tube. The image of the object to be televised in color is separately focussed by means of lenses 65, 66, and 67 upon the three photoelectric surfaces 72, 74, and 75. These three photoelectric areas 72, 74, and 75 are respectively approximately selectively sensitive to the three primary colors red, green, and blue; so that the electric charges built up in the photoelectric condenser 71 will be for each elemental point of 72 proportional to the intensity of the red in the light 73 falling on each elemental point of 72, and the amount of green in the light 73 falling on 74, and the amount of blue in the light falling on 75. The photoelectric surfaces 72, 74, and 75 are separated from the metal plate 77 by an insulator 76. Each of the minute photoelectric globules of 72, 74, and 75 emits electrons, the number of which is proportional to the intensity of light falling thereon. This causes an electric stress between surfaces 72, 74, 75 and the conductor 77. The electron beam 80 sweeps these photoelectric globules line by line and discharges each minute condenser, thereby resulting in a minute variation of current between metal plate 77 and the cathode of the electron gun. Consequently, an impedance 78 connected across the cathode of the electron gun and metal plate 77 will have potential variations set up across its terminals. The grid and cathode of an amplifying tube 79 can be connected to the terminals of this impedance and the potential variations are then amplified. If the electron beam scans the photoelectric surface in the order red, green, blue, there will be produced the line 15, 16, 17 of Fig. 2. In view of the difficulty of getting the photoelectric materials to respond sharply and selectively to exactly the three spectral frequencies required, it is advisable to use color filters 68, 69, and 70, which pass red, green, and blue respectively. These filters may be placed either before or after the focussing lenses 65, 66, 67. These filters can, moreover, be so designed so as to compensate also for inequalities in electronic emissiveness of the three photoelectric surfaces.

In the event that the complementary color method is used the only changes required are the reduction of lenses, filters, and photoelectric surfaces from three to two. The two color filters

and the two photoelectric surfaces are now responsive to each of a pair of complementary colors, say red and green. Then if each line scans first red and then green, the line 50, 51 of Fig. 6 is produced.

In Fig. 8 the only change made is the substitution of a uniform photoelectric surface 88 to replace the three photoelectric surfaces 72, 74, 75. In this figure similar parts to that shown in Fig. 7 are primed. The photoelectric material should be approximately equally sensitive to all colors, particularly to red, green, and blue. Inequality of sensitivity to the three primary colors can be compensated for by a proper design of filters 82, 83, and 84. Light from the object to be televised in natural colors passes through the red filter 82, the green filter 83, and the blue filter 84, and is focussed by lenses 85, 86 and 87 upon the three separate areas of photoelectric surfaces 88. The operation of Fig. 8 is from this point on identical with that given for Fig. 7.

To use the method of Fig. 8 for the complementary color method it is merely necessary to substitute two filters of complementary colors for the three primary colored filters of Fig. 8.

Fig. 9 represents a perspective view of the photoelectric condenser of a photoelectric transmitting tube, where the surface of photoelectric globules 89 is separated from the metal plate 91 by an insulating film 90. The novel feature of the invention is the conductive strip 92 which is connected to the cathode of the electron gun, or to the internal conductive coating of the photoelectric transmitting tube, or to ground, depending on the circuit arrangement used. As the conductive strip 92 of Fig. 9 will function exactly as the internal conductive coating 106 of Fig. 10 a detailed description will not be given.

Fig. 10 represents a longitudinal view of a photoelectric transmitting tube 93 which contains an electron emitting cathode 94. Electrons pass through an aperture in the anode 95 thereby resulting in an electron beam 100 which is subjected to an electric field by the two parallel deflecting plates 96 and 97, and to an electromagnetic field by the two coils 98 and 99. Light from an object 103 passes through a color filter 104 and thence through a lens 105 which focusses the image of object 103 upon the photoelectric surface 108 which is composed of a large number of minute photoelectric globules. The photoelectric surface 108 is separated by an insulating film 109 from a metal plate 110 which latter is connected to the grid of an amplifying tube. The electron beam 100 is subjected to the electric and electromagnetic scanning fields and becomes either electron ray 101 which scans the photoelectric surfaces 108, or else either of the electron rays 102 which falls upon the conductive coating 106 which is connected to the ground 107. The deflecting fields are so biased or regulated, as to cause, in the case of the primary color method of colored television, the electronic beam 101 to scan the photoelectric surface for one-third of the length of a single complete scanning line, and beam 102 to fall upon the conductive coating for two-thirds of the length of a single complete scanning line. Consider three tubes R, G, and B of the type shown in Fig. 15 together with their respective associated equipment, and also consider the scanning wave shown in Fig. 2. Say that photoelectric transmitting tube R is actuated by red light, tube G by green light, and tube B by blue light. Represent the electronic beam of tube R by  $r$ , that of tube G by  $g$ , and

that of tube B by b. Then, in Figs. 11, 12, and 13, the small letters r, g, b corresponding to the electronic beams of the photoelectric transmitting tubes respectively actuated by red, green, and blue, will be followed by the numerals 15, 16, or 17 depending upon which part of the scanning line of Fig. 2 is influencing the ray. Thus, in Fig. 11, r 15 represents the middle point of the scanning line 15 of Fig. 2. In Figs. 11, 12, and 13, the photoelectric surface is represented by 108, and the internal conductive coating by 106. It will be seen from an inspection of Figs. 11, 12, and 13 that the ray of each of the three tubes is scanning the photoelectric surface for one-third of a scanning line. Line 18 of Fig. 2 represents the return sweep to start a new scanning line.

The application of this technique to color television by the complementary color method requires merely the use of two photoelectric transmitting tubes actuated by a pair of complementary colors, instead of the three tubes actuated by primary colors as described above.

Although throughout this description there have been described methods of scanning by first scanning a line in the order red, green, blue, it remains within the scope of this invention to scan the images in any order of colors, and also, if desired, to scan completely a whole picture in the red, then the whole picture in the green, and then the whole picture of the blue.

This invention is not limited to the particular embodiment described, but may be variously modified without departing from the spirit and scope of the invention. Furthermore, although in the description, the scanning wave used was of the saw-tooth type, it is not intended to limit the scope of the invention only to saw-tooth scanning, as other types of scanning waves may be employed.

It is further understood that the photoelectric transmitting tubes described were merely illustrative, and that it lies within the scope of the claims to apply the principles herein disclosed to other types of such tubes.

Thus there have been described various means for transmitting and receiving television images in natural colors.

What is claimed is:

1. In a television system, means for receiving television images in natural colors, including a single cathode ray oscillograph comprising a cathode, a single modulating electrode, an anode, deflecting devices, and a fluorescent screen divided into three distinct and separate areas such that one of these areas emits light of one of the primary colors, a second area emits light of a second primary color, and the third area emits light of the third primary color whereby the entire screen is scanned by a single cathode ray beam.

2. In a television system, means for receiving television images in natural colors, including a single cathode ray oscillograph comprising a cathode, a single modulating electrode, an anode, deflecting devices, and a uniformly coated fluorescent screen capable of emitting light in each of the spectral bands of the three primary colors, the color separation being effected by three independent and separate color filters and being acted upon by a single cathode ray beam.

3. In a television system, means for receiving television images in natural colors, including a single cathode ray oscillograph comprising a cathode, three separate modulating electrodes,

an anode, three separate sets of deflecting devices, and three separate and distinct fluorescent screens, one of the three screens being capable of emitting light of one of the primary colors, a second screen to a second primary color, and a third screen of the third primary color.

4. In a television system, means for receiving television images in natural colors, including a single cathode ray oscillograph comprising a cathode, a single modulating electrode, an anode, deflecting devices, and a fluorescent screen divided into two separate and distinct areas such that one of these areas emits light of one of a pair of complementary colors, and the other area emits light corresponding to the other of the pair of complementary colors the cathode ray oscillograph emitting a single beam to act upon the screen.

5. In a television system, means for receiving television images in natural colors, including a single cathode ray oscillograph comprising a cathode, a single modulating electrode, an anode, deflecting devices, and a uniformly coated fluorescent screen capable of emitting light in each of the spectral bands of a pair of complementary colors, the color separation being effected by means of separate and distinct color filters which are acted upon by a single cathode ray beam.

6. In a television system, means for receiving television images in natural colors, including a single cathode ray oscillograph comprising a cathode, two separate modulating electrodes, an anode, two separate sets of deflecting devices, and two separate and distinct fluorescent screens, one of the two screens being capable of emitting light of one of a pair of complementary colors, and the other screen of the other of the pair of complementary colors.

7. In a television system adapted for receiving television images in natural colors and including a single cathode ray oscillograph having the image reproducing face thereof divided into three separate and distinct areas, such that the image reproducing face of each of these separate areas is differently colored, each area being colored to correspond to each of the three primary colors, said screen being acted upon by only a single beam from the oscillograph.

8. In a television system adapted for receiving television images in natural colors and including a single cathode ray oscillograph having the image reproducing face thereof divided into two separate and distinct areas, such that the image reproducing face of each of these separate areas is differently colored, each area being colored to correspond to each of a pair of complementary colors, said screen being acted upon by only a single beam from the oscillograph.

9. A television system for the transmission of television images in natural colors, including in combination a single photoelectric transmitting tube, the photoelectric surface of said tube being divided into three separate and distinct areas, each area being sensitive to different colors, the colors being each of the three primary colors.

10. A television system for the transmission of television images in natural colors, including in combination a single photoelectric transmitting tube, the photoelectric surface of which tube has a uniform photosensitive surface which is responsive to each of the three primary colors, and three separate and distinct color filters for such color separation.

11. A television system for the transmission of television images in natural colors, including in

combination a single photoelectric transmitting tube, the photoelectric surface of which is divided into two separate and distinct areas, each area being sensitive to different colors, the colors being each of a pair of complementary colors.

12. A television system for the transmission of television images in natural colors, including in

combination a single photoelectric transmitting tube, the photoelectric surface of which has a uniform photosensitive surface which is responsive to each of the two colors of a pair of complementary colors, and two separate and distinct color filters for effecting color separation.

ROBERT LORENZEN.