March 2, 1943. M. CAWEIN 2,312,800

COLOR TELEVISION APPARATUS

Filed Aug. 15, 1941 2 Sheets-Sheet 1

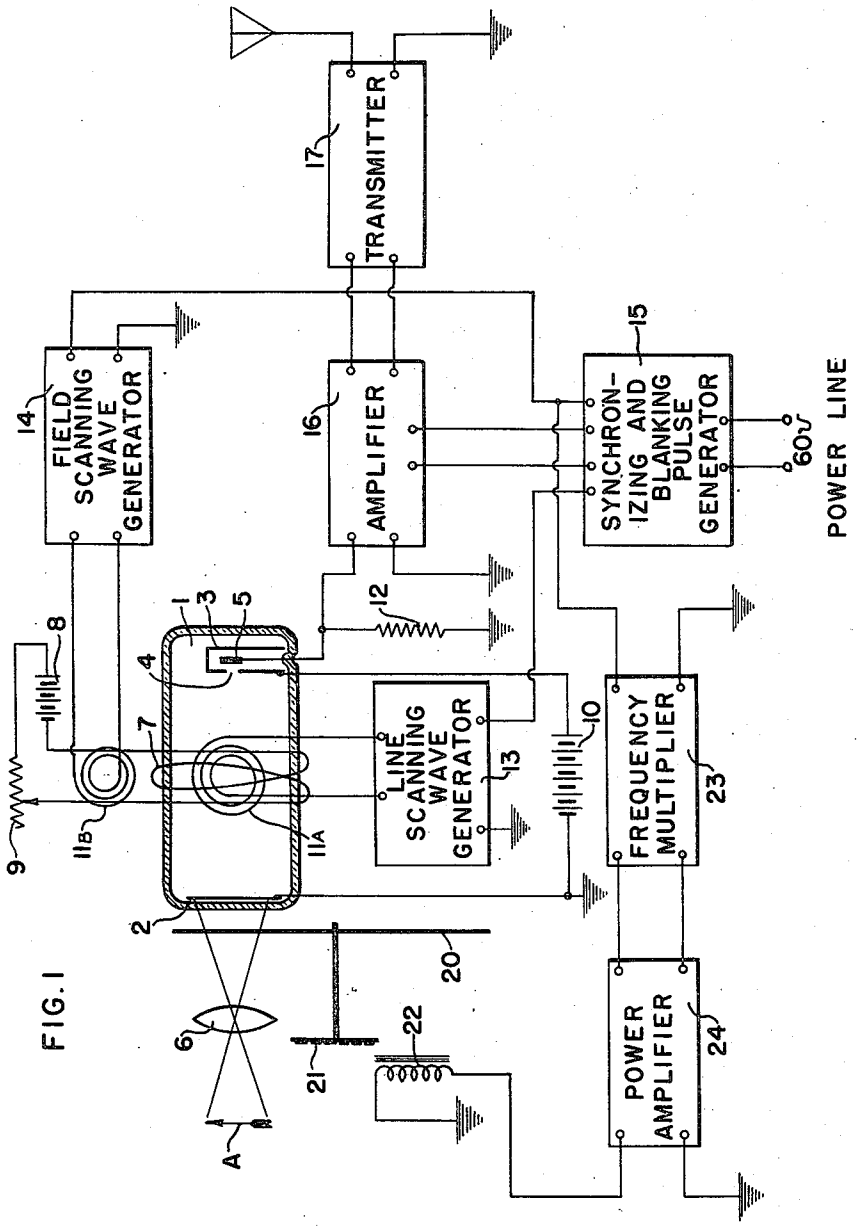


FIG. 1

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FIG. 2

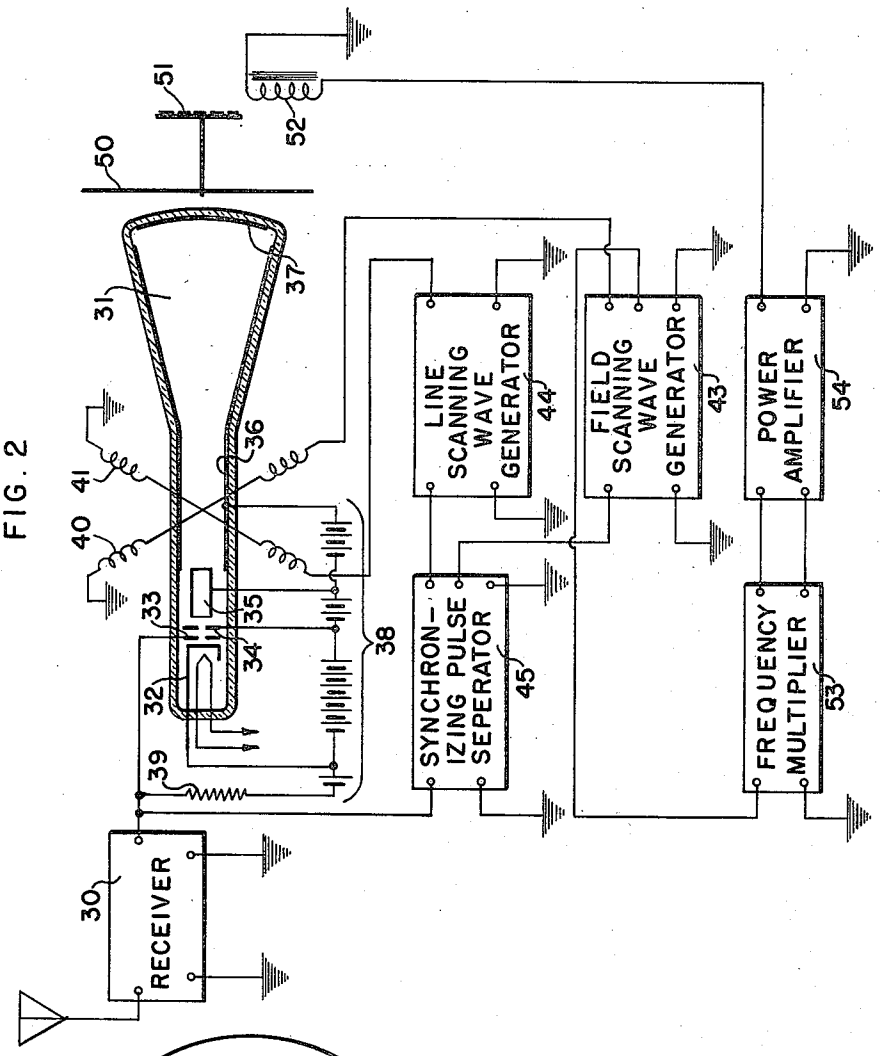
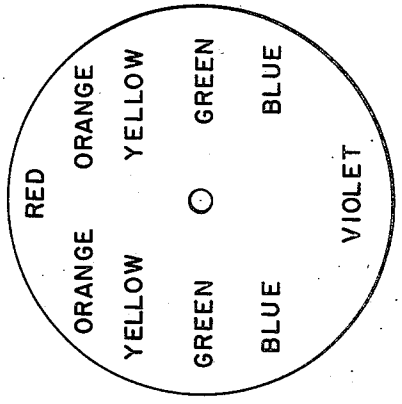


FIG. 3



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Patented Mar. 2, 1943 2,312,800

UNITED STATES PATENT OFFICE

2,312,800

COLOR TELEVISION APPARATUS

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Application August 15, 1941, Serial No. 406,952

9 Claims. (Cl. 178—5.4)

This invention relates to television apparatus for transmitting and receiving television pictures in natural colors.

In conventional color television systems, two or three color components are usually transmitted, these color components being of such nature that it is possible therewith to transmit a variety of different colors, as well as white. The variety of color mixtures or hues which can be transmitted with a three-color system is greater than with a two-color system but is still very limited. In order to obtain a more faithful reproduction of the natural color hues, it is desirable to use more than three color components. In conventional systems, however, in which the color is changed after the completion of each scanning field, an increase in the number of colors beyond three would give rise to objectionable color flicker, since the rate of color repetition would become increasingly lower, with increasing number of colors. While it would be possible to employ a finite number of colors greater than three and periodically to change the color after completion of a fraction of a scanning field only, extremely accurate synchronization of the color filter produced at a transmitter and a receiver would be required, since the difference in color transmission characteristics in adjacent sections of a color filter would be appreciable, and faulty synchronization would cause certain picture elements to be reproduced in a color which greatly differs from the color in which this picture element should be reproduced.

It is the object of the present invention, therefore, to provide a new and improved color television system capable of more faithful reproduction of color hues than conventional systems, requiring less accurate synchronization between color filtering means at a transmitter and a receiver.

In accordance with the present invention, there is provided a method of picture transmission and an arrangement for transmitting television pictures in natural colors having a photosensitive member and means for projecting an optical image of the object to be transmitted upon this member, as well as means cooperating with the photosensitive member for developing picture signals representative of the light characteristics of successive elemental areas of the image, in accordance with cyclically recurring scanning field patterns. Color filtering means having sections of different color transmitting characteristics are disposed in the optical path between the projection means of the photosensitive member for successively selecting different color components from the light emanating from predetermined elemental areas of the object. This color filtering means correspondingly changes the color of the image light incident upon the photosensitive member in such manner that the color continuously and repeatedly drifts between the two ends of the visible spectrum. Finally, means are provided for moving the color filtering means at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

In accordance with the invention, there is also provided a television receiver for reproducing television pictures in natural colors, including means for reproducing a television image composed of substantially white light, in accordance with received picture signals, whereby successive elemental areas of the image are reproduced in accordance with cyclically recurring scanning field patterns. Color filtering means are disposed between the image of white light and an observer, this filtering means being adapted to select, from the white light emanating from predetermined elemental areas of the image, successive color components in such manner that the components continuously and repeatedly drift between the two ends of the visible spectrum. Fnally, means are provided for moving the color filtering means at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings, Fig. 1 shows an arrangement for transmitting television pictures, while Fig. 2 shows a receiver for reproducing television pictures in natural colors, both embodying the present invention. Fig. 3 shows a color filter disc, in accordance with the present invention.

Referring now more particularly to Fig. 1 of the drawings, there is shown television transmitting apparatus comprising a picture signal generating tube 1, commonly known as the Farnsworth image dissector, having a transparent photoelectric cathode 2, an anode shield 3 with a scanning aperture 4, housing a target 5, positioned in alignment with the scanning aperture 4. This

tube is well known in the art and all parts thereof, such as the electron multiplier, not essential to the understanding of the invention, have been omitted for the sake of clarity.

For the purpose of projecting an optical image of the object to be transmitted, schematically indicated by the arrow A on the photoelectric cathode 2, there is provided an optical system 6. For developing in the plane of the scanning aperture 4 an electron image of the emission from the cathode 2, there is provided a cylindrical focusing coil 7 surrounding the tube and energized by means of a battery 8 in series with a variable resistor 9. Operating voltage between the cathode 2 and the anode 3 is provided by a battery 10 or any other suitable voltage source.

For deflecting the electron image in two directions across the scanning aperture 4 in the anode shield 3, there are provided line and field deflecting coils, schematically indicated at 11A and 11B. The deflecting coils 11A and 11B are energized by the line scanning wave generator 13 and the field scanning wave generator 14, respectively, both synchronized by synchronizing pulses developed in a synchronizing and blanking pulse generator 15. The line scanning wave generator 13 develops saw-tooth current waves at a frequency of 15,750 C. P. S., while the field scanning wave generator 14 develops similar waves at a frequency of 60 C. P. S., thereby to produce a 525-line interlaced scanning pattern at a frame frequency of 30 C. P. S. and an interlace ratio of 2:1.

The target 5 of the tube 1 is connected to an output resistor 12, across which picture signals are developed, which are applied to an amplifier 16, to which blanking and synchronizing pulses are also applied from the synchronizing and blanking pulse generator 15, as is conventional, thereby to develop in the amplifier 16 the conventional composite television signal comprising picture signals as well as blanking and synchronizing signals. To the output of the amplifier 16 there is coupled a transmitter 17 for transmitting the composite television signal modulated on a carrier wave.

In order periodically to change the color of the optical image incident upon the photoelectric cathode 2, there is provided a color filter disc 20, driven by a phonic wheel comprising a rotor 21 and a stator 22, as schematically indicated in the drawings. For driving the color disc 20 at 36 revolutions per second, in synchronism and in fixed phase relation with the scanning motion of the electron image, there is provided a frequency multiplier 23, to the input of which field synchronizing pulses, having a periodicity of 60 cycles, are applied and which derives therefrom a frequency of 360 C. P. S. For developing the necessary driving power for the color disc 20, there is provided a power amplifier 24, to which the signal output from the frequency multiplier 23 at 360 cycles is applied. The output of the power amplifier is connected to the stator 22 on the phonic wheel. If the phonic wheel rotor 21 is provided with five pole pieces or a multiple thereof, and the stator 22 with twice as many pole pieces, the color disc 20 is caused to rotate at 36 R. P. S. Naturally, any other suitable means for driving the color field disc 20 can be employed, as long as it drives the disc in fixed phase relationship with the scanning motion of the electron image.

Fig. 3 schematically illustrates the color disc in accordance with this invention, comprising adjacent differently colored segments which, following the periphery of the disc clockwise, range from red to violet and back to red, preferably with all intermediate colors of the spectrum.

Fig. 2 shows a television receiver embodying the present invention, comprising a wireless receiver 30, preferably of the superheterodyne type and adapted to develop at its output terminals the demodulated composite television signal. For reproducing the television picture in accordance with the received signals, there is provided a cathode ray picture reproducing tube 31 of conventional design, comprising an indirectly heated cathode 32, a control element 33, a first anode 34, a second anode 35, a wall coating 36 and a fluorescent screen 37, the latter being capable of emitting white light upon electron bombardment. Operating voltages are applied to the tube 31 by means of a battery arrangement 38. A composite television signal is applied from the output of the receiver 30 to the control element 33, to which is also connected a grid leak resistor 39. For deflecting the modulated electron beam developed by the cathode 32 across the fluorescent screen 37, in cooperation with the electrodes 33, 34, 35 and 36, there are provided two sets of deflecting coils 40 and 41, connected to a field scanning generator 43 and a line scanning wave generator 44, respectively, operating at 60 C. P. S. and 15,750 C. P. S., respectively. For synchronizing these generators, there is provided a synchronizing pulse separator 45, connected to the output of the receiver 30 for receiving therefrom the composite television signal. To the output of the separator 45, at which the synchronizing pulses appear without the picture signals, are connected the scanning wave generators 43 and 44, for synchronization thereof, as is conventional.

For selecting different color components from the white light of the television image reproduced by the fluorescent screen 37, there is provided a color filter disc 50, preferably of the same construction as disc 20 of Fig. 1, driven by means of a phonic wheel arrangement comprising a rotor 51 and a stator 52, also preferably of the same construction as the phonic wheel arrangement of Fig. 1. The color disc is disposed closely adjacent to the fluorescent screen 37 and between the latter and an observer of the television picture. For driving the color disc 50 at the desired speed of 36 C. P. S. and in predetermined relationship with respect to the scanning motion of the electron beam in the reproducing tube 31 and in synchronism and phase with the disc 20 at the transmitter, there is provided a frequency multiplier 53, whose input is connected to the field scanning wave generator 43, for deriving therefrom a 60-cycle signal. The output of the frequency multiplier 53 is a 360-cycle signal applied to a power amplifier 54, whose output is connected to the stator 52 of the phonic wheel arrangement for driving the color disc 50.

In operation, an optical image of the object A to be transmitted is projected by means of the optical system 6 upon the photoelectric cathode 2. The emission from the cathode 2 is focused in the plane of the scanning aperture 4 of the anode shield 3 by the cooperation of the electrical field produced therebetween by the battery 10 and the magnetic field produced by the focusing coil 7. The electron image is deflected in two directions across the scanning aperture 4 by means of the magnetic fields developed by the coils 11B and 11A, energized by saw-tooth

wave currents having frequencies of 60 cycles and 15,750 cycles, respectively. A small number of electrons corresponding to successive elementary areas of the electron image enter through the scanning aperture 4 and arrive at the target 5 to produce a picture signal across the output resistor 12. The scanning motion of the electron image is synchronized and held in fixed phase relationship with the 60-cycle power mains by means of the synchronizing and blanking pulse generator 15, as is conventional in the art.

The picture signals developed at the output resistor 12 are applied to the amplifier 16 for amplification thereof and to be mixed with synchronizing and blanking signals derived from the generator 15 to produce an amplified composite television signal, which is supplied to the transmitter 17, wherein it is modulated upon a carrier wave and radiated into space.

The 60-cycle pulses developed by the generator 15 are applied to the frequency multiplier 23, in which an output voltage wave of 360 C. P. S. is developed. This frequency multiplier may be of the type of a harmonic generator or any other suitable type. The 360-C. P. S. output wave from the multiplier 23 is applied to a conventional power amplifier 24 for amplification thereof and the output of this amplifier is applied to the stator 22 of the phonic wheel arrangement for driving the color disc 20. The rotor 21 of the phonic wheel arrangement completes one revolution after each ten of the 360-cycle pulses applied to the stator 22, so that the color disc 20 is driven at a speed of 36 R. P. S. The direction of rotation of the color disc is such that the motion of the boundary lines of adjacent different colors is the same as the vertical motion of the electron image, when considering the portion of the color disc covering the optical image projected on the cathode 2.

Consider the optical image effectively being scanned line by line from top to bottom and left to right, in accordance with an interlaced pattern, at a rate of 60 scanning fields per second and 30 complete scanning frames per second. Assume that the portion of the optical image scanned during the first few scanning lines of a field is composed of the red light only emanating from the corresponding portion of the object to be transmitted, due to a certain position of the color filter disc 20. Since the scanning motion is more rapid than the motion of the filter disc, a portion of the optical image is soon reached by the scanning action, which is composed of orange light only, whereby the transition from red to orange occurs very gradually because substantially all spectral colors are included in the filter. Picture signals are then developed which are representative of the orange color component of the light of the picture elements being scanned. As the scanning action progresses from toward the bottom of the optical image, further color transitions occur so that the entire visible spectrum is gradually traversed. During the subsequent field scanning interval, in which the image is again scanned from top to bottom, the color disc completes the revolution which began at the beginning of the previous field scanning interval with the red filter section being at the top of the image. Since a single disc revolution requires $\frac{1}{36}$ second, and a field scanning interval equals $\frac{1}{60}$ second, the red color appears in the image during scansion of the lower half of the image during the second field, or, to be exact, when the second field is two-thirds completed. At this time, signals representative of the red color component of the picture elements which are two-thirds of the field height down from the top thereof are developed. Hence, the color repetition period differs from the field scanning interval and is in non-integral relationship thereto, which is necessary to obtain a shift of the different color sections across the image for successive fields.

As is evident from the above, picture signals representative of the red color component of picture elements of different portions of the image are developed during subsequent scanning field intervals. Of course, a similar color shift or drift takes place during other subsequent fields. This drift occurs with a certain periodicity, which is five scanning field intervals for the values given above. This period is commonly referred to in the art as the color coincidence period, that is, the time which elapses between successive transmissions of the same color component of the same picture elements. The color repetition rate, that is, the rate at which the same color recurs in any portion of the image, is much higher, since nearly all colors appear during each successive field scanning interval. What has been explained above in connection with the red color component naturally holds true also for all other color components.

It will be understood that different numbers of fields per second and disc revolutions per second can be chosen without deviating from the spirit of the invention. Likewise, the filter disc can also be moved in the direction opposite to that of the vertical scanning motion, in which case the disc can be run at a slightly lower speed than in the case above described, but, again, at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

At the receiving station, the receiver 30 amplifies and demodulates the received modulated carrier waves, whereby the composite television signal is developed at the output terminals of the receiver 30. This composite signal is applied to the control electrode 33 of the cathode ray reproducing tube 31, to control the emission from the cathode 32. The electrodes 34, 35 and 36, held at suitable operating potentials by the battery 38, develop an electron beam directed at the fluorescent screen 37. This electron beam is scanned across the fluorescent screen in accordance with the 525-line interlaced scanning pattern by means of the magnetic fields developed by the deflecting coils 40 and 41, energized by the field scanning wave generator 43 and the line scanning wave generator 44, respectively. These scanning wave generators are synchronized by synchronizing pulses obtained from the synchronizing pulse separator 45, to the input of which the composite television signal is applied from the receiver 30. The synchronizing pulse separator 45 is of conventional design and adapted to separate synchronizing signals from picture signals. Sixty-cycle pulses derived from the field scanning wave generator 43 are applied to the frequency multiplier 53, which may be of the same design as the frequency multiplier 23 at the transmitting station, whose output signal has a frequency of 360 C. P. S. This output signal is amplified by the power amplifier 54 and applied to the stator 52 of the phonic wheel arrangement, also comprising the rotor 51. Connected to the rotor 51 and driven thereby is the color disc 50, positioned closely adjacent the fluorescent

screen 37. The color disc 50 is of substantially the same design as the color filter disc 20 at the transmitter and rotates in synchronism and phase therewith. The different sections of the color disc 50 selectively transmit different color components of the television picture composed of white light developed at the fluorescent screen 37. In this manner, an observer, viewing the white image at the fluorescent screen 37 through the color disc 50, is given the impression of seeing a television picture reproduced in natural colors.

Since adjacent color filter sections differ in color transmission characteristics by a few Angstrom units only, it is evident that a slight phase displacement between the color filters at the transmitter and receiver, respectively, will cause a slight falsification of the reproduced color of a particular picture element, which, because of its negligible amount, remains substantially unnoticed by the human eye. While, in the case of a color filter disc having adjacent sections of greatly differing color transmitting characteristics, such as, for example, red and blue, where a relatively small phase displacement can cause a color error in the order of 1,000 Angstrom units if a picture element is reproduced in red color instead of blue, the color error in the present case, for the same phase displacement, will amount to relatively few Angstrom units only. Hence, the present system can be operated with a much greater phase deviation tolerance between the phases of the color filters at the transmitter and receiver than in systems hitherto proposed, in which colors are changed during useful scanning intervals at the transmitter and receiver.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An arrangement for transmitting television pictures in natural colors having a photosensitive member, means for projecting an optical image of the object to be transmitted on said member, means cooperating with said photosensitive member for developing picture signals representative of the light characteristics of successive elemental areas of said image in accordance with cyclically recurring scanning field patterns, color filtering means having sections of different color transmitting characteristics disposed in the optical path between said projecting means and said photosensitive member for successively selecting different color components from the light emanating from predetermined areas of said object thereby correspondingly to change the color of the image light incident upon said photosensitive member in such manner that said color continuously and repeatedly drifts between the two ends of the visible spectrum, and means for moving said filtering means at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

2. An arrangement for transmitting television pictures in natural colors having a photosensitive member, means for projecting an optical image of the object to be transmitted on said member, means cooperating with said photosensitive member for developing picture signals representative of the light characteristics of successive elemental areas of said image in accordance with cyclically recurring scanning field patterns, color filtering means having sections of different color transmitting characteristics disposed in the optical path between said projecting means and said photosensitive member for successively selecting different color components from the light emanating from predetermined areas of said object thereby correspondingly to change the color of the image light incident upon said photosensitive member in such manner that said color continuously and repeatedly drifts between the two ends of the visible spectrum substantially without omission of any spectral color, and means for moving said filtering means at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

3. An arrangement for transmitting television pictures in natural colors having a photosensitive member, means for projecting an optical image of the object to be transmitted on said member, means cooperating with said photosensitive member for developing picture signals representative of the light characteristics of successive elemental areas of said image in accordance with cyclically recurring scanning field patterns, color filtering means having adjacent areas of which the filtering characteristics have the wave length order of the spectral colors from red to violet and violet to red in the order recited and being disposed in the optical path between said projecting means and said photosensitive member for successively selecting different color components from the light emanating from predetermined areas of said object thereby correspondingly to change the color of the image light incident upon said photosensitive member in such manner that said color continuously and repeatedly drifts between red and violet substantially without omission of any spectral color, and means for moving said filtering means at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

4. A television receiver for reproducing television pictures in natural colors including means for reproducing a television image composed of substantially white light in accordance with received picture signals, whereby successive elemental areas of said image are reproduced in accordance with cyclically recurring scanning field patterns, color filtering means disposed between said image of white light and an observer, said color filtering means being adapted to select from the white light emanating from predetermined elemental areas of said image successive color components in such manner that said components continuously and repeatedly drift between the two ends of the visible spectrum, and means for moving said filtering means at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

5. A television receiver for reproducing television pictures in natural colors including means for reproducing a television image composed of substantially white light in accordance with a received picture signal, whereby successive elemental areas of said image are reproduced in accordance with cyclically recurring scanning field patterns, color filtering means disposed between said image of white light and an observer, said color filtering means being adapted to select

from the while light emanating from predetermined elemental areas of said image successive color components in such manner that said components continuously and repeatedly drift between the two ends of the visible spectrum substantially without omission of any spectral color, and means for moving said filtering means at such a speed that the color repetition period and the field scanning interval are in nonintegral relationship with each other.

6. A television receiver for reproducing television pictures in natural colors including means for reproducing a television image composed of light of substantially white color in accordance with a received picture signal, whereby successive elemental areas of said image are reproduced in accordance with cyclically recurring scanning field patterns, endless color filtering means disposed between said image of white light and an observer, said color filtering means having adjacent areas of which the filtering characteristics have the wave length order of the spectral colors from red to violet and violet to red in the order recited and being adapted to select from the white light emanating from predetermined elemental areas of said image successive color components in such manner that said components continuously and repeatedly drift between the two ends of the visible spectrum, and means for moving said filtering means at such a speed that the color repetition period and the field scanning interval are in non-integral relationship with each other.

7. The method of transmitting television pictures in natural colors comprising the steps of projecting an optical image of the object to be transmitted upon a photosensitive member, developing picture signals representative of the light characteristics of successive elemental areas of said image in accordance with cyclically recurring scanning field patterns, successively selecting different color components from the light emanating from predetermined areas of said object thereby correspondingly changing the color of the image light incident upon said photosensitive member in such manner that said color continuously and repeatedly drifts between the two ends of the visible spectrum, and moving said filtering means at such a speed that the color repetition period and the scanning field interval are in non-integral relationship with each other.

8. The method of transmitting television pictures in natural colors comprising the steps of projecting an optical image of the object to be transmitted upon a photosensitive member, developing picture signals representative of the light characteristics of successive elemental areas of said image in accordance with cyclically recurring scanning field patterns, successively selecting different color components from the light emanating from predetermined areas of said object thereby correspondingly changing the color of the image light incident upon said photosensitive member in such manner that said color continuously and repeatedly drifts between the two ends of the visible spectrum substantially without omission of any spectral color, and moving said filtering means at such a speed that the color repetition period and the scanning field interval are in non-integral relationship with each other.

9. The method of transmitting television pictures in natural colors comprising the steps of projecting an optical image of the object to be transmitted upon a photosensitive member, developing picture signals representative of the light characteristics of successive elemental areas of said image in accordance with cyclically recurring scanning field patterns, successively selecting different color components ranging from red to violet substantially without omission of any spectral color from the light emanating from predetermined areas of said object thereby correspondingly changing the color of the image light incident upon said photosensitive member in such manner that said color continuously and repeatedly drifts between red and violet visible spectrum, and moving said filtering means at such a speed that the color repetition period and the scanning field interval are in non-integral relationship with each other.

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