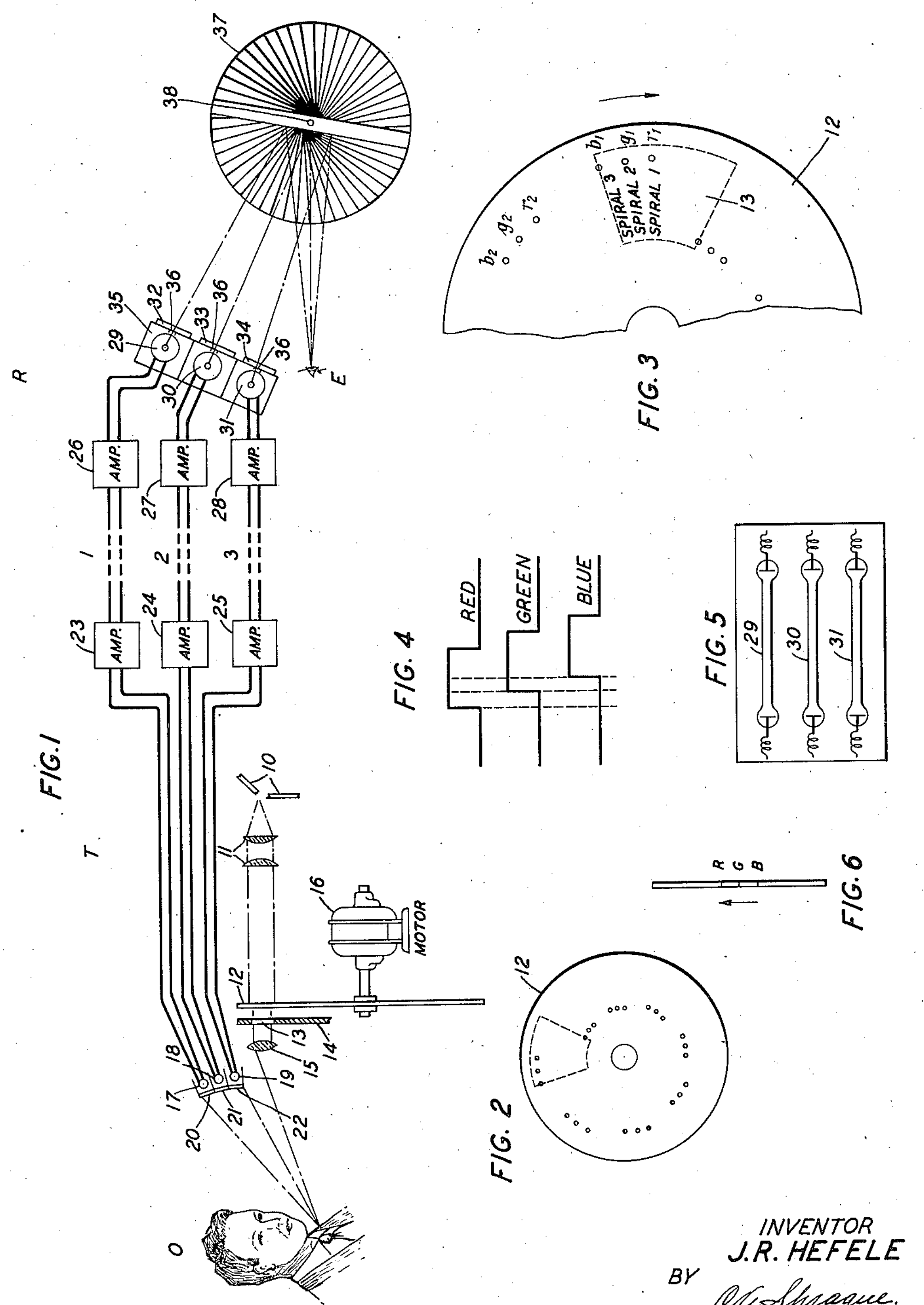
April 14, 1936. J. R. HEFELE 2,037,166

ELECTROOPTICAL SYSTEM

Filed May 31, 1935

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Patented Apr. 14, 1936

2,037,166

# UNITED STATES PATENT OFFICE

2,037,166

## ELECTROOPTICAL SYSTEM

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Application May 31, 1935, Serial No. 24,219

7 Claims. (Cl. 178—6)

This invention relates to electrooptical systems and more particularly to television.

An object of the present invention is to provide novel means for producing an image of an object or field of view in natural color.

In order to produce a television image in natural colors, it is necessary to combine light of the so-called primary colors modulated in accordance with the light-tone characteristics of the elemental areas of the object or field of view, an image of which is to be produced, several beams of modulated light to be simultaneously effective with the synthesizing apparatus at the receiving station. It has already been proposed to do this with a mirror helix as the synthesizing means by mixing the several beams of modulated light of primary colors in a so-called "mixing box" and using the mixed light with the helix as though it came from a single strip light source. This arrangement is relatively expensive and wasteful of light.

In accordance with this invention, the use of a mixing box is avoided, the light sources being used to supply light separately and simultaneously to the helix. Each elemental area of the object or field of view is scanned for each of the primary colors and the resulting plurality of image signals for the same elemental area are given a phase difference with respect to each other just sufficient to compensate for the spacing of the light sources at the receiver and makes unnecessary any optical mixing means.

In the preferred embodiment of this invention, a scanning disc at the transmitter has apertures and color filters therefor so arranged that each elemental area of the object is scanned in close succession for red, green, and blue. The light reflected from the object falls upon light sensitive cells which respectively have filters similar to those used with the apertures. Each of these filters passes a band of light waves having its center in the appropriate color. The resulting image currents are transmitted over separate communication channels to energize strip light sources in each channel, respectively, which preferably are associated with appropriate filters to produce red, green, and blue light, respectively, as in a system using a mixing box. If the object at the transmitter is scanned at the same time for red, green, and blue, as is ordinarily done, the image seen by the observer in the mirror helix will consist of a red, a green, and a blue image slightly displaced with respect to each other because of the physical displacement of the red, green, and blue strip light sources from each other. If, however, delay means, such as the delay introduced at the transmitter by the scanning disc, are used, the images produced by two of the sources are sufficiently delayed so that all three images are superimposed.

This invention is preferably adapted to reception of images televised from a colored object or film, but is not necessarily limited to such for it could be used with a lenticular kodacolor film with the use of appropriate light filters.

The invention will be more readily understood from the following description taken in connection with the accompanying drawing forming a part thereof, in which:

Fig. 1 is a schematic diagram of a television system for producing an image of an object in color;

Fig. 2 shows a disc with three spirals of apertures used for scanning the object;

Fig. 3 is an enlarged view of a portion of the scanning disc shown in Fig. 2;

Fig. 4 shows the displacement of the red, green, and blue signals with respect to each other;

Fig. 5 is a detail view showing the strip light sources used in the receiving system; and

Fig. 6 shows a single element of the mirror helix used at the receiver in a situation where delay means at the transmitter are not used.

The invention will be hereinafter described as embodied in a television system employing three separate color bands, lying within the range to which the eye is sensitive, and in which the predominant colors are, respectively, red, green, and blue. It should be clear, however, that the invention is not limited to the use of three channels nor to these specific colors.

Referring more particularly to the drawing, Fig. 1 shows a television system for the transmission of colored images. The system comprises a transmitter T, suitable connecting means (such as line or radio carrier channels 1, 2, and 3), and receiver R. Scanning apparatus at the transmitting station T includes the powerful light source 10, the light from which is directed by a lens system 11 upon the scanning area of a rotating disc 12, provided with a single spiral repeated three times as shown in Figs. 2 and 3. The path of the scanning light from the source 10 is through one of the apertures in the disc 12 and the aperture 13 of a screen 14, which latter aperture is so dimensioned that light coming through the aperture in the disc 12 can pass through a lens 15 and be directed thereby to the object O, as in the ordinary beam scanning method.

The disc 12, as shown in detail in Figs. 2 and 3 comprises a disc having three apertures in place of each aperture of the usual single spiral. This may be considered as three spirals. All of the apertures of spiral 1 are covered with red filters, those in spiral 2 with green ones, and those in spiral 3 with blue filters. For each set of three apertures (all apertures in a set have the same radius from the center of the disc) an elementary line of the object is scanned for each of the three colors, there being a slight delay between corresponding picture elements for the different colors due to the physical spacing of the apertures. The disc 12 is rotated by a motor 16, at a substantially uniform speed, to completely scan the object once for each color per revolution and within the period of persistence of vision.

The aperture 13 of the screen 14 is preferably so placed that the object can be scanned in a vertical direction so that a horizontal axis mirror helix can be used at the transmitter. In a situation where the object scanned is a continuously moving film, the shape of the aperture 13 would be similar to the one shown in Fig. 2 of a patent application of H. E. Ives, Serial No. 700,413, filed December 1, 1933. Of course, it is to be understood that the object can be scanned horizontally as a vertical axis mirror helix may be used at the receiving station. In this latter situation the aperture 13 would be at the top rather than at the side of the disc. Fig. 2 shows the placing of the aperture for horizontal scanning while Fig. 3 illustrates a position which is suitable for vertical scanning.

As the scanning disc 12 rotates it causes moving beams of intense light of the primary colors respectively, to pass from the apertures $r_1$, $g_1$, $b_1$, etc. to scan the object O to be televised in a series of parallel paths, each elemental area being scanned in succession for each of the primary colors, and light representing the light-tone values of successively scanned elemental areas of the object is reflected therefrom and impressed upon a plurality of color selective, highly sensitive photoelectric cells 17, 18, and 19, one for each color band. Each of the different photoelectric cells, as the result of the scanning operation, is activated to cause the production of image currents varying in accordance with the color characteristics of the elemental areas of the object, and each is connected with an individual transmission channel. The photoelectric cells 17, 18, and 19 are either inherently selective or made selective by positioning light filters 20, 21, and 22 between them and the object O. By means of this color selectivity, three electro-optical channels are established, and each channel is maintained from its origin at the light sensitive cell of the transmitting station to its respective receiving lamp at the receiving station. A plurality of groups of color selective light sensitive cells may be used, in place of the single cells illustrated, and the cells responsive to the same color or spectral band are connected to the same channels. The light cells of any group responsive to all of the different colors are placed close together, so as to view the object through as small an angle as is practicable in order to prevent the different channels from producing their part of the received picture as though the object were illuminated by differently located color light sources, which would cause the produced image to show color fringes. The different groups are preferably separated and differently oriented with respect to the subject so that the image will appear as though the subject were illuminated from different positions.

The light energy, varying in accordance with the reflective power and the color value of the elemental areas of the object being scanned, is translated by the photoelectric cells 17, 18, and 19 into electric currents. The currents from the color selective cells are amplified and controlled by suitable amplifiers 23, 24, and 25, one amplifier being located in each channel. These amplifiers are arranged so that the amount of amplification for each channel can be adjusted, and thus permit adjusting the output current in the channels to the proper strength irrespective of any difference in response due to the sensitivity of the different light sensitive cells used for the different spectral bands.

The incoming picture currents, transmitted over the different channels, are respectively impressed upon the amplifiers 26, 27, and 28. The currents transmitted over the channels are alternating currents of varying amplitudes representative of light variations above and below the average tone values of the successive elemental areas of the object being scanned and of their color characteristics. For any particular elemental area of the object O the picture signal channel 1 will be slightly ahead in time with respect to the signaling channel 2 and similarly the signal in channel 2 will be slightly ahead of that in channel 3.

Fig. 4 shows a typical image signal of an object which has a white elemental area (thus reflecting all three primary colors) between two black elemental areas (reflecting none of the three colors). This figure shows plainly the effect produced by the delay means in the signal currents as the increase in amplitude in the image current occurs later in the green signal than it does in the red and still later in the blue. Of course, the order of scanning may be varied so as to be green, blue, red, or blue, green, red, instead of red, green, blue as above described.

The incoming image currents, after being amplified by the devices 26, 27, and 28, are respectively applied to the strip light sources 29, 30, and 31, arranged in the preferred embodiment with their axes horizontal and each adapted to supply light radiations of different wave-lengths corresponding respectively to the wave bands respectively selected by the devices 17, 18, and 19 of the transmitter. This may be effected by using light sources which inherently produce light radiations of the different wave-lengths or colors or by using sources for producing the desired wave-lengths and associating a light filter with each source, the respective filters being adapted to transmit radiations of the desired wave-lengths while suppressing undesired wave-lengths.

Light sources 29, 30, and 31 may be of any suitable type adapted to produce an elongated line of light which will vary in intensity with the variations of the received image current. A more detailed view of these light sources is shown in Fig. 5. Glow lamps, charged with inert gases at a pressure of a few millimeters of mercury or lamps in which a positive column is produced in a capillary tube, may be used. When glow lamps are used, the gas charge may include a small percentage of active gas as disclosed and for the purpose set forth in an application of F. Gray, Serial No. 441,481, filed April 8, 1930. Thus, amplifier 26 may supply image current from channel

1 to a neon lamp 29 having associated therewith, or not, as the case may be, a red filter 32; and amplifiers 27 and 28 may supply image current to argon lamps 30 and 31, having associated therewith, respectively, a green filter 33 and a blue filter 34. For a more complete description of suitable light sources and filters for the receiving station and filters for the transmitting station, reference may be made to an article on "Television in colors by a beam scanning method" by H. E. Ives and A. L. Johnsrud in the Journal of the Optical Society of America, January 1930, pages 11 to 22.

The light sources 29, 30, and 31 are preferably placed in the same plane, as shown in Fig. 5, in individual compartments of a lightproof receptacle 35. The receptacle 35 has tiny apertures 36 (one for each light source) so that three parallel strip light sources are produced.

The light from these three sources is directed onto a mirror helix 37 preferably having a horizontal axis 38. This helix comprises a number of rectangular strips threaded on the shaft 38 and progressively annularly displaced. This helix is constructed in accordance with the disclosure in a patent to H. E. Ives No. 1,964,580, issued June 26, 1934. The reflecting faces of the mirror elements of the mirror helix 37 are preferably made concave cylindrical surfaces as described in this patent. In this way, the light sources 29, 30, and 31 may be located closer to the mirror helix 37 for a given position of the observer's eye E than in the case where the reflecting surfaces are plane mirrors.

For the purpose of explaining the operation of this system, let it be assumed that the signals in the transmission channels 1, 2, and 3 are in phase. The eye E of the observer would thus see a red, a green, and a blue image slightly displaced with respect to each other. If, however, means are introduced for delaying the signals in channels 2 and 3 with respect to the corresponding signal in channel 1, and if these signals are delayed the proper amount, the image seen by the eye E in the mirror helix is a superposed image of the three light sources 29, 30, and 31. As explained above, this desired delay is introduced at the transmitter by the use of the special scanning disc.

The method of operation of this system may be better understood by referring to Fig. 6 where a single element of the mirror helix 37 is shown. The mirror spiral is supposed to rotate in such a way on a horizontal axis that the reflected images of the capillary lamps 29, 30, and 31 move upward in the direction of the arrow. If it is imagined that the red image is seen without delay at R, then the green and blue images would be seen at G and B, respectively, in the same phase as the image at R. At some previous time, however, the red image has occupied the positions G and B in turn, and if the spacing of the lamps 29, 30, and 31 is properly compensated for by the spacing of the apertures of the scanning disc 12 the green and blue images can be put in the phase of the red image when it occupied these positions. The three images will then be identical and superposed. The actual delay in time depends on the construction of the mirror helix, the number of frames scanned per second, the spacing of the lamps 29, 30, and 31 from each other, and their distance from the mirror helix 37. When this time is determined, the distance of aperture $g_1$ from $r_1$ and $b_1$ from $g_1$ on the scanning disc 12 may be easily determined.

While there has been described a special scanning disc for introducing the delay in channels 2 and 3, it will, of course, be obvious to those skilled in the art that this invention is broad enough to include any other means for introducing the delay in these circuits for the purpose desired in this system.

It is readily apparent that this invention does not require the use of lenses, mirrors, or prisms at the receiver for mixing the light from the capillary lamps 29, 30, and 31. The full intensity of the light from these normally low intensity gas discharge tubes is thus utilized and a stronger and clearer image can be attained.

While this invention has been described for use in connection with a mirror helix, it is obvious that any other suitable rotating scanning device having a plurality of light directing means each of which simultaneously cooperates with a plurality of fixed, separated light sources for producing a composite image in color may be used as well, as, for example, a lensed disc.

Various other modifications may obviously be made without departing from the spirit of the invention, the scope of which is defined by the appended claims.

What is claimed is:

1. An electrooptical system comprising a rotating scanning device having a plurality of light directing elements equal in number to the number of elemental lines of the image, a plurality of light sources simultaneously cooperating with each of said light directing elements in turn, said light sources being such that when light from the different sources is mixed in different proportions, the various colors of the spectrum are produced, and means for producing and impressing on said sources, respectively, a plurality of independent out-of-phase image currents respectively representative of the light-tone values of the elemental areas of the field of view taken in succession along parallel elemental strips thereof but for different primary colors corresponding, respectively, to the light from said sources, the difference or differences in phase of said currents being of such value as to compensate for the separation of said sources, whereby a plurality of complete images of said field are set up by said rotating scanning device in cooperation with said sources, which images are substantially superimposed to produce a composite image in natural colors.

2. An electrooptical system for producing images in natural color comprising at a receiving station a mirror helix and a plurality of strip light sources such that when light from the different sources is mixed in different proportions, the various colors of the spectrum are produced, said sources being parallel to the axis of rotation of said mirror helix and having their long axes in different planes intersecting in said axis, and means for producing and impressing on said sources, respectively, a plurality of independent out-of-phase image currents respectively representative of the light-tone values of the elemental areas of the field of view taken in succession along parallel elemental strips thereof but for different primary colors corresponding, respectively, to the light from said sources, the difference or differences in phase of said currents being of such value as to compensate for the separation of said sources, whereby a plurality of complete images of said field are set up by said helix in cooperation with said sources, which images are substantially superimposed to produce a composite image in natural colors.

3. An electrooptical system comprising a rotating scanning device having a plurality of light directing elements equal in number to the number of elemental lines of the image, a plurality of light sources simultaneously cooperating with each of said light directing elements in turn, said light sources being such that when light from the different sources is mixed in different proportions, the various colors of the spectrum are produced, means at the transmitter for producing a plurality of independent out-of-phase image currents respectively representative of the light-tone values of the elemental areas of the field of view taken in succession along parallel elemental strips thereof but for different primary colors corresponding, respectively, to the light from said sources, and means for impressing these out-of-phase image currents on said sources, the difference or differences in phase of said currents being of such value as to compensate for the separation of said sources, whereby a plurality of complete images of said field are set up by said rotating scanning device in cooperation with said sources, which images are substantially superimposed to produce a composite image in natural colors.

4. An electrooptical system comprising a rotating scanning device having a plurality of light directing elements equal in number to the number of elemental lines of the image, a plurality of light sources simultaneously cooperating with each of said light directing elements in turn, said light sources being such that when light from the different sources is mixed in different proportions, the various colors of the spectrum are produced, means at the transmitter for producing a plurality of independent out-of-phase image currents respectively representative of the light-tone values of the elemental areas of the field of view taken in succession along parallel elemental strips thereof but for different primary colors corresponding, respectively, to the light from said sources, means for impressing the respective out-of-phase image currents upon different transmission channels for transmission to a receiving station including said light sources, the difference or differences in phase of said currents being of such value as to compensate for the separation of said sources, whereby a plurality of complete images of said field are set up by said rotating scanning device in cooperation with said sources, which images are substantially superimposed to produce a composite image in natural colors.

5. An electrooptical system as described in claim 1 in which a scanning disc is used to introduce the difference or differences in phase of the currents corresponding respectively to the different primary colors.

6. An electrooptical system as described in claim 1 in which a scanning disc is used to introduce the difference or differences in phase of the currents corresponding respectively to the different primary colors, said scanning disc comprising a number of spirals of apertures, the number of spirals corresponding to the number of primary colors used, and the spirals being respectively displaced from each other by a distance less than the length of a scanning line.

7. An electrooptical system for producing images in natural color comprising at a receiving station a mirror helix and a plurality of strip light sources such that when light from the different sources is mixed in different proportions, the various colors of the spectrum are produced, said sources being parallel to the axis of rotation of said mirror helix and having their long axes in different planes intersecting in said axis, and means at a transmitting station for setting up image currents for said receiving station comprising means for scanning in elemental parallel strips in succession a field of view and each elemental area of each strip for each of a plurality of primary colors corresponding to the colors of said sources at the receiving station, said scannings of the same elemental area being separated in time by an amount less than a strip scanning period and just sufficient to compensate for the effect of having said sources at the receiving station spaced apart, whereby a plurality of complete images of said field are produced in said primary colors, respectively, and are substantially superimposed to produce a composite image in natural colors.

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