

Nov. 23, 1937.

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2,099,889

TELEVISION SYSTEM

Filed Aug. 18, 1933

2 Sheets-Sheet 1

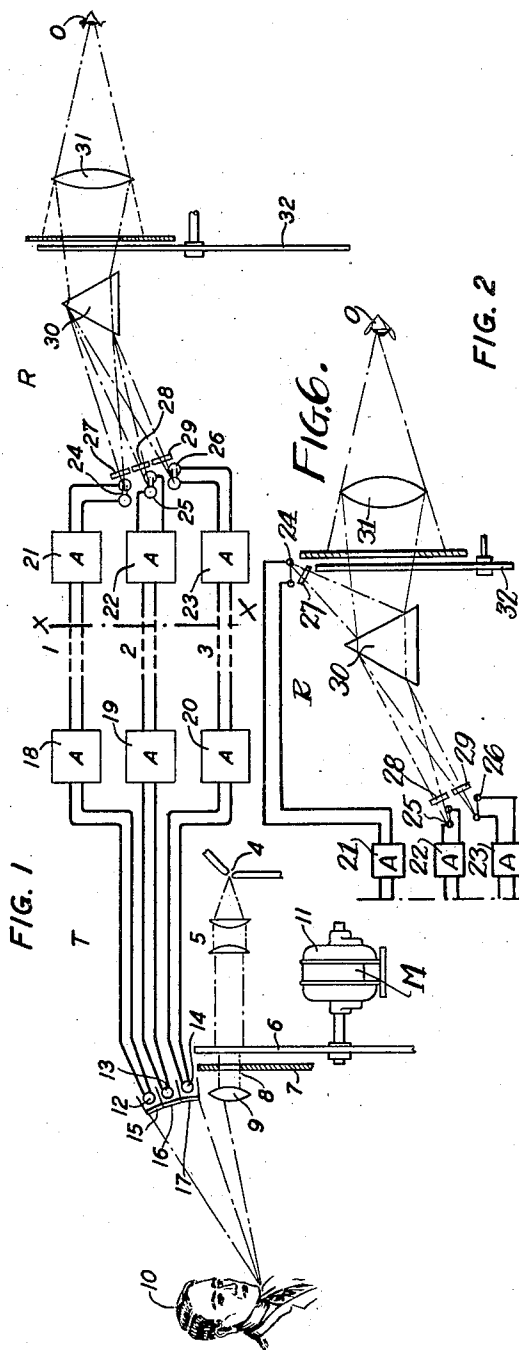


FIG. 2

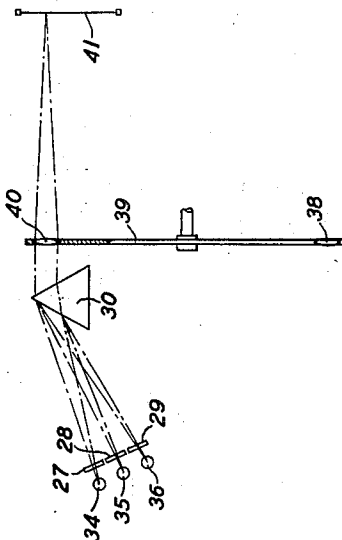
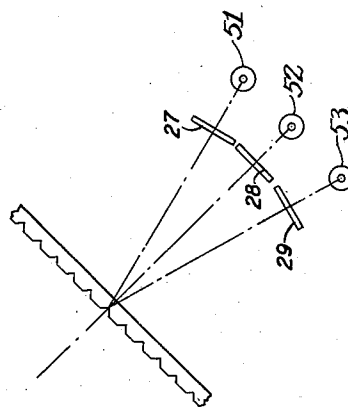


FIG. 5



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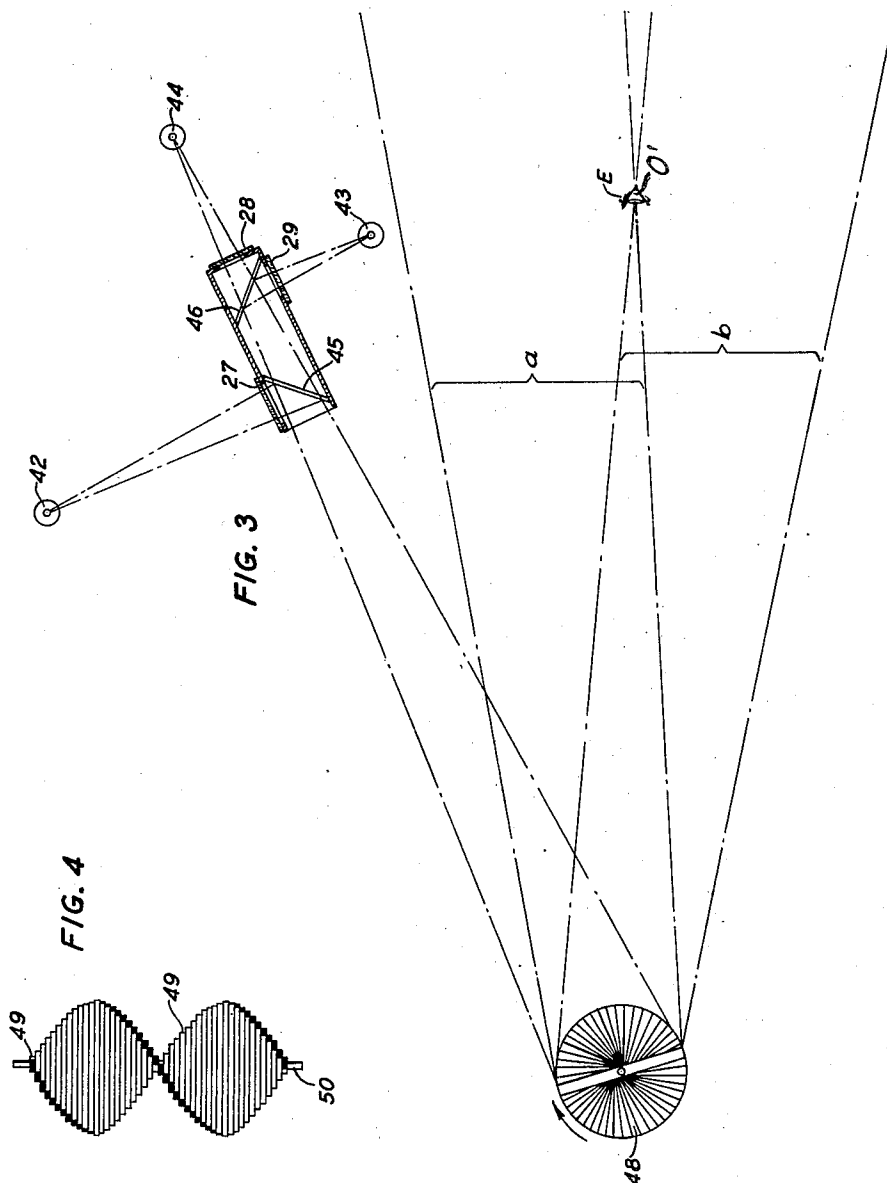
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TELEVISION SYSTEM

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2 Sheets-Sheet 2



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2,099,889

TELEVISION SYSTEM

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Application August 18, 1933, Serial No. 685,685

8 Claims. (Cl. 178—5.4)

This invention relates to television systems and more particularly to means for producing an image in color.

It has heretofore been proposed to produce an image in color by passing light from a point light source through a prism to produce a spectral band, the green, red and blue rays of which are respectively gathered by lenses and applied to light valves which are respectively supplied with image currents received from a transmitting station over separate communication channels. The differently colored light beams, emerging from the valves, which are thereby caused to vary as the tone values of a distant object, pass through a second prism which serves to superpose them and thereby produce a beam of light of composite color. The composite beam passes through apertures in a moving scanning member to trace a colored image of the distant object upon a screen.

Such a system embodies a complicated and inefficient optical system, and is limited in practice to the use of some form of light control device, or light valve for varying the intensity of the light supplied by a source of constant intensity.

An object of the present invention is to provide a simplified but practical apparatus including image current controlled strip sources of light for producing an image in color.

In one embodiment, the incoming image currents transmitted over separate communication channels are respectively used to energize strip light sources, each supplying light waves of different lengths, within the range to which the eye is sensitive, to a prism which serves to produce superposed images of the light sources. Such images, varying in tone values with the successive elemental areas of an object scanned at the transmitting station, are observed through a spiral of apertures in a rotating disc, which is so positioned with respect to the superposed images of the light sources that a binocular view of a complete image of the subject in color may be seen by the observer.

A second embodiment comprises the image current controlled strip light sources associated with semi-transparent mirrors for superposing images of the sources, these images are reflected by a rotating helix of plane mirrors, so that a binocular view of a complete image of the subject in color may be seen by one or more observers occupying positions within a restricted angle with respect to the helix.

A detailed description of the invention follows and is illustrated in the attached drawings, in which

Fig. 1 diagrammatically illustrates a television system embodying the invention;

Fig. 2 illustrates an alternative receiving ar-

range which may be used for that shown in Fig. 1;

Fig. 3 shows a different arrangement for directing the composite light to the eyes of the observer;

Fig. 4 illustrates a detail of the apparatus of Fig. 3;

Fig. 5 illustrates another arrangement for producing the composite light;

Fig. 6 illustrates an alternative arrangement of the apparatus to the right of section line X—X, Fig. 1.

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.

As shown in Fig. 1, the system comprises a transmitting station T connected to a receiving station R by three communicating channels 1, 2 and 3. While the channels are herein illustrated as wire lines, they may be separate channels of a wire carrier or radio system.

The scanning apparatus at the transmitting station includes a powerful light source 4, whose light is directed by a lens system 5 upon the scanning area of a rotating disc 6, provided with a row of apertures arranged in a spiral line. The path of the scanning light from the source 4 is through one of the apertures in the disc 6, the aperture 8 of screen 7, which aperture is so dimensioned that light coming through only one aperture in the disc 6 can at any instant pass through a lens 9, to the object 10. Disc 6 is rotated by a motor 11 at a substantially uniform speed, to completely scan the object once per revolution and within the period of persistence of vision.

As the scanning disc rotates, it causes a moving beam of intense light to pass through each one of the apertures to scan the object to be transmitted in a series of parallel paths, and light reflected from successive elemental areas of the object so illuminated is impressed upon a plurality of color selective light sensitive translating devices 12, 13 and 14, one for each color band. This apparatus operates to scan the object in the manner disclosed in an application of F. Gray, Serial No. 227,649, filed October 21, 1927.

Each of the different translating devices, as a result of the scanning operations, is activated to cause the production of current variations in accordance with the color characteristics of the elemental areas of the object, and each is connected with an individual transmission channel.

The selective light sensitive devices or cells 12, 13 and 14 are either inherently selective or are made selective by positioning light filters 15, 60

16 and 17 between them and the object 10. By means of this selectivity, three channels are established, and each channel is maintained from its origin at the light sensitive cells of the transmitting station to the receiving lamps 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 channel. 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 separate channels from producing their part of the received picture as though the object were illuminated by differently located colored light sources, which would cause the produced image to show color fringes.

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 light sensitive cells into electric current. The current from each color selective sensitive cell is amplified and controlled by suitable amplifiers 18, 19 and 20 for each channel, respectively. These amplifiers are arranged so that the amount of amplification for each channel can be adjusted, and thus permit adjusting the output current from all 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 21, 22 and 23. The current transmitted over each channel is an alternating current of varying amplitude representative of light variations above and below the average tone value of the successive elemental areas of the object being scanned and of their color characteristics.

The apparatus, so far described, operates in the manner disclosed in U. S. Patent 1,878,147 of H. E. Ives, issued Sept. 20, 1932, to which reference may be made for a more complete disclosure of its mode of operation.

The incoming image currents, after being amplified by the devices 21, 22 and 23, are respectively applied to the strip light sources 24, 25 and 26 arranged 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 12, 13 and 14 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 length while suppressing undesired wave lengths. Light sources 24, 25 and 26 are energized with current, either from the source supplying plate current to the amplifiers 21, 22 and 23 or from a separate source or sources, to produce light corresponding to the average tone value of the image to be produced.

Light sources 24, 25 and 26 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 currents. Glow lamps charged with a rare gas at a pressure of a few millimeters of mercury, or in which a positive column is produced in a capillary tube

may be used. For certain colors, a mercury arc lamp 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 U. S. Patent 1,871,266 of F. Gray, issued Aug. 9, 1932. Thus amplifier 21 may supply image current from channel 1 to a neon lamp 24 having associated therewith, or not, as the case may be, a red filter 27; amplifiers 22 and 23 may supply image currents to argon lamps 25 and 26, having associated therewith, respectively, a green filter 28 and a blue filter 29.

Light sources 24, 25 and 26 should be placed with respect to each other and the face of the prism 30 on which light passed by the filters 27, 28 and 29 is incident, that they cooperate to produce composite lines of light which illuminate the spirally apertured scanning area of a rotating disc 32. The refractive index of the prism is so chosen that the differently colored radiations are superposed on the retina of the eye of an observer O. Compositely colored light passes through the apertures in the disc 32, which is rotated in synchronism and in phase with the disc 6 at the transmitting station and hence operates to control the production of an image of the object scanned at the transmitting station, once for each revolution of the disc and within the period of persistence of vision. A suitable synchronism system for this purpose is disclosed in U. S. Patent 1,999,376 of H. M. Stoller, issued April 30, 1935.

The lens 31 not only acts to focus the composite light beams, passing through the respective apertures of the disc, on the retina of the eye of the observer, but also serves to magnify the colored image produced by the cooperative action of the scanning disc, the light sources and the prism.

As the disc rotates, each of its apertures, as it moves longitudinally of the compositely colored line of light will direct light from different small portions of the line to first one eye and then to the other eye of the observer in succession, the time interval between the application of the small light portions to the respective eyes being so short that they appear to occur simultaneously. In this manner, the observer obtains a binocular view of the image in color.

In place of the prism 30, a diffraction grating could be used to superpose differently colored lines of light produced by the sources 24—25—26 cooperating with filters 27—28—29. Preferably this grating should be one which concentrates the majority of the light into one order.

Since a neon lamp is much more efficient than argon lamps, only a small part of the light supplied by the former would be used when associated with argon lamps. It would be possible to introduce the light from the neon lamp, with or without a red filter, as is found necessary, by means of a transparent reflector or by reflection from one face of the prism. The latter method of introducing light from the neon lamp is shown in Fig. 6, as an alternative. According to this method the lamp 33 is included in the output circuit of the amplifier 21, in place of the lamp 24, and it is so positioned that light therefrom is directed either through a filter 27 or not, as required, to that face of the prism 30, which is adjacent the disc 32. This light is superposed on that supplied by sources 25 and 26 through the filters 28 and 29, and the compositely colored line of light is applied to the scanning section of the disc 32.

Referring to Fig. 2, there are shown point

sources of light 34, 35 and 36, of high intensity, each adapted to supply light rays of a different color, due either to their inherent characteristics or because of the presence of filters 27, 28 and 29.

5 The light sources are respectively included in the output circuits of amplifiers 21, 22 and 23, and light therefrom passes through the prism 30 to produce a beam of light of composite color which is applied to the scanning section of a rotating disc 39. As in Fig. 1 the refractive index of the prism is such that the light rays of respectively different colors are superposed at a single position. This disc is provided with a series of lenses 40 arranged in a spiral, which operate to project beams of compositely colored light upon a screen 41. Disc 39 is rotated in synchronism and in phase with the disc 6 at the transmitting station and hence its lenses operate to produce on the screen 41 an image which corresponds in color to the object scanned at the transmitter.

Fig. 3 illustrates a different arrangement which enables an observer to binocularly view a colored image.

Light rays of different colors respectively produced by the sources 42 and 43 are combined with light radiations from the source 44, by the semi-transparent mirrors 45 and 46 enclosed in a housing 47. The sources 42, 43 and 44 are similar to those of Fig. 1, i. e. they are strip light sources which, as explained above, may have filters 27, 28 and 29 associated with them. The compositely colored beam is supplied to a helix of mirrors 48 which directs them to the eye or eyes of an observer O' or observers located within a restricted angle with respect to the helix of mirrors 48.

Because of the fact that the linear light sources 42, 43 and 44, which cooperate to provide the compositely colored light source, and mirror helix 48 must of necessity be at different distances from the eyes of the observer, it results that there is only one viewing distance for each position of the sources in which the rectangular projection of the rotating helix is exactly filled from one side to the other. This distance is, of course, a function of the length of the mirror strips and of the angle between them. The different distances, between the light sources and the eyes of the observer on the one hand and between the latter and the helix mirror on the other hand, may be determined on the assumption that the light sources and the eyes of the observer are effectively in the same straight line, that no light deviating device is included in the path of the composite light beam, and that the helix has plane mirror surfaces. In practice, the light source and the eye must have sufficient angular separation to clear each other as shown in the figure, and this will introduce minor modifications in the result. If the field to be scanned is square, the length of the mirror surface D is unity, the distance of the helix from the light source is y, the distance between the helix and the eye of the observer is l and the angle between the successive mirror surfaces is a, the following relation holds

$$y = \frac{Dl}{4l \sin \frac{a}{2} - D}$$

A plot representing different values of y results in a parabolic curve, and plots representing a series of different values of the angle a, i. e., for different numbers of scanning lines and for different values of y results in a series of curves. These curves are each of parabolic form, and they take positions successively further from the origin,

as the number of scanning lines is increased with a consequent decrease in the angle a. For example, for a distance between the light source and the helix of eight feet, the curve shows that the observing distance for a seventy-two line square should be twenty feet. This observing distance is much greater than is required in order to see a practically structureless picture. In any structured picture there is a minimum viewing distance at which satisfactory results can be obtained fixed by the size of the structure. The smaller the structure the shorter the distance from which the picture may be viewed. With the mirror helix a set of conflicting conditions exists. As the angle between the strips is decreased the observing distance must be increased in order that the frame can be filled. On the other hand, as the number of strips is increased, the observing distance for properly utilizing the number of strips used is decreased. As a consequence there comes a point, where increasing the number of scanning strips and the detail of the image, becomes of no value because of the greater distance to which the observer is forced. The practical problem, therefore, becomes that of making the observing distance at which the frame is filled, at least as small as the distance which the picture structure would make possible.

The general relationship between the number of scanning lines n and the observing distance y is obtained as follows:

The width of the strip for a square frame will be

$$\frac{D}{n}$$

The angle e subtended is given by the relation:

$$\frac{D}{n} = 2 \tan \frac{1}{2} e$$

Since e is quite small

$$y = \frac{D}{ne}$$

The relationship is parabolic. The observing distance, in order that the frame may be just filled, i. e.,

$$y = \frac{Dl}{4l \sin \frac{a}{2} - D}$$

may also be expressed in terms of n, for if a is small we have

$$\sin \frac{a}{2} = \frac{a}{2} = \frac{n}{2} = \frac{\pi}{n}$$

so that

$$y = \frac{nD}{4\pi - \frac{nD}{l}}$$

Having decided upon the length of the reflecting elements and selected the distance of the light source from the helix so that the frame is just filled, the optimum position for the observer's eye, i. e., to avoid line structure is expressed as

$$l = \frac{nD}{4\pi - \frac{nD}{y}}$$

Applying this formula to the case where the length of the reflecting surface is one foot, the light source is eight feet from the helix, scanning is effected in 48 lines and hence the angle a is 7.5°, the eye of the observer should be positioned slightly over seven feet from the helix. For a

more complete disclosure of the operation of the helix mirror, reference may be made to U. S. Patent 1,964,580, issued June 16, 1934, to applicant.

As the helix of mirrors is rotated the reflecting surfaces will each reflect light from the superposed light sources in a relatively large, diverging, compositely colored beam. As indicated for the two extreme positions of the reflecting surfaces by *a* and *b*, the point *E* is common to the reflected beams and hence successive small portions of the several beams of light are reflected to the eye of an observer occupying the position *E*. The observer thus sees the lamp as if the reflecting surfaces were a narrow slit through which he looks at a lamp behind it, this slit and the lamp appearing to move transversely of the plane of the paper as the mirror helix rotates in the direction of the arrow. Similar but laterally displaced moving strips of light are produced in the field of view, as the successive adjacent reflecting surfaces are illuminated by the colored beam from the sources and hence these strips are applied to the eyes of an observer in succession provided they are in a line at right angles to the paper which passes through the position *E*.

The entire illuminating areas of the lamps are varying in intensity in accordance with the tone values and color characteristics of successive scanned areas of the object at the transmitting station, and it is necessary that the helix of mirrors reproduce the elemental areas in the same sequence as they are scanned for transmission.

Light sources 42 to 44 must be at least of sufficient length that both eyes of the observer are within the divergent beam reflected by the mirror helix, and, if they are sufficiently long, it has been found that the observer is not only permitted a certain latitude of movement in a direction at right angles to the plane of the drawings, but that several persons, occupying positions within a restricted angle relatively to the mirror helix may simultaneously view the image. This condition is attained when the observer or observers are so positioned that their eyes are in the line joining successive points indicated by *E*.

By way of example, Fig. 4 illustrates a plan view of a mirror helix, which may be used. This helix comprises forty-eight rectangular strips 49 threaded on a shaft 50 and progressively angularly displaced. This helix is constructed in accordance with the disclosure in an application of F. Gray, Serial No. 539,463, filed May 23, 1931 in which it is disclosed for use in the production of a monochromatic image.

Referring now to Fig. 5 which illustrates an arrangement for superposing the radiations of different colors, respectively, supplied by sources 51, 52 and 53. These sources are placed side by side, are similar to those included in Fig. 1, and may have associated therewith color filters 27, 28 and 29, if necessary.

Light rays supplied by the sources 51, 52 and 53 pass through a prismatically ridged structure having ridges so calculated as to refract images of the sources into the same apparent position, whereby the differently colored radiations are superposed to provide a compositely colored beam.

The receiver is completed by using the rotating disc 32, Fig. 1, through the apertures of which and lens 31 the composite light beam passes to the eye or eyes of an observer *O*.

The present invention therefore provides a television system including a simple arrangement for producing an image in color and also for present-

ing such images to both eyes of an observer or to several observers simultaneously.

What is claimed is:

1. Electro-optical apparatus for producing images in color, comprising a plurality of light sources each emitting a strip of diffused light, the respective strips comprising light waves of different lengths within the range for which the eye is sensitive and simultaneously controlled by incoming image currents, means acting upon said light waves to form a superposed image of said sources, and a helix of mirrors for directing light from said superposed image to a field of view.

2. An electro-optical apparatus for producing an image in color comprising a plurality of light sources each emitting a strip of diffused light, the respective strips comprising light waves of different lengths within the range for which the eye is sensitive, means for receiving and simultaneously applying to the respective light sources image currents respectively corresponding to said different light wave lengths, means for superposing said light waves to produce a compositely colored beam of light, and a helix of mirrors for directing light from said beam to an image field.

3. An electro-optical apparatus for producing images comprising a plurality of parallel light sources each emitting a strip of diffused light, means for supplying incoming image current to said sources simultaneously, and a helix of mirrors for directing light from said sources to an image field.

4. Electro-optical apparatus for producing images in color, comprising a plurality of primary strip light sources respectively emitting light waves of different lengths within the range for which the eye is sensitive, means for simultaneously applying incoming image currents to said sources to cause all portions of each source to emit light when energized, means acting on said light waves to form a superposed image of said sources, and a helix of mirrors for directing light from said superposed image to a field of view.

5. An electro-optical apparatus for producing an image in colors comprising a plurality of primary strip light sources respectively emitting light waves of different wave lengths within the range for which the eye is sensitive, means for receiving and simultaneously applying to the respective light sources image currents respectively corresponding to said different light wave lengths to cause all portions of each said source to emit light when energized, means for superposing said light waves to produce a compositely colored beam of light, and a helix of mirrors for scanning said beam.

6. An electro-optical apparatus for producing images of an object scanned at a transmitter comprising a plurality of parallel primary strip light sources, means for simultaneously supplying incoming image currents to said sources for causing all portions of each said source to emit light when energized, and a helix of mirrors for directing light from the respective portions of said sources in succession to a viewing field for thereby presenting a binocular image of the object scanned to the eyes of an observer.

7. An electro-optical apparatus for producing colored images comprising a plurality of primary strip light sources respectively emitting light waves of different wave lengths to which the eye is sensitive and simultaneously controlled by separate image currents, means acting on said waves to produce a divergent beam of light hav-

ing composite color characteristics, and means for causing different portions of said beam to be directed in succession to a position from which an image may be observed with both eyes simultaneously by directly viewing said last mentioned means.

8. Apparatus for producing television images in natural color comprising prismatic light refracting means, means for causing light to be impressed upon said prismatic means consisting of light of different characteristics capable when mixed of producing different color sensations on the eye dependent upon the mixing proportions, said means comprising a plurality of parallel pri-

mary strip light sources adapted to emit light of said different characteristics, respectively, and each modulated in accordance with a distinctive color characteristic of the object whose image is to be produced, a scanning disc rotatable in a plane substantially parallel to said light sources, apertures in said disc arranged spirally, said disc receiving light from said prismatic means in the form of a divergent beam, and means for directly binocularly viewing said scanning disc comprising a light converging lens having conjugate focal planes in the region of said light sources and the viewing position respectively.

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