May 21, 1935. H. E. IVES 2,001,730

ELECTROOPTICAL SYSTEM

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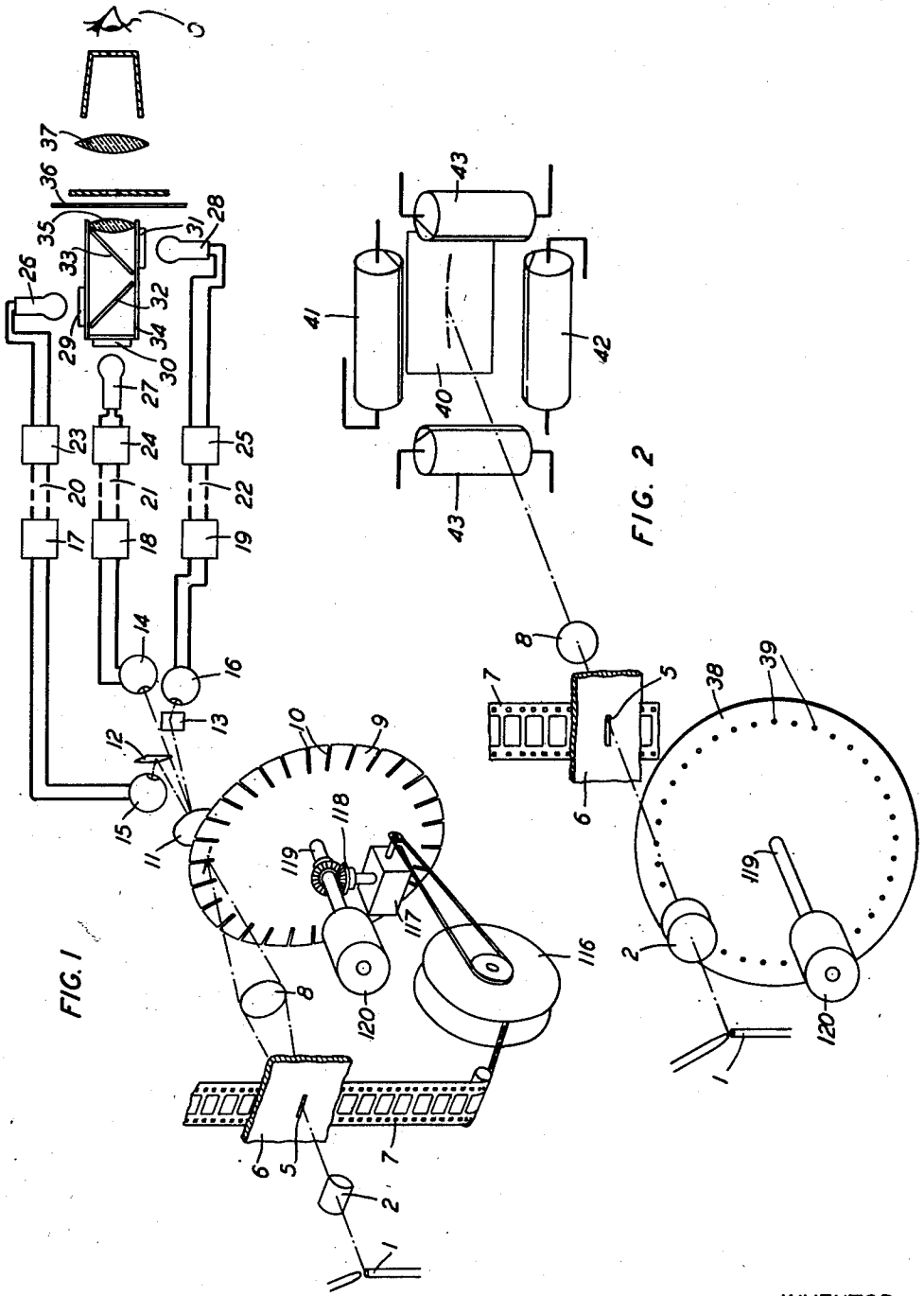


FIG. 1

FIG. 2

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FIG. 3

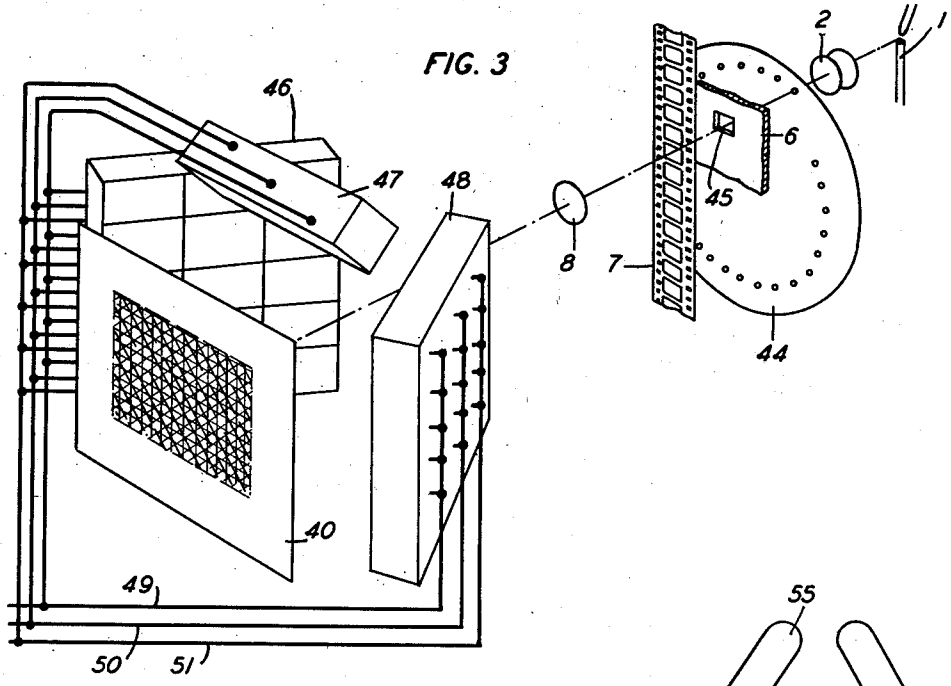
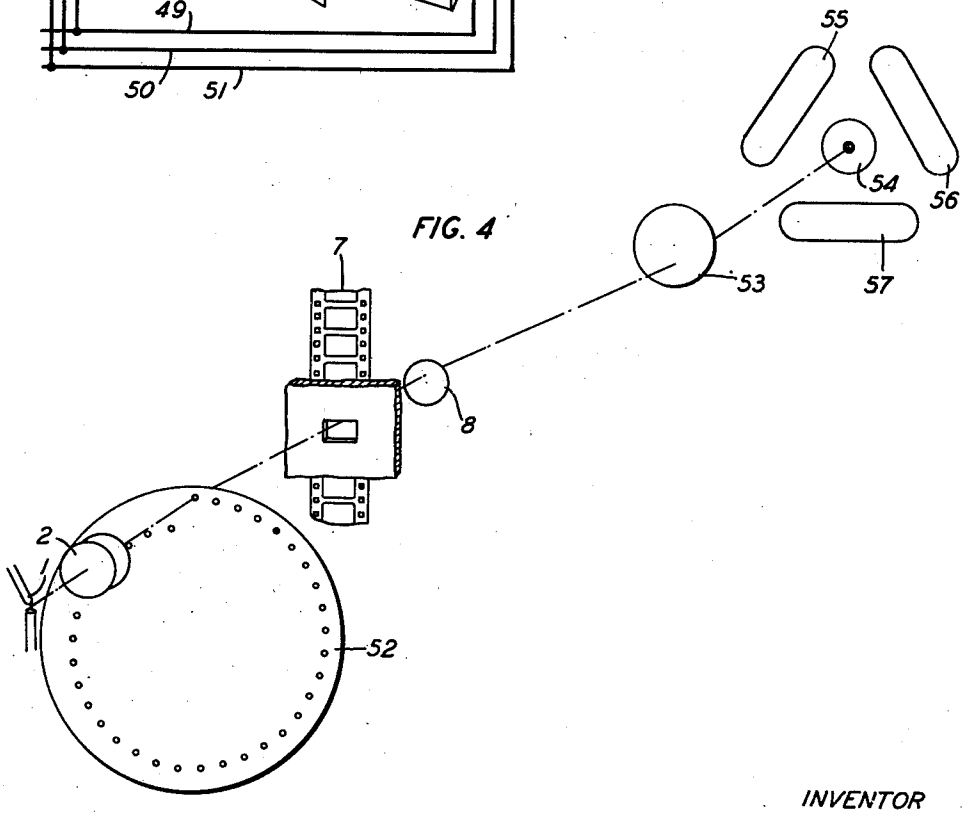


FIG. 4



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ELECTROOPTICAL SYSTEM

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Application October 11, 1930, Serial No. 487,967

20 Claims. (Cl. 178—6)

The present invention relates to electrooptical systems and more particularly to methods of and means for controlling the production of signal currents corresponding to pictures.

It has heretofore been suggested to analyze a photographic record by passing light through successive elemental areas of the record to a light sensitive device. It has also been proposed to illuminate successive elemental areas of a colored record and to direct the light reflected from each elemental area to a plurality of light sensitive electric devices selective of different colors to cause the production of image currents, which are used to control the production of a similarly colored record.

The prior art includes a picture transmission system comprising a film having color characteristics for controlling the light supplied to a single photoelectric cell which is activated to produce picture currents that are supplied to a single light source for illuminating a lenticulated sensitized photographic film to produce a record at a receiver. It is stated that the invention may be used to produce picture or television images in color. However, the disclosure does not embody means at the transmitter for separately controlling the value of the picture currents corresponding to the different colors which combine to produce the color characteristics of elemental areas of the film, nor means at the receiver for supplying controllable amounts of light of the different colors which must be combined to duplicate the color characteristics of the transmitted film. Hence such system cannot be operated to effect the result set forth.

An object of the invention is to provide a novel method of and apparatus for scanning a picture.

Another object is to utilize a photographic record, having color characteristics, in television systems for controlling the production of a plurality of image currents respectively corresponding to different colors, whereby an image in color of the subject photographically recorded may be produced.

In accordance with one embodiment of the invention, light of constant intensity passes through unit lines of a colored photographic record, and a lens for projecting a colored image of each line in the plane of a moving image member having slots for scanning each line to produce a moving beam of light, colored in accordance with the color characteristics of successive elemental areas of the record, which is projected on a plurality of light sensitive electric devices, arranged singly or in groups, each of which, or each group of which, is selective of light of a different color, whereby they are activated to cause image currents corresponding to the different colors to be respectively transmitted over different communicating channels. The respective image currents energize separate light sources, each of which supplies light of the respective colors, and of a predetermined intensity to produce a composite light beam, which is scanned to produce an image corresponding in subject matter and color to the photographic record.

The present invention also contemplates a system in which successive elemental areas of a photographic record, which has been colored or has color characteristics, are projected upon a diffusely reflecting or transmitting screen to provide separate beams of light to activate a plurality of light sensitive devices, selective of different colors, to cause the production of separate image currents, which are used to control the production of an image in colors. In accordance with this aspect of the invention the photographic record may be moved continuously across a slot in a stationary baffle through which successive unit lines of the record are projected to occupy the same position on the screen and elemental areas of each line may be successively scanned by a movable member having apertures, or the successive elemental areas may be separately projected to occupy the same position on the screen. In either case, each frame of the record is projected on the screen at a rate within the period of persistence of vision.

According to this invention in one aspect, a moving beam of light is utilized to scan a photographic film or pictorial transparency in such manner that light, modulated in accordance with the characteristics of the picture is projected on a diffusely reflecting screen and light reflected from the screen is directed to light sensitive electric means, which is thereby activated to cause the production of a signal current varying as the characteristics of successive elemental areas of the picture.

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

Fig. 1 diagrammatically illustrates a system involving the invention.

Figs. 2, 3 and 4 are perspective views of scanning apparatus which may be substituted for that shown in Fig. 1.

As shown in Fig. 1, light of constant intensity from the source 1 is projected by a lens 2 upon the slot 5 in the mask 6 and passes through the

colored film 7, which is continuously driven at a definite rate transversely of the slot 5.

The film 7 may carry a colored picture, produced by the Technicolor or similar process, and is moved continuously across the slot 5 by a suitable driving unit.

Lens 8 focuses an image of the slot 5 in the plane of the disc 9 provided with slots 10 which sweep across the image of slot 5 to produce a beam of light corresponding in color to successive elemental areas of the film. A magnified image of the beam is projected by the lens 11 upon mirrors 12 and 13 and the light sensitive device 14. Mirrors 12 and 13 direct the light rays incident upon them to light sensitive devices 15 and 16, respectively.

Light sensitive devices 14, 15 and 16 are either selective of different bands of the spectrum or are rendered selective thereof by the use of color filters. In either case, they will be activated by different portions of the colored light beam to cause the production of separate image currents corresponding in amplitude to the different primary color components which combine to produce the color characteristics of successive elemental areas of the film.

The driving unit for the film 7 comprises an element 117 conected by a belt and a slip clutch, commonly used in motion picture projectors, coupled by a gearing 118, having the desired gear ratio, to a shaft 119 carrying the disc 9.

The disc 9 is mounted on shaft 119 of motor 120 which drives the disc at such speed that each picture carried by the film is completely scanned during one revolution of the disc and within the period of persistence of vision and also drives the film continuously at a rate definitely related to the speed of the disc.

The separate photoelectric or image currents are amplified by the devices 17, 18 and 19, respectively, and are supplied to distinct communicating channels 20, 21 and 22, which respectively include, at the receiver, amplifiers 23, 24 and 25.

Amplified currents produced by 23, 24 and 25 are respectively supplied to light sources 26, 27 and 28, with which are respectively associated red, green and blue filters 29, 30 and 31. Light passing through these filters from the sources 26, 27 and 28 is directed into a common path by means of transparent mirrors 32 and 33 in the chamber 34. The composite or mixed beam of light, comprising the three primary colors, is transmitted through lens 35, apertures in the scanning disc 36 and lens 37 to the eye of an observer O.

Sources 26, 27 and 28 may comprise glow lamps of suitable design, for example, of the type disclosed in a patent of H. W. Weinhart, Patent No. 1,918,309, issued July 18, 1933.

In accordance with well known practice, disc 36 is provided with apertures arranged in a spiral line, which operate to spread out the unit lines, successively scanned at the transmitter, to constitute a complete image in color of each picture carried by the film. Disc 36 is rotated at such speed that a complete image is integrated during each revolution of the disc and at a rate within the period of persistence of vision. Discs 9 and 36 must be operated in phase and in synchronism, and this may be effected by using a system of the type disclosed in an application of H. M. Stoller, Serial No. 442,564, filed April 8, 1930.

The gain of the respective amplifiers 23, 24 and 25 is so adjusted and the densities of the filters 29, 30 and 31 are so chosen that the amount of red, green and blue light is controlled to produce a composite beam of white light, when a white elemental area is being scanned at the transmitter. When a colored elemental area is being scanned at the transmitter the amplitudes of the currents supplied by the amplifiers 23, 24 and 25 will have such relative values that the color of the composite beam will be modified to correspond to the color characteristics of successive elemental areas of the transmitted film.

In the system shown in Fig. 2, light of constant intensity from the source 1 is gathered by the lens 2 to illuminate a section of a scanning disc 38 provided with apertures 39 arranged in a circle. Light passes through the apertures in the form of a beam, which longitudinally traverses a slot 5 in a mask 6, to illuminate successive elemental areas of unit lines of a film 7, which is in continuous motion transversely of the slot 5.

The film 7 may carry colored pictures produced by the Technicolor or other suitable process, or may embody a representation of a subject in black and white identifying color characteristics, i. e. a film prepared by the Kodacolor or other similar process, and may be moved continuously across the slot 5 at a definite rate, with respect to the speed of disc 38, by a driving unit similar to that included in the system of Fig. 1.

The light beam passes through successive elemental areas of each unit line of the colored representation, if a Technicolor film is used and through a projecting lens 8 to produce a colored image of the elemental areas successively in a single line upon a white screen 40. If a Kodacolor film is used, the projecting lens 8 is of the usual type employed for projecting films of this character, i. e., it is provided with a screen carrying red, green and blue filters. These filters cooperate with the lenticular elements of the film to project upon the screen 40 a unit line made up of successive elemental areas in color. In either case the successive unit lines of the representation occupy the same position on the screen 40.

Light reflected from the successive elemental areas of the line projected on the screen 40 activates light sensitive devices 41, 42 and 43 (the latter being shown as consisting of two elements) each selective of a different color, to cause the production of three photoelectric currents. These devices may be inherently selective of wave lengths in different portions of the spectrum or color filters may be used to render them selective of the respective bands. As shown, devices 41 and 42 may be respectively selective of two bands including different primary colors, while the two-part cell 43 may be selective of a band including a third primary color. Preferably the units 41, 42 and 43 should each comprise a group of photoelectric cells, selective of the three color bands and should be arranged symmetrically with respect to the screen 40. The cells of the different groups, which are selective of the same band, are connected in parallel to the respective amplifiers 17, 18 and 19. As in the system of Fig. 1 the amplified currents supplied by amplifiers 17, 18 and 19, respectively, are transmitted over channels 20, 21 and 22 to the receiver, therein shown, which is thereby actuated to produce an image in color.

Fig. 3 illustrates a system for transmitting a film 7 adapted to be moved intermittently, frame by frame, in which each picture is scanned to

project an image thereof on the screen 40. This system comprises a constant light source 1, a lens sytem 2, a scanning disc 44 provided with apertures arranged in a spiral, a mask 6 having an opening 45 commensurate with the size of the picture, a motion picture film in color or one having color characteristics, a lens 8, screen 40 and units 46, 47 and 48 including groups of light sensitive devices.

Units 46, 47 and 48 are mounted symmetrically of the screen 40 and are provided with light sensitive devices selective of different primary colors. As indicated by the conductors 49, 50 and 51, the light sensitive devices of the different units, which are selective of the same color, are connected together and to the respective amplifiers 17, 18 and 19. For example, the red sensitive cells may be connected to conductor 49, over which current is supplied to the amplifier 17; those sensitive to green may be connected to conductor 50, leading to amplifier 18, and those sensitive to blue may be connected by conductor 51 to amplifier 19. For the sake of clarity, the circuit connecting the group of cells to the respective amplifiers is indicated by a single conductor.

As in the system of Fig. 1, the screen 40 is illuminated by colored light passing through the successive elemental areas of the picture and is reflected to the light sensitive devices of units 46, 47 and 48, which are thereby activated to cause the production of three distinct image currents which are transmitted over the respective channels to a receiver including three light sources as shown in Fig. 1.

The spiral of apertures in the disc 44 extend over an angle less than 360° so as to leave between its terminals a blank space, corresponding to the time period required to shift the film from frame to frame. A disc similar to disc 44 is used at the receiver, which in other respects is identical with that described above.

In Fig. 4 there is shown a source of constant light 1, a lens 2 for gathering light from the source 1 and projecting it upon the periphery of a disc 52 provided with a spiral of apertures, a mask having an opening commensurate with the picture carried by the film 7, a lens 8, all of which are identical with similarly identified elements of Fig. 3, for use with a film moved frame by frame.

In addition, there is provided a lens 53 in the path of the beam of light passing through the apertures of disc 52 and the film 7. This lens serves to focus the beam of light, passing through the different elemental areas of the picture, upon a single spot in the screen 54. Associated with the screen and symmetrically positioned with respect thereto are three photoelectric cells, or three groups of cells 55, 56 and 57 selective of light of different colors.

As in the systems of Figs. 2 or 3, as the case may be, elemental areas of a colored film, or one carrying color characteristics, are successively illuminated and projected in color or with color characterization upon the screen 54 which reflects light to the photoelectric cells which are thereby activated to cause the production of three photoelectric currents which are respectively supplied to amplifiers 17, 18 and 19 and transmitted over channels 20, 21 and 22 to the respective light sources 26, 27 and 28 included in a receiver, identical with that disclosed in Fig. 1. This receiver operates to integrate an image corresponding in color to the picture scanned at the transmitter, which image may be seen by an observer O.

If the film is moved continuously, a mask 6 with a slot 5 will be used, disc 52 will be similar in design to disc 38, and disc 36 will be used at the receiver. For a film driven frame by frame, the disc 52 will be similar to disc 44 of Fig. 3 and a disc of the same design will be used at the receiver.

In the systems of Figs. 2, 3 and 4 the disc 38, 44 or 52 must be operated in synchronism and in phase with disc 36. This may be accomplished by the system disclosed in the above mentioned Stoller application.

In case the film used at the transmitter is one produced by the Kodacolor process, the image of the pictures carried by it is projected upon the screen 40, or 54, in accordance with motion picture projection practice, through a lens 8 provided with a screen carrying color filters.

Screens 40 and 54 of Figs. 2, 3 and 4 are diffusely reflecting and the light sensitive units 41 to 43, 46 to 48, and 55 to 57, respectively, are mounted in front of the illuminated surface of the screen. However, this invention contemplates the use of screens which are diffusely transmitting, i. e., of material which has been treated to cause the light transmitted therethrough to be radiated in different directions, for example, frosted glass or material provided with lenticulated or prismatic elements. In accordance with this aspect of the invention, the light sensitive units will be similar to those hereinbefore described, but they will be placed behind the screen, i. e., adjacent the surface of the screen opposite to that upon which the beam of light impinges.

The invention is not confined to the use of Technicolor or lenticulated films produced by the Kodacolor process. Other types of colored or lenticulated films or like emulsion carrying material may be used. The term "film" is used herein to denote, not only the well known celluloid film, but also forms of emulsion carrying material other than celluloid.

While filters for transmitting primary colors are herein referred to, it is to be understood that these filters are each adapted to transmit a band of colors including one of the primary colors.

Ives application Serial No. 488,304, filed Oct. 13, 1930, discloses a receiver which may be used in place of the receiver herein shown and described.

What is claimed is:

1. An electro-optical system for producing an image in color from a color record comprising a screen, means for successively scanning elemental areas of the record with a moving beam of light passing therethrough to project each area in its natural color upon said screen, and a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the area projected.

2. An electro-optical system comprising a transparent photographic color record, a screen, means for successively scanning elemental areas of the record with a moving beam of light passing therethrough to project each area in its natural color upon said screen, and a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by

light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the area projected.

3. An electro-optical system comprising a color record, a screen, means for illuminating and scanning successive elemental areas of each line of said record to produce an illuminated strip in its natural color on said screen, and a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of an elemental area of said strip.

4. An electro-optical system comprising a screen, a transparent photographic color record, means for continuously moving said record, means for scanning successive elemental areas of said record with a moving beam of light passing therethrough to project each area in its natural color upon said screen to produce successive lines which are projected on said screen to occupy the same position, and a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the area projected.

5. An electro-optical system for producing an image in color from a color record comprising a screen, means for successively scanning elemental areas of the record with a moving beam of light passing therethrough to project each area in its natural color upon said screen, and a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the elemental areas projected, said devices being so located with respect to said screen that the reflected light received thereon is substantially the same for all the elemental areas.

6. An electro-optical system for producing an image of a transparent photographic color record comprising a screen, a plurality of light filters of different colors, means for successively scanning elemental areas of the record with a moving beam of light passing therethrough and through said color filters to project each area in its natural color upon said screen, and a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the area projected.

7. An electro-optical system comprising a colored photographic record, a screen, means for successively scanning elemental areas of the record with a moving beam of light passing therethrough to project each area in its natural color upon said screen, and a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the area projected.

8. An electro-optical system comprising a colored photographic record, means for projecting said record in its natural color on a screen an elemental area at a time, a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the elemental area projected.

9. An electro-optical system comprising a colored photographic record, means for projecting said record in its natural color on a screen an elemental area at a time so that a plurality of said projected elemental areas occupy the same position on said screen, a plurality of light sensitive devices each selective of light of a different color band and variably responsive to at least some of the radiations of different wave lengths constituting the band and activated by light reflected from said screen to cause the simultaneous production of a plurality of separate image currents each representative at any instant of a different color characteristic of the elemental area projected.

10. The method of scanning a transparent picture which comprises projecting an elemental spot of light through the picture onto a diffusely reflecting surface, moving said spot over the picture at sufficiently high speed to project the picture in a point-by-point fashion on said surface so that it is visible as a complete picture thereon, and energizing a light sensitive device in accordance with the light of said spot reflected from said surface.

11. The method of scanning a transparent film which includes the steps of illuminating a diffusely reflecting screen with a moving scanning spot from a scanning beam, positioning the transparent film in the path of said beam to modulate the intensity of said spot, whereby said spot projects on said screen, in a point-by-point fashion, an image of the film, and translating the light reflected from said screen into corresponding photoelectric currents.

12. The method of scanning which comprises producing an elemental spot of light, projecting said spot on a diffusely reflecting surface, modulating said spot in accordance with the shade characteristics of elemental areas of a picture to be transmitted, moving said spot at sufficiently high speed to project on said surface, in a point-by-point fashion an image of the picture to be transmitted, and positioning a light sensitive device adjacent said screen to be energized by the light diffusely reflected therefrom.

13. The method which comprises producing a constant intensity moving scanning spot of elemental area, modulating the intensity of said spot in accordance with the light transmission

characteristics of the elemental areas of a picture to be transmitted, interposing in the path of said spot a diffusely reflecting surface, and moving said spot over said surface at sufficiently high speed to produce on said surface, in a point-by-point fashion, an image of the picture to be transmitted, and positioning in front of said surface a light sensitive device to be energized by the light reflected therefrom.

14. In a system of the character described, means for producing a constant intensity scanning spot of elemental area, a diffusely reflecting screen, means for projecting said spot on said screen, means for modulating said spot in accordance with the shade characteristics of elemental areas of a picture to be transmitted, means for moving said spot at a sufficiently high rate of speed to project on said screen, in a point-by-point fashion, an image of the picture to be transmitted, and a light sensitive device energized by the light reflected from said screen.

15. In a system of the character described for obtaining an image of a picture the means for producing a constant intensity light spot of elemental area, a diffusely reflecting screen, means for moving said spot at a sufficiently high speed to scan the picture and simultaneously project on said screen, in a point-by-point fashion, an image of said picture, and a light sensitive device adjacent said screen and energized by the light reflected therefrom.

16. In a system of the character described, means for producing a scanning light spot of elemental area, a diffusely reflecting screen, means for moving said spot over a picture to scan the same in a point-by-point fashion, and simultaneously to project an image of said picture in a point-by-point fashion on said screen, and a plurality of light sensitive devices energized by the light of said spot reflected from said screen.

17. In a system of the character described, means for producing a concentrated scanning light spot of elemental area, means for moving said spot over a picture to be transmitted to modulate said spot by the shade characteristics of successive elemental areas of the picture, a screen interposed in the path of the modulated light, said spot in moving over said picture simultaneously projecting on said screen an image of the picture in a point-by-point fashion, and a plurality of light sensitive cells energized by the light diffusely reflected from said screen.

18. In a system of the character described, a diffusely reflecting screen, a scanning light spot of elemental area, means for moving said spot to scan a picture film and to simultaneously project, in a point-by-point fashion, an image of said film on said screen, a plurality of light sensitive devices adjacent said screen, and energized by the light diffusely reflected therefrom.

19. In a system of the character described, the combination of a scanning light spot, a transparent picture film, a diffusely reflecting screen, a television scanner between said spot and screen for moving said spot over said film to scan the film and simultaneously to project on said screen a point-by-point image of said film, and a light sensitive cell positioned to be energized by the light reflected from said screen.

20. A system according to claim 19 in which the scanning spot is moved by means of a scanning device in the form of a spirally perforated disc.

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