

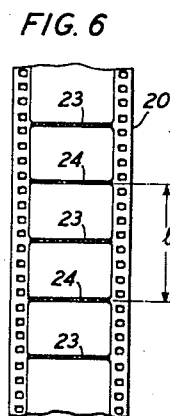
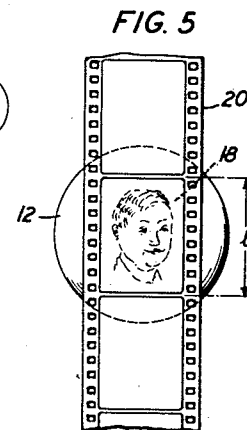
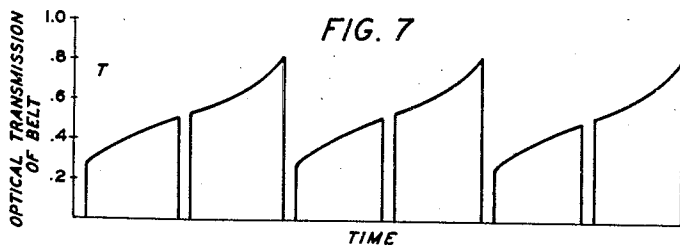
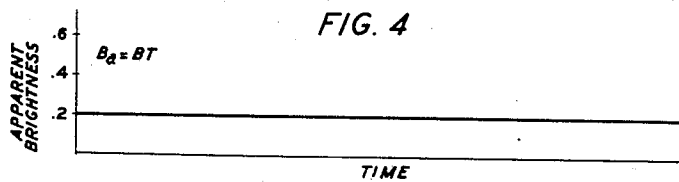
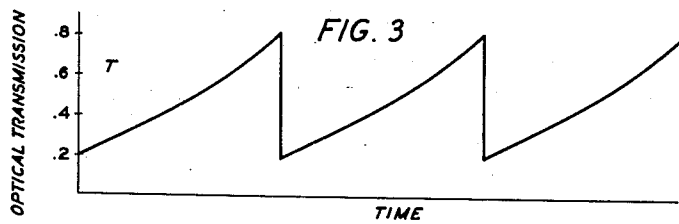
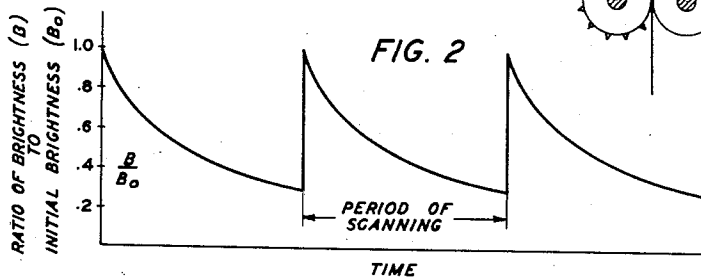
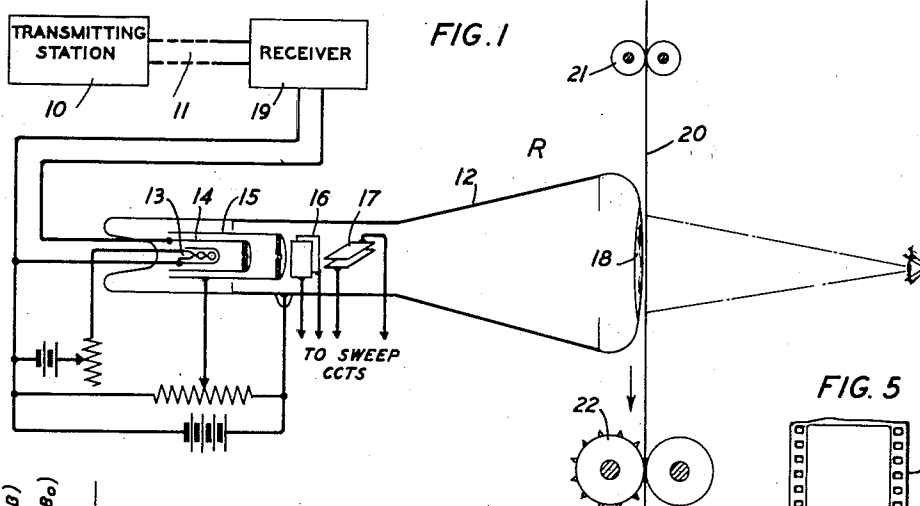
Aug. 8, 1939.

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2,169,179

ELECTROOPTICAL SYSTEM

Filed Nov. 5, 1935



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2,169,179

ELECTROOPTICAL SYSTEM

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Application November 5, 1935, Serial No. 48,299

15 Claims. (Cl. 178—7.5)

This invention relates to television and, more specifically, to television employing low speed scanning.

Television images are ordinarily televised in a period of time within the period of persistency of vision so that they may be viewed without any flicker effect being present. It is not always desirable to scan at this speed as a slower rate of scanning reduces the frequency range required for transmission.

One method of producing images from currents produced by scanning the object at low speed comprises producing them on a screen which continues to glow after being exposed to an exciting illumination or beam as, for example, a phosphorescent screen. Such images, however, are normally produced with an objectionable amount of flicker. The brightness of an elemental area of the image decays rapidly after being produced on the phosphorescent screen, and flashes up again at each reproduction. The relatively low frequency of flashing results in an objectionable amount of flicker.

An important object of this invention is to provide a novel method of and means for reducing this flicker which results from scanning an image in a period of time greater than the period of persistency of vision.

Other objects and the various aspects of the invention will be apparent from the following description and the appended claims.

The brightness of the phosphorescence of an elemental area begins to decrease the instant the excitation ceases. The decay is of such a nature that the fractional decrease in brightness is substantially independent of the initial intensity of phosphorescence. If B_0 is the phosphorescent brightness of the elemental area the instant the excitation ceases, and B is the brightness at any time t after the excitation ceases, then the ratio

$$\frac{B}{B_0}$$

is independent of B_0 . This ratio decreases with time in the same manner, for all parts of the phosphorescent image, independently of the initial brightness. A curve, plotted with the ratio

$$\frac{B}{B_0}$$

and t as coordinates, shows how this decay may be measured. The jumps in brightness as the scanning beam passes over the elemental area together with the decay thereafter would normally produce an objectionable amount of flicker

especially if a slow scanning speed is used. It has been discovered, however, that this flicker may be compensated for by inserting in front of the area a screen moving at the rate at which the scanning proceeds in a direction transverse to the line scanning direction, the optical transmission of which varies with distance along the screen in the inverse manner that

$$\frac{B}{B_0} \quad 10$$

varies with time. The apparent brightness of the image as transmitted through the screen would thus be substantially constant. The correcting screen may be, for example, in the form of a film continuously moving across the field of the phosphorescent screen.

The emission of light from an elemental area of the phosphorescent screen within the short period of time that the exciting beam is passing over it may be so great that a special correction will be necessary. One way of accomplishing this is to modify the transmission at the edge of the section of the movable screen in order to maintain the apparent brightness at a constant level during the interval in question. Another method of correcting for this interval is by covering the screen from the view of the observer during the passage of the exciting beam as, for example, by having narrow opaque strips at the edge of each section of the screen, the screen having zero transmission over these strips. To prevent flicker, additional opaque strips may be included in each section so that any point in the field is traversed by opaque strips in a time interval within the period of persistence of vision.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawing, in which:

Fig. 1 is a diagrammatic view of a television system utilizing the invention;

Fig. 2 is a graphical representation of the decay of brightness with time of a phosphorescent screen;

Fig. 3 shows the characteristics of a compensating screen;

Fig. 4 represents the apparent brightness of the phosphorescent screen as seen through the optical correcting screen;

Fig. 5 is an end view of the receiving tube showing its relation to the compensating screen;

Fig. 6 shows a strip of film for correcting for the initial increase in brightness of the elemental areas of the phosphorescent screen; and

Fig. 7 is a graphical representation of the optical transmission with respect to time of film shown in Fig. 5.

Referring more particularly to the drawing, Fig. 1 shows a television system comprising a transmitting station 10, a suitable wire or radio channel 11, and a receiving station R. Image currents modulated in accordance with the tone values of successively scanned elemental areas of a field of view are produced at the transmitting station 10 and transmitted over the wire or radio channel 11 to the receiving station R which has been represented, by way of example, as including a cathode ray receiving device 12. The cathode ray receiving device comprises a cathode 13, a modulating cylinder or grid 14, an anode 15, two sets of electrostatic deflecting plates 16 and 17 and a phosphorescent screen 18. The incoming image currents are received, and amplified if necessary, at the receiver 19 and applied between the cathode 13 and the modulating cylinder or grid 14 thereby modulating the cathode ray beam which is caused to scan every elemental area of the phosphorescent screen 18 by the well-known action of the electrostatic fields between the plates 16 and 17.

In order to produce the frequency range required for transmission, the object at the transmitter is preferably scanned at a lower rate of speed than that normally used, i. e., the object is scanned in a period of time greater than the period of persistency of vision. Accordingly, therefore, when the phosphorescent screen 18 is viewed by the observer at the receiving station, there is present an objectionable amount of flicker. This may be compensated for by inserting in front of the screen 18 a correcting screen 20 moving at the rate at which the scanning proceeds in a direction transverse to the line scanning direction. This correcting screen 20 has, for purposes of illustration, been shown as an endless film 21 moving between two sets of rollers 22 and 23. Fig. 5 shows the end of the cathode ray tube 12 as viewed through the correcting or compensating screen 20.

In order to understand the purpose and operation of the correcting screen 20, reference will now be made to Figs. 2, 3 and 4. The phosphorescent screen 18, which may be of any suitable material, such as zinc sulphide, continues to glow after being exposed to an exciting illumination or beam. The brightness of phosphorescence begins to decrease the instant the excitation ceases. This decay is of such a nature that the fractional decrease of brightness is substantially independent of the initial intensity of phosphorescence. Fig. 2 represents graphically the decay of brightness

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$$\frac{B}{B_0}$$

of the excited elemental area with respect to time in which B represents the brightness at any time t and B₀ represents the initial brightness. Phosphorescent materials for a short time after excitation obey the approximate equation

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$$\frac{B}{B_0} = 1 - a\sqrt{t}$$

where a is a constant. The actual decay of the screen may be measured and a correcting screen constructed to have the transmission characteristics graphically represented in Fig. 3 where T represents the optical transmission through the screen.

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Suppose that a correcting screen were placed in front of the phosphorescent screen 18 and that the transmission T of the screen varies with time in such a manner that

$$T = c \frac{B_0}{B} \quad (1)$$

as shown in Fig. 3, the constant c being less than one. Then the apparent brightness B_a of the area would be

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$$\begin{aligned} B_a &= Bt \\ &= B_0 \left(\frac{B}{B_0} \right) \left(\frac{B_0}{cB} \right) \\ &= cB_0 \end{aligned} \quad (2)$$

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In other words, the apparent brightness will be proportional to the product of the curves of Fig. 2 and Fig. 3 and therefore for a still subject independent of time as shown in Fig. 4. Consequently, there would be no flicker in the reproduced field. The brightness would, however, be proportional to the intensity of the exciting beam, a necessary condition for the reproduction of an image.

In most cases it is impractical to correct an entire image field in the manner just described, but substantially the same result may be attained by moving a suitable transmission screen across the image field. As an example, take the case of an image reproduced on a phosphorescent screen in a cathode ray tube as shown in Fig. 1. The cathode beam sweeps repeatedly across the screen 13 in a horizontal direction to reproduce the image strip, and moves slowly down the screen as the successive strips are reproduced. For all practical purposes the reduction of flicker may be carried out as if all parts of an elemental strip were reproduced in the same instant, simply neglecting the short period of line scanning in comparison to the much longer period required to reproduce an entire image.

The flicker may be reduced by a transmission screen in the form of a continuous belt moving down across the field as shown in Fig. 1. This belt is divided into sections of length l just equal to the height of the image field. The optical transmission of any one of the sections increases from the bottom edge to the top edge in the proper manner to eliminate flicker. For this purpose the optical transmission should vary with distance along the sections in the inverse manner that

$$\frac{B}{B_0}$$

varies with time.

This condition may be expressed more exactly in mathematical terms as follows: The ratio

$$\frac{B}{B_0}$$

is a function of time and may be expressed as

$$\frac{B}{B_0} = F(t) \quad (3)$$

Then, if x is the distance measured up from the bottom of the section, the transmission of the section varies along its length so that

$$T = \frac{K}{F\left(\frac{x}{v}\right)} \quad (4)$$

where K is a constant and v is the velocity of the screen. The transmission varies periodically in this manner over each section along the belt. The motion is synchronized with the cathode

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beam so that the edge of the section moves down across the field with the beam as it reproduces the image. This synchronization may be done in any well-known manner.

Considering any one strip of the image, the transmission of the screen in front of the strip at any time t after the passages of the beam is found by substituting

$$x=vt \quad (5)$$

in Equation (4). This gives

$$T=\frac{K}{F(t)} \quad (6)$$

The transmission of the screen in front of the elemental line thus varies with time in the manner already found desirable above. Neglecting the short period of line scanning, the instantaneous brightness of an elemental area in the strip is

$$B=B_0F(t) \quad (7)$$

The apparent brightness through the screen is

$$\begin{aligned} B_a &= BT \\ &= B_0F(t)\frac{K}{F(t)} \\ &= KB_0 \end{aligned} \quad (8)$$

For a still subject, the apparent brightness is thus independent of time, and there will be no flicker in the reproduced field. The same theory can, of course, be applied to a moving subject although the actual brightness, of course, varies from time to time.

Up to this point, the emission of light from an elemental area of the screen during the short period of time while the exciting beam is passing over it has been neglected. The integral effect of this brightness may be so great that it requires special correction. For this purpose, the optical transmission at the edge of a section may be modified in the proper manner to maintain the apparent brightness of the constant level during the interval in question. The required transmission may be determined from measurements of brightness as a function of time.

Another method of correcting for this interval is to cover the screen from the view of the observer during the passage of the exciting beam. This may be done by a narrow opaque strip 24 at the edge of each section of the belt, as illustrated in Fig. 6. The belt has zero transmission over this strip. Such strips passing slowly across the field would, in themselves, introduce flicker. To prevent such flicker, additional strips 23 are included in each section, so that any point in the field is traversed by opaque strips separated from each other by a time interval less than the period of persistency of vision. For example, assuming that images are reproduced at a rate of ten per second, an additional strip 23 may be included in the middle of each section as shown in Fig. 6 so that any point in the field is traversed by opaque strips at the rate of twenty per second. If desired, the screen may be mounted on a rotating cylinder or disc and carried across the field in that manner or any other suitable method for moving the screen may be employed.

Fig. 7 discloses graphically the optical transmission through the belt shown in Fig. 6. It may thus be seen from this figure that the optical transmission of the belt is zero every time the opaque strips 23 or 24 pass in front of the phosphorescent screen 18.

Instead of designing the transmission screens from measurements of the decay of brightness, they may be made photographically. For this purpose a strip of phosphorescent screen may be instantaneously excited and then photographed on a moving film. After proper development, the film itself serves as a correcting screen or it may be used to make correcting screens.

While this invention has been described in connection with a beam of cathode rays traveling over a phosphorescent screen on the end of a cathode ray tube 12, it is obvious that the invention is not limited thereto as it may be applied as well to any moving beam of radiations projected on a phosphorescent screen. If desired, the cathode ray tube 12 and its accompanying correcting screen 20 may be located in a projection booth and the image corrected for flicker projected onto a screen.

The invention is not narrowly limited to use with phosphorescent screens as it may be utilized with any apparatus producing an image whose brightness decays with time after an element of the image has been produced. For example, it may be used in conjunction with a bank of hot filament lamps or with a bank of light valves closing slowly with time. In the latter case, it might be more convenient to locate the moving screen sections in a projection apparatus instead of moving them across the large screen on which the image is projected. 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. Image producing means comprising means for emitting light at any elemental portion of a field when impulsively energized in that portion, which light thereafter slowly decreases in intensity in a predetermined manner, means for causing image current representative of light tone values of successively scanned elemental areas of an object or field of view to control the impulsive energization of said light emitting means for each elemental portion of said field in turn and repeatedly at such a rate that said alternate increases and decreases in light intensity become apparent as a flicker to the eyes of an observer upon which said light impinges, and means through which said light passes and which is placed between said light emitting means and said observer for reducing said flicker, said last-mentioned means comprising a light transmitting screen, the transparency of which varies along its length.

2. Image producing means comprising means for emitting light at any elemental portion of a field when impulsively energized in that portion, which light thereafter slowly decreases in intensity in a predetermined manner, means for causing image current representative of light tone values of successively scanned elemental areas of an object or field of view to control the impulsive energization of said light emitting means for each elemental portion of said field in turn and repeatedly at such a rate that said alternate increases and decreases in light intensity become apparent as a flicker to the eyes of an observer upon which said light impinges, and means through which said light passes and which is placed between said light emitting means and said observer for reducing said flicker, said last-mentioned means comprising an optical correcting screen and means for causing said screen to move across the field of view of said light emitting means,

said screen having light transmission characteristics which compensate for the decrease in light intensity of the light emitting means with respect to time.

3. Image producing means comprising means for emitting light at any elemental portion of a field when impulsively energized in that portion, which light thereafter slowly decreases in intensity in a predetermined manner, means for causing image current representative of light tone values of successively scanned elemental areas of an object or field of view to control the impulsive energization of said light emitting means for each elemental portion of said field in turn and repeatedly at such a rate that such alternate increases and decreases in light intensity become apparent as a flicker to the eyes of an observer upon which said light impinges, and a moving film through which said light passes and which is placed between said light emitting means and said observer for decreasing the higher values of light intensity whereby said flicker is reduced, said film having opaque strips uniformly placed thereon.

4. Image producing means comprising means for emitting light at any elemental portion of a field when impulsively energized in that portion, which light thereafter slowly decreases in intensity in a predetermined manner, means for causing image current representative of light tone values of successively scanned elemental areas of an object or field of view to control the impulsive energization of said light emitting means for each elemental portion of said field in turn and repeatedly at such a rate that such alternate increases and decreases in light intensity become apparent as a flicker to the eyes of an observer upon which said light impinges, and means through which said light passes and which is placed between said light emitting means and said observer for decreasing the higher values of light intensity whereby said flicker is reduced, said last-mentioned means comprising a moving light transmitting film having opaque strips uniformly placed thereon, said strips adapted to cut off from the eyes of the observer the high values of light intensity as they are produced, and additional opaque strips located between said first-mentioned strips for preventing said first-mentioned strips from causing a flicker effect.

5. Image producing means comprising means for emitting light at any elemental portion of a field when impulsively energized in that portion, which light thereafter slowly decreases in intensity in a predetermined manner, means for causing image current representative of light tone values of successively scanned elemental areas of an object or field of view to control the impulsive energization of said light emitting means for each elemental portion of said field in turn at such a low speed that said alternate increases and decreases in light intensity become apparent to an observer as a flicker, and means at said elemental portions acting in a manner complementary to said decrease in intensity whereby the intensity of light reaching the observer is substantially uniform with respect to time for at least a large part of the time that light is emitted.

6. Image producing means comprising means for emitting light at any elemental portion of a field when impulsively energized in that portion, which light thereafter slowly decreases in intensity in a predetermined manner, means for causing image current representative of light tone values of successively scanned elemental areas of an object or field of view to control the impulsive

energization of said light emitting means for each elemental portion of said field in turn at such a low speed that said alternate increases and decreases in light intensity become apparent to an observer as a flicker, and means at said elemental portion acting in a manner complementary to said decrease in intensity whereby the intensity of light reaching the observer is substantially uniform with respect to time for at least a large part of the time that light is emitted, said last-mentioned means comprising a screen, the optical transmission of which varies along its length.

7. The combination with means for setting up transient images comprising an array of light emitting elements which when activated emit light with decaying intensity for a time after activation, means for activating elemental portions of said array in succession and at a rate such that all of said elements are activated in a period much greater than that of persistence of vision, and a moving film having opaque portions thereon for interrupting the light reaching an observer from each of said elemental portions for relatively brief intervals at a periodicity which is an integral fraction of that required to set up a complete image.

8. Light emitting means, means for causing said light emitting means to intermittently emit light, the intensity of which varies during each period of emission in a predetermined manner, and means interposed in the path of said light on its way to an observer, the effective optical transmissibility of which last-mentioned means varies in a manner complementary to said variation in intensity throughout each period of light emission.

9. Light emitting means, means for causing said light emitting means to intermittently emit light, the intensity of which varies during each period of emission in a predetermined manner, optical means interposed in the path of said light on its way to an observer to cause the intensity of said light leaving said optical means to be substantially uniform throughout any period of emission, the effective optical transmissibility of which last-mentioned means varies in a manner complementary to said variation in intensity throughout each period of light emission, and means for varying the intensity of light emitted from said light emitting means in accordance with signals.

10. Image producing apparatus comprising a plurality of light emitting elements, means under control of incoming image current for controlling said elements to cause them to emit light in succession to produce light tone values representative of the object, an image of which is to be formed, said light from each element varying in intensity during each period of emission, and means interposed in the path of light from said elements on its way to an observer to cause the intensity of said light leaving said means to be substantially uniform throughout any given period of light emission, said last-mentioned means comprising a moving film, the transparency of which varies over its surface.

11. Image producing means comprising means under control of incoming image current for causing light to be emitted from each elemental area of the image field in succession and to persist at each elemental area after control by the incoming image current ceases, and a moving film, the transparency of which varies over its surface interposed in the path of light from said light emitting means on its way to an observer for periodically obscuring said light.

12. Image producing means comprising means

under control of incoming image current for causing light to be emitted from each elemental area of the image field in succession and to persist at each elemental area after control by the incoming image current ceases, and means including a film, the transparency of which varies over its surface interposed in the path of the light from said image field to a position where it may be utilized for controlling the period during which said emitted light is effective.

13. Image producing means comprising means under control of incoming image current for causing light to be emitted from each elemental area of the image field in succession and to persist at each elemental area after control by the incoming image current ceases, and means including a film, the transparency of which varies over its surface interposed in the path of light from said light emitting means for controlling the period of persistence of the effective light from said light emitting means and also for variably modifying said light as a function of time.

14. Television image producing apparatus comprising a member formed of elements which are capable of emitting light for a period after initial acceleration from without takes place and the effective light emitting portions of which form an array of elements in straight parallel lines, of means for initiating the emission of light from said elemental light emitting portions progressively along parallel lines thereof in succession at a rate such that the emission period of each element overlaps those of a large number of other

elements, a member having parallel straight light-obstructing portions interspersed with portions of relatively great light-transmissibility, and means for moving said member so that said portions cross the paths of light from said elements to cause said opaque portions to become effective in succession to intercept light from one elemental line after another of said light emitting member at the rate at which said lines are energized in succession.

15. Television image producing apparatus comprising a member formed of elements which are capable of emitting light for a period after initial acceleration from without takes place and the effective light emitting portions of which form an array of elements in straight parallel lines, of means for initiating the emission of light from said elemental light emitting portions progressively along parallel lines thereof in succession at a rate such that the emission period of each element overlaps those of a large number of other elements, a member having parallel straight light-obstructing portions interspersed with and decreasing in light-obstructive power in a predetermined manner to portions of relatively great light-transmissibility, and means for moving said member so that said portions cross the paths of light from said elements to cause said opaque portions to become effective in succession to intercept light from one elemental line after another of said light emitting member at the rate at which said lines are energized in succession.

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