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B. KAZAN

2,926,263

PICTURE STORAGE DEVICE

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Fig. 1.

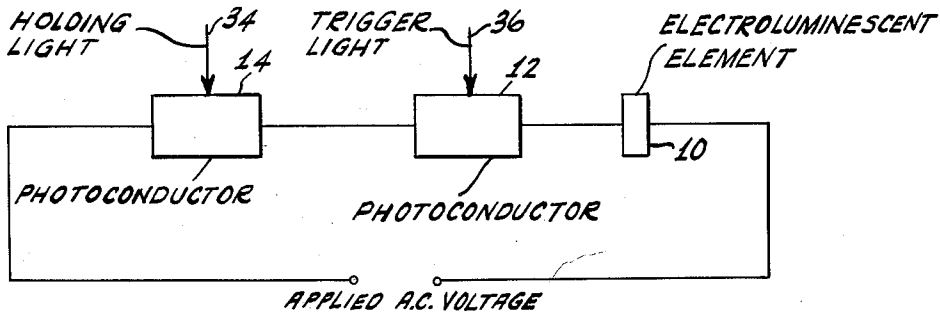


Fig. 2.

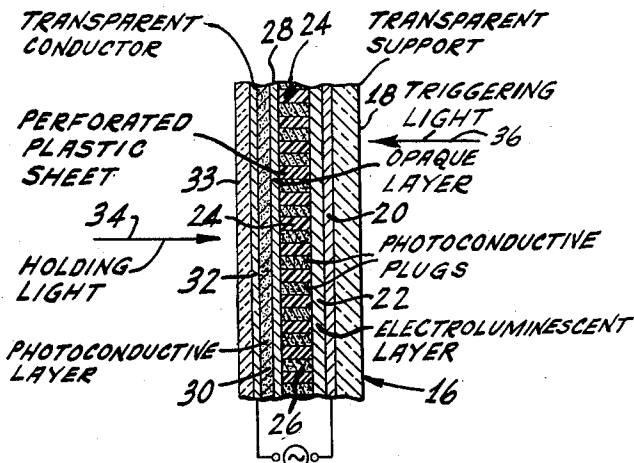
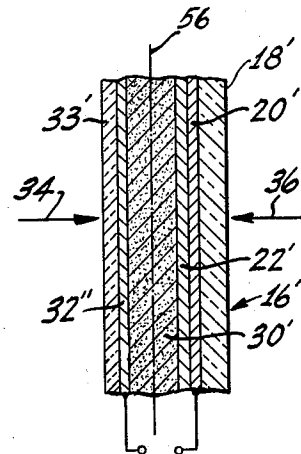


Fig. 3.

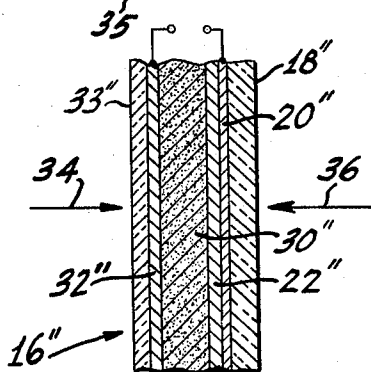


Fig. 4.

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PICTURE STORAGE DEVICE

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10 Claims. (Cl. 250—213)

This invention relates to electroluminescent devices. In particular this invention relates to electroluminescent devices of the type adapted to store electrical signals.

It is known in the art that many phosphor materials may be caused to emit visible radiations by subjecting them to electric fields. This phenomenon has been termed electroluminescence, and may be effected by applying a potential across the selected phosphor. If the phosphor is suspended in a transparent dielectric material, prior to the application of the potential, a direct current voltage across the phosphor will induce a burst of electroluminescence in the phosphor as an electric field builds up thereacross. The electroluminescence will cease when the full charge has been received and the electric field stabilized. The subsequent removal of the direct current voltage, and the discharge of the accumulated charge, will produce a second burst of electroluminescence as the electric field collapses.

Thus, if an alternating current voltage is applied across the phosphor, bursts of electroluminescence will occur for each charge and discharge induced by the alternating current voltage. For this reason, alternating current voltage has been used in the art to produce seemingly constant electroluminescence since, if the frequency of the applied alternating current voltage is high enough, the bursts of electroluminescence will occur at intervals shorter than the retentivity of the human eye, thus making the electroluminescence appear to be continuous.

Electroluminescence may also be produced by providing each particle of the electroluminescent phosphor with a suitable series resistance to permit a certain current flow when a direct current voltage of sufficient value is applied. Such electroluminescence appears to be continuous and its intensity may be controlled by varying the amount of current flow through the phosphor particles.

Several theories explaining the above described phenomenon have been advanced, none of which are entirely satisfactory. However, it seems to be agreed that the electroluminescence results from a redistribution of electrons in the crystal structure of the electroluminescent material and the consequent emission of radiations from such material.

Electroluminescent devices have been known, prior to this time, that would amplify light images. Some of these prior devices have been capable of retaining, or storing, these images for any desired length of time. These devices include those which are capable of storing an image and are devices of the "frame on-off type," i.e. the entire image must be erased, or discharged, at one time. In these devices, no provision is made for selectively erasing portions of the stored image while retaining other portions.

There are many occasions when it is desirable to selectively erase a portion of a stored image, and then store a different image on the portion of the device from which the original image has been erased. For example, it may be desirable to compare a second image with an original image. Another such condition is in radar systems where

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it is desirable to selectively erase portions of an image just prior to the storing of another image.

It is therefore an object of this invention to provide an improved electroluminescent device capable of storing images and one where elemental areas of the device may be selectively erased.

It is another object of this invention to provide a novel electroluminescent device in which the luminescence of selected areas may be cut off independently of the luminescence of other areas of the device.

It is yet another object of this invention to provide improved structures for storage type electroluminescent devices.

These and other objects have been accomplished in accordance with this invention by providing an electroluminescent device for the storage of images, wherein each elemental unit of the electroluminescent device includes a series circuit including an electroluminescent element, a first photoconductive part and a second photoconductive part. The first photoconductive part and the electroluminescent element are so arranged that when the electroluminescent element luminesces, light from the electroluminescent element strikes the first photoconductive part so that a regenerative feedback is developed and thus the image is stored. During operation, with an alternating current potential applied across all of the elemental units, an auxiliary or holding light is directed onto the second photoconductive part, to lower the resistance thereof, and thus most of the potential drop across an elemental unit occurs across the first photoconductive part and the electroluminescent element. When input signal light is applied to the first photoconductive part most of the voltage drop occurs across the electroluminescent element causing the element to luminesce. This luminescence continues after the signal light has been removed from the first photoconductive part due to regenerative feedback, and continues until the holding light is removed from the second photoconductive part. In a device containing a plurality of the elemental units, the stored image may be selectively erased by selectively removing the holding light from the second photoconductive part in the selected elemental units.

The invention will be more clearly understood when read in conjunction with the accompanying single sheet of drawings wherein:

Figure 1 is a schematic representation of a single unit of a device in accordance with this invention and including an electroluminescent element, and a pair of photoconductors;

Figure 2 is an enlarged fragmentary sectional view of a panel comprising a plurality of the elemental units of the type described relative to Figure 1; and

Figures 3 and 4 are enlarged fragmentary sectional views of embodiments of an electroluminescent panel in accordance with this invention.

Referring now to Figure 1 there is shown a schematic representation of a single electroluminescent unit in accordance with this invention. The elementary unit comprises a series circuit of an electroluminescent element 10, a first photoconductor 12 and a second photoconductor 14. Although not shown in the schematic drawing of Figure 1, elements 10 and 12 are so positioned that light from the electroluminescent device 10 will strike the photoconductor 12, but not the photoconductor 14. The circuit is connected across a source of alternating current potential (not shown). When the elementary unit is operated, a potential is applied across the series circuit that is sufficient to cause electroluminescence of the element 10 when most of the potential drop within the circuit occurs across the element 10. When the potential is first applied there is no light emitted from the element 10, since both photoconductors 12 and 14 are

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of high resistance when in the dark. When light, hereinafter referred to as the holding light, is directed onto photoconductor 14, the photoconductor 14 becomes conductive and most of the potential drop within the series circuit now occurs across the electroluminescent element 10 and the photoconductor 12. When a pulse of light, hereinafter referred to as the signal or trigger light, is applied to the photoconductor 12, the photoconductor 12 becomes momentarily conductive so that the voltage drop in the circuit is now mostly across the electroluminescent element 10 resulting in light being produced by the element 10. The light from the element 10 strikes the photoconductor 12 and causes a regenerative feedback action which results in the photoconductor 12 retaining a continuous low resistance. Thus, the luminescent element 10 continues to produce light whether or not the trigger light is applied to the photoconductor 12 or not.

When it is desired to erase the stored information, i.e. to cause the electroluminescent element 10 to stop producing light, the operator may remove the applied potential from the circuit. This system is practical only when considering an elemental unit, such as that shown in Figure 1, but is impractical for selective erasure when considering a complete device, unless each elemental unit is connected to a different potential source. In accordance with this invention the stored information may be erased by selectively cutting off the holding light from the photoconductor 14, which is removed from the path of light from the electroluminescent element 10. Thus, the elemental unit 10 can be turned off even if the trigger light is striking photoconductor 12.

Referring now to Figure 2 there is shown an enlarged fragmentary sectional view of an electroluminescent panel in accordance with this invention. The panel 16 comprises a transparent support plate 18 having a transparent conductor 20 on one surface thereof. Covering the other surface of the transparent conductor 20 is a layer of electroluminescent phosphor material 22 which in turn is covered by a perforated sheet of opaque electrically insulating material 24. The perforations in the sheet 24 are filled with plugs of photoconductive material 26 that are in contact with the electroluminescent layer 22 on one side of sheet 24 and with an opaque electrically insulating layer 28 on the other side of sheet 24. Covering the opaque layer 28 is a photoconductive layer 30, which in turn is covered by a transparent conductor 32. The transparent conductor 32 may be supported on a transparent support member 33 when desired for support purposes. Connected across the device, by being connected to transparent conductors 20 and 32 is a source 35 of alternating current potential.

The device, or panel, 16 may be constructed of the following materials: the transparent support members 18 and 33 may be any transparent material such as Pyrex glass and may be approximately one fourth of an inch in thickness. The transparent conductors 20 and 32 may comprise a transparent conductive coating such as tin chloride or tin oxide, and may be deposited on their respective transparent support members 18 and 33 by any known means. The electroluminescent layer 22 may be formed of any known electroluminescent phosphor such as copper activated zinc sulphide. The layer 22 may be deposited on the transparent conductor 20 by known techniques such as spraying or silk screening and may be approximately 1 mil thick. The perforated sheet 24, which should be opaque in order to isolate elemental units and which should be electrically insulating, may be formed of a plastic, for example polystyrene dyed to be opaque or coated with an opaque layer. The perforated sheet 24 may be pressed onto the electroluminescent layer 22 and may be approximately 5 mils thick. The photoconductive plugs 26 may be any of known type of photoconductive material for example cadmium selenide or cadmium sulphide and may be in

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the solid or powdered form. As is known, solid photoconductors may be deposited by evaporation, while a powdered photoconductor may be applied by mixing the powder in a plastic binder and then filling the apertures in sheet 24 with the selected photoconductive material. The photoconductive plugs 26 should be thick enough to make good electrical contact with the electroluminescent layer 22 and the opaque layer 28. The opaque layer 28 may be any type of electrically insulating layer such as a black lacquer or lamp black in a suitable binding medium, e.g. ethyl cellulose. The opaque layer 28 is sufficiently thin, e.g. a fraction of a mil, so that it has a relatively low alternating current impedance for currents through it and may be deposited by any known technique such as by spraying. The photoconductive layer 30 may be similar in material, thickness, and method of deposition to the photoconductive plugs 26. The panel 16 may be finally formed by pressing the transparent support member 33 against the surface of the photoconductive part 30. Alternatively the photoconductive part 30 may be coated with a thin transparent conductive layer with the support member 33 omitted.

During operation an alternating current source, of approximately 500 volts, is connected across the electroluminescent device 16 which, from a circuit standpoint, comprises the electroluminescent element 22 in series with photoconductive plugs 26 and in series with the photoconductive layer 30. When no light is incident upon the photoconductive plugs 26 and the photoconductive layer 30, these materials exhibit a very high impedance that is practically an open circuit, and substantially all of the voltage drop in the circuit will appear across these photoconductive parts. When one of the photoconductive materials is illuminated, e.g. photoconductive layer 30, the photoconductive plugs 26 continue to act substantially as an open circuit. Therefore, it is necessary that light be directed onto both of the photoconductive parts 26 and 30 at the same time in order for any substantial amount of the applied voltage to appear across the electroluminescent element 22 to cause it to luminesce.

During operation, a holding light whose direction is represented by arrow 34 luminesces one side of panel 16. The holding light passes through the transparent support 33 and the transparent conductive layer 32 onto the photoconductive layer 30. The holding light 34 does not pass through the opaque layer 28 and the photoconductive plugs 26 retain their high resistance. Now, if triggering pulses of a beam of light, represented by arrow 36, strike the selected photoconductive plugs 26 from the opposite side of panel 16, plugs 26 become conductive, and the electroluminescent layer 22 produces light, only in those elemental areas that are struck by the triggering light. The opaque layer 24 prevents the light from spreading to adjacent photoconductive plugs. Due to the fact that each photoconductive plug 26 is in a light exchange relationship with electroluminescent layer 22, light produced by layer 22 excites the adjacent photoconductive plugs 26 so that the electroluminescent layer 22 will continue to produce light by a regenerative feedback action.

When it is desired to erase the luminance information that has been stored on device 16, the holding light 34 can be removed, or the energizing potential can be removed. In some instances it is desired to selectively erase portions of the stored information. In these latter instances selected areas, or portions, of the holding light 34 are removed. Then the photoconductive layer 30 reverts to its original high resistance state in the areas causing a corresponding drop in voltage across the electroluminescent layer 22 in corresponding areas.

As is well known, there are many methods for removing a portion of a holding light 34. One method is to utilize a mechanical light panel that is normally on but can be cut off in selected areas.

Referring now to Figure 3 there is shown an enlarged

fragmentary sectional view of an embodiment of this invention comprising an electroluminescent device, or panel, 16'. The device 16' comprises a transparent support plate 18' having a transparent conductive coating 20' on one surface thereof. On the conductive coating 20' there is provided a layer of electroluminescent material 22' which in turn has a layer of photoconductive material 30' thereon. On the other surface of the photoconductive material 30' is a transparent conductive layer 32''. The transparent conductive layer 32'' may be supported on a transparent support 33'. In this embodiment, the photoconductive layer 30' is of a thickness whereby a holding light 34 does not penetrate the entire layer, and therefore, the unexcited portion of the thickness remains as an open circuit. Also, the layer is of such a thickness that light from the electroluminescent layer 22' does not penetrate the entire layer of the photoconductive material 30'. Thus, when using a holding light and a trigger light of equal brightness, the holding light 34 decreases the resistance of approximately one half of the thickness of the photoconductive layer 30', while the trigger light 36 decreases the resistance of the other half of layer 30'. This division in the layer 30' is schematically represented as a dot-dash line 56. These two halves of the photoconductive layer 30' constitute two photoconductive parts which are analogous to the separate photoconductive parts 12 and 14 of Fig. 1 and the parts 26 and 30 of Fig. 2.

The materials used in the electroluminescent device 16' may be substantially the same as those described in connection with Figure 2. In practice it has been found that targets including an electroluminescent layer in series with a photoconductive powder layer about five mils thick will be capable of storage, due to regenerative feedback, whereas thicker layers are not sufficiently penetrated by the electroluminescent light to enable storage. With a five mil thick photoconductive layer, about five foot lamberts of electroluminescent light are produced during the storage action with about 250 volts of alternating current applied. Therefore, the device shown in Figure 3 includes a photoconductive layer 30' that is approximately ten mils thick; the alternating current source is about 500 volts, the holding light has a value of approximately five foot lamberts, and the triggering light 36 has a value of approximately five foot lamberts. The balance of the operation of the device 16' is similar to that described in Figure 2 in that both the holding light 34 and the trigger light 36 must strike a selected elemental unit of device 16' to energize this unit. Once the unit is energized, the holding light 34 must be removed from the elemental unit to de-energize this unit.

Referring now to Figure 4 there is shown an embodiment of this invention comprising a device 16''. The device 16'' comprises a transparent support member 18'' having a transparent conductive coating 20''. On the transparent conductive coating 20'' there is provided a layer of electroluminescent material 22'' that produces a particular color of light. On the electroluminescent layer 22'' there is provided a composite photoconductive layer 30'' that includes a mixture of photoconductive materials; one of which responds to light of the same color as that produced by electroluminescent layer 22'', and the other of which does not respond to light of this color. On the photoconductive layer 30'' there is provided a transparent conductive coating 20'' which may be supported on a transparent support member 33''.

The materials and their method of deposition, for device 16'', may be similar to those described previously. One example of the materials which operate in a device of this type is to utilize a copper activated zinc sulphide phosphor for the luminescent layer 22'', which emits green light. In this example the photoconductive layer may comprise a mixture of cadmium selenide and cadmium sulphide. The cadmium sulphide responds to light of a green color while the cadmium selenide is peaked at about 8500 angstrom units and is not activated by green

light. In this example, the trigger light may be of a wave length of approximately 6000 angstrom units while the holding light may be peaked at a wave length of approximately 9000 angstrom units.

In the example given above, the holding light is directed onto the composite photoconductive layer 30'' and decreases the resistance of the cadmium selenide photoconductive particles and the majority of the voltage drop occurs across the cadmium sulphide photoconductive particles. When the trigger light is turned on the cadmium sulphide photoconductive particles are energized and the electroluminescent layer produces light which continuously energizes the cadmium sulphide photoconductive particles. When the holding light is removed from selected elemental areas of the photoconductive layer 68, the cadmium selenide photoconductive particles return to their original high resistance in the selected elemental areas and form the open circuit which cuts off the selected elemental units of the electroluminescent device 16''.

The devices in accordance with this invention may be used to store information. The stored information may be selectively erased, and additional information stored in place of the original information.

What is claimed is:

1. A storage device comprising a first photoconductive part, a second photoconductive part and an electroluminescent element arranged in the order named and connected in an electrical series circuit, said electroluminescent element being in light exchange relationship with said second photoconductive part only.

2. A storage device comprising a plurality of elemental units, each of said units including a first photoconductive part, a second photoconductive part and an electroluminescent element arranged in the order named and electrically connected in series, said second photoconductive part only being positioned in light exchange relationship with said electroluminescent element.

3. A storage device comprising a transparent support member, a transparent conductive coating on one surface of said support member, a layer of electroluminescent phosphor on said conductive coating, photoconductive means including a first photoconductive part on said phosphor, said first photoconductive part being in light exchange relationship with said phosphor, and a second photoconductive part electrically coupled in series with said first photoconductive part and said phosphor layer, said second photoconductive part being optically shielded from said phosphor layer.

4. A storage device as in claim 3 wherein said first and second photoconductive parts are portions of a single layer of photoconductive material.

5. A storage device as in claim 1 wherein said first photoconductive part is formed by one photoconductive material in a mixture of photoconductive materials, and said second photoconductive part is formed by a second photoconductive material in said mixture.

6. A storage device as in claim 5 wherein said electroluminescent element comprises a material which electroluminesces in a particular color to which only one of said photoconductive materials is sensitive.

7. A storage device, comprising a transparent support member, a transparent conductive coating on one surface of said support member, a layer of electroluminescent phosphor on said conductive coating, a perforated sheet of material on said phosphor, photoconductive material in the perforations of said sheet and extending from said phosphor through said sheet, a layer of opaque material on said sheet and in contact with said photoconductive material, a layer of photoconductive material on said opaque layer, and a transparent conductor on said layer of photoconductive material.

8. Apparatus for storing light signals comprising a first photoconductive part, a second photoconductive part and an electroluminescent element arranged in the

order named, said photoconductive parts being electrically coupled in series with each other and said electroluminescent element, only one of said photoconductive parts being constructed and arranged to respond to light from said electroluminescent element, whereby light from said electroluminescent element decreases the resistance of only said one of said photoconductive parts, means for applying holding light to said one photoconductive part, and means for applying a signal light to the other one of said photoconductive parts.

9. Apparatus for storing light signals comprising first and second photoconductive parts, and an electroluminescent element arranged in the order named and connected in an electrical series circuit said electroluminescent element being in light exchange relationship with only said second photoconductive part, means for applying holding light to said second photoconductive part, and means for applying a signal light to said first photoconductive part.

10. Apparatus for storing light signals, and comprising a transparent support member, a transparent conductive coating on one surface of said support member, a layer of electroluminescent phosphor on said conductive coating, photoconductive means including a first photoconductive part on said phosphor, said first photoconductive part being in light exchange relationship with

said phosphor, a second photoconductive part electrically coupled to said first photoconductive part, said second photoconductive part being optically shielded from said phosphor layer, means for applying holding light to said one photoconductive part, and means for applying a signal light to the other one of said photoconductive parts.

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