United States Patent

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[73] Assignee **The United States of America as represented by the Secretary of the Army**

[54] **PROTECTIVE LIGHT IMAGE TRANSLATING SYSTEM**
10 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **250/213 R,** 250/208
[51] **Int. Cl.** **H01l 15/00**
[50] **Field of Search** ..... 250/213, 213 R, 213 VT; 313/208, 208 A

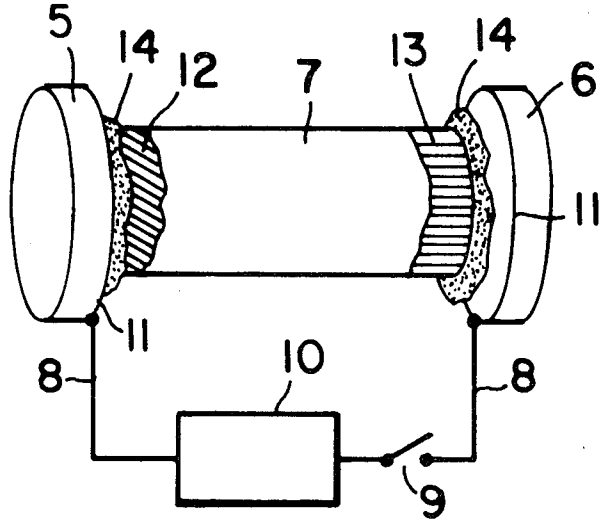
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ABSTRACT: A light image translating system comprising a plurality of metallic rods insulated one from the other. Each rod, at opposite ends, is provided with an electroluminescent film and a photoconductive film or layer. The rods are mounted with like ends together in tight parallel relation between and abutting with two spaced transparent electrodal elements which are connected with a voltage supply source to cause the electroluminescent film to start to glow when the illumination on the photoconductor layer is at a minimum, and to increase with increasing illumination. The ends of the metallic rods carrying the electroluminescent films thus provide an amplified reproduction of whatever illuminated picture is observed by the opposite photoconductive ends of the rods.



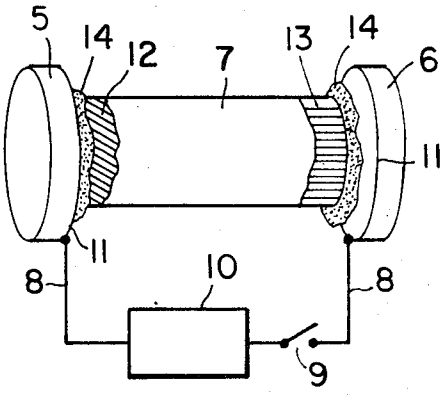


Fig. 1

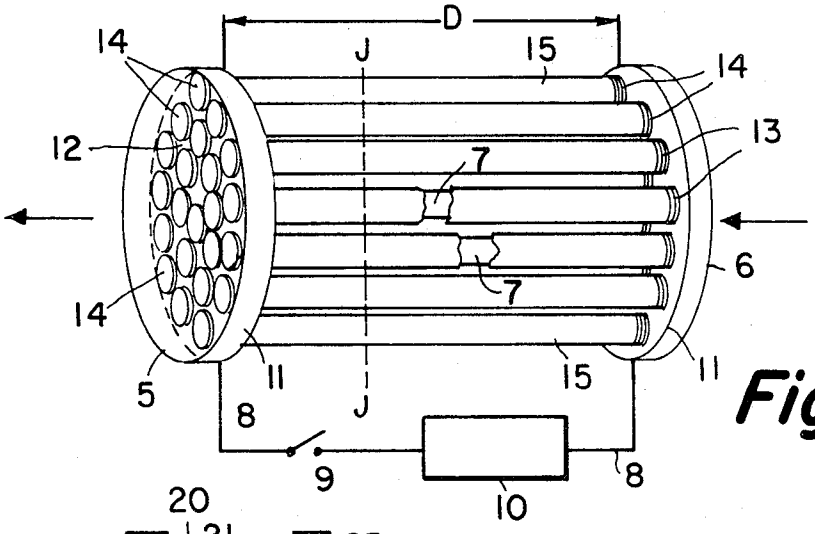


Fig. 2

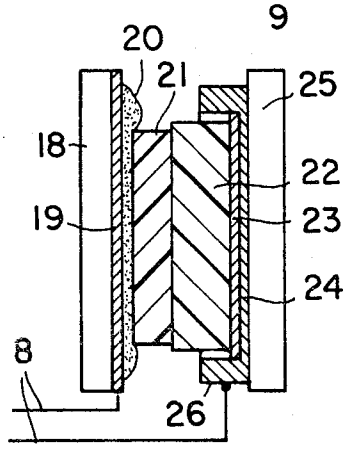


Fig. 3

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PROTECTIVE LIGHT IMAGE TRANSLATING SYSTEM

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

The present invention relates to photoconductively controlled light translating systems, and more particularly to multiple element photoconductive light image translating systems.

It is an object of this invention to provide an improved light image translating system wherein photoconductivity control can be applied effectively and efficiently for the reproduction of electroluminescence corresponding to a received light image, and without the transfer of direct light energy.

It is also an object of this invention to provide an improved light image translating system which may be constructed with a plurality of simple light controlling elements which are in duplication one of the other, for easy and low-cost production.

It is a further object of this invention to provide improved eye protection system which is effective against the hazards of nuclear flash and laser flash blindness.

In accordance with one form of the invention, a single element light amplifier or light translating device is constructed by placing in series contacting relation, and in the following order, a transparent electrode, an electrically conducting, transparent, viscous liquid film as a contact element. a relatively thin electroluminescent layer or film formed on one end of an elongated metal rod, a photoconductive layer or film at the opposite end of said rod, a second electrically conducting, transparent, viscous liquid film as a contact element similar to the first film, and a second transparent electrode.

A power supply source is connected between the electrodes to supply operating current, through the series current path thus formed, sufficient to allow the electroluminescent film to grow slightly when illumination on the photoconductive film is at a minimum. The glow then increases when the photoconductive film or layer receives light, in direct proportion thereto. Thus the present light image translating system consists of a construction containing thin photoconductors or photoconductive films or layers and electroluminescent films or layers placed in series as electric circuit elements. The electroluminescent layers may be anodic films and the photoconductive layers may also be anodic films to attain desired thinness.

The electroluminescent qualities of impurity doped aluminum oxide films have been improved to the point that easily observable change occurs when the applied voltage is varied about 100 volts and a corresponding current density change is provided in the electroluminescent film. When an anodic aluminum oxide or like electroluminescent film and a photoconductor layer, which may be a commercial photoconductive cell, are placed in series, the total voltage on both may be adjusted to a point where, with the photocell not illuminated, the electroluminescent film is just below the threshold of visible glow. Illumination of the photocell then causes the electroluminescent film to glow correspondingly in degree or intensity. Thus for nonimaging light transmission, a single rod or like element may be used between the two transparent electrodes.

This single light-conducting device may be replicated many times and assembled in a multielement unit to provide two composite end surfaces for image translation and intensification. In this case the individual elements, as above described and of equal length and size, are assembled and bundled into a tight elongated unit between two common transparent end electrodes, with an insulation layer on all of the said elements except at flat end surfaces thereof which carry the respective photoconductive films or layers and the electroluminescent films or layers. As indicated above, these provide two composite end surfaces for the unit, one for picking up an overall picture and the other for reproducing the image thereof indirectly through electron or current flow. The light image translating system of the present invention, thus transmits no direct light energy. Thus it is effective for protecting against the hazards of nuclear flash and laser flash blindness. It accomplishes this because it transmits none of the incident photons, but rather, converts them to an electric current which is limited by the saturation characteristic of the photoconductor. Furthermore, the brightness of the image produced on the electroluminescent surface cannot exceed the maximum output brightness for the material used. Thus the image brightness provided by this system can be limited to safe levels regardless of the incident light intensity or wavelength.

The invention will be further understood from the following description when considered with reference to the accompanying drawing, and its scope is pointed out in the appended claims.

In the drawing,

FIG. 1 is a view, in perspective, of a single-element light image translating amplifier or device as constructed in accordance with the invention,

FIG. 2 is a view, in perspective, showing a light image translating system comprising a plurality of devices of the type shown in FIG. 1, arranged and constructed in accordance with the invention, and

FIG. 3 is a cross-sectional view of a modification of the single element light amplifier and light-translating device of FIG. 1 showing a further construction in accordance with the invention.

Referring to the drawing, wherein like parts throughout the various figures are designated by like reference numerals, and referring particularly to FIG. 1, a pair of transparent electrodes 5 and 6 of flat, circular, disc shape are spaced apart in parallel relation to each other at the opposite ends of an elongated relatively small diameter conductor such as a metallic rod 7. For the sake of clarity in the figure, this is shown in greatly enlarged form. The electrodes 5 and 6 may be of any suitable transparent material such as glass and coated on their inner faces, that is, the faces toward the ends of the rod 7, each with a thin layer 11 of conducting material. This may be tin oxide, SnO_2,in a transparent film. These thin conductive coatings or films are provided with electrical circuit leads 8 connected through a control switch 9 with an adjustable voltage supply source 10.

On one end of the rod 7, which may be of aluminum, adjacent to the electrode 5, is electroluminescent film 12 which may be a pure or doped aluminum oxide, Al_2O_3,film. The rod may also be of cadmium or zinc or other metals in that group adapted to provide electroluminescent films by anodic or like electrolyte deposition means and having the necessary level of electroluminescent brightness.

Typical characteristics of the electroluminescent film suitable for this use are those having a high impedance, of the order of 100,000 ohms or more per square centimeter and with a high dielectric breakdown strength, together with electroluminescent intensity varying sharply over a relatively narrow voltage range and reaching a sufficient level of brightness to be easily seen against a reasonably light background with applied voltages of the order to from 100 to 300 volts.

The metal rod 7, which may be anodized to produce the electroluminescent layer 12, may be alloyed with controlled low concentrations of other metals which subsequently appear as impurities in the anodic film and contribute desired characteristics to the film. Such impurities include manganese alloyed in aluminum anodes to provide manganese ion impurities in the aluminum oxide film 12 which thereby exhibits enhanced electroluminescent intensity. It may be noted that the properties of the anodic film 12 may be controlled in directions favorable to the accomplishment of greater electroluminescent intensity through control of the anode composition or through control of the electrolyte composition in depositing the anode film. For example, maganese may be added to the Al_2O_3film as an anode alloy constituent, or by anion deposition of manganese dioxide, MnO_2,initially present as an anion constituent or cadmium sulfide ZnS or CdS, films by anion deposition, or copper may be incorporated in such films from an anode alloy constituent.

Although anodic electroluminescent films are suitable for this purpose because of a desired thinness that may be at-

tained thereby, other electroluminescent materials are useful also. For example, Mn, Al. Cu, doped ZnS or CdS dispersed as a paste in an organic vehicle or deposited by vacuum evaporation, can be substituted for the anodically formed oxide films.

At the opposite end of the rod **7**, and adjacent to the electrode **6** on the end of said rod, is placed a photoconductive element or film **13**, the impedance of which matches that of the electroluminescent layer **12** to within one order of magnitude at least. The photoconductive element or film **13** is effectively a relatively thin layer on the end of the rod **7** and may likewise be deposited thereon by any of the well known anodic processes. This photoconductive material may be any one of several elements such as cadmium sulfide, and in any case must exhibit a change in conductance of one-half order of magnitude or more when transferred from total darkness to the level of illumination for which amplification or action is required. Thus when the level of illumination is varied significantly within the range for which amplification is required, the photoconductor **13** will exhibit a significant change in conductivity and give rise to a corresponding change in brightness of the electroluminescent layer as will be described hereinafter. The photoconductor or photoconductive film **13** furthermore must have a dielectric breakdown strength approximately equal to that of the electroluminescent film **12**. To operate these two elements in series, the power supply device **10** must provide suitable voltage either AC or DC depending on the requirement of the particular electroluminescent film and the photoconductor or photoconductive film.

To provide good electrical contact with each of the electrodes **5** and **6** for the elements **12** and **13**, an electrically conducting transparent viscous liquid or semisolid layer or film, as indicated at **14** are provided. These electrically join the electroluminescent and photoconductive films or layers with the transparent electrodes, and may be of a number of known electrically conducting transparent viscous liquid or semisolid materials, such as boric acid, H_3BO_3,or sodium borate in glycerine. Such materials have been found to provide intimate contact between the transparent electrodes and the photoconductive or electroluminescent films, and do not have any adverse effect on the properties of the latter two materials, or interfere with their operation in use.

While the photoconductive layer **13** or photocell as it may be designated commercially, may be constructed of any suitable material, the photoconductivity of anodically formed cadmium sulfide, CdS, films have been known and demonstrated in the past. Therefore, such a film at **13** may be provided by anodic deposition of cadmium sulfide. In any case, both the film or layer **12** and the film or layer **13** must be very thin to be most effective.

With the device of FIG. **1** in operation, the switch **9** is closed to apply operating voltage from the source **10** which is then adjusted until the electroluminescent film glow is just perceptible when the illumination on the photoconductor **13** is at the minimum level of the anticipated operating range. The photoconductor **13** is then illuminated, resulting in a decrease in its electrical resistance and an increase in the potential on the electroluminescent layer or film **12**, which causes the latter to glow with greater intensity depending upon the strength of the light applied to the photoelectric layer **13**. Thus the device means serves to electronically or electrically transmit or translate light from the the electrode **6** through to the electrode **5** where it may be observed at the open end thereof. Thus for nonimaging light translation, a single rod or like element may be used between the two transparent electrodes with electroluminescent and photoconductive films at the opposite ends thereof. The rod is adapted for anodic processing or coating at each end by such materials as aluminum or cadmium or like metals in that group. By this means the structure is made to contain a thin photoconductive film or photoconductor and a thin electroluminescent layer in series as electric circuit elements. The electroluminescent layer may be an anodic film and the photoconductor may likewise be anodic film for insuring thinness. Thus in accordance with the invention, in each unit of the light image translating system, the following elements are placed in series relation:

1. A transparent electrode,
2. An electrically conducting transparent viscous liquid film or layer,
3. An electroluminescent film or layer formed on one end of an elongated slender metal rod which is one of the conducting elements,
4. A photoconductive layer or film, which may also be a commercially available photoconductor device, at the opposite end of the rod,
5. A second film or layer of electrically transparent viscous liquid film similar to the first, and
6. A second transparent electrode.

In most cases both electrodes may preferably be of thin-oxide coated glass and in the form of circular, thin, disclike elements substantially as shown. These elements may be enlarged to permit the number of conductor elements between them to be multiplied many fold as will be seen hereinafter.

The light-amplifying unit or device shown in FIG. **1** may be replicated many times in a light image translating system or unit. In other words the element **7** may be used in multiple between the electrodes **5** and **6** which may be enlarged as above indicated, to take the required number of such elements, of equal length and in parallel, to provide composite end surfaces for deriving a mosaic light pattern through the output electrode **5** from the input electrode **6**, which is subject to the light or, picture or object to be reproduced. This type of multiple element device or system is shown in FIG. **2**, to which attention is now directed along with FIG. **1**.

In the device or system of FIG. **2**, the output electrode **5** and the input electrode **6** are both greatly enlarged in diameter to accommodate the required number of rod elements to provide the desired size and detail of the mosaic in the output picture. Necessarily the rods are relatively small in diameter down to only a few thousands of an inch in diameter, in some cases, and increase number in the hundreds as presently contemplated to provide the desired image intensification and detail.

The parts of the individual elements are the same as those shown in FIG. **1**, with the addition of an insulating layer **15** on each rodlike element **7**, as indicated at FIG. **2**. The insulating layer **15** is relatively thin and extends the full length of the anode metal but not over the ends which are exposed for the two layers **12** and **13**. Thus when bundled together the rods are out of electrical contact with one another. The insulating layer, **15**, may be formed anodically and may further be impregnated with an organic dielectric to increase its resistance and breakdown strength. Thus each rod individually transmits its own response to light picked up by the photoconductive layer and transmits it to its own electroluminescent layer for viewing in the mosaic pattern created in this manner.

The resolution of the light image translating system in this form depends chiefly on the cross-sectional area of the anode metal elements or rods **7**. These are of relatively small cross-sectional area as may be determined from the fact that in a system such as that shown, rods of the order of 0.003 inch in diameter may be used. Operating procedures and voltages for the multielement unit are similar to those for the single element unit of FIG. **1**, the voltage being applied from the adjustable voltage source **10** through the switch **9** and the input leads **8** to the thin oxide coating or layers **11** on the electrodes **5** and **6**. As indicated, in this system, each rod element is provided with its own electrically conducting transparent viscous liquid contact film or element **14** and, likewise, at the opposite ends of the rods are indicated the electroluminescent films or layers **12** and the photoconductive layers or films **13**. Thus when the input electrode **6** is subjected to light from an object or picture giving off illumination, each of the elements transmits that light level which it picks up or "sees" and these are thus transmitted in varying degrees to the output electrode **5** where a mosaic picture is produced in a pattern or image in a composite end surface corresponding to that of the light or picture coming into input electrode **6**, and may be con-

siderably amplified and brightened thereby, depending upon the voltage used and the type of electroluminescent film at 12 on each rod.

The rods 7 between the electrodes 5 and 6 can be considerably shortened and made into a disc form as will be seen from a consideration of the modification shown in FIG. 3 which is the single element type of FIG. 1, and to which attention is now directed along with FIG. 1. In this modification, which is an alternate form of thin film light-translating device, there is provided a thin-film structure which includes a transparent electrode 18 of thin-oxide coating glass, for example, of circular flat disc construction similar to that of FIG. 1. The thin oxide coating or thin layer is indicated at 19 which is in contact with a thin transparent liquid conductor film or layer 20. This engages a disc of photoconductive material or a photoconductor 21 on one face, and the opposite face of the photoconductor 21 engages an opaque semiconductor disc 22 which corresponds to the rod 7 of FIG. 1, as a transmitter of electrical signals between the photoconductor 21 and an electroluminescent plate or film 23 through a backup plate 25 of glass or other suitable material of circular disc shape similar to that of the electrode 18. The thin film of anode metal 24 is provided with a circular outer flange base 26 of somewhat thicker construction to give it strength, and both this flange base and the thin oxide film 19 are provided with the electrical leads 8 for the application of voltage to the device.

Thus there is provided serially, substantially the same as the device of FIG. 1, a transparent electrode 18 having a thin-oxide coating, a transparent liquid contact element 20, a photoconductor element or device 21, an electrical conductor, which in this case is the semiconductor element 22, the anodic or like thin film of electroluminescent material 23 on the thin film anode metal 24 and backed up by the transparent and essentially inert supporting or electrode element 25. The characteristics of these materials are essentially those of the corresponding components of the device shown in FIG. 1 and the characteristics of the support 25 are not critical provided that this element is transparent, electrically nonconducting and chemically inert.

In order to prepare the anodic film electroluminescent layer, the anode metal 24 is first deposited on the glass support 25 which provides effectively the second electrode with a conducting film of controlled thickness. The semiconductor element 22 and the photoconductor 21 are placed over the anodic film 23 and the unit is assembled as shown. The electrical leads 8 are then connected to a power supply means which is not shown but which has the characteristics of the power supply means in FIG. 1. Operation of the light amplifier or translating device shown is essentially like that of the device shown in FIG. 1. A further modification of the anodic film light amplifier is that in which both the electroluminescent film and the photoconductor are formed by anodic means.

In this or any of the forms shown, one of the features of the invention is the incorporation therein of an electroluminescent film or layer as an active element of the light-transmitting system and to provide that this film be relatively thin, in any case, to obtain better resolution because the received light then does not spread through the layer. Therefore the deposition of these films by anodic processes from an electrolyte or otherwise is desirable.

Either of the single elements of FIG. 1 or FIG. 3 may be used to provide the multiple element systems of FIG. 2, wherein the assembled rods or conductors provide a composite photoconductive surface at one end for picking up a picture or object as viewed at that end, and provide a composite electroluminescent surface at the opposite end for reproducing the picture or object as an image translated through the rod elements individually electronically.

Thus no direct light energy is transmitted by this system which can thus provide effective eye protection against nuclear and laser flash. As referred to hereinbefore, none of the incident photons are transmitted by this system, but only the electric current which is limited by the saturation characteristic of the photoconductive surface. In addition, the brightness of the image at the electroluminescent surface cannot exceed the maximum output brightness for that material. The image brightness provided by this system, depends on the electric current which is limited by the saturation characteristic of the photoconductive surface. In addition, the brightness of the image at the electroluminescent surface cannot exceed the maximum output brightness for that material. The image brightness provided by this system can thus be limited to safe levels regardless of the incident-light intensity or wavelength.

I claim:

1. A protective light-translating system having the capability to show differentiation between different intensities of light and to show fluctuation in light intensities, comprising in combination:

a metallic electrically conducting, light opaque rod having a relatively thin electroluminescent film on one end thereof and a photoconductive film on the other end thereof; said rod comprising the sole support means for the electroluminescent and photoconductive films;

a pair of transparent flat electrodes spaced apart in parallel relation to each other at opposite ends of said rod and having thin transparent conducting surface films in contact therewith; and

means for applying an operating voltage between said electrodes in connection with the said surface films to effect a minimum glow on said electroluminescent film with a predetermined minimum light level on said photoconductive film,

thereby to transmit the effect of light variations through said rod from the photoconductive end without the transmission of incident light thereon.

2. A light translating system as defined in claim 1, wherein the electroluminescent film is composed of a compound of a metal, said metal being selected from the group consisting of aluminum, cadmium and zinc and said compound being of relatively high electrical impedance and dielectric breakdown strength, and wherein the photoconductive means is a cadmium sulfide film of substantially equal impedance.

3. A light translating system as defined in claim 1, wherein the electroluminescent film is an anodic film of impurity-doped aluminum oxide, and wherein the photoconductive means is a thin anodic film of cadmium sulfide.

4. A protective light-translating system, having the capability to show differentiation between different intensities of light and to show fluctuation in light intensities, comprising in combination;

a plurality of like electrically insulated light opaque metallic rods each having an electroluminescent film thereon at one end and a photoconductive film thereon at the other end said rods each comprising the sole support means for their respective electroluminescent and photoconductive films;

a pair of transparent flat disclike end electrodes in spaced relation to each other;

said metallic rods mounted in tight parallel relation with like ends together between and abutting said end electrodes to provide composite electroluminescent and photoconductive end surfaces in contact with said electrodes and a series current paths through said end films and rods between said electrodes; and

means connected with said end electrodes for applying an operating voltage therebetween of a magnitude to effect current flow through said path and an initial visible glow on the composite electroluminescent surface with predetermined minimum illumination on the photoconductive surface,

thereby to effect light image translation in varying degrees through said rods individually from the photoconductive surface "without the transmission of incident light thereon" to the electroluminescent surface, and respective image pickup and reproduction thereby in a mosaic pattern and with limited brightness.

5. A protective light image translating system as defined in claim 4, wherein the electroluminescent and the photoconductive films on the rods are respectively of aluminum oxide and cadmium sulfide and wherein the end electrodes are of glass coated on each contact surface with tin oxide in a thin transparent film to render the glass surface electrically conducting.

6. A protective light image translating system as defined in claim 5, wherein the electrical conductivity between the end electrodes and the rods through said end film is enhanced by an interposed viscous transparent contact film containing boric acid.

7. A light image translating system for eye protection against nuclear and laser flash effects, having the capability to show differentiation between different intensities of light and to show fluctuation in light intensities, comprising in combination:

a pair of spaced transparent flat electrodes providing light image input and output elements for said system;

means providing a thin transparent electrically conducting film on one face of each of said electrodes;

a plurality of like electrically conducting, light opaque rods insulated one from the other and extending in tightly bunched parallel relation between said electrodes and the conducting films thereon as individual current conductors and light image translating elements for said system;

said rods being of equal length and each being a small fraction of an inch in diameter to provide two finely divided high resolution composite flat end surfaces at said electrodes;

means providing a photoconductive film on each rod in the composite end surfaces at the input electrode;

means providing a relatively thin electroluminescent film on each rod in the composite end surface at the output electrode, said rods each comprising the sole support means for their respective electroluminescent and photoconductive films; and

means connected with said electrodes and the conducting films thereon for applying an operating voltage thereto of a value for effecting a current flow therefrom through said rods and end surfaces to effect an initial glow in the electroluminescent surface in response to minimum illumination of the photoconductive surface,

thereby to effect light image translation through said rods by current variation and voltage change on said end surface, and respective change pickup and reproduction with brightness limited to safe levels independent of incident light intensity and wave length and without transmission of incident light.

8. A light image translating system as defined in claim 7, wherein the electrically conducting rods are of a material which can be anodized and which are insulated each with an anodic film along its entire length, and wherein the electroluminescent film on each rod is of aluminum oxide and the photoconductive film on each rod is of cadmium sulfide.

9. A light image translating system as defined in claim 7, wherein the electrically conducting rods are composed of metal selected from the group consisting of aluminum, cadmium and zinc, and wherein the electroluminescent film on each rod is of zinc sulfide and the photoconductive film on each rod is cadmium sulfide.

10. A light-translating system, having the capability to show differentiation between intensities of light and to show fluctuation in light intensities, comprising in combination:

a transparent electrode having a conducting surface, an electrically conducting transparent viscous layer in contact with said surface;

an elongated slender metal, light-opaque rod having an electroluminescent layer on one end in contact with said viscous layer;

a photoconductive layer on the opposite end of said rod, said rod comprising the sole support means for the electroluminescent and photoconductive films;

a second electrically conducting transparent viscous layer in contact with said photoconductive layer;

a second transparent electrode having a conducting surface in contact with said second viscous layer;

means connected with said electrodes for applying a voltage thereto,

for establishing a current flow through said series connected elements to effect an initial visible glow on said electroluminescent layer with predetermined minimum illumination in said photoconductive layer without the transmission of incident light thereon.

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