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2,160,383

LIGHT SENSITIVE ELECTRIC DEVICE AND CIRCUIT THEREFOR

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FIG. 1

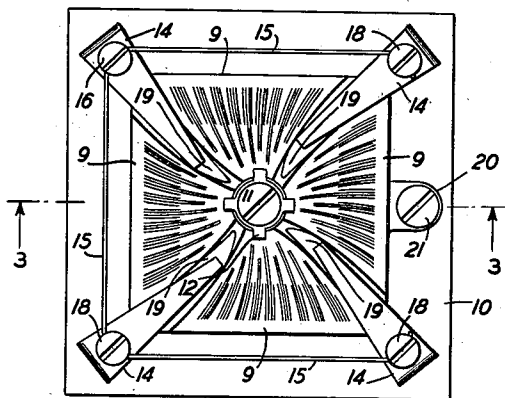


FIG. 2

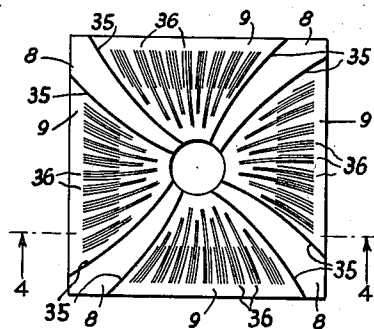


FIG. 3

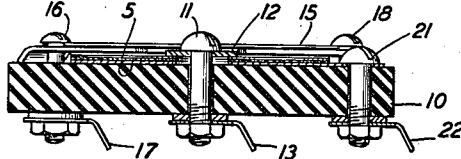
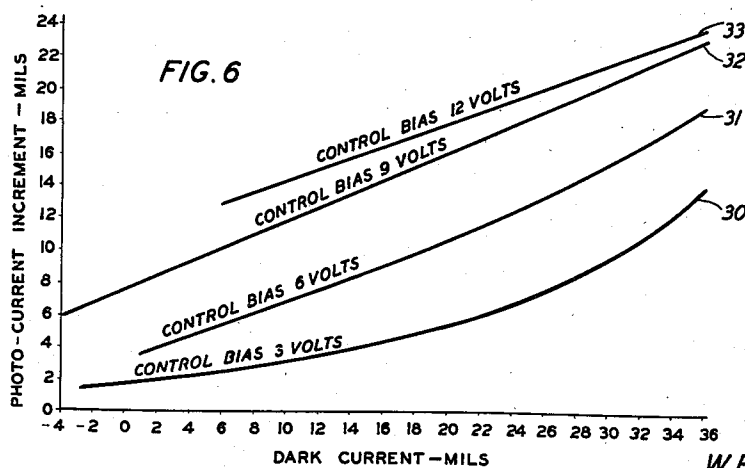
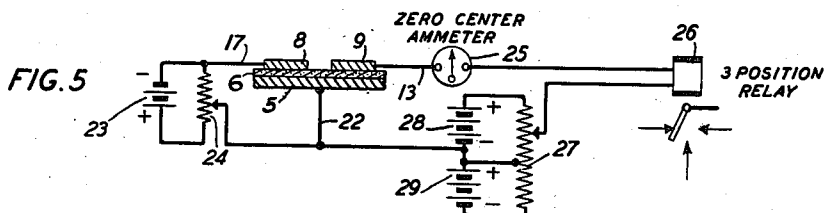
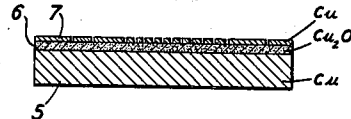


FIG. 4



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LIGHT SENSITIVE ELECTRIC DEVICE AND
CIRCUIT THEREFOR

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8 Claims. (Cl. 250—41.5)

This invention relates to light sensitive electric devices and more particularly to devices, called herein photo-emf cells, comprising a layer of semi-conducting material having conductive electrodes on opposite faces thereof between which electrodes a voltage is developed when one face is exposed to light.

An object of the invention is to provide an improved form of photo-emf cell.

A specific embodiment of the invention described herein by way of illustration comprises a layer of cuprous oxide on a copper plate and a thin layer of copper on the other surface of the oxide, such copper layer being separated into discrete portions to constitute electrodes one of which is permeable to light and another either opaque or screened from light. By suitably biasing these electrodes with respect to the copper plate large response to change of illumination may be obtained. A change in the nature of the response may be effected by changing the bias.

A more detailed description of the invention follows having reference to the accompanying drawing.

Fig. 1 is a face view of one embodiment of the invention;

Fig. 2 is a face view of the copper plate with the overlying layers of cuprous oxide and copper showing portions of the copper layer removed to form discrete electrodes;

Fig. 3 is a cross-sectional view of Fig. 1 along the line 3—3;

Fig. 4 is a cross-sectional view of Fig. 2 along the line 4—4, the thickness of the plate and layers thereon being greatly exaggerated;

Fig. 5 is a schematic circuit arrangement according to this invention; and

Fig. 6 illustrates the response characteristics of the circuit of Fig. 5 under various light conditions.

The specific form of photo-emf cell herein described by way of example is illustrated in Figs. 1 to 4, inclusive. A relatively heavy copper plate 5 which has a hole drilled therethrough at its center has formed on one surface a layer 6 of cuprous oxide. The exposed surface of the cuprous oxide is reduced in suitable manner to produce a conductive layer 7 of copper. This layer 7 is scored as shown by the curved lines 35 and 36 in Fig. 2. This scoring removes the reduced copper but does not extend for any appreciable distance into the layer 6 of cuprous oxide.

The scored copper layer 7 constitutes discrete electrodes. Portions 8 separated from portions

9 by scoring lines 35 which extend from the edges of the plate to the center hole are used together as a control electrode and portions 9 with the shorter scoring lines 36 to render these portions more permeable to light are used together as the photoelectrode.

The plate 5 is mounted on an insulating block 10 of wood. Contact with the photoelectrode portions 9 is secured by means of screw 11, washer 12 and terminal 13. The washer 12 has four integral extensions which contact with the portions 9, the circular portion of the washer being smaller than the hole in the plate 5 so as not to contact with the portions 8 of the copper layer 7. Contact with the control electrode portions 8 is secured by brass contact arms 14 conductively connected together by wire 15, screw 16 and terminal 17. Screw 16 holds one contact arm in position while the other contact arms are held by screws 18. Each contact arm 14 presses upon a sheet of lead 19 which covers practically all of portions 8. The purpose of this sheet of lead is to screen from light the layer 6 of cuprous oxide which underlays the portions 8 of copper layer 7 and also to improve the electrical contact between the control electrode 8 and the brass arms 14. Contact with the copper plate 5 is secured by means of extension 20, screw 21 and terminal 22. After assembly the whole surface of the device may be given a coating of transparent lacquer to prevent detrimental chemical reactions.

The device above described may be used to advantage in the circuit of Fig. 5. As shown the control electrode 8 is connected through terminal 17 to the negative terminal of battery 23 the positive terminal of which is connected to one terminal of potentiometer 24. The variable contact of potentiometer 24 is connected to the copper plate 5 of the light sensitive device through terminal 22. The photoelectrode 9 is connected through terminal 13 and a zero center ammeter 25 to one terminal of a three-position relay 26. The other terminal of relay 26 is connected through the variable and middle contacts of potentiometer 27 and terminal 22 to the copper plate 5 of the light sensitive device. Potentiometer 27 is connected across two batteries 28 and 29 in series the joined terminals of which are connected to the middle contact of potentiometer 27. This potentiometer and battery arrangement provides a simple means for impressing either positive or negative voltages of varying amounts on the photoelectrode 9 with respect to the electrode 5.

The curves of Fig. 6 illustrate the effect of vari-

ous amounts of control bias on the responses to a given amount of light. For example, for a control bias of nine volts from battery 23, the voltage from potentiometer 27 being adjusted to give zero dark current, the response is approximately 7.5 mils when the cell is illuminated. This is shown by curve 32. If the potentiometer 27 is adjusted to give a dark current response of minus four mils; then, when the cell is illuminated, the response is plus two mils. This is also shown by curve 32. From the foregoing it is seen that with the device and circuit according to this invention various effects can be produced merely by changing from the dark to the light condition or vice versa.

The response with a control bias of three volts is shown by curve 30, of six volts by curve 31, and of twelve volts by curve 33. In each case the potentiometer 27 is adjusted to give the indicated dark current.

The circuit of Fig. 5 can also be adjusted so that for a given illumination of the cell the current will be zero in the relay 26 while for an increase in such illumination current will flow in one direction through the relay and for a decrease in the illumination it will flow in the opposite direction. For example, assume a control bias of nine volts and an adjustment of potentiometer 27 to give a dark current of minus four mils. Now, if the cell is illuminated to the intensity used in obtaining curve 32 of Fig. 6, the current would become plus two mils. At some lesser value of illumination the increment due to illumination would just equal the negative dark current of four mils and the net current would be zero.

An important feature of the arrangement of Fig. 5 is the facility with which dark current conditions may be manipulated.

The contacts of relay 26 may be used to control other electrical circuits in accordance with various degrees and conditions of illumination of the photosensitive cell.

The copper plate 5 may be treated in any well-known manner to produce the cuprous oxide layer 6 with the layer of copper 7. Suitable methods are described in W. F. Kannenberg Patent No. 2,046,686, patented July 7, 1936.

Instead of forming a layer of copper, certain portions of which are later removed mechanically to form discrete electrodes, the reduction of the surface of the cuprous oxide may be caused to take place only over such portions of the cuprous oxide surface as it is desired to have the copper layer. Suitably shaped stencils or masks may be used to protect the portions not to be reduced. For example, the mask may take the form of those portions of the surface of the semi-conductive material which are not to be covered with conductive electrodes. This may be said to be a "positive" mask, because after the reducing mixture has been sprayed on, the design is that of the desired electrodes. If a "negative" mask is used, clear lacquer is first sprayed on the surface and, after it has dried, the whole surface is sprayed with the reducing mixture.

Any other known method of applying the electrodes to the surface of the semi-conductive material may be used.

It is believed that the operation of the improved photo-emf cell of this invention is dependent upon the combined use of the photo-emf effect and the rectifier action of such cells in a novel manner. As hereinbefore stated, the scoring

lines 35 do not extend for any appreciable distance into the layer 6 of cuprous oxide. A path for electrical current therefore extends between control electrode 8 and photoelectrode 9 through the layer 6 of cuprous oxide independently of the copper plate 5. The current in relay 26 is dependent not only upon the current flowing through the layer 6 of cuprous oxide between copper plate 5 and photoelectrode 9 but also upon the current flowing between control electrode 8 and photoelectrode 9 through the layer 6 of cuprous oxide. It is believed that this latter current is dependent to some extent upon the current flow between copper plate 5 and control electrode 8 through the layer 6 of cuprous oxide. Due to these interrelated circuits the current relationships illustrated in Fig. 6 are obtainable. However, independently of any theory of operation, applicant has provided a new and useful photo-emf cell and circuit therefor.

This invention may take various forms which come within the purview of the appended claims.

What is claimed is:

1. A light sensitive device comprising a base conductor, a layer of light sensitive semi-conducting material on said base conductor, a plurality of electrodes overlying and in contact with separated portions of the surface of said semi-conducting material, one of said electrodes being permeable to light, and means to exclude light from the surface overlaid by another of said electrodes.

2. A light sensitive device comprising a copper conductor, a layer of cuprous oxide on said conductor, a light permeable conductive layer on a portion of said oxide surface, and an opaque conductive layer on a separated portion of said oxide surface.

3. A light sensitive device comprising a copper plate, a layer of cuprous oxide on said plate, and a layer of copper on said cuprous oxide layer divided into separated portions, one portion being light permeable and another portion screened from light.

4. A light sensitive device comprising a copper plate, a layer of cuprous oxide on said plate, a light permeable layer of copper overlying a portion of said oxide layer, a layer of copper overlying a separated portion of said cuprous oxide layer, an opaque sheet of lead overlying said last-mentioned layer of copper and a terminal member contacting said layer of lead.

5. A light sensitive device comprising a copper plate, a layer of cuprous oxide on said plate, a plurality of light permeable separated portions of a layer of copper on said cuprous oxide layer, a plurality of other portions of a layer of copper on said cuprous oxide layer, one such portion lying intermediate of two light permeable portions, and means to keep light from reaching the cuprous oxide layer underlying said second-mentioned plurality of portions.

6. A light sensitive device comprising a base conductor, a layer of light sensitive semi-conducting material on said base conductor, a plurality of electrodes overlying and in contact with separated portions of the surface of said semi-conducting material, one of said electrodes being light permeable, means to exclude light from the surface overlaid by another of said electrodes, and means to impress voltages independently between said base conductor and said overlying electrodes.

7. A light sensitive arrangement including a

light sensitive device comprising a base conductor, a layer of light sensitive semi-conducting material on said base conductor, a plurality of electrodes overlying and in contact with separated portions of the surface of said semi-conducting material, one of said electrodes being light permeable, and means to exclude light from the surface overlaid by another of said electrodes, means to impress voltages independently between said base conductor and said overlying electrodes, and a work circuit included in the circuit between the base conductor and the light permeable electrode.

8. A circuit including a light sensitive device

comprising a copper plate, a layer of cuprous oxide on said plate, a light permeable conductive layer on a portion of said oxide surface, and an opaque conductive layer on a separated portion of said oxide surface, a source of direct current having its positive terminal connected to said copper plate and its negative terminal connected to said opaque conductive layer, and a work circuit comprising a source of direct current, one terminal of said work circuit being connected to said copper plate and the other terminal to said light permeable conductive layer.

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