

May 26, 1931.

V. K. ZWORYKIN
LIGHT SENSITIVE ELEMENT

Filed Nov. 6, 1928

1,807,056

Fig. 1.

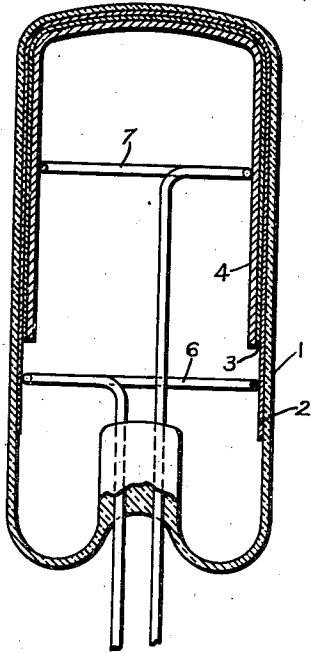
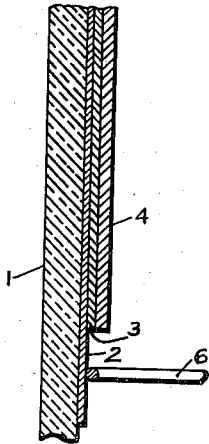


Fig. 2.



INVENTOR
Vladimir K. Zworykin

BY *Robert E. Barr*
ATTORNEY

UNITED STATES PATENT OFFICE

VLADIMIR K. ZWORYKIN, OF SWISSVALE, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

LIGHT SENSITIVE ELEMENT

Application filed November 8, 1928. Serial No. 317,598.

My invention relates to light sensitive electrical conductors and particularly to selenium cells.

One object of my invention is to produce a light sensitive electrical conductor in which the fractional change of conductivity corresponding to a given intensity of illumination shall be as great as possible.

Another object of my invention is to produce a light sensitive electrical resistance, the operating characteristics of which do not change with time or use.

A further object of my invention is to provide a method for producing selenium resistors which is simple and inexpensive to carry out.

Further objects of my invention will become apparent upon reading the following specification taken in connection with the drawings in which

Figure 1 is a longitudinal section of a light sensitive cell embodying the principles of my invention, and

Fig. 2 is a detailed view in section of a glass plate supporting a selenium conductor made in accordance with the principles of my invention.

Conductors of selenium, the electrical conductivity of which varies in response to the intensity of radiation incident upon them, have been previously employed to permit the flow of currents in electrical circuits to be varied in accordance with an illumination to be measured. However, it has been customary heretofore to form such selenium resistors of appreciable thickness. Selenium is a substance which absorbs light to a considerable degree so that, as a matter of fact, only the layers relatively close to the surface of such selenium conductors are really affected by the illumination falling upon them, the light never reaching the underlying portions of the metal. Selenium is a material having a high electrical resistivity and accordingly the underlying layers of the selenium acted simply as dead resistance in the electrical circuit, thereby reducing the net fractional change of electric resistivity for a given intensity of incident radiation. Since it is in practically every case the fractional

change of resistivity which is the useful quantity, the underlying layers of selenium reduced the effectiveness of the entire arrangement without having any counterbalancing advantage.

In accordance with the principles of my invention, I produce the selenium cell in the form of a layer the thickness of which is barely sufficient to absorb the major part of the incident radiation, no superfluous underlying layers being present to cut down its efficiency as a light sensitive resistor. In order to subject the entire body of the selenium layer to incident radiation and at the same time to make electrical contact to an entire surface thereof, I form one electrical contact of a highly reflecting metallic surface with which the thin layer of selenium is in contact, and form the opposed contact surface of a layer of metal so thin as to be substantially transparent to the incident radiation. By this means, radiation falling on the last named layer penetrates through it into the underlying selenium where approximately half of it may be absorbed in its first passage through the latter. The portion of the radiation which is not absorbed in its first passage through the selenium is reflected by the mirror surface above described, and follows a return path into the selenium, where most of the remaining light is absorbed. In consequence, the greatest possible fractional change of resistivity of the selenium is produced by this double passage of the radiation, and substantially all the selenium present undergoes this large change in resistivity. Accordingly, the maximum possible fractional change of resistivity, for a given incident radiation, is obtained.

With the foregoing principles and objects in mind my invention is better understood by reference to Fig. 1 of the drawings in which the reference numeral 1 designates a glass container of conventional form. Upon the interior wall of this container is deposited a layer 2 of metal, which may be gold, and which is so thin as to transmit a substantial fraction of the radiation which may fall upon it. Numerous methods for forming such metallic films are well known in

the art; for example, the deposit may be made by providing a filament of gold capable of being heated electrically, in the interior of the container 1. The latter may be evacuated and if the gold wire is electrically heated to a sufficient temperature, the gold will volatilize and gradually deposit as a film on the walls of the container 1. By controlling the duration of the heating, the thickness of the gold deposit may be given any value desired. An alternative method would be to provide a pair of electrodes within the container 1, one of them being of gold and connected to act as a cathode. By producing an electric discharge through a rarified atmosphere within the container, the action generally known as sputtering will result in a gradual vaporization of the gold electrode and deposit of the vapor as a thin film on the container wall. The thickness of the film should be regulated by controlling the duration of the discharge so that it transmits from fifty to eighty percent of the illumination falling upon it.

The metallic film having been formed on the container wall as above described, a thin film 3 of selenium is deposited in turn on the surface of the gold. The selenium film may likewise be produced by cathode sputtering, producing a discharge from a selenium cathode in a similar manner to that already described in reference to a gold cathode. The thickness of the selenium layer thus produced should be sufficient to absorb, in a single passage through it, from fifty to seventy percent of radiation incident upon it. This thickness will, of course, vary with the wave lengths of the radiation, which it is desired to absorb but since the co-efficients of absorption of selenium for various wave lengths are well known, it is possible to regulate the thickness to the required value without difficulty.

Alternatively, the selenium may be deposited by heating selenium in an evacuated enclosure communicating with the container 1. Selenium will vaporize and deposit on the walls of container 1 to form the desired film 3.

On the inner surface of the selenium layer 3 is deposited a third layer 4 of a metal having a high reflectivity for radiation of the wave lengths which it is desired to measure. For ordinary light, silver will be found a suitable metal. The metallic film 4 may likewise be deposited by the method of cathode sputtering, or by electrically heating a wire of the corresponding metal in the interior of the evacuated container. The layer 4 thus forms a reflecting mirror contiguous to the free face of the selenium film. The deposit of the metal 4 should preferably be so thick as to be opaque to radiation.

It will be recognized that it is not absolutely essential that the backing mirror

should actually be formed in contact with the selenium but that for many purposes it will be sufficient to form the backing mirror as a separate unit; for instance, as a silvered glass blank, of such form that it may be positioned in contact with the selenium layer.

As an alternative arrangement, the mirror surface may be formed first, the selenium deposited upon it by evaporation of selenium through heat in vacuum, and the transparent thin gold contact layer be formed on the outside of the selenium by the evaporation methods already described.

In order to make electrical contact to the structure described in connection with Fig. 1, inleading wires passing through the walls of container 1, may be provided with resilient extensions 6 and 7 bent into the form of closed rings of less diameter than the interior of the container 1. The wires 6 and 7 may be held as closed loops under stress by fusible links of some low melting metal while the films 2, 3 and 4 are in course of deposition. Thereafter, currents may be induced in the closed loops aforesaid by means of high frequency electric fields, thus fusing the links and permitting the loops to expand into contact with the layers 2 and 4, respectively. In this way electric current may be conducted through wire 6 to film 2, through the selenium film 3 into the film 4 and out through the other wire 7.

Fig. 2 shows, in magnified detail, the above described structure of the selenium cell, the reference numeral 1 designating the container wall; 2, the contact film of gold; 3, the selenium film and, 4, the mirror backing.

While Fig. 1 illustrates a selenium film deposited in the interior of a closed container, it will be evident that various deposits described may equally well be formed on a separate supporting member, such as a watch glass. The watch glass may be placed inside a separate containing vessel while the films above described are being deposited, the container being exhausted to a high vacuum, if necessary, in order to prevent oxidation of the films during formation.

While I have described the specific metals, gold and silver, as being employed for the contact faces of the selenium cell, it will be understood that, for any purposes, other metals will be at least equally desirable and that the use of such other suitable metals is within the purview of my invention. It will also be recognized that other conductors, which are sensitive to radiation, may be substituted for selenium without departing from the principles of my invention.

Since many specific embodiments of the principles of my invention, other than those above described, will be evident to those skilled in the art, I desire that the following claims shall be given the broadest con-

struction consistent with their terms and with the limitations of the prior art.

I claim as my invention:

1. A light sensitive device comprising a transparent supporting medium, a metallic film thereon so thin as to transmit a substantial fraction of radiation incident thereon, a translucent film on said metallic film comprising a conductor the resistivity of which varies in response to the intensity of radiation incident thereon, and a reflecting conductor in contact with said translucent film.

2. In combination with a good reflecting surface, a layer of selenium of such thickness as to absorb substantially fifty percent of radiation incident thereon and a conducting film on the free surface of said selenium so thin as to transmit a substantial fraction of radiation incident thereon.

3. A light-sensitive device comprising a transparent supporting medium, a metallic film thereon so thin as to transmit a substantial fraction of radiation incident thereon, a translucent film on said metallic film comprising a conductor the resistivity of which varies in response to the variation in the intensity of radiation incident thereon, and means for reflecting the light which passes through said translucent film back therethrough.

4. A light-sensitive device comprising a transparent supporting medium, a metallic film thereon so thin as to transmit a substantial fraction of radiation incident thereon, a translucent film of selenium on said metallic film, and means for passing a given beam of radiant energy a plurality of times through said film of selenium.

5. A light-sensitive device comprising a transparent supporting medium, a metallic film thereon so thin as to transmit a substantial fraction of radiation incident thereon, a translucent film on said metallic film comprising conducting material the resistivity of which varies in response to the variation in the intensity of radiation incident thereon, and means for passing a given beam of radiant energy a plurality of times through said translucent film.

6. A light-sensitive device comprising a transparent supporting medium, a film on said supporting medium comprising a conducting material the resistivity of which varies in response to variations in the intensity of radiation incident thereon, and a light-reflecting conductor in contact with said film.

7. A light-sensitive device comprising a transparent supporting medium, a film on said supporting medium comprising a conducting material the resistance of which varies in response to variations in the intensity of radiation incident thereon, said film being so thin that only a portion of radiation incident thereon is absorbed there-

by, and means for reflecting the remaining portion of said radiation through said film.

In testimony whereof, I have hereunto subscribed my name this 31st day of October, 1928.

VLADIMIR K. ZWORYKIN.

70

75

80

85

90

95

100

105

110

115

120

125

130