May 7, 1935. A. H. LAMB 2,000,642

PHOTOELECTRIC DEVICE

Filed July 14, 1932

Fig. 1.

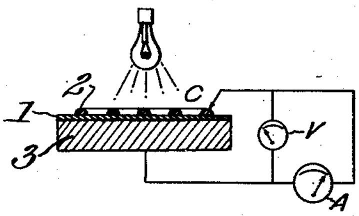


Fig. 2.

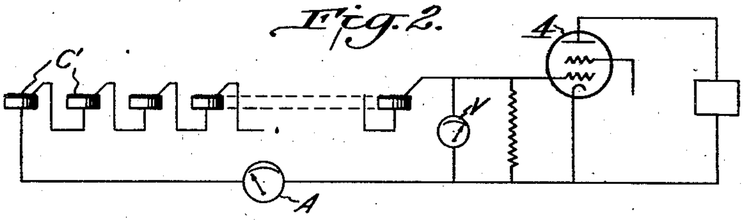


Fig. 3.

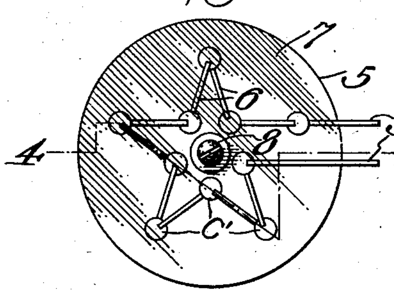


Fig. 4.

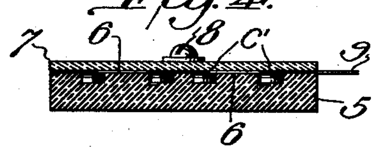


Fig. 6.

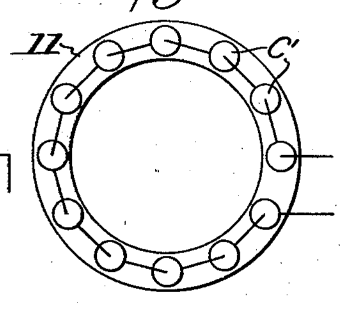


Fig. 5.

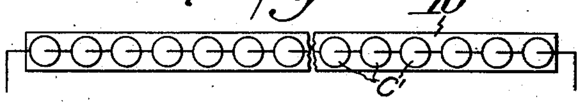


Fig. 7.

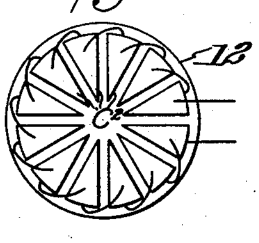
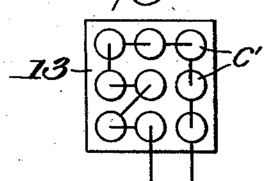


Fig. 8.



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UNITED STATES PATENT OFFICE

2,000,642

PHOTOELECTRIC DEVICE

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Application July 14, 1932, Serial No. 622,531

5 Claims. (Cl. 136—89)

This invention relates to photoelectric devices and more particularly to photoelectric cells of the type including an actinoelectric material such as cuprous oxide, selenium, tellurium, selenides, tellurides and the like.

Photoelectric cells of this type have been designed and used as "current-change" devices for the operation, either directly or through amplifiers, of current-response devices since, in general, the maximum voltage generated is too low to actuate satisfactorily a static amplifier, or to actuate directly a dynamic amplifier. Photocells of the evacuated tube type are essentially "voltage-change" devices in that the current output is so minute as to be of no practical use, whereas the voltage change resulting from wide variations in illumination is of substantial magnitude. The phototubes are not, however, sensitive to small changes within the range of relatively low illumination.

An object of the invention is to provide photoelectric devices of the voltage-change type, and which are characterized by a higher sensitivity than the known phototubes. A further object is to provide photoelectric devices of high voltage output, and of the type including a layer of actinoelectric material disposed between two electrode terminals.

These and other objects and advantages of the invention will be apparent from the following specification, when taken with the accompanying drawing, in which:

Fig. 1 is a somewhat diagrammatic sectional view of a photocell of the current generating type,

Fig. 2 is a diagram of a circuit including a plurality of such cells,

Fig. 3 is a plan view of a device embodying the invention,

Fig. 4 is a sectional view on line 4—4 of Fig. 3, and

Figs. 5 to 8, inclusive, are somewhat diagrammatic plan views of other mountings for cascaded cell units.

In the drawing, the reference numeral 1 identifies the actinoelectric layer of material that is arranged between a "collector" or grid electrode 2 and a second electrode 3 to form a photoelectric cell C. The layer 1 may consist of selenium that was applied in molten state to the backing electrode 3, and then heat treated to produce a crystalline structure. The collector electrode 2 is shown as a grid with relatively large openings but it is to be understood that this showing serves only for purpose of illustration as the collecting electrode may have other known forms, such as that of a translucent film of metal.

Whether the actinoelectric layer be crystalline selenium or one of the other materials noted above, a photo-electric device such as shown in Fig. 1 has the property of generating a voltage between the electrodes 2, 3 when the collecting electrode face of the layer 1 is exposed to light and its opposite face is dark. The voltage so developed is of a very low order of magnitude but a substantial flow of current may be established in an external circuit between the electrodes. The absolute values of the voltage and current will be different, of course, for the different actinoelectric materials, the collecting electrode construction and the intensity of the illumination but in all cases the action will be of the type indicated graphically in Fig. 1. If appropriate voltage and current measuring instruments are employed, as indicated diagrammatically by instruments V and A, respectively, it will be found that the maximum voltage obtainable under strong illumination is quite small but the current output is appreciable. In view of this characteristic of the devices, they have been uniformly employed with auxiliary equipment that responded to changes in current flow.

As indicative of the low voltages developed, it has been impossible to obtain potentials greater than from 75 to 150 millivolts as the relatively rapid variation in voltage which results from variations in relatively low illumination does not extend over the entire range of illumination, a saturation effect preventing any increase in voltage with increasing illumination.

Voltages of the order stated are too low to operate satisfactorily the voltage-response devices that are employed with photo-electric devices of the vacuum tube type.

I have discovered that cells of the current-change type may be cascaded to develop a voltage, when working into a circuit of such high resistance as to substantially prevent all current flow, that is substantially the sum of the voltages developed by the individual cells, and that the size of the cascaded cells may be but a small fraction of the size of the cells commonly formed of the same materials and for use as current-change devices. The current output of current-change cells of the solid type is dependent upon the exposed area of the cell but I have found that the desired voltage addition effect may be obtained by cascading a plurality of current-change cell units which are each of such small size as to develop only a negligible current.

As shown in Fig. 2, a plurality of cells C' may be cascaded by connecting the collecting electrode of one cell to the back electrode of the adjacent cell. The terminals of the cascaded cells may be connected to a thermionic amplifier 4 or other voltage response device, the number of cells being so chosen that the voltage developed between the terminals is sufficient to actuate the amplifier. As indicated graphically by the measuring instruments V, A, in Fig. 2, the input resistance of the amplifier is so high that there is no current flow, but the open-circuit voltage produced upon exposing the cells to light is relatively high. The open-circuit voltage of the cascaded cells cannot be measured by a sensitive millivoltmeter connected across the terminals, since the instrument winding will short-circuit the cells and the voltage will fall approximately to zero, and it is to be understood that the showing of the voltmeter V indicates only the magnitude of the open-circuit voltage, and not a circuit for measuring that voltage. With ten cascaded cells, for example, over 300 millivolts were developed at 5 foot-candles and over 1½ volts were developed at 250 foot-candles. The high millivolt sensitivity at low illumination is thus rendered available for control purposes as the absolute value of the voltage change corresponding to a given change in illumination may be stepped up to any desired magnitude by choice of the number of cascaded cells.

One practical arrangement for a device comprising a plurality of cascaded cells is shown in Figs. 3 and 4. An insulating base 5 is recessed to provide seats for receiving a plurality of small cells C' and the lower ends of approximately Z-shaped connecting strips 6; the upper ends of the strips overlying an adjacent recess, whereby the strips make contact between the collecting electrode of one cell and the base electrode of the next cell. A glass cover plate 7 is secured to the base 5 by a screw 8 and holds the outer ends of the connecting strips 6 in contact with the respective collecting electrodes. Terminal strips 9 extend from opposite faces of the two end cells to points beyond the base 5.

It is to be noted that the size of a multiple cell potential-generating device is not directly related to the size of the known current-generating cells employing the same materials. The individual cell units C' may be, and preferably are, quite small and the dimensions and shape of the complete multi-cell device may be the same as those of a single cell C of the current-change type, thus facilitating the manufacture of mountings and auxiliary equipment by making one construction available for use with cells of both the voltage-change and the current-change types.

It will be apparent that there is considerable latitude in the choice of the materials of the individual cell units, and in the physical arrangements of the cascaded cells.

As illustrated in Fig. 5, a plurality of individual cells C' are alined and carried by a narrow strip 10 of insulating material. This form of mounting is particularly desirable when a comparatively extended region is to be protected by a light-sensitive alarm or control system. The strip 10 may, for example, be mounted along the side of an elevator door to energize a signal light or to open a circuit-breaker when any object is in such position as to be injured by closing the door or starting the elevator.

The mounting plate 11 may be of annular form, as shown in Fig. 6, or a circular mounting 12 may support a plurality of unit cells C² which are of sector shape. Or, as shown in Fig. 8, a plurality of unit cells C' may be compactly arranged on a square mounting plate 13.

The number of cascaded cells and their arrangement may, of course, be varied to suit the particular design requirements in any given case.

I claim:

1. A photoelectric device of the voltage-change type comprising a base of insulating material having recesses in one face thereof, a current-generating photoelectric cell snugly received within each of said recesses, each of said cells being of disk form and comprising a layer of actinoelectric material between a back electrode and an upper light-transmitting electrode, conducting strips connecting said cells in cascade, each strip having an end extending to the bottom of one recess and an opposite end overlying the upper electrode of a cell in an adjacent recess, a glass plate overlying said cells and connecting strips, and means clamping said plate to said base to retain said strips in electrical contact with the several cells.

2. A photoelectric device as claimed in claim 1, wherein the actinoelectric material of said cells is selenium, whereby said cells have a high resistance when not illuminated.

3. A photoelectric device of the voltage-change type comprising a base of insulating material, a plurality of connecting strips on said base and each having an outer end overlying and spaced from the inner end of an adjacent strip, a photoelectric cell unit of the current-generating type between each set of opposed inner and outer ends of adjacent strips, each cell unit comprising a layer of actinoelectric material between a back electrode and an upper light-transmitting electrode, and means securing said cells to said base and retaining the respective ends of said strip in electrical contact with the cell electrodes adjacent thereto.

4. A photoelectric device as claimed in claim 3, wherein each cell unit is below the size capable of developing an appreciable current output.

5. A photoelectric device of the voltage-change type comprising a recessed base of insulating material, a plurality of photoelectric cell units of the current-generating type mounted on said base and with the outer surface thereof substantially flush with the surface of said base, each cell unit comprising a layer of actinoelectric material between and united to a back electrode and an outer light-transmitting electrode, a pair of terminals electrically connected to electrodes of different types of two of said cell units, a plurality of conducting members connecting the said cell units in cascade between the said pair of terminals, each connecting member having one outer end overlying the light-transmitting electrode of one cell unit and an inner end in contact with the back electrode of an adjacent cell unit, and means securing said cell units to said base and retaining said connecting members in electrical contact with their associated cell unit electrodes.

ANTHONY H. LAMB.