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2,674,700

PHOTOCONDUCTIVE CELL

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FIG. 1

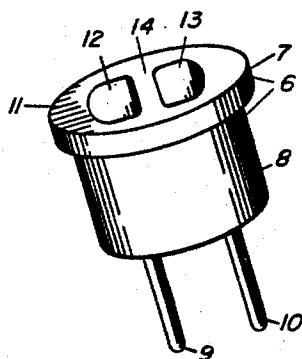


FIG. 2

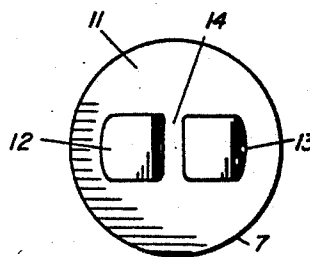


FIG. 3

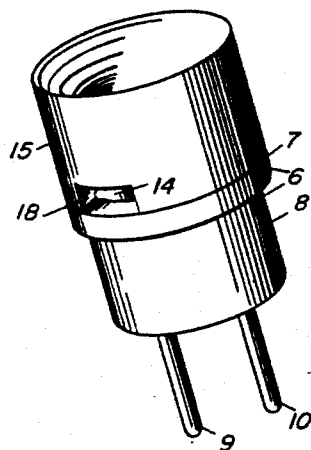


FIG. 4

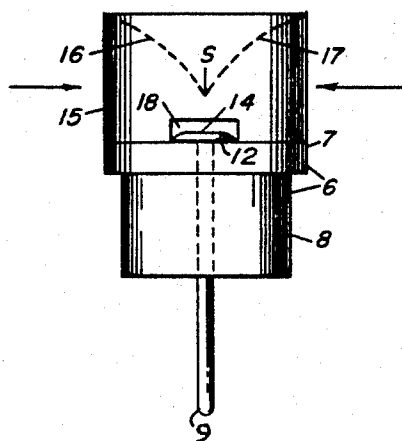
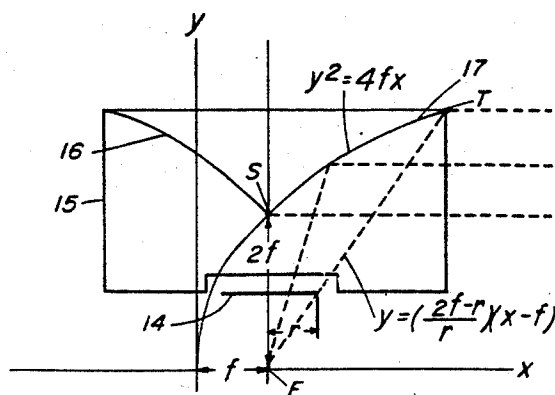


FIG. 5

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PHOTOCONDUCTIVE CELL

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5 Claims.

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This invention relates to a new and improved bead-type photo-conductive cell which is particularly adaptable for hemispherical response.

A principal object of this invention is to advantageously adapt prior art end-on bead-type photoconductive cells for hemispherical response.

Another object of this invention is to obtain a relatively uniform hemispherical response from bead-type photoconductive cells.

Another object of this invention is to provide a photoconductive cell which is easily adaptable to both end-on and hemispherical response.

Another object of this invention is to improve the operating stability of bead-type photoconductive cells.

Heretofore, photoconductive cells generally utilized in commercial installations have comprised the characteristic hermetically sealed envelope typical of most vacuum tubes. With the further development of photoconductive materials, such as lead sulfide, the art has advanced to the point wherein photoconductive materials can be satisfactorily applied or otherwise deposited on an external or outer surface of a relatively small solid bead which acts as a support for this material. If the necessary electrical connections are made to the photoconductive material through the use of terminal pins or lead wires, a satisfactory photoconductive cell results. Furthermore, if the applied photoconductive material is effectively isolated from ambient gases, particularly oxygen and water vapor, a cell of this construction is generally superior to photoconductive cells constructed of the same materials located within hermetically-sealed envelopes.

Because of the relative ease in applying photoconductive materials to flat surfaces, the bead-type photoconductive cells recently introduced have generally a flat surface to which a flat layer of lead sulfide is applied. This configuration therefore naturally presents maximum sensitivity to radiation which impinges at a normal axis to the plane of said lead sulfide. If this radiation deviates from this normal axis, the response obtained from the cell varies in the usual cosine manner, whereby this type of cell construction, for all practical purposes, presents a negligible sensitivity to radiation emanating from sources which lie in the plane of said lead sulfide layer.

This directional response characteristic prevents the use of these bead-type photoconductive cells in many applications for which they would otherwise be highly satisfactory. For example, in certain types of fire detectors wherein photoelectric cells are utilized to detect flame radiation,

it is required that these photoelectric cells present a substantially wide angle response to possible fire sources. If the novel cell hereof is mounted on a wall or ceiling of a room which is to be supervised for fire, a relatively large response is provided to radiation traveling substantially in the plane of the photoconductive material. The end-on bead-type photoconductive cell is incapable of providing this type of response, for the reasons previously noted. Furthermore, to adapt this bead-type structure by applying lead sulfide to a dome-type surface in lieu of a flat surface, would highly complicate the fabrication processes for the cells; and, at the same time, would greatly increase the cost thereof.

The photoconductive cell hereof utilizes as a basic and major subcomponent the end-on cell previously described. A novel feature contemplates a special-type cylindrical lens having a parabolic recess formed therein. This recess has a wall defined by rotating a particular parabolic segment about its latus rectum. The lens is closely coupled to the photoconductive surface whereby radiation emanating from sources other than at an angle which is substantially normal to the flat surface of the photoconductive material is reflected by the walls of this recess, so as to impinge at a substantially normal angle upon the photoconductive material which is preferably located a defined distance from the focal point of the lens.

In order that the features of this invention and the mode of operation thereof may be readily understood, a detailed description follows hereinafter with particular reference being made to the drawings wherein:

Fig. 1 is a perspective view of the basic end-on bead-type photoconductive cell;

Fig. 2 is a plan view of the active surface of the photoconductive cell shown in Fig. 1;

Fig. 3 is a perspective view of the novel photoconductive cell hereof showing the lens with its parabolic recess;

Fig. 4 is a side-elevation view of the photoconductive cell shown in Fig. 3; and

Fig. 5 is a side-elevation view of the parabolic lens hereof, together with a graphical diagram of assistance showing the principles involved in constructing the parabolic recess thereof.

Referring now generally to Figs. 1 and 2, a preferred embodiment of an end-on bead-type photoconductive cell comprises, for example, a glass or ceramic body 6 having a disc-shaped upper portion 7 and a cylindrical lower supporting portion 8. From a generic aspect, however, this bead-

type body may assume any shape that is capable of supporting a layer of photoconductive material. However, inasmuch as the invention hereof comprises and is applicable to end-on bead-type cells, the body used should have at least one relatively flat surface, to which is applied the activated photoconductive material. In the usual instance, it will also be obvious that construction of the cell can be simplified and also be made more cheaply if the photoconductive material is applied to such a flat surface.

Metallic pins 9 and 10 are sealed to body 8 so that a substantial portion of each of the pins protrudes therefrom. The upper ends of pins 9 and 10 are flush with the upper surface of disc portion 7. The top surface of this portion is covered with a layer of photoconductive material 11.

Electrodes 12 and 13 mechanically and electrically couple the flush ends of pins 9 and 10 (not shown) to the thin layer of photoconductive material 11, whereby the electrical impedance measured between pins 9 and 10 is determined principally by the small area of photoconductive material at 14 between electrodes 12 and 13.

The photoconductive material at 14 is the active portion of the cell structure; that is, the appropriate wave lengths of radiant energy must impinge thereon to cause the characteristic photoconductive impedance change. The exposed surface of photoconductive material 14 is preferably covered by a protective compound coating (not shown) whereby the active area at 14 is isolated from water vapor which tends to impair the stability of the cell. Electrical circuit connections are made to the cell by inserting pins 9 and 10 into a small-size female socket. The projecting rim of portion 7 with respect to body portion 8 merely facilitates the manual insertion and removal of the cell from its socket and is therefore not actually required for the operation of the cell.

By coupling lens 15 to the upper surface of the photoconductive cell, as shown in Figs. 3 and 4, the angle of response of the cell is increased, whereby substantially any radiation emanating from any hemispherical source will create a substantial output response from the cell. Lens 15 may be constructed of any of the many optical materials which are well known in the lens art having at least an index of refraction greater than a minimum value hereinafter determined. This lens has preferably a cylindrical outer wall, whereby a contiguous surface is presented with respect to projecting rim 7. An inverted parabolic recess 16 and 17 is formed from the upper surface, with a principal axis corresponding to that of the principal axis of the cylindrical lens. The contours of this lens from the base to the apex of the conical recess are formed by rotating a parabolic segment about the latus rectum for the parabola.

A slotted groove 18 is formed from the bottom surface of lens 15 whereby electrodes 12 and 13 do not disturb the seating of lens 15 on the upper surface of disc portion 7. Lens 15 may be cemented or otherwise mechanically bonded to body 8 by suitable conventional means.

A side-elevational view of lens 15 is shown in Fig. 5 with certain graphical construction superimposed thereon whereby the principles involved in determining the shapes of parabolic segments 16 and 17 may be readily understood. In order to simplify the explanation, only the design of parabolic segment 17 will be stated in detail.

It should be understood, however, that parabolic segment 16, as well as the entire inverted recess, is constructed by rotating segment 17 about the latus rectum for the parabola of which segment 17 is a portion.

Parabolic segment 17 forms a portion of the upper half of the parabola $y^2=4fx$, which is symmetrical about the x axis and whose vertex is located at the origin for the x and y axes. The focal point F is located a distance f from the origin. Point S represents the intersection of parabola segments 16 and 17 and is located at the extremity of the latus rectum, a distance of $4f$ from focal point F .

The equation for the parabola is therefore

$$y^2=4fx$$

Point T represents the intersection of parabolic segment 17 with the side wall of lens 15. The line drawn from point F to point T is represented by the equation

$$y = \frac{(2f-r)}{(x-f)}$$

and is the reflected ray for the incident ray at point T .

Surface 14 represents the active photoconductive area of the cell hereof. This area is preferably located somewhat above focal point F , whereby parallel radiation impinging upon segment 17 is diffused over surface 14. The radius of surface 14 is represented by r which is the length of the normal to latus rectum SF extended to FT . It should be noted that the radiation impinging upon surface 14 becomes more diffuse as surface 14 is elevated toward point S . If it is desired that this radiation have an extreme concentration, surface 14 should be located so that it passes through focal point F . In the usual cell construction, however, concentration of radiation upon a small photoconductive surface is not highly desirable, inasmuch as improved cell characteristics can be obtained if this radiation is spread uniformly over all of the active area of the cell. The index of refraction of the material forming lens 15 should be such that a ray impinging at point S will have an angle of reflection greater than the critical angle, whereby said ray will be reflected and not refracted.

It is to be understood that the above-described arrangement is illustrative of the application of the principles of this invention, and numerous other arrangements may be devised by those skilled in the art without departing from the scope thereof.

I claim:

1. A photoconductive cell comprising a support, a layer of photoconductive material applied to said support, and a lens mechanically coupled to said support, said lens having an inverted recess formed by rotating a parabolic segment about its latus rectum.
2. A photoconductive cell comprising a support, a layer of photoconductive material applied to said support, and a lens mechanically coupled to said support, said lens having an inverted recess formed by rotating a parabolic segment about its latus rectum, said photoconductive layer being positioned at a normal angle to said latus rectum.
3. A photoconductive cell comprising a support, a layer of photoconductive material applied to said support, and a lens mechanically coupled to said support, said lens having an inverted

5

recess formed by rotating a parabolic segment about its latus rectum, said photoconductive layer being positioned at a normal angle to said latus rectum and being centrally disposed thereabout.

4. A photoconductive cell comprising a support, a layer of photoconductive material applied to said support, and a lens mechanically coupled to said support, said lens having an inverted recess formed by rotating a parabolic segment about its latus rectum, said photoconductive layer being positioned at a normal angle to said latus rectum and being centrally disposed thereabout at a distance from the apex of said inverted recess of less than two times the focal length for said parabolic segment.

5. A photoconductive cell comprising a support, a layer of photoconductive material applied to said support, means for establishing electrical connections to said layer of photoconductive material, and a lens mechanically coupled to said support, said lens having an inverted recess

6

formed by rotating a parabolic segment about its latus rectum, said lens being of material having an index of refraction such that a ray impinging at the apex of said inverted recess at an angle of 45° to the normal thereof will have an angle of reflection greater than the critical angle, said photoconductive layer being positioned at a normal angle to said latus rectum and being centrally disposed thereabout at a distance from the apex of said inverted recess of less than two times the focal length for said parabolic segment.

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