June 19, 1934. J. C. CLARK 1,963,692

LIGHT SENSITIVE CELL

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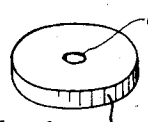

Fig.1

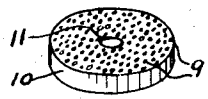

Fig.2

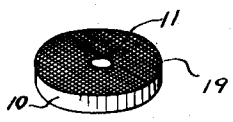

Fig.3

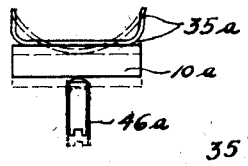

Fig.4a

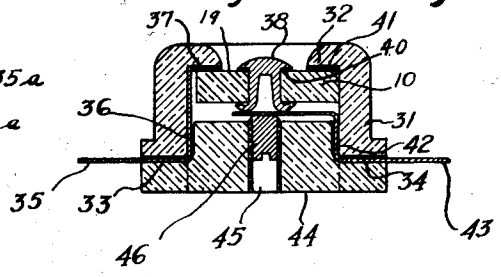

Fig 4

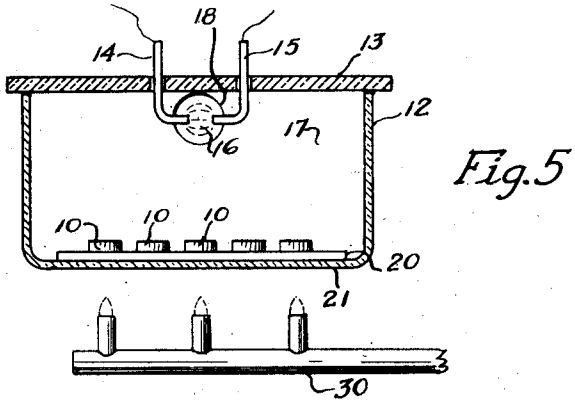

Fig.5

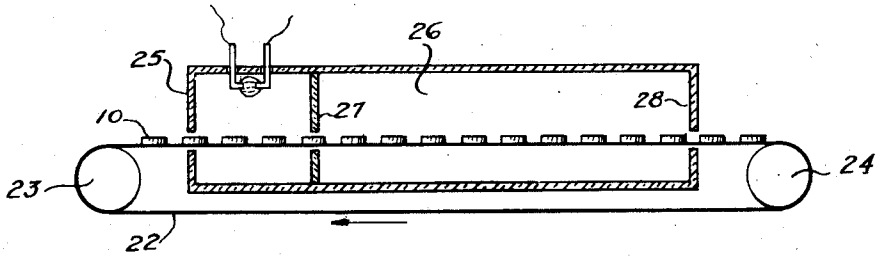

Fig.6

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LIGHT SENSITIVE CELL

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4 Claims. (Cl. 201—63)

This invention relates to light sensitive cells and more particularly to a process and an apparatus for making same and to a circuit in which they may be used.

Although probably the earliest form of light sensitive cells to be made was the so called selenium cell, yet it has not gone into any appreciable commercial use owing to certain defects inherent in such cells as heretofore constructed. In using the designation "selenium cells" it is to be understood that selenium typifies a group of substances each of which under certain conditions has the property of affording variable resistance to the passage of electrical current according to the degree of stimulation thereof by incident light. The incident light may be either in the visible or the invisible spectrum. Thus in construing the term "selenium", equivalent materials such as certain sulphides of silver and of tellurium, and the like, may also be used according to the necessities of the occasion. Light sensitive cells as heretofore constructed have been so prohibitive in price as to militate against successful commercial exploitation, they have been possessed of a time lag of such duration as to render them unavailable for many photoelectric purposes and they have been of such irregular and unpredeterminable resistance as to be untrustworthy. Moreover, owing to the instability of their light sensitive surface they have been of very short life. The problem of producing a thin film of light sensitive material of uniform density and thickness upon a base of insulating material in such manner as to secure substantially identical resistance properties on any pair of a series of cells, and in which the film is so firmly adherent to the insulating base as not to flake or chip off has been too great for the prior art and the production of such light sensitive cells has fallen far short of the demands of the art. The problem of adherence alone has heretofore been insuperable.

In using light sensitive cells in the past it has been necessary to associate each cell with an amplifying unit of such complexity as to militate against their commercial success.

It is among the objects of this invention; to provide a process for forming light sensitive cells; to provide a new and improved light sensitive cell of a wide range of utility, of ruggedness and long life; to provide a light sensitive cell of far greater power than has ever before been developed; to provide a light sensitive cell which is so quickly responsive to stimulation as to be possessed of no appreciable time lag; to provide a base with a thin film of light sensitive material for photoelectric purposes in which the film is so firmly adherent to the base as to obviate chipping and flaking; to provide an improved light sensitive unit as an article of manufacture; to provide a light sensitive cell of greatly reduced cost; to provide a light sensitive cell of uniformity and high efficiency; and many other objects and advantages as will become more apparent as the description proceeds.

In the accompanying drawing:

Fig. 1 represents a perspective of the insulating base forming the support for the light sensitive film,

Fig. 2 represents a similar view of the insulating base with a coating of powdered light sensitive material comprising an intermediate stage in the process of making a cell,

Fig. 3 represents a similar view of the final stage of the light sensitive cell,

Fig. 4 represents a vertical section through an assembled light sensitive unit incorporating a light sensitive cell of this invention,

Fig. 4*a* represents a diagrammatic end elevation of a fragmentary unit incorporating a variable resistance factor,

Fig. 5 represents a vertical section through a form of apparatus which may be used to cause the deposition of powdered light sensitive material upon the insulating bases and in which the fusing and annealing steps may also take place,

Fig. 6 represents diagrammatically a slightly modified form of apparatus for forming the cells according to the invention herein set forth.

A light sensitive cell, such as a selenium cell for instance, may be formed by applying a very thin coating sheet of selenium or other light sensitive material upon the surface of an insulating base, if the material is suitably annealed. The coating may be very thin, of homogeneous texture, of equal density throughout its area, and must adhere to the base with permanence to prevent its being chipped or flaked from the base. So far as known it is not possible to secure such adherence by the use of any known adhesive, as adhesives prevent the proper photoelectric functioning of the film, and, moreover, they cannot stand the annealing temperatures.

The insulating materials of which the bases of the cells may be formed obviously include a wide range. The only preferences being for materials which will stand the annealing temperatures, are of suitable insulating properties

and which have a relatively smooth surface upon which the film of light sensitive material may be deposited. Without necessarily limiting the invention thereto, it has been discovered that glass, porcelain, mother-of-pearl, and some of the phenolic condensation products are satisfactory materials for the bases of the cells of this invention.

The process forming part of this invention comprises the step of applying selenium or other light sensitive material in a powdered form to the upper surface of a suitable base, then fusing and annealing the selenium or other light sensitive material in position on said base. In order to secure the deposition of the powdered light sensitive material upon the surface of the base it is preferred to use an apparatus like the chamber disclosed in Fig. 5, or that disclosed in Fig. 6.

The insulating base 10 disclosed in Figs. 1, 2 and 3 preferably has a central aperture 11 concentric with the periphery of the base in the event that the round or annular base disclosed in Figs. 1, 2, 3 and 4 be used. As will be pointed out later other shapes of bases may be used according to requirements. Referring to Fig. 5, the chamber 12 has a removable lid 13 through which, in insulated relation, extend the electrodes 14 and 15 forming a spark or arc gap 16 within the chamber. The electrodes carry a high potential (10,000 volts having been found satisfactory) so that an electric arc exists between the terminals of electrodes 14 and 15. An end wall 17 of the chamber 12 has an opening 18 in registry with the spark gap between the electrodes and forms an opening for the insertion of selenium or the like. A suitable number of bases 10 may be mounted on a removable plate 20 disposed on the bottom 21 of the chamber 12. Introduction of selenium or similar light sensitive material into the electric arc subjects the material to such an intense heat as to vaporize or gasify the material. Such gasification fills the chamber with a reddish gas (in the case of selenium) from which there is a precipitation of a dust or powder 9, which, being heavier than air, settles upon the upper surfaces of the multiplicity of bases 10. The dispersion of the powder incident to the gasification of the material secures a uniform distribution of the particles 9 on the surfaces of the respective bases. It is probable that the powder is an oxide of selenium, when selenium is the material used, as it is of a distinctly reddish tinge. The precipitation of the powder gives a particle distribution such as is substantially indicated in Fig. 2. The gasification preferably takes place with casing 12 subjected to merely atmospheric pressures and temperatures aside from such elevation of temperatures as may be incident to the use of the electric arc.

In the disclosure of Fig. 6 the endless conveyor 22 moving in the direction indicated by the arrow about rollers 23 and 24 carries a series of bases 10, and in its travel passes within the gasifying or precipitation chamber 25. Continued travel of the conveyor 22 carries the bases from the precipitation chamber 25 into the annealing chamber 26 defined by end walls 27 and 28. Obviously the conveyor 22 may be comprised of a series of conveyors of varying speeds if desired.

It will be clear also that any other means or mechanisms may be used to secure the deposition of the powder 9 on the surface of the insulating base as shown in Fig. 2. As it requires very careful handling of the cells in the stage of that in Fig. 2, and as shown in Fig. 5, it is preferred for certain purposes that the powdered material be subjected to a preliminary fusing temperature to enable the facile handling of the units. It has been found that a temperature of 100° C. is sufficient for such preliminary fusing. The fusing may take place in the chamber shown in Fig. 5 although it is preferable that such powder as has been deposited on other surfaces of the chamber such as on the plate 20 adjacent insulating bases 10, be first removed. If desired the chamber shown in Fig. 5 may also be used as the fusing and annealing chamber without removing the units therefrom. To this end a suitable burner 30 may be provided to raise the temperature of the chamber to the annealing temperature. It is preferable, however, as noted, that the annealing take place in another chamber which may be similar to chamber 12 of Fig. 5, except that there need be no electrodes and no material introducing aperture in the wall thereof. As noted the provision of the plate or false bottom 20 facilitates the removal of powdered covered bases from one chamber, and insertion in another without disturbing the powder on the respective bases.

With an insulating base uniformly covered with the powdered particles as shown in Fig. 2, it is necessary to anneal the material on the base. The annealing consists in elevating the temperatures to a suitable annealing heat and maintaining such heat for a perceptible interval of time. It has been found that very satisfactory results may be obtained by maintaining a temperature of 180° C. for a period of approximately four hours. In the disclosure of Fig. 6 the chamber defined by the walls 27 and 28 and designated as 26 may have this temperature and the speed of the conveyor may be so proportioned as to cause each unit to remain in the chamber 26 for the desired length of time. It will be understood that the temperatures and times given are those which in practice have been found best suited to obtain the most desirable results but variations in either the temperature or the time of annealing are to be construed as within the scope of this invention.

It is found that the initial elevation of the temperature causes a fusing or coalescing of the previously independent and detached particles into a uniform homogeneous apparently molten film. The fusing seems to be accompanied by the driving off of the oxides assumed to be present in the powder, as the reddish powder in fusing turns to the dark silver gray of the light sensitive material. It is preferred that the completed fused cells be permitted to return to room temperature at a reasonably slow rate in order that the benefits of the annealing be retained.

The finished cell as shown in Fig. 3 comprises the base 10, the upper surface of which is coated with a thin film 19 of light sensitive material of uniform density, thickness and resistance, in which the light sensitive film 19 is permanently adherent to the base 10 without the use of adhesives or other extraneous material.

In order to assemble the cells in operative merchandisable units it is preferred to provide some such structure as is shown in Fig. 4. In this figure a tubular shell 31 is provided having an internal annular flange 32 concentric with the axis of the shell and having substantially radial connector passages 33 and 34. A connector 35 passing through the opening 33 may be received in a notch 36 cut in the wall of the shell 31 or in

the plug to be described, and terminates in an annulus 37 of substantially the same radial thickness as the flange 32. The internal diameter of the shell 31 is such as to afford a sliding fit for the round base 10 of the light sensitive cell. A completed cell 10 having the fused light sensitive coating 19 is provided with an axial rivet 38 or the like, comprising a contact in the central aperture 11 and the head of the rivet is established in firm electrical contact with the light sensitive surface 19 by means of a layer of tinfoil or other deformable material 40. The assembled cell with its central contact element 38, is then inserted axially into the shell 31 and into firm electrical contact with the annulus 37 of the connector 35 by means of a layer of tinfoil, or the like, 41. The shell 31 or the plug to described has a notch 42 to receive a connector 43 passing through the plug 44 and up to electrical contact with the bottom of rivet 38. The plug 44 having an axial threaded bore 45 is provided to close the bottom of the shell 31 with a tight fit. This plug may be cemented in place or may be held frictionally against undesired retraction in any desired manner. A set screw 46 is threadably engaged in the bore 45, and is vertically adjustable to abut the inner end of the connector 43, to simultaneously establish and maintain good electrical contact between the rivet 38 and connector 43, and also to push the light sensitive cell up into firm engagement and good electrical contact with the annulus 37 of connector 35 through the medium of the interposed tinfoil.

With the parts made of any suitable insulating material it will be observed that the rivet 38 is substantially concentric with the flange 32 of shell 31 so that there is an annular band of light sensitive material 19 exposed to the action of such light rays as may be incident thereon. The entire construction is of great strength and the sensitive surface 19 is protected from impacts and other disruptive actions by the reinforcing and protecting wall constituted of the flange 31.

According to a modification of this invention the bases instead of being round as in the preferred form may be rectangular or of any other desired configuration, and may be associated with contact elements in such a manner that the resistance available may be varied within wide limits according to the necessities of a given installation, or in order to make each of a given series of cells have identically the same or predeterminedly different resistance factors. In this case as shown in Fig. 4*a*, the base 10*a* is vertically movable under the influence of an adjustable element such as a set screw 46*a* to abutting engagement with a pair of spaced curved contact spring elements 35*a*, of which but one is shown. The arrangement being such that the tighter the engagement of the base 10*a* with the spring elements, the greater the area of light sensitive material engaged by said elements and, conversely, the smaller the urge from the set screw or other adjusting element, the smaller the area of light sensitive material engaged by the contacts. This same action can be accomplished with the disclosure of Fig. 4 by substituting a crinkle-washer of resilient material for the annulus 35 to secure the variable resistance.

I claim:

1. A light sensitive cell comprising a shell having a rigid permanent flange having an axial sight opening, a light sensitive cell mounted in the shell and abutting the flange, the cell having a sensitive surface, a contact engaged between the flange and the sensitive surface of the cell, a second contact mounted on the cell in electrical engagement with the sensitive surface, a connector leading into the shell to engagement with the second contact, a plug closing the shell, and means movable relative to the shell and operative relative to the cell for forcing the connector into engagement with the second contact and also for forcing the cell into engagement with the first mentioned contact.

2. A light sensitive resistance comprising a cylindrical shell having an inward radial flange having an axial opening, a light sensitive disc of resistance material disposable in the cylindrical shell and abutting said flange, a plug closing the end of said shell, contacts extending into the shell to contact with the light sensitive disc, said plug having an aperture and an adjusting element mounted in the aperture and effective on one edge of the disc to push the disc against said flange.

3. A light sensitive unit comprising an insulated shell having an inward radially extending flange having an axial opening, an arcuate contact disposed in parallel relation to the flange and having a connecter leading out of the shell, a disc having an axial opening, a film of light sensitive resistance material on the disc surrounding the opening, a contact mounted in the opening and engaging the film and having a part extending beyond the disc, a connecter leading into the shell to engagement beneath the said last mentioned contact, a plug mounted in the end of said shell and having an axial threaded bore, a set screw mounted in said bore and bearing upon said last mentioned connecter and contact to force the film on the disc into electrical engagement with the first mentioned contact.

4. A light sensitive unit comprising a shell of insulating material having a rigid permanent inwardly directed flange having an axial sight opening, a light sensitive cell mounted in the shell and abutting the flange and having a light sensitive surface, an arcuate contact engaged between the flange and the sensitive surface of the cell, a connector leading into the shell and connected with said arcuate contact, a second contact disposed in electrical engagement with the light sensitive surface, a second connector leading into the shell and connected with said second contact, a plug closing the opposite end of the shell in spaced relation to the flange, means movable relative to the shell for forcing the cell toward said flange into engagement with said arcuate contact.

JOSEPH C. CLARK.