Sept. 22, 1942. C. W. HEWLETT 2,296,670

PHOTO-ELECTRIC CELL

Filed March 21, 1934

Fig. 1.

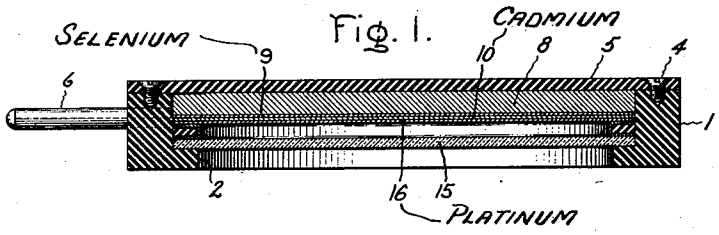


Fig. 2.

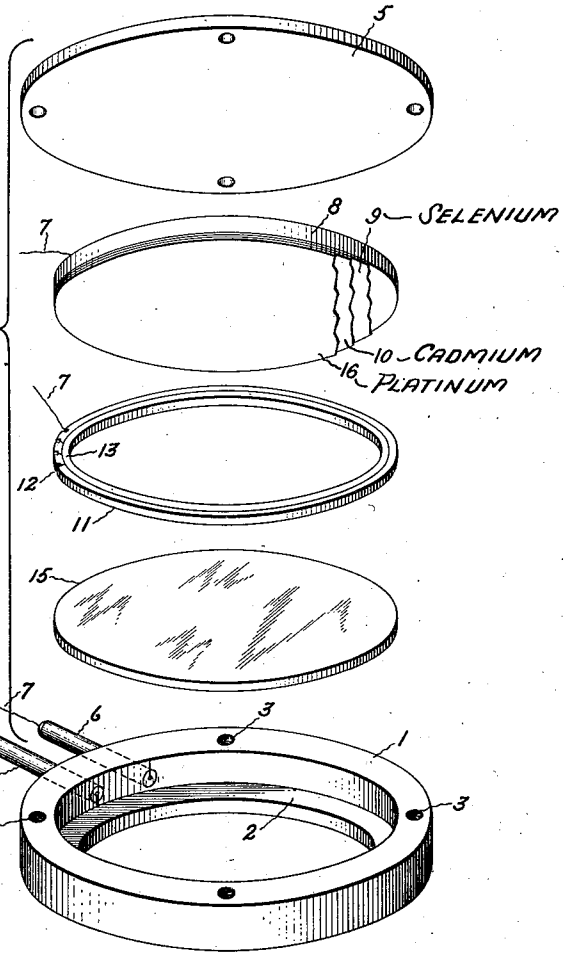
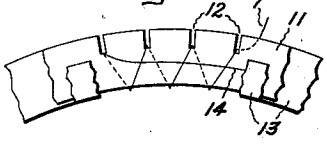


Fig. 3.



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2,296,670

PHOTOELECTRIC CELL

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5 Claims. (Cl. 136—39)

The present invention relates to light-sensitive devices, more particularly to photo-electric cells, which generate a measurable electromotive force when subjected to light of practical intensities.

An object of the invention is to provide a highly sensitive photo-electric cell, which responds efficiently to light radiations, giving rise to greater potentials, so that the cell may be employed as a direct-reading photometer. Another object is to provide a light-sensitive device of this character in which the response to the light radiations, as measured in terms of the output current, shall follow faithfully the undulations of the light which impinges on the device.

A still further object is to improve the method of manufacturing a cell of this sort so as to adapt the technique of manufacture to quantity production methods and still obtain devices of standard or uniform performance with a high operating efficiency.

Due to its high degree of sensitivity, the improved cell is particularly applicable to the various electrical systems in which a light-sensitive cell is an integral part thereof and specifically to the transmission of photographs, facsimile and the like, and to television systems wherein it is essential to employ a highly efficient cell with respect to light sensitiveness and current output.

In carrying out these objects, my invention contemplates the use of a disk of iron or other suitable metal with a coating of selenium and layers of certain metals (specifically cadmium and platinum) superposed on the selenium, as will be explained hereinafter. The invention will be better understood when reference is made to the following specification and accompanying drawing in which Fig. 1 represents a cross-sectional view of the improved light-sensitive member; Fig. 2 shows an exploded view of the various parts of the device, arranged in the order in which they are assembled, and Fig. 3 is a fragmentary view showing a preferred method of making contact between an external conductor and a thin metal layer which is deposited on the light-sensitive substance.

Referring to Fig. 1, numeral 1 designates a cylindrical casing or container, preferably made of insulating material such as a phenolic condensation product. The casing is provided at the bottom with an inwardly extending flange 2 which conveniently serves as a ledge or shoulder for the light-sensitive unit, described hereinafter. At the upper edge of the member 1, as shown, there are several threaded holes 3 (four in number) adapted to receive screws 4 for rigidly securing a cover 5, preferably also of a phenolic condensation product, to the casing. There is a pair of contact pins 6, shown more clearly in Fig. 2, arranged adjacent one another in parallel arrangement and secured in any suitable manner to the periphery of the casing. For example, these pins may be fitted snugly within openings extending parallelly through the casing. The contact pins have a fine central bore, as shown in Fig. 2, which receives a conductor 7 for bringing out, in a convenient manner, electrical connections from the active surfaces of the light-sensitive unit.

The light-sensitive unit itself is shown more clearly in Fig. 2 and consists essentially of a circular disk 8 constituted of a base metal such as iron or nickel and having a diameter as to fit snugly within the inner surface of the casing. On one side of the disk, on the lower side as shown, there is a thin layer of selenium 9 which may be coated on the disk in any suitable and well-known manner, for example, by evaporation or by pasting. Before the selenium is applied to the disk, it is preferred that the latter be ground to make it smooth and clean, then sand-blasted in order to give the selenium a good grip on the surface. The plate may be mounted in a vacuum chamber and the selenium evaporated in a high vacuum and condensed on the sand-blasted surface. The coated disk may be heated slightly above the melting point of selenium and the evaporated layer melted. The coated disk is then quickly cooled and placed in an oven at a temperature of approximately 180° C. and held at this temperature for a time interval determined by experiment and depending upon the quality and kind of selenium employed. This time interval will usually be between 24 and 72 hours. The heat treatment converts the selenium into the metallic light-sensitive form.

It is necessary of course to be able to make good electrical contact with the treated selenium layer and for this reason, a metal layer is coated thereon which consist of a non-oxidizable metal such as platinum. The platinum may be applied in any suitable and well-known manner but it is preferred to sputter the material. Instead of coating the selenium directly with platinum, I have found it advantageous first to apply a thin layer 10 of a metal of the second group of elements appearing in the Mendelejeff periodic table, preferably cadmium. For this purpose, the selenium-covered iron disk may be placed in a chamber containing argon and the selenium

surface sputtered with an exceedingly thin layer of cadmium. The pressure of the argon in the chamber may be maintained at about 200 microns, and a sputtering current of approximately 50 milliamperes employed. During this sputtering process, a flask of liquid air is arranged to penetrate into the sputtering chamber so that any condensible vapors may be immediately removed from the discharge. It is preferred that the sputtering process be carried out in short flashes so as to avoid heating of the selenium surface as much as possible. The optimum thickness of the cadmium deposited in this manner is exceedingly small and is so thin as can just barely be seen on the surface.

The cadmium- and selenium-treated disk may then be removed from the sputtering chamber and laid aside in the air to age until the current sensitivity produced by the stimulus of the surrounding light acting on the selenium through the thin layer of cadmium, comes down to practically zero. This reduction in current may be indicated on a microammeter. As the current diminishes, the open circuit electromotive force as measured between the cadmium layer and the metal disk, goes up rapidly. When the current sensitivity reaches substantially zero and the generated electromotive force increases to its greatest value, the aging step is terminated. The disk treated in this manner may then be immersed in an atmosphere of argon in an evacuated chamber and a thin layer 16 of platinum sputtered over the thin layer previously laid down. Platinum has a lower specific conductivity than cadmium but its effect is to restore conductivity to the combined selenium-cadmium surface and to make good electrical contact therewith. In case the platinum is sputtered onto the cadmium in an argon atmosphere, the pressure of the latter may be maintained at about 200 microns of mercury and a sputtering current of about 50 milliamperes employed, as in the case of the cadmium. The current is also preferably applied as short flashes in order not to heat the selenium surface unduly. The platinum layer should be extremely thin, just barely seen on the surface because as will be pointed out hereinafter, the light, in order to reach the selenium layer has to pass through both metal layers.

As stated hereinbefore, the iron or nickel disk 8 constitutes one of the terminals of the light-sensitive device and the platinum layer, the other terminal. Adequate contact can be readily made between one of the conductors 7 and the iron disk 8 by means of pressure exerted on the conductor when the light-sensitive unit is assembled in the manner described hereinafter, but special provision must be made for making proper contact between the other external conductor 7 and the platinum layer which is extremely thin.

While various ways of making this last-mentioned contact will suggest themselves to those skilled in the art, I prefer to employ an arrangement in which contact is made over a peripherally complete annular surface of the platinum layer and for this purpose, I employ a cardboard ring 11 which has several slots or notches 12 cut in the periphery thereof. The outside diameter of this ring is approximately the same as that of the iron disk and the width of the ring may be approximately $\frac{3}{32}$", the thickness approximately .060". This cardboard ring is lined on the inner surface and over the entire width of the under side, as shown, but only partly over the width of the upper side, with a layer of tinfoil 13, illustrated more clearly in Figs. 2 and 3. The wire 7 which is provided to contact with the platinum layer may be wound between the inner edge of each slot and the inner surface of the cardboard ring, as shown in Fig. 3, leaving a free end 14 which extends over the upper surface of the ring 11 for a distance of approximately the same length as the distance over which the slots 12 extend. This wire 14 is rigidly secured to the ring 11 by means of the tinfoil 13 which covers the same and tends to hold it by friction against the cardboard. The other end of the wire 7 extends through one of the slots and is threaded through the internal bore of the terminal pin 6, as shown more clearly in the lower view of Fig. 2, and finally soldered to the pin at its outer end. The other pin 6 is electrically connected to the iron disk 8 by means of a wire 7 which also passes through a central bore in the pin 6 and is soldered thereto.

As stated hereinbefore, the tinfoil ring 13 extends over the entire width of the cardboard ring 11 only at one face of the latter (i. e. the lower face as shown) but at the upper face, extends approximately over one-half the width of the ring. This construction is desirable to avoid leakage along the peripheries of the elements constituting the light-sensitive unit. If the foil extended over the entire width of the upper face of the ring 11, the outer edge of the foil, at the top of the ring, might curl upwardly and bridge the thin platinum, cadmium and iron electrodes, thereby short-circuiting the cell, because the foil is at the potential of the platinum or other exterior metal layer.

For assembly, the casing 1 is placed in the position shown in Fig. 2 and a transparent glass plate 15 first placed within the opening in the casing, the diameter of the glass plate being such as to permit it to fit snugly within the annular space provided. The purpose of the glass is to protect the delicate surface of the light-sensitive layer. If desired, the glass may be entirely dispensed with and the platinum layer simply covered with a protective transparent lacquer, except at the place where contact is to be made. The ring 11 is then placed on top of the glass plate with the portion half covered by the tinfoil uppermost, or in case a glass window is not provided, directly within the annular space in the casing.

The light-sensitive unit which consists of the iron disk and the selenium and platinum layers with or without the cadmium, is next introduced into the annular space, at the same time the wires 7 are threaded through the openings in the contact pins 6 which have previously been secured in place. As stated hereinbefore, these wires are electrically connected to the disk 8 and the contact ring 13 respectively.

The protective cover 5, having a diameter of approximately the same size as the outer diameter of the casing, may then be secured to the latter by the screws 4. The last step of course is to solder the ends of the wires 7 to their respective contact pins 6 and cut off the excess wire.

It will be apparent that the light-sensitive member is contained wholly within the casing and is protected at the front or lower side, as shown, by the glass plate 15 or the lacquer layer referred to hereinbefore, and at the back or upper side, as shown, by the cover 5. The construction is extremely rugged. Adequate provision has been made for bringing out leads from

the active members and for permitting practically the entire surface of the light-sensitive member to be subjected to light. Light may be introduced through the glass window 15, directly onto the platinum layer, which on account of being semi-transparent, permits the radiation to pass through and affect the under layer of cadmium or the selenium layer, or both.

While I do not desire to be limited to any particular theory of operation, it appears that when light falls on the layers of material including the selenium, it causes the liberation of electrons from the selenium and delivers them to the metal layers. These electrons flow from the metal layer 16 through the tinfoil gasket 13 which connects with the wire 14 and out through the conductor 7 to the terminal pin 6. These electrons constitute a current which may flow through a load circuit consisting of a measuring instrument, such as a microammeter calibrated in foot candles, back to the iron plate. A cell which has been fabricated in accordance with the method set forth hereinbefore, employing the cadmium layer, is capable of delivering from 100 to 300 microamperes per lumen, which readily enables the device to give an adequate reading on a microammeter when exposed to daylight or other light of practical amounts.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A photo-electric cell comprising an annular casing of insulating material provided at one end on the interior, with a flange, and at the other end, with a cover of insulating material, a light-sensitive unit contained between said flange and cover, said unit including a metal plate coated successively with selenium, cadmium and platinum.

2. A photo-electric cell comprising an annular casing of insulating material provided at one end on the interior, with a flange, and at the other end, with a cover of insulating material, a light-sensitive unit contained between said flange and cover, said unit including a metal plate coated successively with selenium, cadmium and platinum, a conductor connected to said plate and a metal ring conductor contacting with the platinum.

3. A photo-electric cell comprising an annular casing of insulating material provided at one end on the interior, with a flange, and at the other end, with a cover of insulating material, a light-sensitive unit contained between said flange and cover, said unit including a metal plate coated successively with selenium, cadmium and platinum, a conductor connected to said plate, a metal ring conductor contacting with the platinum, and a protective layer of transparent material coated on the platinum within the interior of said metal ring conductor.

4. A photo-electric cell comprising a base metal coated successively with selenium, cadmium and platinum.

5. A photovoltaic cell comprising a conducting base plate, a layer of light-sensitive material consisting substantially of selenium in crystalline form upon said base plate, a translucent intermediate layer consisting substantially of cadmium in intimate molecular contact with the crystalline surface of said light-sensitive layer and a translucent homogeneous covering layer consisting substantially of platinum upon said intermediate layer.

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