

Dec. 6, 1938.

J. H. DE BOER ET AL

2,139,223

PHOTOELECTRIC DEVICE

Filed May 11, 1931

Fig. 1

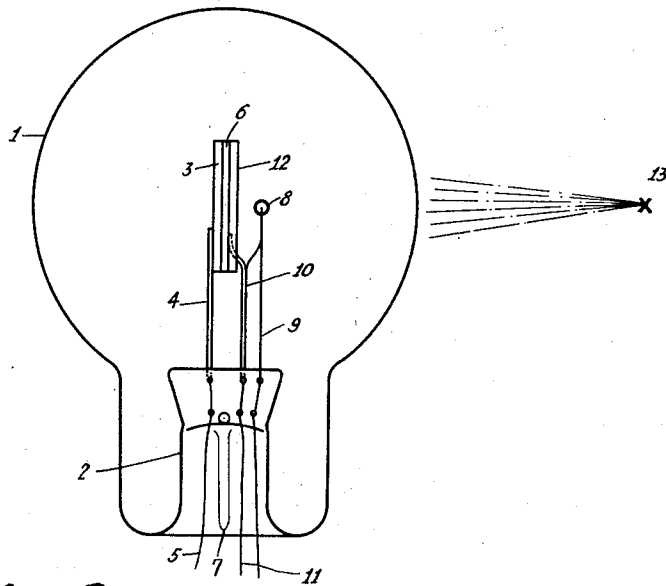
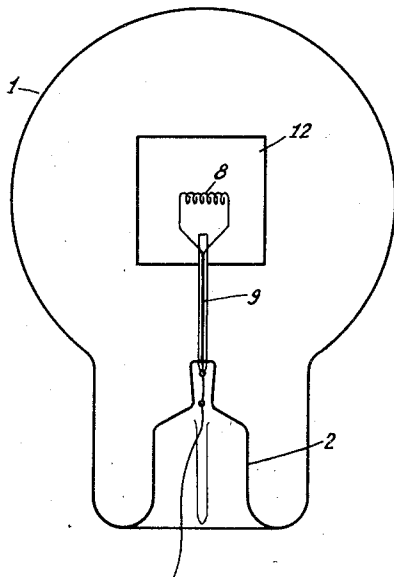


Fig. 2



INVENTOR
JAN HENDRIK DE BOER
WILLEM CHRISTIAAN VAN GEEL
BY *H. S. Swover*
ATTORNEY

UNITED STATES PATENT OFFICE

2,139,223

PHOTOELECTRIC DEVICE

Jan Hendrik de Boer and Willem Christiaan van Geel, Eindhoven, Netherlands, assignors to Radio Corporation of America, a corporation of Delaware

Application May 11, 1931, Serial No. 536,648
In the Netherlands May 10, 1930

8 Claims. (Cl. 136—89)

(Granted under the provisions of sec. 14, act of March 2, 1927; 357 O. G. 5)

This invention relates to photo-electric devices, i. e., devices by means of which certain electric phenomena may be produced by light rays.

A photo-electric device according to the invention comprises an electrode consisting at least partly of a photo-electric substance, and separated from another electrode consisting of electrically conducting material by a layer comprising one or more semi-conducting solid materials. By the term "photo-electric substance" is to be understood hereinafter a substance which is capable of emitting electrons when being irradiated by means of visible or invisible light rays.

Excellent results may be obtained by making the photo-electric electrode of one or more alkali or alkaline earth metals. By the combination of such a photo-electric electrode comprising an intermediate layer consisting of semi-conducting substances the device is rendered extremely sensitive.

On irradiating the photo-electrically active electrode a potential difference appears to be set up between both electrodes of the device, said potential difference being extremely great if the photo-electrically active substance consists of an alkali or of an alkaline earth metal. If the electrodes of the device are connected to the terminals of a galvanometer the potential difference set up by the irradiation causes the passage of a current through the galvanometer. The value of the potential difference set up and consequently of the current traversing the galvanometer appears to depend on the intensity of the light by which the photo-electric electrode is irradiated.

In many cases the manufacture of the device may be simplified by forming the intermediate layer of a compound of the metal of which one of the electrodes of the device is made. If one of the electrodes consists, for example, of a metal whose oxide is semi-conducting then the intermediate layer may be easily obtained by oxidizing that electrode.

Especially if the photo-electric substance consists of an alkali- or of an alkaline earth metal the sensitiveness of the device may be increased by causing the photo-electric substance to be adsorbed by the intermediate layer.

In many cases the value of the potential difference set up on irradiation between the electrodes may be favourably affected furthermore by making the photo-electric electrode so thin that it is transparent to light, so that the rays may penetrate to the boundary surface of the photo-electric electrode and the semi-conducting sub-

stance. To this end the photo-electric electrode may be advantageously made of a monomolecular layer of a photo-electric substance.

Another means for increasing the sensitiveness consists in the provision of particles of a photo-electric substance, preferably of an alkali- or alkaline earth metal, in the intermediate layer.

The invention will be more clearly understood by reference to the accompanying drawing, representing, by way of example, one embodiment thereof. In this drawing Figs. 1 and 2 are different views of the device.

The device illustrated comprises a sealed envelope 1 made of glass, quartz or similar material, to which a stem 2 is sealed, on which the electrodes of the tube are mounted. One of these electrodes is constituted by a plate 3 which may be of silver, and which by means of a support wire 4 is fixed to the stem of the tube. This support wire is connected to a supply conductor 5.

Before introducing the silver plate 3 into the envelope it is exposed on one side to the action of iodide vapour, due to which semi-conducting layer 6 of silver iodide is formed on the silver plate. After mounting the silver plate 3 with the iodide layer 6 in the envelope and after exhausting the latter, which may be effected by means of a vacuum pump connected to the tube 7, barium is precipitated on the thin silver iodide layer. To this end a filament 8 consisting of zirconium is provided in the envelope and fixed to a supply conductor 9 and to a lead wire 10, part of which bears elastically on the silver iodide layer. This lead wire 10 is connected to the supply conductor 11. Before mounting the filament 8 in the envelope, it is coated with barium oxide which is reduced by the zirconium on heating the filament. The barium produced evaporates, deposits on the semi-conducting layer of silver iodide, and forms the photo-electric electrode 12 thereon, which is connected to the lead wire 10. After forming the photo-electric electrode the envelope 1 may be filled, if desired, with an inert gas or vapour.

On irradiating the barium layer 12 thus formed, for example by means of a light source 13, a potential difference is set up between the electrodes 3 and 12, said potential difference causing the passage of a current through a device such as a galvanometer connected between the wires 5 and 11. Since the potential difference set up appears to depend not only on the wave length of the light but also on the intensity of the exposure, the device may be used for trans-

lating light variations into current variations. In contradistinction to the photo-electric cells hitherto known the device according to the invention does not require the interposition of a separate source of potential between the electrodes.

The sensitiveness of the device above referred to may be increased still further by heating the envelope and the electrodes after precipitating the barium, due to which part of the barium penetrates into the intermediate layer 6 comprising semi-conducting substances.

The electrode 3 may also be made of copper, the semi-conducting intermediate layer of copper oxide, and the photo-electric substance of caesium. A good adsorption of the caesium to the semi-conducting intermediate layer may be obtained by coating the copper oxide with a thin layer of caesium oxide. To this end, first of all a small quantity of caesium may be precipitated on the copper oxide, whereupon oxygen is introduced into the envelope, due to which the caesium will be converted into caesium oxide. After removing the excessive oxygen a fresh quantity of caesium may be introduced into the envelope thereby forming a thin layer of caesium adsorbed by the caesium oxide film, said layer constituting the photo-electric electrode of the device. The sensitiveness of a device made in this way proves to be very great. If desired, substance capable of absorbing the photo-electrically active substance may also be mixed with the semi-conducting substance of which the intermediate layer essentially consists.

The intermediate layer comprising a semi-conducting substance may also be formed in a manner which is different from those outlined above. It is possible, for example, to apply this semi-conducting substance to one of the electrodes by volatilization, or by spraying, or even by placing it as a separate plate between the electrodes.

What we claim is:

1. A photoelectric device comprising a sealed envelope at least a portion of which is transparent, a silver electrode, a second electrode formed from a photoelectric film of barium arranged to face the transparent portion of the envelope and for co-operative relationship with the said silver electrode, said electrodes being mounted adjacent each other in said envelope, and a substantially uniform thickness layer of electrically conducting silver iodide filling the space between said electrodes and in contact with both said electrodes, said electrically semi-conducting filling containing particles of barium.

2. A photoelectric device comprising a sealed envelope at least a portion of which is transparent, a silver electrode supported within said envelope, a thin semi-conducting substantially uniform thickness surface layer of silver iodide supported by said silver electrode, and a co-operating photoelectric electrode facing said transparent portion of the envelope and comprising a film of barium in contact with and adjoining said semi-conducting layer, and electrical connections for each of said electrodes passing through the wall of said envelope.

3. A photoelectric device comprising a sealed envelope at least a portion of which is transparent, a sheet electrode of a metal of the type of copper and silver supported within said envelope, a cooperating electrode facing the transparent portion of the envelope and formed from a thin film of a photoelectric metal having a work func-

tion not exceeding two and a half volts, a substantially uniform thickness layer of a semi-conducting compound of the metal from which said sheet electrode is formed interposed between and in contact with both of said electrodes, the said semi-conducting layer being of the type of copper oxide and silver iodide for the copper and silver sheet electrodes respectively, and metallic conductors connected directly to the sheet electrode and to the cooperating electrode.

4. A photoelectric device comprising a sealed container at least a portion of which is transparent to light, a plate electrode of the type of copper and silver housed within said envelope, a continuous and substantially uniform thickness layer of a solid electrically semi-conducting binary compound of said metal upon one face of said plate electrode, said compound being of the type of copper oxide and silver iodide for the copper and silver plate electrodes respectively, a light transmitting film of photo-electric metal facing the transparent portion of the container and having a work function not greater than two and a half volts, said film being in contact with the surface of said semi-conducting layer and electrical connections to said plate and film electrodes, and metallic conductors connected directly to the plate electrode and the film of photoelectric material.

5. A photoelectric device comprising a sealed vitreous envelope having at least a portion thereof transparent to light, a silver plate electrode supported within said envelope, a co-operating photoelectric electrode facing the transparent portion of the envelope and comprising a film of barium, and a thin semi-conducting surface layer of silver iodide in uniform contact with the silver plate electrode and the photoelectric electrode and adjoining said layer, and electrical connections to said silver electrode and said photoelectric electrode.

6. A photoelectric device comprising a sealed envelope at least a portion of which is transparent, a sheet electrode of the type of copper and silver enclosed within said envelope, a co-operating electrode facing the transparent portion of the envelope and formed of a thin film of a photoelectric material chosen from the group including caesium and barium, said photoelectric metal group being characterized by a work function of less than two and a half volts, a semi-conducting substantially uniform thickness layer of the type of copper oxide and silver iodide respectively interposed between and in contact with both said electrodes and metallic conductors connected directly to the sheet electrode and to the cooperating electrode.

7. A photoelectric device comprising a sealed envelope at least a portion of which is transparent, a sheet electrode of a metal of the group including copper and silver, a co-operating electrode facing the transparent portion of the envelope and formed of a thin film of a photoelectric metal chosen from the group including caesium and barium, and which group is characterized by a work function of less than two and a half volts, a semi-conducting layer of a solid compound of the metal of said electrodes interposed between and in contact with both of said electrodes, said compound being of the type of copper oxide and silver iodide respectively for said copper and silver sheet electrodes, and metallic conductors connected directly to the sheet electrode and the cooperating electrode.

8. A photoelectric device comprising a sealed envelope at least a portion of which is light trans-
parent, an electrode having an extended surface
within said envelope, a thin layer of copper oxide
5 on said surface, a light-transparent film of an
alkali metal adsorbed on the surface of said cop-

per oxide layer and arranged to face the trans-
parent portion of the envelope, and metallic con-
ductors connected directly to the electrode and
the alkali metal film.

JAN HENDRIK DE BOER.

WILLEM CHRISTIAAN VAN GEEL.