

Aug. 1, 1939.

H. C. RENTSCHLER ET AL

2,167,777

PHOTOELECTRIC TUBE

Filed Sept. 26, 1936

Fig. 1.

Fig. 2.

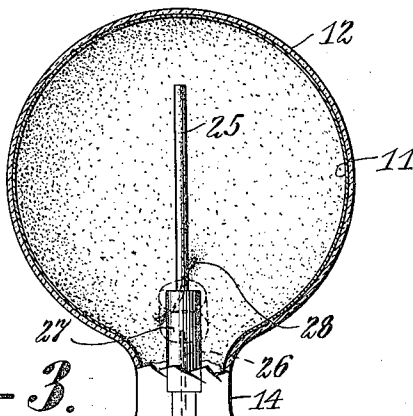
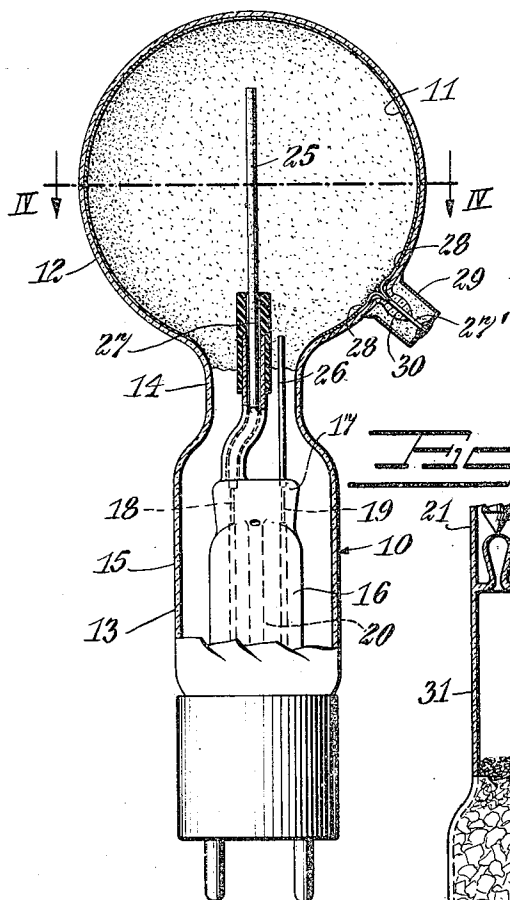


Fig. 3.

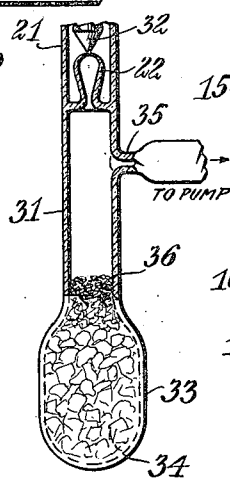
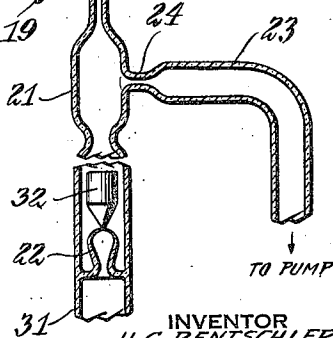
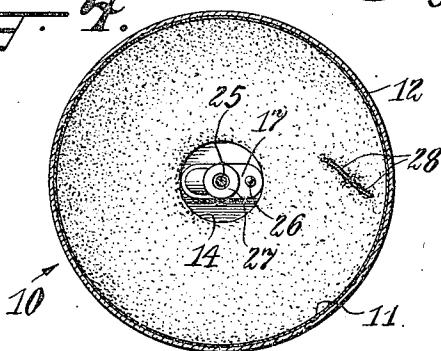


Fig. 4.



INVENTOR
H. C. RENTSCHLER
D. C. HENRY
BY *J. W. Greenhow*
ATTORNEY

UNITED STATES PATENT OFFICE

2,167,777

PHOTOELECTRIC TUBE

Harvey C. Rentschler and Donald E. Henry, East Orange, N. J., assignors, by mesne assignments, to Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application September 26, 1936, Serial No. 102,641

7 Claims. (Cl. 250—165)

This invention relates to photo-electric devices and more particularly to a tube which is sensitive to ultra-violet and other radiation.

The principal object of our invention, generally considered, is the provision of an improved photo-electric tube and method of making.

Another object of our invention is the production of a photo-electric tube which is adapted to indicate the aggregate of radiations from all directions, rather than merely one direction.

A further object of our invention is the production of a photo-electric tube in which the active surface is substantially spherical for receiving radiations, and particularly those in the sun and sky, in all directions.

A still further object of our invention is the provision of a method of making a photo-electric tube involving the sputtering of a refractory metal, of the group consisting of titanium, tungsten, uranium, thorium, and zirconium, on the inner surface of a spherical portion of an envelope composed of ultra-violet transmitting material, from a generally central electrode to provide an active film which receives light on its outer surface and emits photo-electrons from its inner surface.

An additional object of our invention is the provision of a method of exhaust employing degasified, refrigerated charcoal.

In order to develop a device which is capable of measuring light, for example, ultra-violet radiation received from sun and sky in all directions, we have taken a tube in which the active portion thereof is generally spherical and formed of material, such as quartz, Corex, or other high transmission glass, and coated on substantially the entire inner surface of said spherical portion with a film of photo-emissive material such as titanium, tungsten, uranium, thorium, zirconium, that is, one of the heat refractory metals of groups IV and VI, or other metal, the film being so thin that electrons are emitted from the inner surface thereof when the radiation falls on the surface of the film next to the glass. In order that the active material may be deposited on the glass in a pure state, we desirably apply it by sputtering from a centrally disposed electrode of the desired material while the bulb contains a filling of a monatomic gas, such as argon, which is inert toward the active material.

In order to provide a connection with the photo-active material on the inner surface of the bulb, a lead-in conductor is desirably provided extending through the lower portion of the spher-

ical bulb so as not to interfere, any more than is necessary, with the conduction of light to the emissive material. After the desired coating is applied to the inside of the spherical envelope and over the lead-in conductor, the gas which carries the discharge for purposes of sputtering the material on the glass, as between a centrally disposed electrode then acting as a cathode and an auxiliary electrode, is desirably removed with the creation of a high vacuum in said bulb.

A preferred construction of the tube and method of producing the same will appear more fully in connection with the following detailed description, referring to the accompanying drawing in which:

Fig. 1 is an elevational view partly in section through the longitudinal axis of a tube embodying our invention;

Fig. 2 is an elevational view partly in section and corresponding to Fig. 1, but looking from a direction at right angles to that of Fig. 1 and showing connections with the tube for the purpose of exhaust;

Fig. 3 is an elevational view, partly in section, of a bulb of coconut charcoal which may be used for exhaust purposes; and

Fig. 4 is a horizontal sectional view on the line IV—IV of Fig. 1 looking in the direction of the arrows.

Referring to the drawing, we have a photo-electric tube 10 in which the cathode consists of a deposit of photo-emissive material, such as titanium, tungsten, uranium, thorium, or zirconium, sensitive to ultra-violet radiation, which material is in the form of a very thin film 11 uniformly distributed on substantially the entire inner surface of the generally spherical portion 12 of the bulb or envelope 13, which is formed of material conductive to ultra-violet radiation, as before explained.

The envelope 13 has a restricted neck portion 14 and a lower portion 15 carrying the reentrant portion 16 provided with a press 17 through which leading-in conductors 18 and 19 extend. The reentrant portion 16 is desirably provided with an exhaust tube 20 formed with an enlargement 21 across which a thin glass bulbous partition 22 extends, sealing the lower portion of the tube against the atmosphere.

A tube 23 serves to initially exhaust the envelope 13 and allow for the filling thereof with a rare or monatomic gas, such as argon, preferably at a pressure of about 1.8, or from 1 to 6, millimeters of mercury. After this gas filling has been provided, the envelope is sealed-off at 24

and a glow discharge created between the central electrode 25 of titanium, or other metal which it may be desired to sputter on the spherical portion 12, and an auxiliary electrode 26 of nickel or other suitable material. The leading-in conductor 18 connects with the electrode 25 which may be held, on an extension from the press 17, in a sleeve of lavite or other insulating material 27', while the leading-in conductor 19 connects with the auxiliary electrode 26.

Before the material is sputtered on the spherical portion of the bulb, provision is made for an electrical connection therewith from the exterior. This may take the form of a leading-in wire 27 having extensions 28 which engage the inner surface of the glass so that when the material is sputtered on said glass it will cover and make a good electrical connection with said extensions. The outer end of the conductor 27' may be secured to a brass cap 29, cemented to the pinch 30 through which the leading-in conductor 27' extends, in order to provide for the convenient connection therewith.

The sputtering of the photo-emissive material is produced by making the electrode 25 the cathode and the electrode 26 the anode, with a potential therebetween of from 220 to 400 volts direct current and a suitable resistance in the circuit to limit the current. The discharge between the electrodes 25 and 26 is allowed to continue for several hours or until the substantially uniform film 11 of the desired metal has been applied to the inside of the spherical portion 12.

Care should be taken to provide only a very thin film, as one thin enough to emit electrons from its inner surface when activated by light reaching its outer, or that surface engaging the glass of the envelope, is required.

If a gas filling is desired, it is preferable that a lower gas pressure be used for the sputtering so that the tube may be employed immediately following the glow discharge which causes the deposit of active material on the inner surface. The tube is, of course, employed with the active material 11 serving as the cathode and the central electrode 25 acting as an anode, the auxiliary electrode 26 not being used.

Ordinarily it would be desired to operate such a tube with a vacuum, the best that can be obtained, rather than a gas filling. For that purpose the exhaust tube 31 may be connected to a pump and after the desired vacuum has been secured, the partition 22 is broken by magnetically moving the iron plunger 32, whereupon the gas filling will be quickly withdrawn leaving a vacuum of the desired degree.

Instead of again connecting the envelope 13 to a pump for exhausting the gas filling, said filling is preferably removed by means of a charcoal exhaust device, as will now be described. A bulb 33 is filled with coconut charcoal 34, sufficient in quantity to absorb the gases in the envelope 13. For such a purpose, it has been found satisfactory if the capacity of the bulb 33 is as much as one-tenth of that of the envelope to be evacuated. The charcoal in the bulb 33 is prepared by baking-out while on an exhaust pump and then tipping-off, as at 35, so that we then have an evacuated bulb 33 containing charcoal with a high capacity for gas absorption, which charcoal is desirably held in place by a plug of glass wool 36, and sealed from the exhaust connection 21 by means of the partition 22 previously referred to.

With such an arrangement all that is then

necessary for removal of the gas filling is to place the charcoal-containing bulb 33 in liquid air for a length of time, such as fifteen minutes, allowing it to be thoroughly chilled and then break the partition 22, as by means of the iron plunger 32 being raised by a magnet and allowed to fall by gravity, whereupon the gas filling will rush to the charcoal-containing bulb 33 and be quickly absorbed by the prepared charcoal therein. By using this method of exhaust, there is no chance for air or moisture to get back into the envelope 13 along the exhaust line, after the spherical portion 12 of the tube has been coated with the emission material. In this way all danger of spoiling the emission material, due to oxidation or the introduction of deleterious matter, is avoided. The tube 20 of the bulb 13 may then be tipped off in the usual manner above the enlargement 21.

From the foregoing it will be seen that we have devised a photo-electric tube which has a light-receiving surface almost entirely clear for substantially a full spherical area, and entirely unobstructed in the upper hemisphere where most of the light from the sun and sky is received. As distinguished from prior constructions, the activating light engages the glass-engaging surface of the electron emitting film, rather than the inner surface, the photo-electrons, however, being emitted from the inner surface, as is usual, in order to pass to a centrally located anode. The external circuit would be conventional and is not illustrated.

Although a preferred embodiment of our invention has been disclosed, it will be understood that modifications may be made within the spirit and scope of the appended claims.

We claim:

1. The method of making a photo-electric tube comprising preparing an envelope of high transmission glass with a substantially spherical portion, mounting an electrode of titanium so that it is disposed substantially central with respect to said portion and an auxiliary electrode adjacent said titanium electrode, connecting thereto an evacuated bulb containing degasified charcoal and closed by a frangible partition between the envelope and bulb, exhausting said envelope, introducing therein a monatomic gas at a pressure of from 1 to 6 millimeters of mercury, causing a glow discharge between said electrodes, with the titanium as a cathode, whereby material therefrom is sputtered on the inner surface of said spherical portion, and finally exhausting the gas filling from said envelope by placing the bulb containing degasified charcoal in liquid air and breaking said frangible partition.

2. The method of finally exhausting a sealed envelope comprising connecting thereto a bulb containing charcoal, the connection between said envelope and bulb being initially closed by a frangible partition, baking said charcoal while exhausting the bulb containing the same, sealing said bulb from the exhaust means, and breaking the partition to allow the contents of said envelope to be absorbed by the charcoal in said bulb.

3. The method of finally exhausting a sealed envelope comprising connecting thereto a bulb containing charcoal, the connection between said envelope and bulb being initially closed by a frangible partition, baking said charcoal while exhausting the bulb containing the same, sealing said bulb from the exhaust means, cooling said charcoal by immersing the bulb in liquid air, and breaking the partition to allow the contents

of said envelope to be absorbed by the charcoal in said bulb.

4. A photo-electric tube comprising an envelope having a substantially spherical ultra-violet light-conducting portion, and a generally cylindrical electrode, constructed of a heat refractory metal of groups IV and VI, extending axially of said envelope and positioned centrally with respect to said spherical portion, the inner surface of said portion being coated with a film of material, corresponding with that of said electrode, and so thin that it is adapted to emit electrons from its inner surface when radiation falls on the surface engaging said envelope.

5. The method of making a photo-electric tube comprising preparing an envelope with a substantially spherical portion composed of glass transparent to ultra-violet light, mounting an electrode, constructed of a heat refractory metal of groups IV and VI, so that it is disposed substantially central with respect to said portion, mounting an auxiliary electrode adjacent thereto, exhausting said envelope, introducing therein a rare gas at a pressure of from 1 to 6 millimeters of mercury, causing a glow discharge between said electrodes with the main electrode as a

cathode, whereby metal from said main electrode is coated in a thin film on the inner surface of said spherical portion, and finally removing the gas filling from said envelope by connecting it to a bulb containing refrigerated, degasified charcoal.

6. The method of securing a high degree of vacuum in an envelope comprising, first, exhausting in a conventional manner and, then, connecting said envelope to a bulb containing refrigerated, degasified charcoal.

7. A photo-electric tube comprising an envelope having a substantially spherical ultra-violet light-conducting portion, and a generally cylindrical electrode constructed of titanium extending axially of said envelope and positioned centrally with respect to said spherical portion, the inner surface of said portion being coated with a film of material corresponding with that of said electrode, and so thin that it is adapted to emit electrons from its inner surface when radiation falls on the surface engaging said envelope.

HARVEY C. RENTSCHLER.
DONALD E. HENRY.