

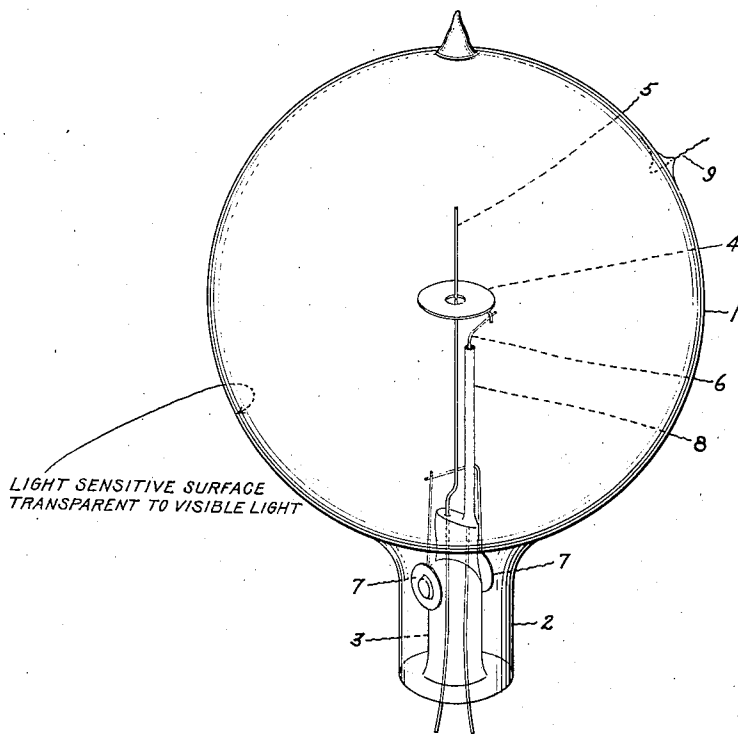
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PHOTOELECTRIC TUBE

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PHOTOELECTRIC TUBE

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The present invention relates to light-sensitive devices, more particularly to photo-electric tubes.

Objects of the present invention are to provide a light-sensitive device of extreme sensitiveness; also one which presents an unusually large field of view to a light source and which responds to light reaching the tube from any and all directions.

Photo-electric tubes ordinarily are made in two types: (1) Those in which the envelope is coated on the interior with a silver layer which serves as a foundation for the light-sensitive material, and (2) those in which the light-sensitive surface is formed on an electrode physically separate from the envelope.

While these various forms of photo-electric tubes have given satisfactory service in the translation of light energy into electrical energy, they are open to certain objections. The first mentioned type has the disadvantage of being opaque to visible light except when there is an opening termed a "window" in the silver layer. The field of view presented by a tube of this type is thus limited to the area of the window, ordinarily quite small. The optimum size of such a window can never exceed the greatest rectilinear dimension of the envelope, so that a tube of this sort responds to light propagated only in certain directions.

In the second type of photo-electric tube, the envelope is transparent to light and the light-sensitive member is contained within the tube physically separate from the envelope. Inasmuch as the position of the light-sensitive cathode is fixed, a tube of this kind is also directive.

The disadvantages of these tubes are at once apparent. As an example, assume it is desired to measure the intensity of rapidly moving sources of light, such as the heavenly bodies, over a considerable period of time, it is clear that the directive type of photo-electric tube must be moved through the same angle as the moving light source if the latter is to be kept within the small field of view. Moreover, in the determination of the integrated amount of light produced by sources of large area over which the light intensity is not uniform, for example daylight, a photo-electric tube of limited view may give an erroneous indication on account of being responsive to light emanated by only a portion of the lighted area.

In accordance with the objects of the present invention, we provide a tube which is not open to the objection of being directive, but, on the contrary, responds to light propagated in any di-

rection that will intercept the tube. The improved tube thus presents an unusually large and unlimited field of view. The invention contemplates a light-sensitive layer formed on the interior of the envelope, preferably by a sputtering process, said layer being so thin as readily to allow the admission of visible light, i. e., radiations of wave lengths between about 4000 Angstroms and 7000 Angstroms, through the envelope. It has been found that a light-sensitive layer which is sufficiently thin to be transparent to visible light is more stable than layers of ordinary thickness; that is, the improved thin layer exhibits less tendency toward having spontaneous changes occur in the structure of the active surface, as is evidenced by the constancy of its photo-sensitivity.

In the drawing, numeral 1 designates an envelope of vitreous material, such as glass or quartz, and preferably of spherical shape. The envelope terminates at the lower portion in a cylindrical elongation 2 which is provided with a reentrant stem 3. Within the envelope there is a pair of electrodes 4, 5 mounted rigidly in the stem. The electrode 4 may take the form of a washer of any base material, such as copper, plated with silver and positioned flatwise above the stem by means of a vertical support wire 6. The electrode 5 constitutes a rod or wire of stiff character, arranged concentrically with the washer. There is a capsule 7 positioned on either side of the stem by means of a framework secured to the rod electrode. These capsules may contain pellets of an alkali metal such as caesium dichromate or other activating material, together with a suitable reducing agent such as silicon.

The improved tube may be manufactured in the following manner, although it is to be understood that various changes in the process and construction will suggest themselves to those skilled in the art, without departing from the spirit of the invention. The silver coating on the washer 4 is first oxidized. This is conveniently accomplished by admitting oxygen into the envelope at a pressure of about 100 microns of mercury and then glowing the bulb by applying high frequency currents to the electrodes from a spark coil but preferably employing a direct current obtained from a high voltage rectifier.

When the desired degree of oxidation has been effected by controlling the time duration and voltage during the glowing period, the excess oxygen is pumped out. The capsules 7 may now be heated, preferably by induced high frequency currents, in order to release the caesium or other

light-sensitive material. The caesium vapor reacts with the oxidized washer and forms thereon a light-sensitive layer. A glass pant-leg 8 may be provided about the wire which supports the washer, in order to prevent electrical leakage between the electrodes 4 and 5.

After the application of light-sensitive material to the oxidized surface of the washer, the bulb is baked out at a temperature of about 300° C., for a period of time which may vary from a few minutes to about two hours, depending upon the amount of alkali metal present in the bulb, the latter being in the meantime connected to a suitable evacuating pump. In this manner all excess caesium or light-sensitive material that did not "stick" is driven out, leaving a thin layer of light-sensitive material covering all the free surface of the oxidized silver. The feature of removing the excess alkali metal is described and claimed in the Bainbridge application, Serial No. 244,533, filed January 4, 1928, and entitled "Photo-electric tubes and a method for preparing the light-sensitive surface therefor." This application has matured into Patent No. 1,901,577, granted March 14, 1933. As stated in the said application, the removal of the excess alkali metal adds to the stability of operation and sensitivity of the layer.

The next step is to transfer the light-sensitive material from the washer onto the envelope, and this conveniently is accomplished by a sputtering operation. For this purpose, the envelope is filled with an inert gas, such as argon, at a pressure of about 100 microns, and a voltage of about 300, alternating current or direct current being applied between the washer and the rod. In the case of direct current, the washer is made the cathode or negative member. The latter is bombarded during this glowing stage with argon ions, which causes the light-sensitive material to leave the washer and to travel toward the envelope, on which it condenses as an extremely thin sensitive layer extending over the entire perimeter of the envelope interior. The duration of the sputtering process depends upon the required thickness of layer, but we have found that when this layer is of minute thickness, in fact so thin as to be substantially transparent to light of wave lengths between about 4000 Angstroms and 7000 Angstroms, the sensitivity of the material may be quite large, and at the same time stable, over long periods of operation. The degree of thinness made possible by this process in order to obtain these qualities lends itself to the fabrication of a photo-electric tube which shows only a slight discoloration of envelope, and, therefore, is readily transparent to visible light. Thus, there is no need of providing a window in the tube, as the entire envelope serves the purpose of admitting light.

In order accurately to determine when a sufficient amount of light-sensitive material has collected on the envelope during the sputtering process, it may be desirable to provide a pair of flush seal conductors, of which only one, designated by reference character 9, has been shown. These conductors may be positioned at opposite points on the bulb so that the resistance of the light-sensitive material which spans the conductors may be measured from time to time. The resistance will be observed to decrease suddenly when the film is of sufficient thickness, and the sputtering treatment should be stopped immediately. The flush seal conductors referred to may be retained and later connected together to constitute

a common leading-in conductor for the light-sensitive film. It will be understood that visual means for determining the proper thickness of film may also be employed, as, for example, by noting the degree of discoloration, in which case only one flush seal conductor is necessary.

As stated hereinbefore, a transparent layer of light-sensitive material, obtained in the manner described and having the minimum thickness as determined by the resistance test or otherwise, is found to offer greater stability than a layer of the ordinary thickness such as is found in photo-electric tubes provided with opaque films. While we are unable to state the exact nature of the light-sensitive material produced on the envelope in this manner, it is probable that it consists of a complex compound involving caesium, oxygen and silver. Regardless of the correctness of this belief, it is sufficient to state that this sensitive material may be derived by a sputtering process from a base metal which has been silver-plated, oxidized, and then coated with a light-sensitive material such as caesium. It also appears that a transparent light-sensitive material having the minimum thickness consistent with a substantial photo-electric effect resists photo-de-activation with time to a marked extent. It is possible that the material is so thin under the conditions stated that it is of fairly uniform composition throughout, so that diffusion of material between the surface and the body of the film does not cause the sensitiveness to change with time.

The portion of the light-sensitive material which remains on the washer 4 after the film has been formed on the envelope does not deleteriously affect the operation of the device. This washer together with the rod electrode may be connected together to constitute the positive electrode of a circuit in which the photo-electric tube is connected so that any photo-electrons which normally would be produced at the washer by a light source are unable to leave the washer. The emanation of photo-electrons is thus confined to the transparent film of light-sensitive material. From the foregoing, it is evident that a photo-electric tube improved in accordance with our invention and provided with a transparent photo-electric surface offers not only advantages in its adaptation to certain uses which require an unlimited field of view, but also offers a greater stability of operation, due to the thinness of layer, than photo-electric tubes of the prior art. It is also apparent that by reason of the spherical configuration of the light-sensitive cathode, the improved photo-electric tube is particularly well suited, from the standpoint of minimum distortion, to measure the intensity of light sources which move over a large field of view.

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

1. A photo-electric tube comprising a hermetically tight envelope coated with light-sensitive material of which all the component parts are intimately mixed to form a homogenous layer, said light-sensitive material covering an area within the envelope which is perimetrically complete and substantially transparent to light, and a cooperating electrode in said envelope.

2. A photo-electric tube comprising a hermetically tight envelope coated with light-sensitive material, of which all the component parts are intimately mixed to form a homogeneous layer, said light-sensitive material covering an area within the envelope which is perimetrically complete and transparent to light, said envelope also

containing a plurality of electrodes adapted to pass a discharge therebetween.

3. In the art of fabricating a photo-electric tube having an envelope, the method which includes the steps of coating a foundation member in said envelope with an oxidizable metal, oxidizing said metal, then depositing an alkali metal layer on the oxidized metal to form light-sensitive material, and then transferring said material from the foundation member to the interior surface of the envelope.

4. In the art of fabricating a photo-electric tube having an envelope, the method which includes the steps of coating a foundation member within the envelope with an oxidizable metal, oxidizing said metal, then depositing an alkali metal layer on the oxidized metal to form light-sensitive material, and then sputtering the light-sensitive material from said foundation member

onto said envelope to form a light-sensitive film substantially transparent to light.

5. A photo-electric tube comprising an envelope, said envelope being coated on the interior with a thin transparent film of light-sensitive material, and containing a plurality of electrodes including a rod member and a metal washer, said washer surrounding said rod and being mounted normal with respect to the axis of said rod.

6. A photo-electric tube comprising a hermetically tight envelope coated with light-sensitive material of which all the component parts are intimately mixed to form a homogeneous layer, the film and envelope together being substantially transparent to light, and a cooperating electrode in said envelope.

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