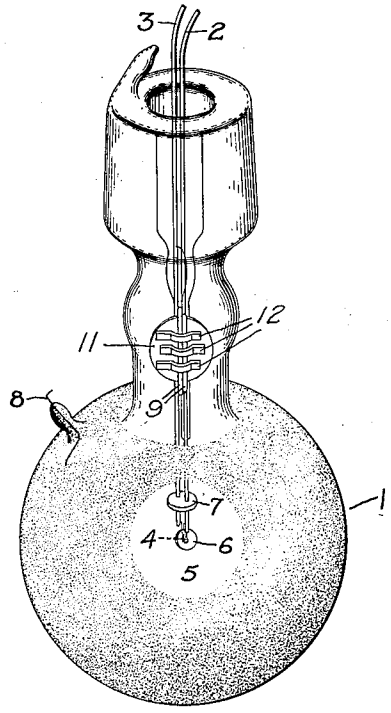
March 14, 1933. K. T. BAINBRIDGE 1,901,577

PHOTO ELECTRIC TUBE

Filed Jan. 4, 1928



Inventor:
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His Attorney.

Patented Mar. 14, 1933 1,901,577

UNITED STATES PATENT OFFICE

KENNETH T. BAINBRIDGE, OF NEW YORK, N. Y., ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

PHOTO-ELECTRIC TUBE

Application filed January 4, 1928. Serial No. 244,533.

The present invention relates to light sensitive tubes and more particularly to tubes having a monatomic layer of highly reactive metal and to a method for preparing a light sensitive surface for such tubes.

While light sensitive tubes having a monatomic layer of light sensitive material have hitherto been made, they have never gone into practical use due partly to the fact that their sensitivity has not been constant and partly to the fact that when made with highly reactive material, such as cæsium or rubidium, the presence of these alkalies impairs the electric insulation of the tube. I have found that both of these difficulties may be overcome by removing substantially all excess alkali metal from the light sensitive tube and that photo-electric tubes made according to the present invention are not only stable and substantially free from electric leakage but are less sensitive to temperature changes than photo-electric tubes heretofore constructed.

In carrying out my invention, a silver coating is provided on the inner walls of an evacuated receptacle and this coating oxidized or provided with an adsorbed gas layer. A coating of cæsium or other suitable alkali metal is then applied to the oxidized coat and all excess alkali metal removed by heating the receptacle to an elevated temperature. By excess alkali I mean all alkali metal that will evaporate at the evaporation temperature of bulk material.

Although I have found it desirable to apply the alkali coating to an oxidized surface such a surface is not essential as some of the benefits of the invention may be obtained by applying alkali metal directly to the foundation metal. It is essential, however, to always remove substantially all excess alkali metal from the receptacle.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, will best be understood from reference to the following specification when considered in connection with the accompanying drawing in which the single figure shows a perspective view of a photo-electric tube which embodies the features of the present invention.

Referring to the drawing, I have indicated at 1 a receptacle provided with a pair of leading-in wires 2 and 3 between which a small filament 4 is mounted. A silver bead, not shown, is initially supported and surrounded by the filament and is adapted to be vaporized when current is supplied to wires 2 and 3. A circular metal disc 6, mounted on leading-in wire 2, constitutes the anode member of the photo-electric tube. When current is supplied to the leading-in wires, the silver bead is vaporized and a silver coating deposited on the bulb portion of the receptacle. Disc 6 prevents deposition of the silver on that portion of the bulb in the rear of the disc providing in this manner a window 5 for the tube. An insulating washer 7 of mica or quartz is mounted on wires 2 and 3 and prevents deposition of silver in the neck portion of the container. A wire 8 extends through the bulb portion of receptacle 1 and is connected with the metallic coating deposited on the inner surface of the container which constitutes the cathode member of the photo-electric tube.

The silver coating, after deposition on the inner walls of the bulb portion of the receptacle, is oxidized. This is accomplished by admitting oxygen into the receptacle until a pressure of about 100 microns of mercury is obtained, and then glowing the bulb by applying a high frequency current thereto from a spark coil. The application of the spark coil to the bulb effects a clean-up of the free oxygen present in the receptacle. The use of the high frequency coil is somewhat objectionable, however, owing to the fact that it may cause portions of the silver coating to be sputtered onto the window portion 5 of the receptacle. This difficulty may be overcome by admitting oxygen as above and then heating the bulb in an exhaust oven to a temperature of about 360° C. for a few minutes instead of applying the high frequency current to the receptacle.

When the desired degree of oxidation has been effected any excess oxygen is pumped out and a highly reactive metal, such as cæsium, rubidium, potassium, or calcium, is distilled

into the bulb portion of the receptacle. The reactive material, as for example cæsium, is preferably provided in sealed glass capillary tubes 9 which are mounted on a metal disc 11 and secured thereto by metal straps 12, as disclosed in the copending application of William E. Ruggles, which has matured into Patent No. 1,768,421 granted June 24, 1930. When the disc 11 is heated by a suitable high frequency current, the end portions of the glass capillaries crack and permit the cæsium to flow out and into the bulb portion of the receptacle. The heating and opening of the capillaries is easily effected without shattering them. If desired, one or more capillaries may be employed to obtain the proper amount of reactive material.

After the application of light sensitive metal, such as cæsium, to the oxidized metal surface, the receptacle 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 on the amount of alkali metal present in the receptacle, the latter being in the meantime connected to a suitable evacuating pump. In this manner all excess cæsium or light sensitive material that did not "stick" is driven out leaving a monatomic layer of light sensitive material covering all the free surface of the oxidized silver. The amount of alkali thus adsorbed may be much greater than would be required to cover a smooth metal surface owing to the greatly increased area of the spongy oxidized surface. If desired, lower temperatures than 300° C. may be employed in the baking out process but if such temperatures are employed a longer time will be required to obtain a suitable layer of reactive material. Temperatures higher than 300° C. are usually undesirable as such temperatures might destroy the light sensitive surface. The optimum temperature for removing excess light sensitive material is different for different materials and will be higher or lower than 300° C. depending upon the melting point of the element employed. For example, in the case of barium a temperature of about 700° C. would be required to produce a monatomic layer. In this case the receptacle may be made of quartz. If desired, the light sensitive surface may be prepared on a removable member, mounted in an evacuated chamber and later mounted in a light sensitive tube.

Photo-electric tubes having a light sensitive surface prepared as indicated above, have a sensitivity about twice as great as that of the best potassium hydride, high vacuum, photo-electric tubes heretofore constructed. For example, a tube constructed according to the present method gave a photo-electric current of 1.4 milliamperes as compared with currents of .680 and .650 milliamperes obtained from two potassium hydride tubes under similar operating conditions. Photo-electric tubes produced in the above manner have a high efficiency and are stable due to the absence of free alkali in the tubes. They are furthermore less sensitive to temperature changes than ordinary photo-electric tubes.

If desired, copper, nickel, tungsten, barium or other metals may be employed instead of silver as the base or foundation metallic layer. These metals may be deposited as thin films on the glass wall or mounted on stems in the form of plates or cylinders. Various alkali or alkaline earth metals may be employed as the light sensitive material and while I have employed the term "alkali metal" in the specification and claims, I intend that this term shall apply equally well to metals of the alkaline earth group.

It is my belief that the light sensitive layer consists of alkali metal alone and not a compound, that is, when cæsium is employed the tube comprises a layer of silver or other foundation metal, a monatomic layer of cæsium and an intermediate layer of oxygen. The cæsium surface is similar to the surface obtained on tungsten filaments which have been oxidized and then coated with cæsium. Although different combinations of foundation metals and reactive metals may be employed, I have found that the best results are obtained when cæsium is applied to a silver oxide surface.

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

1. An electrical device comprising a receptacle, electrodes mounted therein, one of said electrodes comprising a foundation metal in unalloyed state, a coating of alkali metal on said foundation metal, said receptacle containing no free alkali.

2. A light sensitive tube comprising a container, electrodes mounted in said container, one of said electrodes comprising a foundation metallic layer and a layer of alkali metal in unalloyed state mounted above said metallic layer, said tube being substantially free from excess alkali metal.

3. A light sensitive tube comprising an evacuated container, a cathode element and an anode in said container, said cathode comprising a metallic layer, a monatomic layer of alkali metal superimposed on said metallic layer, said tube containing substantially no free alkali metal.

4. A light sensitive tube comprising an evacuated container, electrodes mounted in said container, one of said electrodes comprising a metallic layer, a monatomic layer of cæsium mounted above said metallic layer, said tube containing substantially no free cæsium.

5. A light sensitive tube comprising an evacuated container, a cathode element and an anode in said container, said cathode comprising a foundation metal layer, an upper layer of light sensitive metal and an inter-

mediate layer containing oxygen, said tube containing no free light sensitive metal.

6. A light sensitive tube comprising an evacuated container provided with a foundation metal layer, a layer of cæsium on said metal layer surface, and an electrode cooperating therewith, said tube containing substantially no free cæsium.

7. A light sensitive tube comprising an evacuated container having an oxidized metal layer therein and a layer of light sensitive metal on said oxidized layer, an electrode cooperating therewith, said tube containing substantially no free light sensitive metal.

8. A light sensitive tube comprising an evacuated container having an oxidized metal layer therein and a monatomic layer of light sensitive metal on said oxidized layer, an electrode cooperating therewith, said tube containing substantially no free light sensitive metal.

9. A light sensitive tube comprising an evacuated container, a layer of silver in said container and a monatomic layer of cæsium on said silver, an electrode cooperating therewith, said tube containing substantially no free alkali.

10. A light sensitive tube comprising an evacuated container, a layer of silver in said container, a layer of cæsium and an intermediate layer containing oxygen, an electrode cooperating therewith, said tube containing substantially no free alkali.

11. A light sensitive tube comprising an evacuated container provided with a foundation metal layer having an adsorbed layer, a layer of light sensitive material on said adsorbed layer, and an electrode cooperating therewith, said tube containing substantially no free light sensitive material.

12. A light sensitive tube comprising a container, electrodes mounted in said container, one of said electrodes including a foundation material, a coating of alkali metal on the foundation material, all of said alkali metal being bound to the foundation material at the volatilizing temperature of said metal by an adsorbed gas layer.

In witness whereof, I have hereunto set my hand this 31st day of December, 1927.

KENNETH T. BAINBRIDGE.

CERTIFICATE OF CORRECTION.

Patent No. 1,901,577. March 14, 1933.

KENNETH T. BAINBRIDGE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, after line 96, insert the following paragraph:

The method of preparing a light sensitive coating on a metallic surface herein disclosed is disclosed and claimed in my divisional application, Serial No. 621,499, filed July 8, 1932, and entitled "Method of Preparing Photo-Electric Tubes."

And that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of May, A. D. 1933.

M. J. Moore.

(Seal) Acting Commissioner of Patents.