

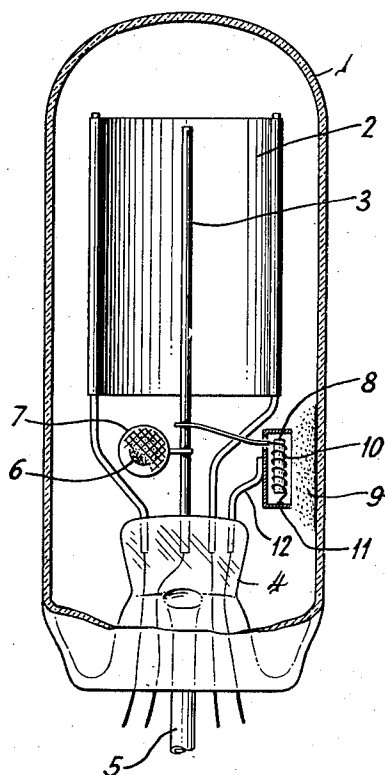
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PHOTOTUBE

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PHOTOTUBE

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My invention relates to photo-electric tubes and particularly to such tubes sensitized with alkali metal.

The preparation of a photo-emissive surface in which caesium or other alkali metal is applied to an oxidized metal surface may involve the presence in the tube of a considerable quantity of excess alkali metal after the desired photosensitivity is obtained. This excess is desirable during the course of manufacture of the phototube for various reasons and also because inequalities in the yield of alkali metal from the sources used in the art are inevitable, and consequently some excess alkali metal must be present as a safety factor in the sensitizing process. The completed tube should be free from excess alkali metal. Therefore, alkali metal absorbents, such as copper oxide, lead oxide and tin oxide are generally used. With such absorbents, which are active whenever the alkali metal vapor is present in the tube, considerable alkali metal is lost to the absorbent during the sensitizing step, and the treatment, and retreatment if necessary, of the cathode with caesium is not under as good control as desirable, since the action of the absorbent is uncontrollable.

It is an object of my invention to provide a phototube which may be manufactured with the sensitizing steps during the manufacture under easy and accurate control. It is another object to provide a phototube which, if incorrectly processed, may be easily reprocessed under controlled conditions to obtain optimum results. It is a further object of my invention to provide a phototube wherein all excess or free alkali metal may be absorbed after the cathode is treated by a single step or after repeated steps of vaporizing alkali metal without danger of the absorbent becoming impaired or saturated during cathode treatment.

In accordance with my invention, I provide within an evacuated envelope containing an alkali metal treated photosensitive surface a source of material which in massive form is substantially inactive with respect to the alkali metal but which in a thin, clean layer or film will absorb the alkali metal and combine with it to clean up alkali metal and render it ineffective. More particularly, I provide a mass of antimony, arsenic or bismuth, enough of which may be vaporized at will following the liberation of caesium or other alkali metal within a phototube to form a film which absorbs the excess alkali metal. In this way the elimination of the effect of the free alkali metal may be controlled very

accurately. Still further in accordance with my invention, I provide a source of material which in its massive form is incapable of absorbing any great quantity of alkali metal but when vaporized or condensed from vapor into a film or thin layer absorbs the alkali metal to the desired degree. As a further feature of my invention, I provide a method of manufacturing phototubes wherein excess alkali metal used in the processing of the tube may be absorbed to an extent and at a time during the processing which is most conducive to the production of optimum photosensitivity. By excess alkali metal I mean all alkali which is not chemically or physically bound on the photosensitive surfaces and which is free to evaporate at the evaporation temperature of bulk material.

A better understanding of my invention will be obtained and other objects, features and advantages will appear from the following description taken in connection with the accompanying drawing wherein the single figure is a longitudinal view partially in section of a phototube embodying my invention.

Referring to the drawing, I provide an envelope or bulb 1 enclosing an electron emissive or photosensitive cathode 2 which in the construction shown is preferably of the arcuate type, and an anode 3 exposed to the photosensitive surface of the photocathode 2 so that it may receive electrons which are liberated from the photocathode under the influence of light. The photocathode 2 and anode 3 are preferably supported by a pinch or press 4 in which are sealed the current carrying leads to the cathode and anode. The tube shown in the drawing is provided with a tubulation 5 through which the tube is evacuated, this tubulation later being sealed following the sensitization process. A source of caesium or other alkali metal either within or without the bulb 1 may be provided, but I prefer to provide a quantity of caesium-bearing compound such as the activator pellet 6 which is in good thermal contact with a metal tab 7 so that caesium may be liberated from the pellet by suitable heat treatment.

In accordance with my invention, I provide an excess alkali absorber such as a mass of vaporizable material which may be vaporized and deposited as a thin film 9 on the inner wall of the bulb 1 at some point remote from the cathode and out of contact with the press 4 and cathode 2.

The excess alkali absorber is selected from the metalloids, arsenic, antimony and bismuth,

although I prefer antimony, which is readily available in massive form and which, when vaporized, forms upon the bulb wall a good film or layer with a metallic luster. In describing the preferred form of my invention I will specifically refer to antimony as the absorber, but it is to be understood that my invention is not limited to antimony, as arsenic or bismuth may be used instead of antimony.

The photocathode 2, preferably of a metal such as silver with an oxidized surface, is activated with alkali metal in the conventional way. Following the evacuation of the bulb 1, oxygen is admitted to the bulb 1 through the tubulation 5 and the silver cathode is oxidized by a glow discharge in oxygen between the cathode and anode. For example, the cathode may be oxidized until a bright green color following a bright red is obtained. The oxygen is then removed, the bulb 1 is highly evacuated, and the activator pellet 6 is heated to liberate alkali metal vapor within the envelope. I have obtained good results and high photosensitivity with a cathode having an area of approximately 1.5 sq. inches using a caesium activator pellet 6 consisting of 45 to 50 mg. of a mixture of one part caesium dichromate by weight to two parts of silicon. This pellet contains a great excess of caesium over that theoretically required for the proper activation of the cathode, for the reason that the quantity of caesium liberated should be in excess of that required for optimum photosensitivity, and the amount of this excess will vary with the yield of the caesium-bearing activator. The activator pellet is preferably heated and caesium vaporized while the tube is at approximately room temperature. Following the vaporization of the caesium, the tube is baked at a temperature of 265° to 285° C. until the cathode turns to a gold or straw color, whereupon the photocathode will be found to have high photosensitivity. At the same time, high reverse current leakage may be present between the cathode and anode which indicates the presence of excess caesium within the tube.

The tube is freed of excess alkali metal, either before or after sealing off, by heating the excess alkali metal absorber 8 to vaporize enough of the antimony or similar material to form on the inner wall of the bulb a bright film 9 of metallic appearance and having an area greatly exceeding that of the absorber 8. The speed of the reaction with the excess alkali metal may be increased by maintaining the envelope or bulb 1 at a temperature of approximately 150° C. during the vaporization of the absorber. For convenience in vaporizing the absorbent at will I prefer to mount a mass of antimony within or on a helically coiled heater filament 10 made of metal having a melting point higher than the vaporization temperature of the absorber 8. To limit the film 9 to the bulb wall and to prevent the absorbent from becoming deposited either on the press 4 or on the cathode 2 I may use a shield member 11 which surrounds the filament 10 which is mounted directly on a current-carrying lead 12 sealed in the press 4. One end of the filament is connected to the conductor 12 and the other end to the anode 3 in order that current may be passed through the filament to heat and vaporize the antimony at will. The amount of the absorbent such as antimony either on or within the helical filament 10 is large in comparison with the amount normally needed to absorb the excess caesium, so that if for any

reason additional absorbent is required, a source within the tube will be available. If a measurement of the photosensitivity indicates that an optimum has not been reached and that the photosensitivity is lower than desired, additional caesium may be vaporized from the activator pellet 6, followed by rebaking of the tube. The tube is then freed of the excess or free alkali metal thus introduced by again heating the absorber 8 and vaporizing enough antimony or similar absorbent to form a new clean, active film on the inner wall of the bulb.

Little or no caesium is absorbed by the mass of material comprising the absorber 8 during the liberation of caesium from the activator pellet 6 even at room temperature, thus permitting the proper formation of the photosensitive surface. The absorbent, either while it is in the vapor stage or immediately after it has been deposited as the film 9, reacts or combines with the caesium or similar alkali metal to convert the alkali metal to a stable product, probably an alloy, which vaporizes with difficulty, so that the excess caesium is rendered ineffective and harmless during operation of the tube.

I have found that metals such as silver do not react with the excess alkali metal to absorb or fix the alkali metal in the same way as antimony, arsenic and bismuth. For example, silver has been evaporated within the tube subsequent to the sensitization of the cathode to form a film on the bulb wall, but leakage measurements indicated substantially no decrease in the quantity of excess caesium following the vaporization of silver.

While I do not wish to be limited to any particular theory to explain the improved results obtained by following the teachings of my invention, it appears that when antimony in the vapor stage is intimately exposed to any excess alkali metal within the envelope a very stable alloy of antimony and the alkali metal is formed, from which the alkali metal will not be released during operation of the tube. Therefore, phototubes made in accordance with my invention may be operated at elevated temperatures without danger of liberating alkali metal from the film of absorbent, whereas many prior tubes using metallic oxides or carbon as a caesium absorbent must be designed to operate at temperatures approximating normal room temperature.

The complete lack of leakage due to the fixing or absorption of excess alkali metal makes my process particularly applicable to the manufacture of television transmitting tubes using either a continuous photocathode or a target electrode of the mosaic type having a multiplicity of silver particles. My process is well adapted for use in the manufacture of such mosaic electrodes wherein the silver particles of the electrode are oxidized, caesium admitted to the tube and the excess caesium absorbed by vaporizing a mass of my alkali metal absorber within the envelope. One of the main problems of forming a photoelectric mosaic under present methods is the elimination of caesium from between the particles. In accordance with my invention, this excess alkali metal deposited between the mosaic particles is absorbed, thereby reducing the electrical leakage between the particles.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no

means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

I claim:

1. A photo-electric tube comprising an envelope enclosing an anode, a cathode photosensitized with alkali metal, and a thin layer comprising an alkali metal and a metallic element selected from the group consisting of antimony, arsenic and bismuth on a portion of the inner wall of said envelope and disposed remote from said cathode.

2. A photo-electric tube comprising an envelope, a cathode, a photosensitive coating of alkali metal on said cathode, an anode exposed to said cathode, a mass of metallic material selected from the group consisting of antimony, arsenic and bismuth mounted within said envelope and a film including a metal selected from the said group of metals on the inner surface

of said envelope adjacent said quantity of metal said film also including an amount of alkali metal absorbed from the atmosphere of said envelope.

3. A photo-electric tube comprising an evacuated envelope, a cathode having a photosensitive coating of alkali metal, an anode exposed to the coating of alkali metal on said cathode, a mass of antimony within said envelope adapted to be vaporized within said envelope and a film of alkali metal-antimony alloy on a surface within said envelope disposed remote from said cathode.

4. A photo-electric tube comprising an envelope, a caesium-treated photosensitive cathode within said envelope, an anode in electron receiving relation with respect to said cathode, a mass of antimony within said envelope adapted to be vaporized within said envelope and a composite caesium-antimony film on a surface within said envelope remote from said cathode and removed from the direct path between said cathode and anode.

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