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ELECTROOPTICAL APPARATUS

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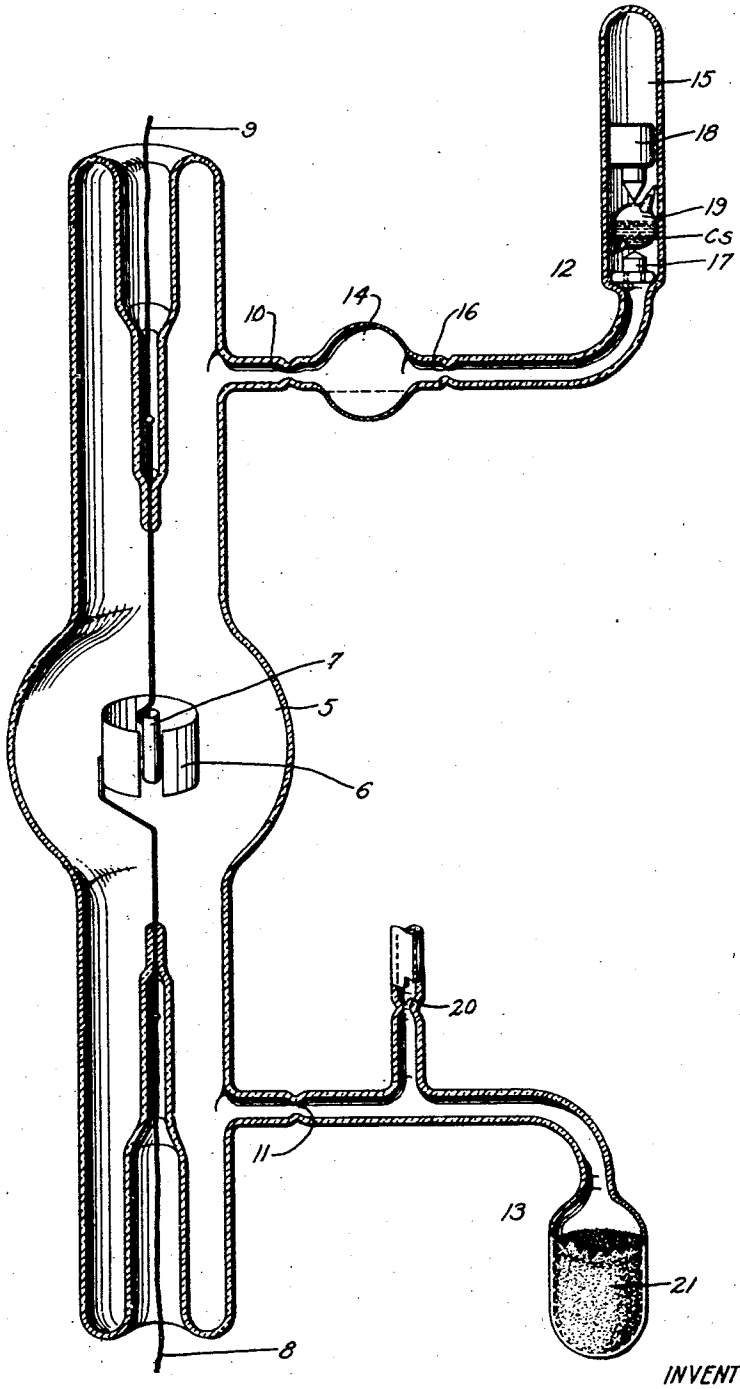

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UNITED STATES PATENT OFFICE

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ELECTROOPTICAL APPARATUS

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This invention relates to electro-optical apparatus, and more particularly to photo-electric tubes.

The invention provides a stable and highly sensitive photo-electric tube characterized by having the photo-electric material in the form of a thin transparent layer.

Such a tube is preferably made by depositing upon an electrically conductive cathode within a highly evacuated cell envelope a uniform thin transparent layer of photo-electric material, any subsequent appreciable change of sensitivity of the cathode layer due to redistribution of the material within the envelope at ordinary room temperatures being prevented. In a preferred form of the invention the amount of photo-electric material which is present in the tube when it is finally completed is limited to that which is required to form a uniform film upon all the exposed interior surfaces of the tube, including the cathode, of such thickness that substantially maximum sensitivity obtains. The uniform layer on the exposed surfaces, other than the cathode, prevents any appreciable changes in the sensitivity of the cathode layer due to redistribution of the material within the envelope on account of spontaneous deposition at ordinary room temperatures. The film may be further stabilized by providing the envelope with an atmosphere of inert gas when the photo-electric material is more volatile than potassium.

A tube in accordance with the invention may comprise, for example, a film of cæsium on a highly polished platinum plate immersed in an atmosphere of argon gas at low pressure. Tubes of this kind have been found to be both sensitive and stable. In one method of producing such a tube cæsium vapor is allowed to diffuse very slowly into the evacuated envelope from a side tube. When maximum sensitiveness has been attained, the side tube is sealed off and an atmosphere of inert gas such as argon is introduced to stabilize the film.

The invention will now be described more in detail having reference to the accompanying drawing which illustrates one example of practice.

The completed photo-electric tube comprises an envelope or enclosing vessel 5 having mounted therein a cylindrically shaped cathode 6 and a cylindrically shaped anode 7 of smaller diameter located co-axially with the cathode 6. The cathode 6 is electrically connected to terminal 8, and the anode 7 to the terminal 9 through sealed-in wires.

The cathode 6 is preferably a highly polished platinum plate upon which there is deposited such a thin film of light sensitive material that maximum photo-electric sensitivity obtains. The thin film is transparent. In a preferred form of tube the film consists of cæsium and the electrodes are immersed in an atmosphere of argon, the envelope being sealed off at the points 10 and 11.

In the manufacture of a cæsium argon filled tube, for example, enclosing vessel 5 is provided with a tubulation 12 for the introduction of the cæsium and a tubulation 13 for purposes of evacuation and control of the pressure of the argon atmosphere. Tubulation 12 consists of a side tube 14 connected to another side tube 15 having a reduced portion 16 in the connecting tube. Within the side tube 15 is a metallic anvil 17 and an iron weight 18 which are adapted for breaking the evacuated capsule 19. The capsule 19 contains a supply of cæsium which has previously been purified by distillation in vacuo. The tubulation 13 comprises a side tube 20 for connection to a vacuum pump and a chamber 21 containing charcoal which may be cooled by liquid air in well-known manner.

In the manufacture of a tube the equipment as illustrated is connected to a vacuum pump and a high degree of vacuum maintained with suitable heating of the apparatus and electronic bombardment of the electrodes to substantially eliminate occluded gases. With the pump still operating the charcoal in side tube 21 is cooled with liquid air. Argon gas is admitted through the tube 20, in well-known manner, a quantity of which is absorbed by the charcoal in the tube 21. When no more argon will be absorbed and a high degree of vacuum is again obtained, the pump is sealed off at the restricted portion of tube 20.

The cæsium capsule 19 is now broken by raising the iron weight 18 with a magnet and allowing it to drop. Heat is then applied to the side tube 15 to distill the cæsium into the side tube 14 after which the side tube 15 is sealed off at the point 16. The cæsium in the side tube 14 is now allowed to diffuse at ordinary room temperature into the vessel 5. Since the diffusion takes place very slowly, the cæsium spreads itself uniformly over the metal parts of the tube and the increase in sensitiveness is watched while the tube is illuminated by connecting the electrodes 8 and 9 to a galvanometer in well-known manner. When the maximum sensitivity has been reached the side tube 14 is sealed off at the point 10. In order to stabilize this film an atmosphere of argon gas is now admitted to the vessel 5 by allowing the cooled charcoal in the tube 21 to warm up. When the pressure of argon within the vessel 5 reaches a desired value which may be between .05 mm. and .1 mm. of mercury, the tubulation 13 is sealed at the point 11 and the cell is ready for use.

The atmosphere of inert gas serves also to provide gas amplification. The gas pressure is adjusted for maximum photo-electric amplification, this gas pressure being dependent upon the electrode distance.

Light sensitive materials which meet the requirements of this invention are cæsium, rubidium, potassium, and sodium. Cæsium and rubidium are more volatile at ordinary room temperatures than potassium and sodium.

These materials may be used in the form of thin films according to this invention without immersion in an atmosphere of inert gas. such as argon. In the case of cæsium and rubidium, however, which metals are more volatile than potassium at ordinary room temperatures, it has been found preferable to employ such an atmosphere.

This invention is not limited to photo-electric tubes having any particular shape of electrodes or containing vessel. A glass vessel and a highly polished platinum cathode have been found to be satisfactory. A magnesium coating on the inside of the glass vessel may also be used as the cathode. Other obvious modifications, coming within the scope of the appended claims, may be used.

What is claimed is:

1. The method of making a photo-electric tube which comprises forming within an envelope electrically conductive cathode and anode, highly evacuating the envelope, and while in the evacuated condition depositing on said cathode a uniform, thin, transparent film of photo-electric material more volatile than potassium, and subsequently providing the tube with an atmosphere of inert gas at such pressure as to prevent a material change of film sensitivity.

2. The method of making a photo-electric tube which comprises forming within an envelope electrically conductive cathode and anode, highly evacuating the envelope, depositing upon said cathode while the envelope is in the evacuated condition a uniform, thin, transparent layer of cæsium thinner than that which would be deposited by spontaneous deposition at average room temperature if an excess of cæsium were present within the envelope, and modifying the atmosphere within the tube to prevent an apreciable change of sensitivity of the cathode layer due to redistribution of the cæsium within the tube at ordinary room temperatures.

3. The method of making a photo-electric tube which comprises forming within an envelope electrically conductive cathode and anode, highly evacuating the envelope, depositing on said cathode while the envelope is in the evacuated condition a uniform, thin, transparent film of cæsium by diffusion at ordinary room temperatures from a side tube containing an excess amount of cæsium, sealing off the side tube when the desired thickness of film has been formed, and subsequently providing the tube with an atmosphere of inert gas at such pressure as to prevent material change of film sensitivity.

4. A photo-electric tube comprising an electrically conductive cathode and anode, a uniform, thin, transparent film of photo-electric material on said cathode, and means for preventing a material change of sensitivity of the cathode film at ordinary room temperatures.

5. A photo-electric tube comprising an electrically conductive cathode and anode, a uniform, thin, transparent film of cæsium on said cathode, and means for preventing a material change of sensitivity of the cathode film at ordinary room temperatures.

6. A photo-electric tube comprising an electrically conductive cathode and anode, a uniform, thin, transparent film of cæsium on said cathode, and an atmosphere of inert gas at such pressure as to prevent a material change of film sensitivity.

7. A photo-electric tube comprising an enclosing vessel, a pair of electrodes within said vessel, and such an amount of photo-electric material within said vessel that a thin film of said material is present on one of said electrodes of such thickness that substantially maximum sensitivity to light obtains, said photo-electric material being one capable of causing an increase of film thickness by spontaneous deposition at normal room temperatures, if a greater amount of the material were present.

8. A photo-electric tube comprising an enclosing vessel, a pair of electrodes within said vessel, photo-electric material of such an amount within said vessel that a thin film of said material is present on one of said elec-

rodes of such thickness that substantially naximum sensitivity to light obtains, said hoto-electric material being more volatile t normal room temperature than potassium, nd an atmosphere of inert gas at low pressure within said vessel.

9. A photo-electric tube comprising an nclosing vessel, a pair of electrodes within aid vessel, a thin layer of cæsium spontaneusly deposited on one of said electrodes to uch a thickness that substantially maximum ensitivity to light is obtained, and an atmosphere of argon at low pressure within said essel.

10. The method of making a photoelectric ube which comprises forming within an envelope electrically conductive cathode and node, highly evacuating the envelope, producing upon said cathode a uniform, thin, ransparent layer of photoelectric material hinner than that which would be produced y spontaneous deposition at average room emperature if an excess of photo-electric naterial were present within the envelope, nd modifying the atmosphere within the ube to prevent an appreciable change of ensitivity of the cathode layer due to redistribution of the material within the tube at rdinary room temperatures.

11. A photoelectric tube comprising an vacuated envelope housing an electrically onductive cathode and anode, said tube having a uniform, thin, transparent film of photoelectric material deposited upon all of its nterior exposed surfaces.

In witness whereof, I hereunto subscribe ny name this 18th day of December, 1928.

HERBERT E. IVES.