

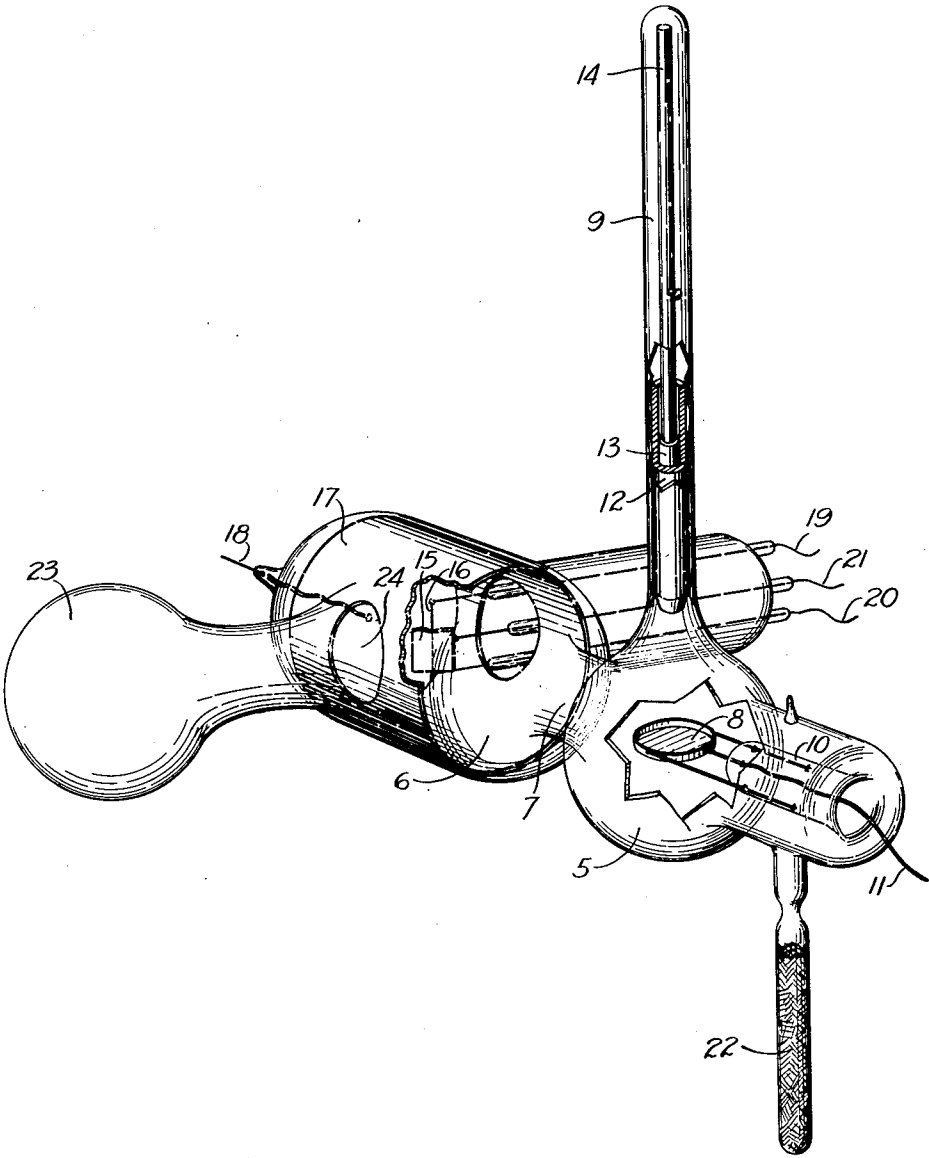
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ELECTROOPTICAL DEVICE

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ELECTROOPTICAL DEVICE

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This invention relates to electro-optical devices and more particularly to photoelectric tubes comprising lithium.

An object of the present invention is to provide an improved photoelectric tube in which the light sensitive material comprises lithium deposited in vacuo.

Heretofore, photoelectric tubes comprising lithium have been made and tested, but the results obtained on all those in which the lithium was deposited in vacuo indicated, so far as applicant is aware, that contaminating elements were present in the lithium, such as the oxides and carbide. The present invention provides a photoelectric tube having light sensitive material consisting of substantially pure lithium deposited in vacuo. By providing, for example, a thin film of lithium on a highly polished tungsten plate in accordance with this invention, a photoelectric cell sensitive to red light is made available.

The handling of lithium is much more difficult than that of the other alkali metals, sodium, potassium, rubidium and caesium. It has considerably higher melting and boiling points and is commonly believed to attack glass and platinum. A more serious obstacle to its manipulation is presented by the extreme toughness and hardness of the shell of oxide which forms on it in air coupled with the extreme lightness of the metal. Attempts to melt and distil it in glass from the lump form in which it is obtained commercially have been quite unsuccessful as the glass blackens and cracks before any lithium metal breaks through its oxide shell. There is reason to believe that the oxide sublimates at a temperature as low as or lower than the boiling point of the metal and the common presence of carbide as an impurity offers a further obstacle to the melting and distilling processes.

To overcome these difficulties a method has been devised in accordance with this invention of introducing unoxidized metallic lithium into a chamber evacuated to such a degree or containing such a gas that the atmosphere within the chamber is inert with

respect to the lithium metal. In the preferred method a thin walled steel tube is forced through a piece of commercial lithium metal, so that on withdrawing the tube contains a cylindrical slug whose sides are protected from air by the tube walls and the only oxide present is on the comparatively small areas at top and bottom. The steel tube with its slug of lithium is placed in a glass container which is eventually to be evacuated. A steel rod somewhat smaller than the inside diameter of the steel tube is placed vertically on top of the lithium. After the container has been thoroughly evacuated the steel tube is heated by a high frequency induction furnace to melt the lithium which is forced out of the tube by the weight of the steel rod. The lithium appears as a globule of clean metal which may hang to the bottom of the tube or drop into a nickle cup which is provided. By holding this globule in a molten condition by the induction furnace metallic lithium is given off which collects on the walls of the chamber from which it may be redistilled in a manner similar to that employed with sodium and potassium.

This method of producing a body of clean substantially pure lithium is not confined to the manufacture of photoelectric tubes, but may be useful in other fields. The claims contemplate such use.

The term "inert atmosphere", as used herein, defines the atmosphere within a space so highly evacuated that the remaining gas is inert, as well as a space occupied by an inert gas, such as argon.

A more detailed description of the invention follows, having reference to the accompanying drawing which illustrates an example of practice.

A procedure which has been found successful for producing a photoelectric tube having a cathode comprising pure lithium metal will now be described. An enclosing vessel adapted to be evacuated consists of two pyrex glass bulbs 5 and 6 with a connecting tube 7. Bulb 5 is provided with a centrally located nickel cup 8 which stands directly below a long glass tube 9 through which the lithium is to be introduced. The cup 8 is supported from the

inverse tube 10, a sealed-in conductor 11 being provided for test purposes.

The procedure of introducing the lithium is as follows:

5 The bottom end of a thin-walled steel tube 12 is turned down to a sharp edge. This tube is then driven through a piece of lithium metal so that on withdrawing the tube contains a cylindrical slug 13 of lithium whose
10 sides are protected from the air by the tube walls and the only oxide present is on the comparatively small areas at top and bottom.

The steel tube 12 with its slug of lithium 13 is placed in the glass tube 9 which is so
15 constricted near its junction with the bulb 5 as to hold the steel tube 12 several centimeters above the nickel cup 8. A long steel rod 14 loosely fitting in the steel tube 12 is next inserted, resting on top of the lithium
20 slug 13. The end of the glass tube is then sealed off. The tube is then exhausted, all the metal parts in the bulb 6 being well baked out and the cup 8 in the bulb 5 being brought to a red heat by a high frequency magnetic
25 field. The tubulation for exhausting the bulbs 5 and 6 may be connected at any suitable point in well-known manner.

The next step consists in heating the steel tube 12 by a high frequency induction furnace until the lithium in the slug 13 melts.
30 When it melts the weight of the steel rod 14 suffices to break the oxide crust and a globule of clean lithium metal appears at the end of the steel tube 12, where it may hang or it may drop into the nickel cup 8. This globule is then held molten by the induction furnace and gives off metallic lithium which collects on the walls of the bulb 5. By means of a
35 bunsen flame this deposited metallic film of lithium is periodically redistilled off the walls and through the connecting tube 7 into the bulb 6. The bulb 6 which is to be the photoelectric tube proper has as cathode a tungsten plate 15 behind which is a tungsten
40 filament 16 to be used for heating the plate 15 by electronic bombardment and has as anode a nickel cylindrical can 17 open at the end toward the bulb 5 and provided with a sealed-in conductor 18. The filament 16 is
45 provided with sealed-in terminals 19 and 20, while the cathode plate 15 has a sealed-in terminal 21. As the distillation proceeds, the metal parts within the bulb 6 become coated with lithium which in appearance and
50 behavior under the flame is very similar to the other alkali metals. The cathode plate 15 is cleaned off by heating to a white heat several times and allowed to recoat. Meanwhile, the bulb 5 becomes somewhat blackened by a deposit which appears to be carbon
55 due to the carbide present in the original lithium. When a good supply of lithium is obtained in the bulb 6, the tube is pumped until a high vacuum is obtained, the obtaining of which is assisted by the charcoal tube

22, later to be placed in liquid air, and the whole is sealed off from the pump. A side bulb 23 connected to the bulb 6 remains free from lithium and serves as a window for the incident light which passes through the hole
70 24 in the anode 17. The cathode plate 15 is shown broken away in the drawing to more clearly show the filament 16.

The tube thus prepared exhibits as the tungsten plate is cleaned off and recoated
75 by gentle warming of the metal on the glass in bulb 6, all the characteristic phenomena shown by the other alkali metals. The cathode first becomes sensitive to blue light then as the film increases in thickness to green,
80 yellow and red. On still further increasing its thickness the red and yellow sensitiveness disappears and the final thick layer is sensitive only to blue light.

The bulb 6 may be sealed off from the
85 tube 7 after a sufficient amount of lithium has been distilled into the bulb 6. The photoelectric tube may also take other forms than that illustrated and the tube bulb may be filled with an inert gas, such as helium, argon,
90 neon, etc.

The same phenomenon of extension of the long wave limit has been observed when the cathode is a nickel platinum weld. It is believed that this phenomenon will be present
95 whenever the light sensitive material does not alloy with the polished cathode.

So far as applicant is aware this is the first time that a photoelectric tube has been made having a cathode comprising lithium in a form which is sensitive to red light. In fact this is the first time that such a tube has been produced which is sensitive to light having a wave length greater than that of green light which is approximately 0.535 microns.
100 Lithium tubes have been made in accordance with this invention which are sensitive to light having a wave length of the order of 0.67 microns which is well within the range of wave lengths representative of red light.
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An advantage of using lithium as a light sensitive substance lies in its great stability which is due to its relatively high fusion and boiling points compared with the other alkali metals, sodium, potassium, rubidium and caesium. Red sensitive cells of this kind are therefore usable under a wider range of temperature conditions.
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Various modifications of the specific structure and procedure herein disclosed come within the purview of this invention. The accompanying claims are drafted in contemplation of such modifications.
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What is claimed is:

1. A photoelectric tube having an anode
120 and a cathode sensitive to red light, said cathode comprising a metal immune to attack by lithium and a thin film of lithium on said metal.

2. A photoelectric tube having an anode
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and a cathode sensitive to light having a wave length greater than 0.535 microns, said cathode comprising a metal which does not readily alloy with lithium and a thin film of lithium on said metal.

3. A photoelectric tube having an anode and a cathode sensitive to light having a wave length of the order of 0.67 microns, said cathode comprising a metal immune to attack by lithium and a thin film of lithium on said metal.

4. A method of producing a deposit of substantially pure lithium within a tube which comprises removing an interior portion from a body of commercial lithium, protecting the major part of the surface of said portion from oxidation, surrounding said protected portion with an inert atmosphere, and producing from said protected portion a body of substantially pure lithium unprotected except by said inert atmosphere.

5. A method of producing a deposit of substantially pure lithium within a tube which comprises forcing a tubular cutter through a piece of commercial lithium to remove a slug of lithium therefrom, introducing said cutter and slug into said tube, producing an inert atmosphere within said tube, and heating said slug to remove it from said cutter.

6. A method of producing a photoelectric tube which comprises cutting a slug from a piece of commercial lithium with a sharpened steel tube, placing the tube and slug in a vertical position in a side vessel connected with the tube chamber with a steel rod resting on top of the slug, evacuating the chamber and side vessel, heating the tube and slug to melt the lithium so that the molten lithium is forced from the tube by the rod, and distilling the lithium into the tube chamber.

7. A method of producing a photoelectric tube which comprises cutting a slug from a piece of commercial lithium with a sharpened steel tube, placing the tube and slug in a vertical position in a side vessel connected with the tube container with a steel rod resting on top of the slug, evacuating the container and side vessel, heating the tube and slug with an induction furnace to melt the lithium so that the molten lithium is forced from the tube by the rod, further heating the molten lithium by induction to distil the lithium on the walls of the tube container, redistilling the lithium for deposition upon a conducting cathode, and sealing off the tube.

8. A method of producing a photoelectric tube which comprises cutting a slug from a piece of commercial lithium with a sharpened steel tube, placing the tube and slug in a vertical position in a side vessel connected with the tube container with a steel rod resting on top of the slug, evacuating the container and side vessel, heating the tube and slug with an induction furnace to melt the lith-

ium so that the molten lithium is forced from the tube by the rod, further heating the molten lithium by induction to distil the lithium on the walls of the tube, and redistilling the lithium for deposition upon a tungsten cathode to a thickness such that the tube is sensitive to red light.

9. A method of producing a photoelectric tube which comprises cutting a slug from a piece of commercial lithium with a sharpened steel tube, placing the tube and slug in a vertical position in a side vessel connected with the tube container with a steel rod resting on top of the slug, evacuating the container and side vessel, heating the tube and slug with an induction furnace to melt the lithium so that the molten lithium is forced from the tube by the rod, further heating the molten lithium by induction to distil the lithium on the walls of the tube, and redistilling the lithium for deposition on a nickel platinum weld to a thickness such that the tube is sensitive to red light.

10. A photoelectric tube having an anode and a cathode, said cathode comprising a nickel platinum alloy and a light sensitive element comprising lithium deposited on said alloy.

11. A photoelectric tube having an anode and a cathode, said cathode comprising a nickel platinum alloy and a thin layer of lithium thereon.

12. A photoelectric tube having an anode and a cathode sensitive to red light, said cathode comprising a nickel platinum alloy and a light sensitive element thereon comprising lithium.

13. The method of making a photoelectric tube which comprises forming within a tube container an anode and a cathode support of metal immune to attack by lithium, heating a supply of lithium to build up a thin film of lithium on said cathode support to form a light sensitive cathode, and cooling the tube when said cathode becomes sensitive to red light.

14. The method of making a photoelectric tube which comprises forming within a tube container an anode and a cathode support of metal immune to attack by lithium, heating a supply of lithium to build up a thin film of lithium on said cathode support to form a light sensitive cathode, and cooling the tube when the cathode has become sensitive to light of desired wave length above 0.535 microns.

In witness whereof, I hereunto subscribe my name this 6th day of March, 1929.

HERBERT E. IVES.