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PREVENTION OF ELECTRICAL LEAKAGE

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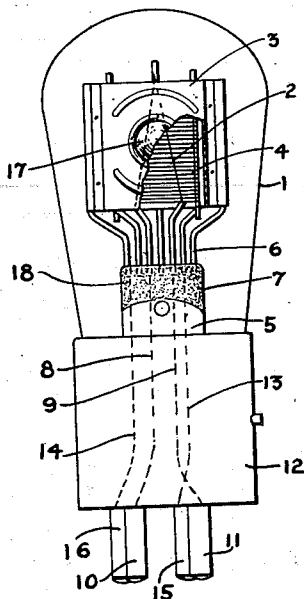


Fig. 1.

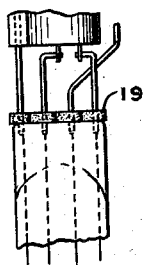


Fig. 2.



Fig. 3.

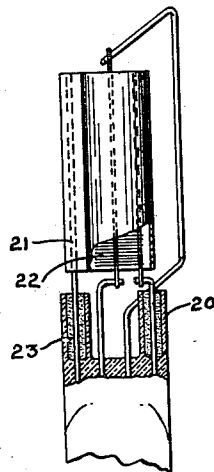


Fig. 4.

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PREVENTION OF ELECTRICAL LEAKAGE

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This invention relates to an electric discharge device and more particularly to the prevention of leakage between the leading-in wires of an electric discharge device containing an alkali metal.

Alkali metals are employed in discharge devices such as photoelectric cells, rectifiers, radio tubes, etc., for many purposes as, for instance, to reduce the potential drop between the electrodes, to serve as a getter, to increase the electron emission from the filament, to increase the current carrying capacity of the device or to increase the sensitivity of the device as a detector of radio signals, etc. The alkali metals, however, particularly such metals as caesium which have a high vapor pressure, tend to cause conductive paths along the walls of the envelope between the leading-in conductors resulting in leakage between the electrodes and deleteriously affecting the operation of the device.

One form of discharge device, such as described in British Patent 208,729 to which the present invention is particularly adapted, is for thermionic valve amplifiers employing an alkali metal such as caesium, rubidium or the like. The alkali metals under proper conditions greatly increase the electron emission of the cathode of a thermionic device at a temperature so low that in the absence of the vapor no substantial electron emission would occur. These results are explained on the theory that a film of the alkali metal is continuously formed on the cathode which resists evaporation at a temperature far in excess of the vaporization point of the alkali metal. The cathode of such a device consists of a metal having a high electron affinity, such as tungsten, molybdenum or nickel, whereas the caesium has a low electron affinity. The formation of the caesium film appears to be greatly facilitated by the presence of an electro-negative gas such as oxygen which, on coming in contact with the filament, forms an oxide or oxygen film on the surface of the filament capable of holding onto the atoms of the alkali metal more strongly than does the surface of the heated electrode.

In devices of this nature considerable difficulty has been experienced in eliminating

the leakage between the lead wires to a sufficient extent to render the tubes practical. In a copending application Serial No. 30,662 of Emil G. Widell, filed May 16, 1925, entitled Electron discharge devices and assigned to the Westinghouse Lamp Company, there is described and claimed a method of preventing leakage between the leading-in wires of electron discharge devices employing alkali metals therein. This process consists briefly, in coating the glass adjacent the leads with a resinous material such as shellac or rosin with which the caesium does not wet to form a continuous conducting film. Such method has proved very successful in preventing leakage between the leading-in wires of tubes containing an alkali metal. However, when employed with tubes of the above nature, depending upon the use of an electro-negative gas layer such as oxygen for binding the alkali metal to the filament, difficulty has been experienced, due to the reduction of the oxide or oxygen layer by the hydrocarbon or carbonaceous vapors given off by the resinous coating. This reduction of the oxygen gas layer interferes with the maintaining of the caesium film on the surface of the cathode and results in loss of the caesium emission.

One of the objects of the present invention is, therefore, to prevent leakage between the leading-in-wires of an electron discharge device employing an alkali metal as the active electron-emitting material, which will not act detrimentally to the emission or life of the device.

Another object is to produce an improved method of preventing the formation of conductive paths between the leading-in wires of an electrical discharge device employing an alkali metal.

Other objects and advantages will hereinafter appear.

The formation of conductive paths on the press between the leading-in wires of a device which employs alkali metals I have found to be due to either one or both of two causes. The alkali metal condenses on the glass press with the formation of a continuous film of the alkali metal between the leading-in wires and

in the case of caesium, for instance, this metal appears to also attack the glass and due to its strong reducing action, serves to reduce the lead oxide or other metallic oxide content of the glass leaving free lead or other metal at the surface which is capable of conducting current between the leading-in wires. Upon initial operation of a tube of this nature, the leakage may be very considerable but after operating a short period most of the caesium becomes vaporized away by the heat of the filament so that the leakage drops down to about 10% of its initial value. This residual leakage, which appears to be due to the decomposition of the glass, persists, however, and prevents the proper functioning of the device.

In accordance with the present invention I coat the glass adjacent the leading-in wires with a compound which under the conditions which exist in the bulb, reacts with the alkali metal deposited on the glass to convert the same into a non-conducting compound which is stable and which will not deleteriously affect the operation or life of the device. The coating substance should be non-conducting and non-hygroscopic and should be free from water of crystallization since any water vapor liberated in the device will be reduced by the alkali metal with the liberation of hydrogen which in turn serves to reduce the oxide or oxygen layer of the filament. The substance should be of such a nature that upon reaction with the caesium no gases are evolved and the compound so formed should be non-conductive. Preferably, the coating substance should have a melting point below the temperature at which the devices are heated during manufacture so that it will become fused onto the glass and form a continuous layer thereover. In addition to reacting with the alkali metal, it forms a protective covering for the glass so as to prevent decomposition thereof.

A class of substances which I have found particularly effective for preventing leakage are inorganic salts containing oxygen, such as potassium nitrate, potassium dichromate, sodium nitrate, barium oxide, etc., although other salts which react with the caesium to form a non-conducting compound and which does not destroy the oxide or oxygen film on the cathode may be used. I prefer to employ a eutectic mixture of potassium nitrate and sodium nitrate having a melting point of only about 218° C. This mixture is readily fused onto the glass during the normal baking out which the device receives during exhaust.

However, any other substance of this same nature having a melting point of 400° to 500° C. or less may be employed. The salt may be pulverized in any suitable manner and mixed with a binder, such as amyl acetate and painted upon the press or glass part which it is desired to protect. Preferably, the pulverized

salt is pressed without the use of a binder into small discs or beads having a center opening so that they can be readily slipped over each of the leading-in wires prior to mounting of the electrodes thereon. If desired, glass tubes may be provided around each of the leading-in wires and the tubing filled with the salt. Other means of applying the material will appear to those skilled in the art.

In order that the invention may be more fully understood reference will be had to the accompanying drawing in which:

Fig. 1 shows an electron discharge device of the type in general use for the amplification of radio signals having the press coated with a protective substance referred to herein;

Fig. 2 is an elevation of the mount showing an alternative method of applying the protective material;

Fig. 3 is a perspective view of the disc or bead of protective material; and,

Fig. 4 is an elevation of a press showing a modified manner of preventing leakage between the leading-in wires.

The device illustrated in Fig. 1 comprises a glass envelope 1 containing the usual filamentary cathode 2, plate electrode 3 and control electrode or grid 4. These electrodes are supported from the stem 5 of the tube by means of support wires 6 sealed into the press 7. In view of the large number of wires which it is required to seal into the press, it is necessary that they be spaced relatively close together, thus greatly enhancing the probability of leakage between the wires.

The terminals of the filament are joined to leading-in wires 8 and 9 connected respectively to the terminal plugs 10 and 11 carried by the base 12. The control electrode 4 and the anode 3 are similarly joined to leading-in wires 13 and 14, also joined to terminals 15 and 16 on the base.

The alkali metal may be introduced into the envelope 1 in any suitable manner such as distillation from the side tube (not shown) or from a capsule 17 welded, soldered or otherwise secured to the anode or other metal part of the device from which it may be liberated by heat. In the case of sodium and some of the less active alkali metals the metal may be introduced in the capsule in metallic form as set forth in copending application of John W. Marden, Serial No. 745,071, filed October 22, 1924, entitled Introduction of vaporizable material into exhausted containers, and assigned to the Westinghouse Lamp Company. However, the more active metals such as caesium may be introduced into the capsule as a non-hygroscopic compound, such as caesium permanganate, mixed with a reducing agent, such as powdered iron or nickel, and the compound decomposed by heat to liberate the metal. This latter method of introducing alkali metal forms the sub-

ject matter of application of John W. Marden, Serial No. 96,335, filed March 21, 1926, entitled Introduction of alkali metals into evacuated containers, and assigned to the Westinghouse Lamp Company.

The caesium or other alkali metal upon being vaporized into the envelope condenses on the various parts of the device causing, in the absence of special precautions, the formation of a continuous conducting layer or coating on the press 7, short-circuiting the leading-in wires where they pass through the glass and causing sufficient leakage to render the device inoperative.

This leakage may be overcome in accordance with the present invention by coating the press with an inorganic salt or mixture of salts 18 which combines with the caesium to form a non-conducting compound and which does not destroy the oxygen or oxide film on the cathode. Preferably, an oxygen containing salt is employed. In addition to those materials heretofore mentioned for preventing leakage between the leading-in wires, the following may also be mentioned as suitable for this purpose: sodium chlorate, sodium dichromate, potassium chlorate, potassium manganate, lithium nitrate, lithium chlorate, calcium and barium chlorates, nitrates and nitrites or suitable mixtures of such salts which have the required melting point. Other salts of this same nature containing oxygen for the purpose of oxidizing the caesium, as will more fully appear, may also be employed.

In order to obtain a substance having a low melting point, a eutectic mixture of potassium nitrate and sodium nitrate is employed. This mixture consists of 55 parts potassium nitrate and 45 parts sodium nitrate and has a melting point of about 218° C. and is readily fused onto the glass portion of the device between the leading-in wires to form a continuous fused coating thereon. In order to degasify the coating substance as completely as possible and thereby simplify and decrease the time required to exhaust the device I prefer to melt the salts or their mixtures in a crucible to form a fused mass and then pulverize the mixture. The pulverized salt or mixture of salts may then be mixed with a suitable binder such as amyl acetate and painted on the press of the device as shown at 18. In order to dispense with the use of a binder, however, I prefer to press the salt or mixture thereof into small beads 19, such as shown in Fig. 2, and to place one of these beads over each of the leading-in wires, as shown in Fig. 3, prior to mounting the electrodes 2, 3 and 4 thereon.

During exhausting of the device it is customary to heat the envelope to a temperature around 400° to drive out all of the water vapor and gases occluded in the glass so that their removal may be effected by the exhaust

pumps. During this baking out process the coating 18 or the beads 19 are fused and form a continuous protective layer over the press adjacent each of the lead wires. When employing the beads 19 it is necessary, of course, to bake the tubes in an upright position in order to cause the salt to flow over the glass.

In Fig. 4 a modified manner of protecting the device from leakage is shown. In this form an insulating tube 20, preferably of glass, surrounds the leading-in wires for the plate or anode 21 and the grid or control electrode 22. The tube 20 is filled with the salt or mixture of salts as shown at 23. Upon heating of the envelope these salts fuse into the tubes and prevent the leakage of current between the lead wires.

In this view I have shown a preferred arrangement of electrode mounting in which the plate and grid electrodes are each supported from the press by a single wire, thus permitting of a wider spacing of the wires in the press and reducing to a minimum the possibility of leakage therebetween. Since the leakage is not troublesome between the filament lead wires it is not essential that they be isolated from each other by the oxidizing coating.

The alkali metal upon condensing on the press, immediately reacts with the inorganic oxygen-containing salt thereon and is oxidized. The caesium oxide so formed is non-conducting and effectively prevents the passage of current between the leading-in wires.

While I have described my preferred embodiment herein it is to be understood that many changes and modifications may be made in the process described herein without departing from the invention and I do not desire to be limited to the exact details shown and described.

What is claimed is:

1. An electric discharge device comprising an envelope containing an alkali metal, current conductors sealed into the envelope and a coating of an inorganic salt containing oxygen on the interior surface of the envelope, between the current conductors.

2. An electric discharge device comprising an envelope containing an alkali metal, current conductors sealed into the envelope and a coating of a non-conducting compound which reacts with the alkali metal to form a non-conducting compound on the interior surface of the envelope between the current conductors.

3. An electric discharge device comprising an envelope containing an alkali metal, current conductors sealed into the envelope and a coating of a nitrate of a metal of the class including the alkali and alkaline earth metals on the interior surface of the envelope between the current conductors.

4. An electric discharge device comprising an envelope containing an alkali metal, cur-

rent conductors sealed into the envelope and a coating of a mixture of oxygen containing salts of metals of the class including the alkali and alkaline earth metals on the interior surface of the envelope between the current conductor.

5 5. An electron discharge device containing cesium metal, conductors sealed therein and a quantity of a mixture of potassium nitrate and sodium nitrate surrounding the conductor adjacent the wall of the device.

10 6. An electric discharge device comprising an envelope containing an alkali metal, an insulating member in said envelope having a plurality of current conductors sealed therein and a coating of a non-conducting compound which reacts with the alkali metal to form a non-conducting compound between the current conductors fused on to said insulating member.

20 In testimony whereof, I have hereunto subscribed my name this tenth day of September, 1926.

ERNEST ANTON LEDERER.

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