March 5, 1935. H. J. SPANNER ET AL 1,993,187

COLD CATHODE DISCHARGE TUBE

Filed Oct. 21, 1929

Fig. 1.

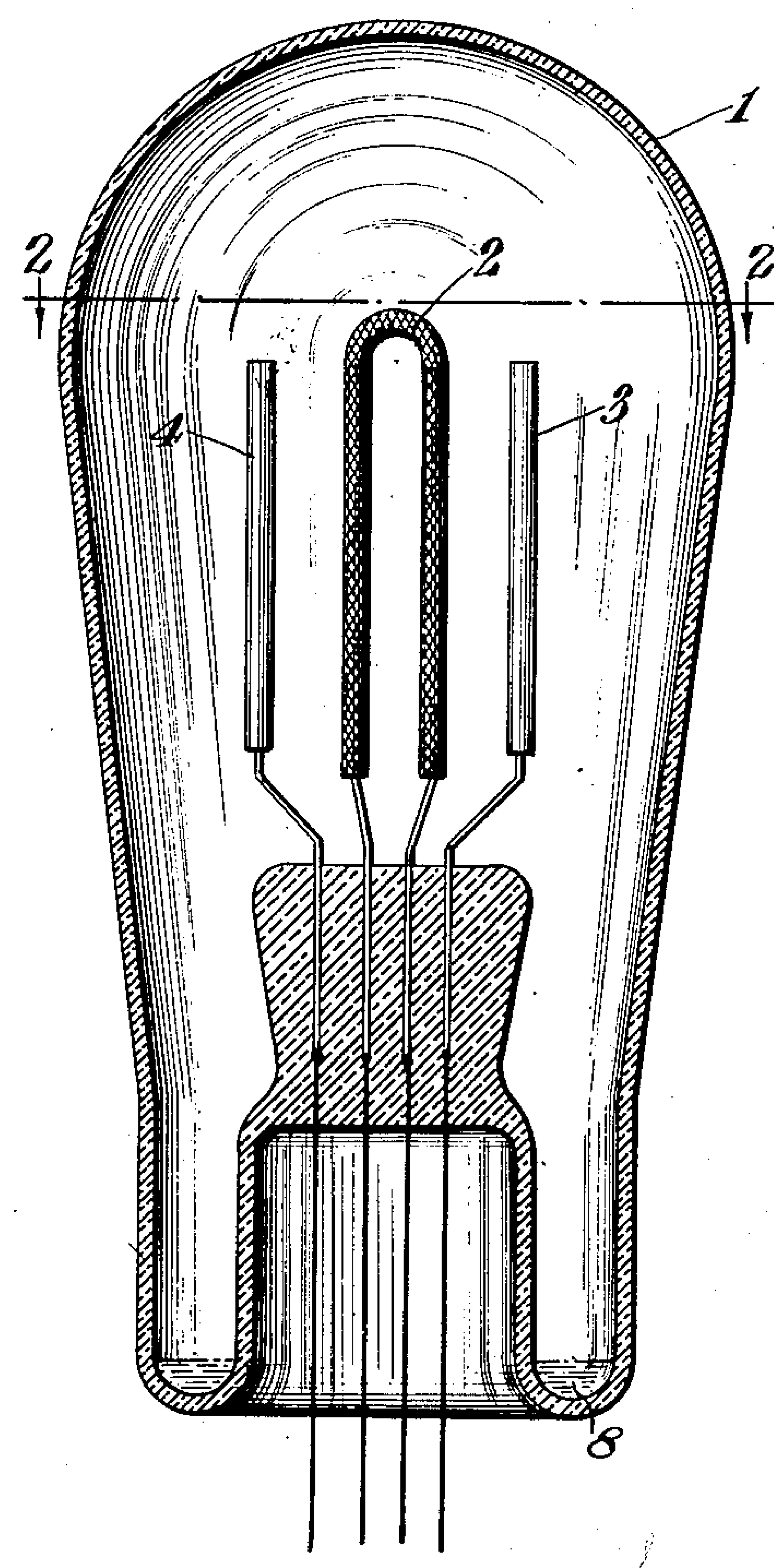


Fig. 2.

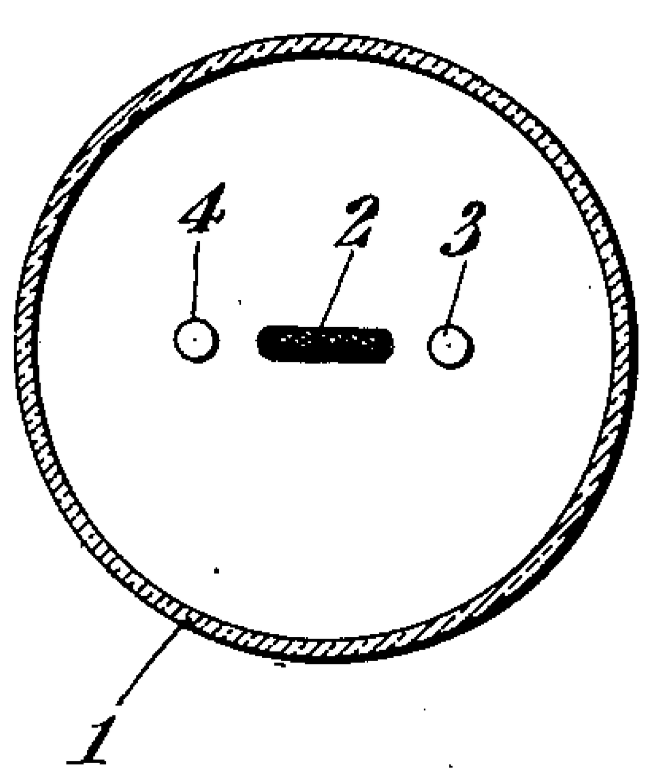
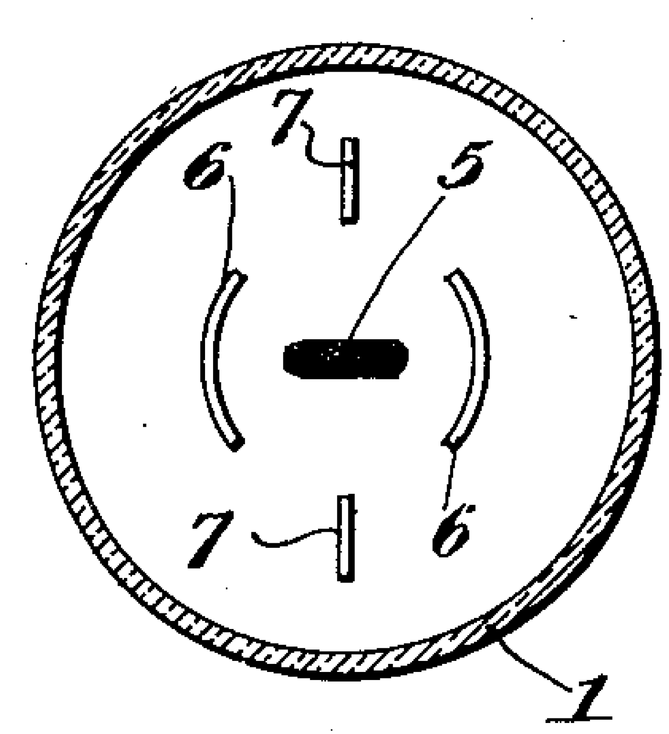


Fig. 3.



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COLD CATHODE DISCHARGE TUBE

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8 Claims. (Cl. 250—27.5)

This invention relates to discharge tubes generally and more particularly to rectifiers employing electron emissive cathodes of the so-called "cold" type.

The object of this invention is to provide an improved electron emissive body which is particularly adapted for employment as a "cold" cathode in an alternating current rectifier or other discharge tube; in other words, an electrode which will have ample emissivity at low current and low temperature, and which shall, in addition, when properly incorporated in the rectifier, have a very small voltage drop, have long emissive life, and be enabled to carry relatively high current loads.

As corollary to this invention, it is also our object to provide a rectifier having high efficiency and economy, particularly one which shall not require a separate heating element, such as a heating coil or spiral, or transformer winding, in order to secure the necessary temperature to bring the cathode body to an emissive state.

We have found quite generally that an electrode having a core of a neutral or inert metal, such as nickel or iron, specially activated, coated or treated with an admixture of a highly emissive or electropositive substance, such as barium or cæsium and a poorly conducting ternary compound consisting of an element or cation of moderately electropositive character and a complex anion which compound is not sufficiently acidic to impede or interfere with electron emission, such as magnesium cuprate, cæsium tungstate or strontium zirconate, or the like, has the desirable properties described above, namely that when employed as a cathode it requires no separate heating element to bring the temperature thereof to a point high enough where it will emit electrons, but will emit at very low temperatures of the core and by the application of relatively very small discharge current by creating hot spots on the coating which become larger with increasing current.

At the same time, it will be found that the life of such an electrode is very long, first, because there can be, of course, no appreciable evaporation where low temperatures are employed, and secondly, because the compounds we have chosen as part of the special activation material are not susceptible to disintegration or dissociation by ionic bombardment under operating conditions and because too, these compounds have a common characteristic that they have relatively high vaporization points.

When employing this electrode as a cathode in the rectifier, we find it advisable and desirable that the rectifier tube contain an inert gas, such as argon, or neon, at a pressure, for argon, of about 1.8 mm., and for neon of about 5 mm. As a matter of fact, these gas pressures are rather critical for the most efficient performance of the tube, and it is well to have present also in the tube a little mercury, cæsium or other suitable metallic vapor.

And as anode, we prefer to use an electrode composed of a substance such as iron tungsten or carbon.

In our preferred embodiment the cathode comprises a strip of intermeshed nickel wires treated or coated in any well-known manner with the special activation substance above described, either before or after ensealing into the tube. A suitable cathode would be one coated or treated with an admixture of barium and cæsium tungstate, for example, and shaped into a hollow body and therein would be inserted two anodes or more, one at least of which is spaced apart from the cathode about 3 mm.

However, our cathode may be made of such small proportions that it may be placed between or surrounded by a plurality of anodes. The anodes may be cylindrical in form with the cathode disposed therebetween.

In the event small cathodes are used, we prefer to shape the anode or anodes in the form of hollow bodies into which we put screens so that the discharge shall follow a fixed path, depending on the potential at the electrode at that time and also that the discharge may not come in contact with the glass wall of the tube, if possible. As a screen, we may use electron clouds, that is, cathode rays. But we may rely upon the mirror formed by the getter metal to keep the discharge from the glass.

In the accompanying drawing which forms part of this specification

Fig. 1 illustrates one embodiment of our invention;

Fig. 2 is a cross-section, on line 2—2, of the tube shown in Fig. 1, to a smaller scale;

Fig. 3 illustrates another embodiment of our invention.

In Fig. 1 the envelope of an electron discharge device or tube is indicated by reference character 1 and contains a cathode 2 of intermeshed wires having the previously described special activating substances applied thereto, and cylindrical anodes 3 and 4 disposed on opposite sides of the cathode. The electrodes may be supported above a press and provided with conducting leads in the usual manner. Since only one cathode lead is necessary in operation as a "cold" cathode, the leads to the cathode 2 may be connected together.

It should be understood that envelope 1 may be provided with a gas filling, such as one or more of the inert gases, and may also contain a small quantity of an easily vaporizable metal, for example mercury, or cæsium, as indicated at 8. In the case of cæsium and other highly electropositive metals, the metal when vaporized may condense in the tube in the form of a thin coating on the inner wall and other relatively cool parts thereof. The gas filling or metal vapor or a mixture of both provides an ionizable atmosphere for the tube.

Fig. 2 is a cross-section of the tube shown in Fig. 1 looking downward upon the electrodes and shows their relative positions.

Fig. 3 illustrates an embodiment of the invention containing a cathode 5 similar to cathode 2 of Fig. 1 but having a plurality of anodes 6 each of which is shaped to form a portion of a cylindrical surface, the anodes taken together forming a substantially cylindrical enclosure for cathode 5. The screens above mentioned may be inserted as shown at 7.

It should be understood however, that the embodiments shown and described herein are merely illustrative and that our invention is not limited to a particular shape of cathode or to a particular arrangement of electrodes.

The operation of our tubes is as follows: When the current source having a difference of potential, say of 100 volts, is applied to the electrodes there appears a blue discharge such as is noticeable in the ordinary form of glow lamps. This discharge then takes an entirely different and more intense form, and electrons are given off exactly as from the heated cathode. An explanation of this rapid building up of the electron flow and profuse emission is that after the initial or starting impulse there occurs automatically a sort of mutually boosting interaction between glow discharge and electron emission; that is, the initially emitted electrons create a glow discharge. This glow discharge causes an increased electron emission. The increased electron emission produces an increased glow discharge, and so on, until a vast electron flow is established limited only by the point of saturation, and we believe that this building up is due to the agitation or stimulation of the special activation material by the glow current.

In the appended claims we have used the word "coating" as synonymous with "activated" or "treated" and where one is used the others may be substituted as being comprehended by the disclosure; that is, where we say "a core coated with a mixture" etc., it may be read as "a core activated with" or "a core treated with" etc.

In a rectifier made in accordance with the above instructions, it will be found that the cathode voltage drop is very low, and that vaporization of the electron emissive material is negligible, and that the rectifier is capable of handling unusually high current loads with unusually high current output.

It will be observed that the ternary compounds of our special activation materials belong to a class of compounds wherein the positive constituent is an electropositive metal and the negative constituent is a complex anion containing oxygen and a metal less electropositive than the cation, but less electronegative than the oxygen.

It will be understood that the size of the electrodes, as well as other factors, will depend upon current load which the rectifier will be required to handle.

And though we have disclosed specific adaptations and embodiments of our invention we are not to be understood as limiting in any way the scope of the invention since it is conceivable that it may be applied to and adapted for discharge tubes of forms and for purposes other than that of and for a rectifier.

Having described our invention, what we claim is:

1. An electron emitting cathode, and an electron emissive coating thereon, the said coating comprising a mixture of a highly emissive substance and magnesium cuprate.

2. An electron emitting cathode, and an electron emissive coating thereon, the said coating comprising a mixture of a highly emissive substance and cæsium tungstate.

3. An electron emitting cathode comprising a core of metal of the iron group in the form of intermeshed wires, and an electron emissive coating thereon, the said coating comprising a highly electron emissive substance and magnesium cuprate.

4. An electron emitting cathode comprising a core of metal of the iron group in the form of intermeshed wires, and an electron emissive coating thereon, the said coating comprising a highly electron emissive substance and cæsium tungstate.

5. An electron discharge device comprising an anode, a cathode having a metallic core the surface of which is activated with a highly electropositive metal, a coating of a ternary compound on said surface which is substantially non-emissive and resistive to ionic bombardment, said compound consisting of a metal of the alkaline group, a less electropositive metal and oxygen, and an ionizable atmosphere in said device containing vapor of the activating metal.

6. An electron discharge device comprising an anode, a cathode, and an ionizable atmosphere containing a rare gas and cæsium, said cathode having a core activated with cæsium and a coating of cæsium tungstate thereon.

7. A cathode adapted to be rendered emissive by ionic bombardment comprising a core activated with a metal of the alkaline group and a coating thereon comprising a compound of a highly electropositive metal and the oxy-acid radical of a more electronegative metal, said compound being highly resistive to dissociation and disintegration by ionic bombardment and the degree of acidity of which is insufficient to interfere with the electron emission of the activated core.

8. An electron discharge device comprising an anode, a cathode having a metallic core activated with a highly electropositive metal, a coating of a ternary compound on said core which is substantially non-emissive and resistive to ionic bombardment, said compound consisting of a metal of the alkaline group, a less electropositive metal and oxygen, and an ionizable atmosphere in said device containing argon at a pressure of about 1.8 mm. of mercury and metal vapor.

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