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COLD CATHODE WITH NICKEL BASE, CALCIUM OXIDE INTERFACE AND MAGNESIUM OXIDE LAYER

Filed April 21, 1961

Fig. 1.

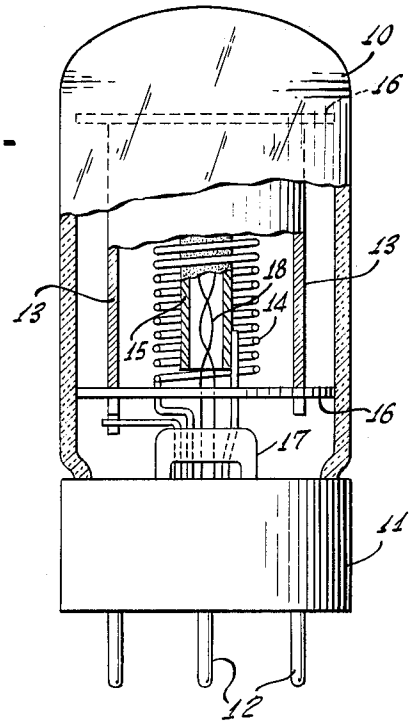


Fig. 3.

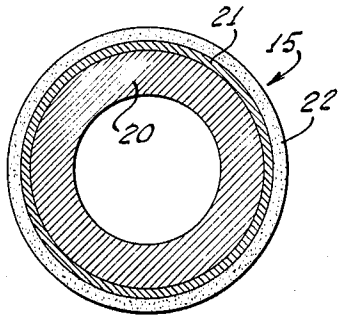
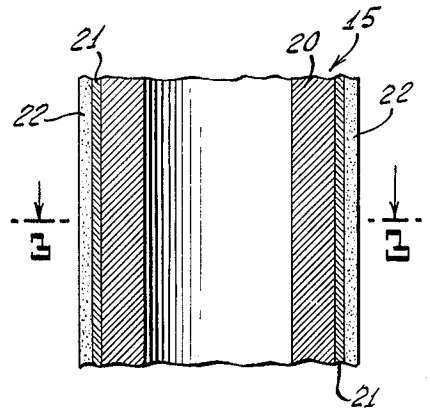


Fig. 2.



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3,242,374

COLD CATHODE WITH NICKEL BASE, CALCIUM OXIDE INTERFACE AND MAGNESIUM OXIDE LAYER

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1 Claim. (Cl. 313—346)

This invention relates to a cold cathode arrangement for vacuum tubes. The invention has particular reference to an intermediate layer which reduces the voltage drop generally found in vacuum tubes having this type of cathode.

Cold cathode tubes using primarily coatings of magnesium oxide, aluminum oxide, and mixtures of aluminum and beryllium oxide are known and have been used in circuits where the absence of a cathode heater is of primary importance. One of the disadvantages of these tubes lies in the fact that after the tube has been started and an anode-cathode current established, the voltage drop existing between the metal cathode sleeve and the space adjoining the outer cathode surface is quite high, about 200 volts. This cathode drop absorbs considerable energy and causes heating of the cathode material, thereby reducing the allowable maximum anode current which can safely be drawn through the tube. The present invention reduces this cathode drop by as much as 20% to 40%, and thereby increases the efficiency of the tube during normal operating conditions.

One of the objects of this invention is to provide an improved cold cathode which avoids one or more of the disadvantages and limitations of prior art arrangements.

Another object of the invention is to reduce the voltage drop in cold cathodes having primary coatings of magnesium oxide and other coatings having self-sustained electron emission.

Another object of the invention is to reduce the power expended when starting conduction in vacuum tubes having cold cathodes.

Another object of the invention is to increase the efficiency and the power available in discharge devices using cold cathodes.

The invention comprises a cathode for electron discharge devices having a base of conductive metal, an intermediate layer of metal oxide, and an outer coating of porous oxide. The intermediate coating, which may be a composite layer of nickel and calcium or similar oxides, forms a low work function interface which permits easy passage of current from the metal base to the oxide coating. The intermediate layer may be formed by coating the nickel sleeve with a dilute solution of a salt such as the nitrate of lithium, calcium, barium, strontium, etc., drying, and then simultaneously oxidizing the nickel surface and salt by heating in dry air or in an oxidizing gas at 700° to 900° C. for a minute or so.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

FIG. 1 is a side view of an electron discharge device with parts cut away to show the internal construction.

FIG. 2 is a vertical sectional view, greatly enlarged, of a portion of the cathode showing the metal base, the interface, and the outer oxide coating.

FIG. 3 is a cross sectional view of the cathode shown in FIG. 2 and is taken along line 3—3 of that figure.

Referring now to the drawings, FIG. 1 shows a conventional vacuum tube having an evacuated envelope **10** secured to a base **11** and having pins **12** for connection

to an external circuit. Inside the envelope **10** is an anode **13**, a sustaining electrode **14**, and a cathode **15**. The tube is exhausted to a condition where the only means of conducting current between the anode and cathode is the electron beam provided by the cathode surface. The vacuum may be maintained by means of chemical getters if desired.

The electrodes within the envelope **10** may be supported in any conventional manner, such as mica spacers **16**. Lead-in conductors which make connection between the pins **12** and the electrodes within the tube may pass through a reentrant stem **17**. The view shown in FIG. 1 includes a cathode heater wire **18** within the cathode. This heater arrangement is not used after the tube has been completed and is employed only during the manufacturing process to give the cathode a preliminary heating to bake out the occluded gasses. The heater wires **18** are generally not connected to any of the pins **12** in the base. For a detailed description of the operation of tubes containing magnesium oxide cold cathodes, reference is made to U.S. Patent 2,950,994 granted to Bernard G. Firth on August 30, 1960.

FIGS. 2 and 3 show the detailed construction of the cold cathode. A metal base **20**, which may be a hollow nickel tube, is the supporting means and connection is made to this part of the cathode for conduction to an external circuit. The interface layer **21** is composed of a mixture of metal oxides such as nickel and barium oxide, calcium oxide, strontium oxide, lithium oxide, or similar low work function coatings. The outer coating **22** is the conventional magnesium oxide which is preferably deposited by means of an electrostatic field which is applied between the nickel base and a ribbon of burning magnesium. Other outer coatings such as aluminum oxide or beryllium oxide may be used.

To form the layer **21** it has been found convenient to first deposit certain salts of the metals onto the nickel surface, and heat the cathode in dry air or in an oxidizing gas so that the salt is reduced to the metal oxide, giving off gas in the process. It has been found that using the nitrates or hydroxides of the metals produces good results. The salt is dissolved in a solution (100 milligrams of calcium nitrate in 20 cc. of distilled water), flowed onto the nickel sleeve, dried by spinning at 2000 r.p.m., and then heated to about 800° C. for about 1 minute to form the oxide surface layer. Magnesium or other suitable oxide is then applied to this surface in any convenient manner. While the electrostatic smoke application gives the best results, spraying also may be used. Calcium oxide is the preferred first coating.

The cathode is now mounted in the tube and processed in the usual manner, see the above mentioned Patent 2,950,994. The resulting vacuum tube has a reduced cathode voltage drop, approximately half the cathode drop found in prior tubes of this general classification. The tube is easier to start, produces less heat, and has greater over-all efficiency.

The tube shown in the drawings is a diode but it will be obvious that the cold cathode described herein may be employed in a triode amplifier, a pentode, or any other type of arrangement which uses a stream of electrons for conduction through an evacuated space.

The foregoing disclosure and drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense. The only limitations are to be determined from the scope of the appended claim.

I claim:

A cold cathode for emitting electrons under the influence of an electric field comprising, a nickel base for conductive connection to an external circuit, a first coating of calcium oxide to form an interface material for increasing conductance from the base to a second coat-

ing, said second coating including a layer of porous magnesium oxide.

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