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Nov. 17, 1953 J. M. LAFFERTY 2,659,685

BORIDE CATHODES

Filed Aug. 8, 1950

W, Mo, Pt w Ta{C, B, N} ctg + Metal boride ctg

Fig.1.

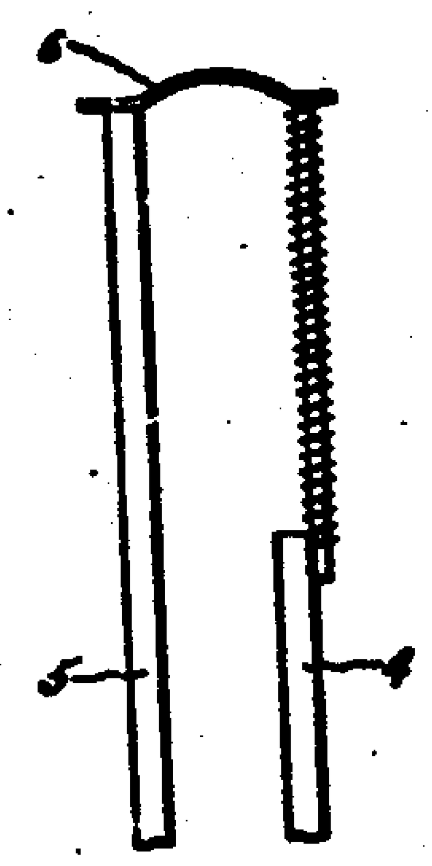


Fig.2.

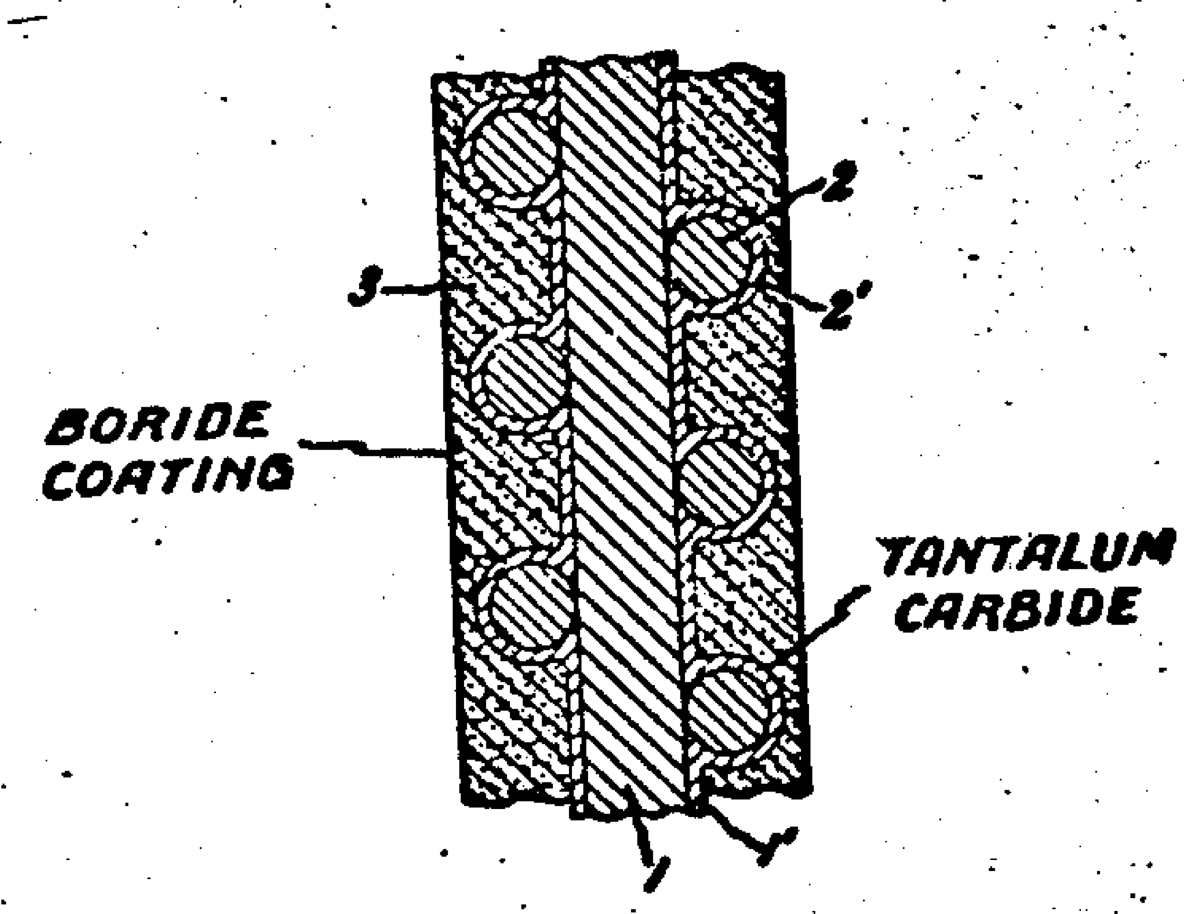
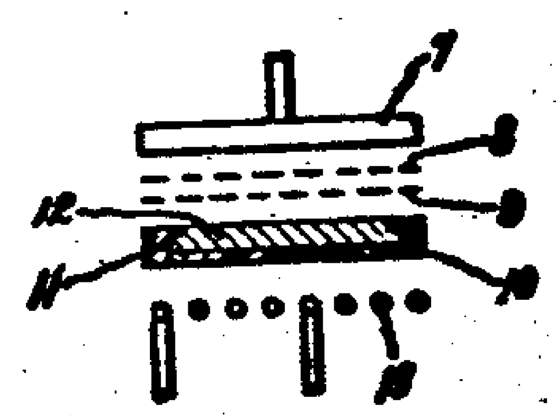


Fig.3.



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BORIDE CATHODES

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6 Claims. (Cl. 148—31.5)

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My invention relates to improved boride cathodes and is in the nature of an improvement on the invention described and claimed in my copending application Serial No. 153,212, filed March 31, 1950, now matured into Patent No. 2,639,399 granted May 19, 1953 and assigned to the assignee of this application.

In the above application it is disclosed that the rare earth metal borides including misch metal boride, the alkaline earth borides, and thorium and uranium borides provide electron emitters having very desirable electrical and chemical properties. These materials are in general capable of operating at high temperatures and I have found that in the operation of cathodes consisting essentially of a coating of one of these borides or a mixture of these borides on a refractory metal support or core that the life of the cathode is relatively short. I have also found that the life of these cathodes is materially lengthened by providing a suitable material between the core metal and the boride coating. It appears that the short life experienced with cathodes made by applying the borides directly to a refractory metal core results from the reduction of the borides and the diffusion, at the relatively high temperatures, of the boron into the refractory metal, leaving the metal of the boride free to evaporate from the cathode surface at a rapid rate.

In accordance with an important aspect of my invention a suitable refractory core metal such as tungsten, molybdenum, platinum, columbium or tantalum is treated to provide at least a surface coating of a material into which the boron of the boride coating will not diffuse substantially at the operating temperature of the boride cathodes which may be, for example, in the order of 1500 degrees C. I have found that treating the core metal by boronizing, carburizing or nitriding is effective for this purpose and of these treatments the carburizing is preferred. As will be readily appreciated by those skilled in the art if the boronizing is carried out only to the extent of boronizing the surface that the operation of the cathode at high temperature will cause further diffusion of the boron into the core metal which is followed by a diffusion of the boron of the boride coating into the surface of the core metal. For this reason when boronizing is employed it is necessary to completely boronize the core material with the result that it is rather brittle. For this reason the nitriding and carburizing are preferred and of these the carburizing is superior. The carbides in general are very

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stable at high temperature and cathodes having a surface of carbide may be operated at elevated temperatures, in the order of 1500 degrees C. without any substantial reaction between the boride coating and the carbide. Of the refractory metal carbides, tantalum carbide is the most stable and provides the most desirable overlayer for the cathode core metal.

In its broader aspects my invention contemplates an interposed layer of graphite between the core metal and the boride emitting material or a graphite support for those cathodes in which a metal support is not required.

My invention will be better understood by consideration of a specific cathode embodying my invention, reference being had to the accompanying drawing in which Fig. 1 is an elevational view of a cathode prepared in accordance with my invention; Fig. 2 is an enlarged elevational view in section of a portion of the cathode of Fig. 1; and Fig. 3 is a schematic representation of a modified cathode construction embodying my invention.

Referring now to the drawing, the cathode proper includes a core wire 1 which may be of tantalum although the other refractory metals previously mentioned may be employed if desired. In a particular cathode constructed in accordance with the invention the core wire was of .020 inch in diameter and it was provided with overwinding 2 of tantalum wire of .010 inch in diameter with the turns of the overwinding spaced apart by .010 inch. The space between the overwound turns was filled with a rare earth boride 3, specifically lanthanum boride. Before applying the boride coating the tantalum core and overwinding was carburized by packing in finely powdered sugar charcoal in a graphite crucible and heated in vacuum for one minute at 2300 degrees C. This provided a surface layer of tantalum carbide having a thickness in the order of 2 mills and illustrated at 1' and 2'' in Fig. 2. The center of a tantalum core remained uncarburized and relatively ductile so that the resultant structure is not too brittle to be commercially practicable. The boride coating was then applied over the tantalum carbide coating on the core and overwinding. The cathode thus constructed was operated at a temperature of about 1500 degrees C. for 2000 hours without any evidence of substantial diffusion of the boron into the core material.

While the use of lanthanum boride was specifically mentioned, any one of or a mixture of the rare earth metal borides including misch metal boride, the alkaline earth borides, and thorium and uranium borides may be employed.

In Fig. 1 the cathode of Fig. 2 is shown supported by a pair of lead-in conductors 4 and 5 suitable for sealing through the wall of a vitreous envelope. The upper end of the cathode is supported by a spring member 6 carried by conductor 5.

It is well understood by those skilled in the art the boronizing may be carried out in substantially the same manner as the carburizing except that a powdered boron powder is employed instead of the finely divided charcoal. Also the nitriding process is well known in the art and may be carried out by subjecting the core material to nitrogen or ammonia at an elevated temperature in the order of 2000 to 2500 degrees depending upon the core metal employed.

While the carbide surface described above is preferred it is to be understood that other forms of carbon such as graphite may be employed as an intermediate layer between the core metal and the boride coating.

In Fig. 3 I have shown a modification of my invention in which the cathode is indirectly heated and includes a graphite support without any core metal. Referring to Fig. 3, there is shown schematically the electrodes of a planar type electric discharge device including an anode 7, a screen grid 8, a control grid 9 and the cathode 10, which is in the form of a graphite disk having a rim 11. The rim and disk define a recess which is filled with a boride emitter 12. The cathode is heated by radiation from a heater coil 13 and may also be heated by electron bombardment if the coil 13 is maintained at a suitable negative potential with respect to the cathode 10.

By making the support for the boride emitter of graphite the life of the cathode is greatly improved. The tendency of the boron to diffuse into the support is essentially eliminated in the same manner as it is in connection with the modification of my invention where the core wire is carbonized. It is apparent that an interposed layer of graphite may be employed in a cathode including a core wire and a boride emitter.

While I have described particular embodiments of my invention it will be apparent to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects and I aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A cathode comprising a refractory metal core, an electron emissive coating thereon consisting essentially of a rare earth metal boride and an interposed layer including the carbide of the core metal for minimizing the diffusion of boron from the coating into the core metal.

2. A cathode comprising a tantalum core, an electron emissive coating thereon consisting essentially of a metal boride selected from the group consisting of the rare earth metal borides and mixtures thereof, an interposed layer of tantalum carbide for minimizing the diffusion of boron from the coating into the tantalum core.

3. A cathode comprising a refractory metal core, an electron emissive coating thereon comprising a metal boride and an interposed layer consisting essentially of carbon for minimizing the diffusion of boron from the coating into the core metal.

4. A cathode comprising a tantalum core, an electron emissive coating thereon comprising a metal boride and an interposed layer consisting essentially of carbon for minimizing the diffusion of boron from the coating into the tantalum core.

5. A cathode comprising a refractory metal core, the metal being selected from the group consisting of tungsten, molybdenum, platinum, columbium and tantalum, an electron emissive coating thereon comprising a metal boride, selected from the group consisting of the rare earth metal borides and mixtures thereof, and an interposed layer selected from the group consisting of the carbide, nitride, and boride of the core metal.

6. A cathode comprising a body of emitting material consisting essentially of a metal boride and a refractory metal support for said emitting material having at least the surface thereof contiguous with the emitting material consisting essentially of carbon.

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