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W. R. GRAMS

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METHOD OF BONDING METAL BORIDES TO GRAPHITE

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Fig. 1.

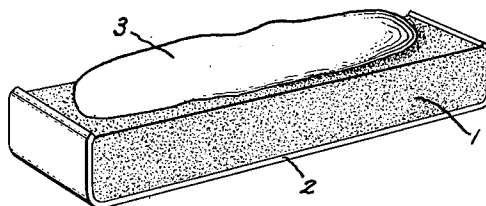


Fig. 2.

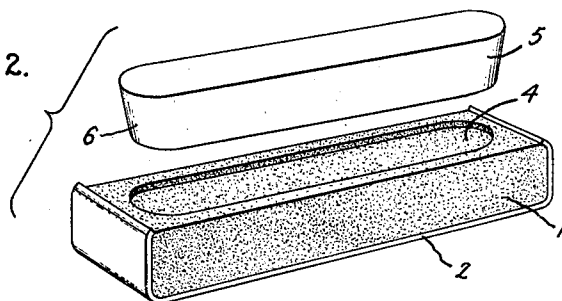
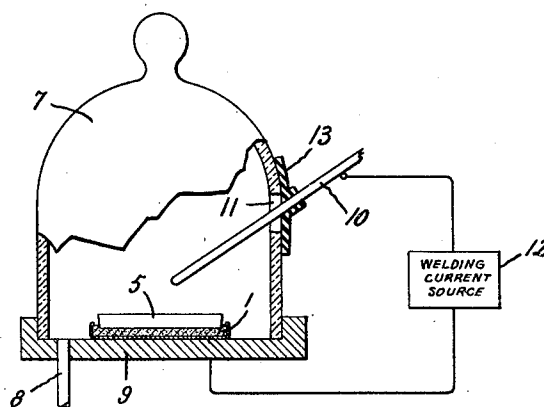


Fig. 3.



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METHOD OF BONDING METAL BORIDES
TO GRAPHITE

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Application July 20, 1953, Serial No. 369,175

4 Claims. (Cl. 117-216)

My invention relates to an improved method of bonding metal borides to graphite and is in the nature of an improvement of an invention described and claimed in a copending application Serial No. 178,201, filed August 8, 1950 by J. M. Lafferty now Patent No. 2,659,685, issued November 17, 1953 and assigned to the assignee of this application.

As disclosed in the prior application the borides of the rare earths, the alkaline earths, and thorium and uranium provide thermionic emitters having very desirable electrical and chemical properties. One difficulty involved in their use however is that at the relatively high temperatures at which they are capable of operating the life of the cathode is relatively short if the borides or a mixture of them are supported by a metal member or core. This appears to be due to the reduction of the borides when applied directly to the metal support member with the result that the boride diffuses into the refractory metal and the metal of the boride evaporates from the cathode surface. This effect can be eliminated by placing the metal boride over a member or layer of carbon instead of placing it directly on the metal support. Even though a carbon support is employed, it is further necessary that a good mechanical bond of the boride support be obtained, however, especially where the cathode is subjected to severe vibration.

It is therefore an object of my invention to provide an improved method of bonding a metal boride to a graphite support.

It is a further object of my invention to provide an improved metal boride cathode capable of resisting destruction due to vibration and shock.

In accordance with my invention the quantity of a metal boride which is to comprise the cathode emitter is placed on a graphite holder or support member. The boride is then heated to the melting point until the entire boride body is melted. The temperature of the melt is maintained uniform without locally increasing the temperatures of the first-melted portions thereof until all of the boride is melted to avoid extensive local dissolution of the graphite body. In this way the metal boride is firmly bonded to the graphite support upon cooling, and, since the boride and the carbon do not chemically combine but instead tend to dissolve in each other, a bond is formed due to the interlacing of the adjacent surfaces of the boride and the graphite support member.

The features of the invention which are believed to be novel are described with particularity in the appended claims. The invention itself, however, both as to its method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which, Fig. 1 represents a cathode made in accordance with the method of my invention,

Fig. 2 shows the cathode of Fig. 1 before assembly, and

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Fig. 3 illustrates the method of forming the cathode of Fig. 1.

Referring now to Fig. 1 a graphite block 1 is shown therein supported on a refractory metal base 2 suitably made of tantalum which has its ends bent up to tightly grip the block 1. At the upper surface of the block is a crystalline body of lanthanum boride 3 bonded thereto. While the hexaboride of lanthanum is preferred, other metal borides where the metal is one of the rare alkaline earths or thorium or uranium or a mixture of them may also be employed. The boride body 3 in the crystalline form possesses certain advantages over the more conventional pressed powder pellet or sintering in that it is mechanically stronger and less subject to disintegration due to ion bombardment or mechanical vibration. While the graphite is preferred as a holder because carbon does not reduce the boride, the shrinkage of the slurry for forming the conventional pressed powder cathode together with vibration frequently encountered in some applications would result in rapid abrasion of the holder and destruction of the bond between the boride body and the graphite holder.

In accordance with my invention the steps of making the cathode of Fig. 1 are respectively illustrated in Figs. 2 and 3. In Fig. 2 the graphite holder 1 is provided with a channel or recess 4 in the upper face thereof to accommodate a lower portion of a block 5 made of pressed boride powder. The pressed powder block 5, while it represents all of the boride material in the completed crystal in body 3, must be considerably larger than that body 3 due to the substantially lower specific density of the boride in the pressed powder form. Accordingly, the sides 6 of the powder block 5 are shaved so that the block will fit within the channel 4 with the excess or remainder of the material extending above the upper surface of the graphite block 1.

The cathode assembly is then heated in an atmosphere which is inert with respect to the assembly in order to melt the lanthanum boride. As may be seen by reference to Fig. 3, a bell jar 7 inverted over the cathode assembly defines a chamber for the inert gas which is supplied thereto through a duct 8 in a base 9. The inert gas may suitably be helium, or other non-oxidizing atmospheres which will not cause a reaction with the materials of the cathode assembly may be employed. To heat the boride body 5 a non-consumable welding electrode 10, suitably made of tungsten, is passed through an aperture 11 in the bell jar 7 to strike an arc between the end of the electrode and the boride body. The terminals of a suitable welding current source 12 are connected between the cathode assembly and the electrode 10. A flexible grommet or diaphragm 13 provides a seal for the aperture 11 between the edges thereof and the welding electrode 10. With such an arrangement the end of the electrode may be placed adjacent any exposed portion of the boride body 5 to thus control the position of the arc and localize the heating of the boride body as desired.

It is important that the boride body 5 be evenly heated insofar as all portions of the body may be melted as nearly simultaneously as possible without further heating of the first-melted portions thereof. Thus, by passing the arc back and forth along the upper surface of the boride body 5, the boride body gradually becomes compacted and as the current is increased the weld pool forms under the electrode. The arc is kept moving over the surface to increase the area of the weld pool. In order to prevent localized dissolving of the graphite under the weld pool, the arc is not directed on the pool already formed nor is the current increased before the pool stops increasing in size. While an oven might seem to

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provide the uniform temperature, it is necessary to utilize localized heating and control it as described to prevent localized dissolution of the carbon. When the lanthanum boride melts it flows into the channel or recess 4, wetting the sides thereof and the arc is immediately removed to prevent the boride from dissolving away the graphite. Other means than the bell jar 7 for shielding the heated boride body from chemical reaction with the atmosphere may be employed, such as arc welding apparatus having means for supplying a stream of inert gas along the electrode tip to blanket the work being heated.

After the molten boride body has cooled to assume the form of a body 2 shown in Fig. 1, it is firmly bonded to the graphite by reason of the interlacing or intermeshing of the facing surfaces of the graphite and the boride body due to their tendency to dissolve in each other. The upper surface of the boride body 3 is suitably finished as by lapping to the desired contour. The cathode assembly is then positioned in place in the desired electron discharge apparatus and can be suitably heated to an operating temperature in the neighborhood of 1500° C. without deterioration of the boride emitting surface. I have further found that cathodes made in accordance with my invention have a high resistance to shock and vibration and that the bond so formed between the graphite and the boride is mechanically adequate without adverse effects upon either substance.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that modifications may be employed without in any way departing from the spirit and scope of the invention. I therefore contemplate by the appended claims to cover any such 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. The method of making a thermionic cathode which comprises placing an amount of a metal boride electron emitting material on a graphite holder, heating the boride at a localized portion until it begins to melt, further heating the unmelted portions until all the boride is melted to avoid localized heating of the melted boride portions and resulting contamination of the boride with carbon, and allowing the melted boride to cool.

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2. The method of making a thermionic cathode which comprises placing an amount of a metal boride electron emitting material on a graphite holder, heating the boride at a localized portion with an electric arc until it begins to melt, further heating unmelted portions by moving the arc over the metal boride until all the boride is melted to avoid localized heating of the melted boride portions and resulting contamination of the boride with carbon, and allowing the melted boride to cool.

3. The method of making a thermionic cathode which comprises placing an electron emitting body of pressed powder metal boride on a graphite support block, heating a localized portion of the boride in an inert atmosphere until a portion of the boride body begins to melt, further differentially heating the boride body to apply more heat to the remaining unmelted portions than to the melted portions to complete the melting of the boride and minimize contamination of the boride with carbon, and allowing the boride to cool.

4. The method of making a thermionic cathode which comprises placing an electron emitting body of pressed powder lanthanum boride on a graphite support block, heating a localized portion of the boride body with an electric arc in an inert atmosphere until a portion of the boride body begins to melt, further directing the arc to the remaining unmelted portions of the boride body until they are melted without substantial contamination of the boride with carbon, and allowing the boride to cool.

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