

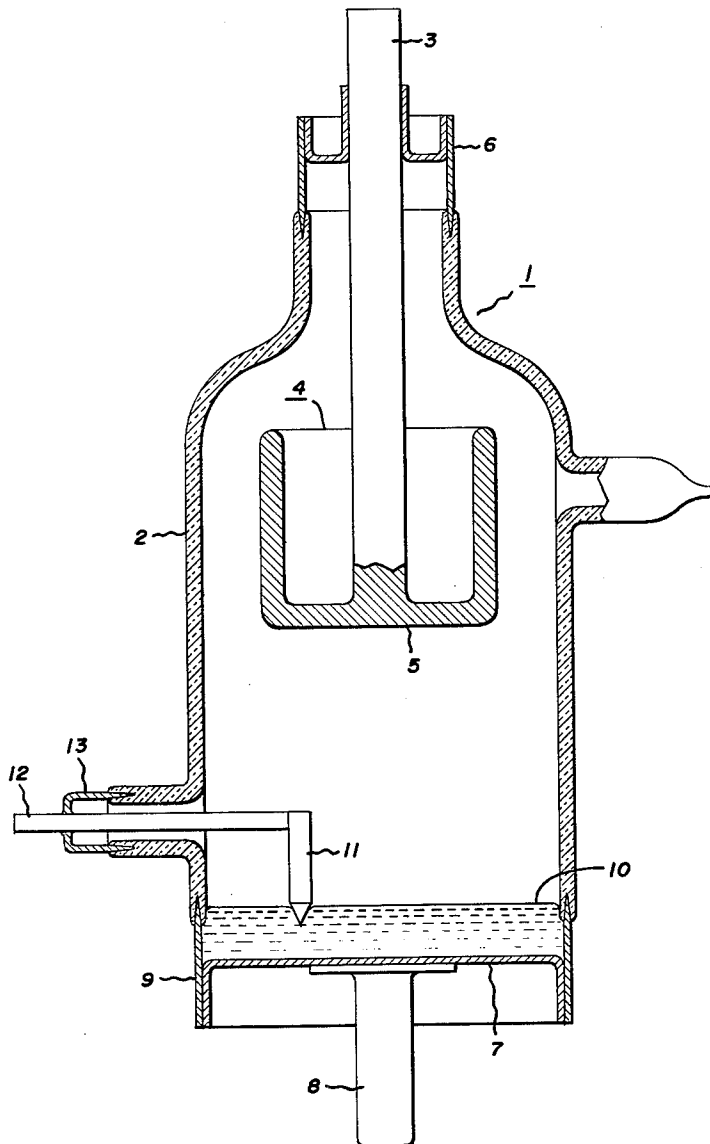
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J. J. PALEY

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MAKE-ALIVE ELECTRODE FOR AN ARC DISCHARGE DEVICE

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INVENTOR:
JAMES J. PALEY,
BY *Philip J. Schlemmer*
HIS ATTORNEY.

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MAKE-ALIVE ELECTRODE FOR AN ARC DISCHARGE DEVICE

James J. Paley, Albany, N.Y., assignor to General Electric Company, a corporation of New York
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My invention relates to arc discharge devices and pertains more particularly to a new and improved arc discharge device and new and improved resistance-type, make-alive electrodes adapted for use in arc discharge devices having a vaporizable reconstructing cathode containing alkali metal, and to the method of making such electrodes.

It has been long established that the operating and control characteristics of arc discharge devices employing vaporizable reconstructing cathodes, such as mercury-arc rectifiers, are substantially improved by extinguishing the cathode spot at the end of each conducting cycle and reinitiating the spot at the beginning of the next succeeding conducting period. This manner of operation affords the charged particles present in the volume of the tube a finite time in which to diffuse and recombine by the normal physical processes and thereby minimizes the tendency of the device to "arc back" or conduct current in the reverse direction. It has also been long established that make-alive electrodes for use in the described types of devices can generally be advantageously formed of combinations of boron and carbon.

Additionally, it has been demonstrated that when an alkali metal is used singly or in an admixture of alkali metals or when an admixture of mercury and one or more alkali metals, as disclosed and claimed in copending U.S. application Serial No. 818,874 of G. H. Reiling and A. O. Jensen, filed June 8, 1959, now patent No. 2,976,451, and assigned to the same assignee as the present invention, is employed as the vaporizable reconstructing cathode material, the voltage difference, or arc drop, between the anode and cathode of the device is substantially reduced. The voltage difference between the anode and cathode, when considered in connection with the continuous current conducted by the device, constitutes watts of energy which are lost, in the form of heat, for the performance of useful service. The use of alkali metal in the cathode, by reducing the arc drop, is effective for increasing the efficiency of the operation of the device and, thus, the presence of the alkali metal is highly desirable.

Further, it is highly desirable to provide a reconstructing cathode type of device including an alkali metal in the cathode material and adapted for functioning with a make-alive electrode of the resistance or semi-conducting type and wherein the cathode spot is initiated and extinguished at the beginning and end, respectively, of each successive conducting period. Efforts to accomplish this desired form of device, namely, one including an alkali metal in the cathode and a resistance, or semi-conducting, type make-alive electrode, have heretofore proved unsatisfactory due to the extreme chemical activity of the alkali metals and the adverse effects thereof on the constituents of the make-alive electrodes. In such devices the hot alkali metal vapors react chemically with constituents of the make-alive electrodes and destroy the electrodes for their intended purpose and thus render the devices inoperative.

I have found that an essentially carbon-free make-alive electrode composed of an admixture of a refractory metal boride, boron nitride and elemental boron pos-

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sesses the electrical, chemical and mechanical properties required for an effective make-alive electrode in the presence of hot alkali metal vapors. Utilizing such an electrode I have been able to provide an improved reconstructing cathode type of device wherein the cathode comprises alkali metal and wherein the make-alive electrode is of the resistance or semi-conducting type.

Accordingly, a primary object of my invention is to provide a new and improved arc discharge device.

Another object of my invention is to provide a new and improved make-alive electrode comprising as essential ingredients a refractory metal boride, boron nitride and elemental boron.

Another object of my invention is to provide a new and improved make-alive electrode which will retain its chemical and mechanical integrity in the presence of hot alkali metal vapor.

Another object of my invention is to provide a new and improved make-alive electrode which will retain its electrical characteristics in the presence of hot alkali metal vapors.

Another object of my invention is to provide a new and improved make-alive electrode which is adapted for initiating a cathode spot on the surface of a cathode pool of either pure mercury, alkali metal or metals, or an admixture of mercury and one or more alkali metals.

Another object of my invention is to provide a new and improved make-alive electrode which will operate from existing auxiliary circuits at energy levels conventionally employed with mercury arc discharge devices.

Still another object of my invention is to provide a new and improved method of producing in quantity make-alive electrodes all having substantially identical physical characteristics.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention I provide an arc discharge device including an anode and a vaporizable reconstructing type cathode comprising alkali metal. Protruding into the cathode is a resistance-type, make-alive electrode composed essentially of a refractory metal boride, boron nitride and elemental boron and which is essentially carbon-free.

For a better understanding of my invention reference may be had to the accompanying drawing wherein is illustrated an embodiment of my invention.

The illustrated embodiment of my invention comprises an envelope 1 including an insulative bulb 2 constituting an insulative wall section of the device and which can be advantageously formed of glass or ceramic. The upper end of the envelope includes an external portion 3 of an anode generally designated 4 which is supported centrally in the envelope and includes an enlarged portion bearing a transversely extending planar active surface 5. The anode 4 is formed preferably of any suitable highly refractory metal. Additionally, the mentioned external portion 3 can serve effectively as an anode connector. A sealing assembly 6 bonded to both the anode and the bulb 2 hermetically seals the anode to the bulb, and the seal afforded by the assembly 6, as well as all other seals in the device, is selected so as to be capable of withstanding the chemical activity of alkali metal in the envelope.

Closing the lower end of the bulb 2 to complete the envelope is a metal header 7 carrying a cathode lead 8. The header 7 can also be advantageously formed of a

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highly refractory metal and is sealed to the lower end of the bulb by a sealing ring 9 adapted also for withstanding the chemical activity of alkali metal.

Contained in the bottom of the envelope is a vaporizable reconstructing or pool-type electrode 10. The electrode 10 can comprise a mixture of mercury and an alkali metal, an alkali metal or a mixture of alkali metals. The cathode can advantageously have the composition of the cathode disclosed in the above-noted copending application of G. H. Reiling and A. O. Jensen. Particular advantage can be obtained from the employment of a pool-type cathode having a composition of between about .02% to about 20% alkali metal and the remainder mercury, as disclosed and claimed in the mentioned copending application.

Cooperating with the cathode 10 is a make-alive electrode of the resistance-type which is generally designated 11 and is constructed in accordance with my invention. The electrode 11 comprises a rod-like element with a tapered lower end or point which is partially immersed in the cathode 10. Additionally, the electrode 11 is supported by a conductive support arm 12 which extends in a suitably sealed manner through a seal member 13 in the side wall of the bulb 2. Upon completion of an energizing circuit through the cathode lead 3, cathode 10, electrode 11 and support arm 12 a cathode spot is initiated for facilitating a conduction discharge through the device between the cathode and anode.

In constructing the make-alive electrode 11 according to my invention, I use a dry powder mixture consisting of a refractory metal boride, boron nitride and elemental boron and the finished electrode is essentially carbon free. In the preferred form of my invention the refractory metal boride constitutes molybdenum boride, however, the borides of the highly refractory metals titanium, tantalum, vanadium, zirconium, chromium and niobium are satisfactorily employable in place of molybdenum boride.

The preferred embodiment of my improved electrode consists of approximately 27% molybdenum boride, approximately 17% boron nitride and approximately 56% elemental boron by weight. In manufacturing the electrode, the mixture of molybdenum boride, boron nitride and elemental boron in the percentage composition above-noted is homogenized in a tumbler or ball for a period of approximately 2 hours. The admixed powder is then poured into a cylindrical graphite crucible which has a bottomed hole drilled to a depth of approximately 3 inches from the top surface and approximately 1/4 inch diameter. The crucible hole is filled with the powdered mixture to within approximately 1 3/4 inches from the top of the cylindrical hole. The crucible cylinder is next placed in a sintering press and is heated to a temperature between approximately 1600° C.-1800° C. for a period of approximately one minute. When the apparent temperature of the cylinder outer surface is in the range of between approximately 1600° C.-1800° C., axially applied pressure is exerted on the contained powder by means of a 1/4 inch diameter carbon rod interposed between a moveable plunger mounted in the sintering press head and the powdered mixture situated in the crucible.

I prefer to apply a pressure of approximately 25 lbs. per sq. inch on the carbon rod. This pressure causes the powdered mixture, which at the temperature between approximately 1600° C.-1800° C. becomes somewhat liquid, to compress to a height of 1 inch from its original height of 1 1/4 inches in the crucible and to fuse to the end of the carbon rod. Upon cooling, the crucible is removed from the furnace and the original powdered mixture, which now has become very hard and dense, is ground to a conical point and the carbon pressure rod is severed at the interface of the two members. Thus the electrode 11 is formed, following which it is mounted in the tube using conventional mounting means such as the conductive support arm 13.

I have found that by increasing or decreasing the ex-

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ternal pressure during the sintering operation, the make-alive electrode can be made more dense or less dense. Thus, the apparent electrical resistance of the electrode when it is immersed in the conducting liquid pool 10, can be decreased or increased as desired by controlling or adjusting predeterminedly the density of the electrode.

I prefer to use an apparent electrical resistance of approximately 50 to approximately 250 ohms when the electrode is immersed between approximately 1/16 to 3/8 inch below the surface of the cathode pool 10. This resistance range permits the initiation of a cathode spot on the pool surface under vacuum with the application of an appropriate electrical impulse of approximately 160 peak volts and 15 peak amperes. I prefer these values due to the fact that they are consistent with energy levels conventionally supplied for pure mercury cathode devices. It has, however, been established that the presence of alkali metal as a cathode material or ingredient will lower this requirement by approximately 10% for both voltage and current.

Additionally, I have found that the electrical resistance of the electrode 11, as measured while immersed in the conducting liquid pool 10, can be altered upwardly by increasing the boron nitride constituent toward approximately 30% by weight and, at the same time, reducing the refractory metal boride toward approximately 14% by weight in the dry powder state prior to sintering. Further, the electrical resistance can be adjusted downwardly by reversing the percentage variation such that the refractory metal boride is altered toward 30% by weight and the boron nitride toward 14% by weight of the mixture with the remainder being elemental boron. Thus, each of the ingredients refractory metal boride and boron nitride can comprise between approximately 14% and approximately 30% by weight of the composition. I have found that by use of these changes in percentage compositions and the technique of changing the applied pressure during sintering to amounts approaching either 20 lbs. per square inch and 35 lbs. per square inch, respectively, depending upon whether relatively higher or lower resistance is desired, electrodes can be constructed of high mechanical, electrical and chemical integrity. For example, by utilizing the procedures above-described I have been able to produce electrodes with apparent electrical resistances of between approximately 600 ohms and 10 ohms and adapted for operating in the mentioned environment without adverse effects to the chemical, mechanical or electrical integrity thereof.

It is to be understood from the foregoing that while a make-alive electrode constructed according to my invention is particularly suited for use in devices wherein the cathode include alkali metal it is also adapted for use where the electrode comprises substantially pure mercury.

While I have described specific embodiments of my invention, I do not desire my invention to be limited to the particular forms described, and I intend by the appended claims to cover all the modifications within the 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 make-alive electrode comprising a body of resistance material consisting essentially of a refractory metal boride, boron nitride and elemental boron.

2. A make-alive electrode comprising a rod-like body of resistance material consisting essentially of boron nitride, elemental boron and a boride of a refractory metal selected from the group consisting of molybdenum, titanium, tantalum, vanadium, zirconium, chromium and niobium.

3. A make-alive electrode comprising a rod-like body of resistance material consisting essentially of molybdenum boride, boron nitride and elemental boron.

4. A make-alive electrode comprising a compressed, sintered, essentially carbon-free mixture of powdered ingredients consisting essentially of approximately 14% to

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approximately 30% of a refractory metal boride selected from the group consisting of the borides of molybdenum, titanium, tantalum, vanadium, zirconium, chromium and niobium, between approximately 14% to approximately 30% boron nitride and the remainder elemental boron.

5 A make-alive electrode comprising a compressed, sintered, substantially carbon-free mixture of powdered ingredients consisting of essentially approximately 27% of a refractory metal boride selected from the group consisting of the borides of molybdenum, titanium, tantalum, zirconium, chromium and niobium, approximately 17% boron nitride and approximately 56% elemental boron by weight of said mixture.

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GEORGE N. WESTBY, *Primary Examiner*.

RALPH G. NILSON, *Examiner*.