Nov. 19, 1946. E. G. F. ARNOTT ET AL 2,411,241

SERIES SPARK GAP DEVICE

Filed Sept. 2, 1944

Fig. 1.

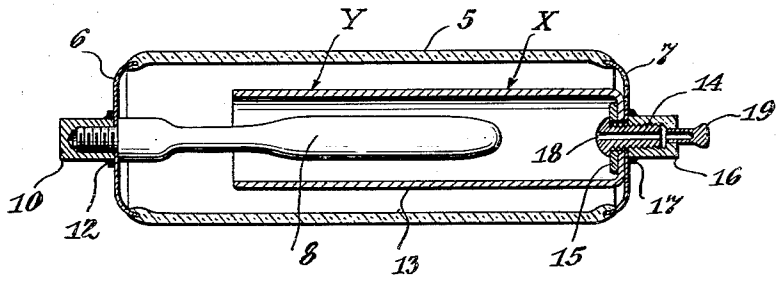


Fig. 2.

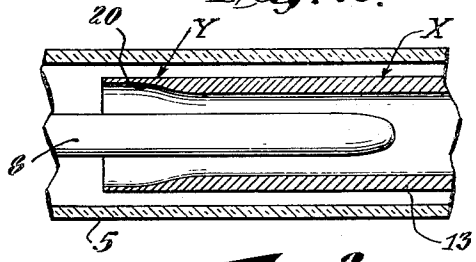


Fig. 3.

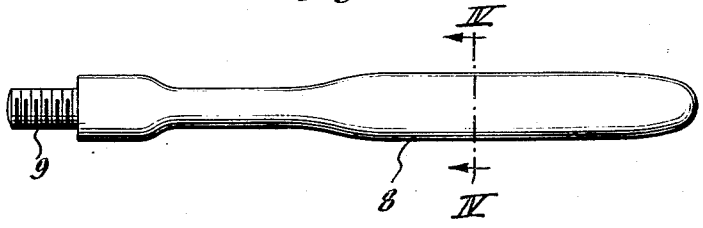
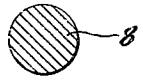


Fig. 4.



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SERIES SPARK GAP DEVICE

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Application September 2, 1944, Serial No. 552,413

7 Claims. (Cl. 250—27.5)

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The present invention relates to discharge devices and more particularly to what are known as spark-gaps now commonly used in connection with pulsing of electrical wave energy.

Devices of this type are most frequently used as a modulator to generate energy pulses of high voltage and accordingly accurate alignment of the electrodes is necessary to maintain definite breakdown voltage during the useful life of the device. It has been found, however, that despite accurate alignment of the electrodes there is a tendency for the arc discharge to concentrate at localized points even with the employment of electrodes devoid of sharp points and edges. This results in the concentrated arc wearing a hole through the cathode adjacent the points at which the arc concentrates on the anode, thus destroying the useful life of the device.

Experiments have shown that the reason for localization of the arc is the fact that the potential gradient at the anode surface is highest at the point where the end of the anode begins to round off. Since heretofore the radius of the hemispherical end is equal to that of the rod-like anode customarily employed, the potential gradient begins to increase as the surface of the anode end changes from a cylinder to a hemisphere. This increase, however, continues for only a short distance since the spacing between the electrodes is increasing at the same time with the result that in effect the potential gradient is substantially concentrated at points on the anode surface causing a hole to be worn into the adjacent surface of the cathode.

It is accordingly an object of the present invention to provide a spark-gap device wherein concentration of the arc discharge, due to an increase of the potential gradient at any point on the anode surface, is eliminated.

Another object of the present invention is the provision of a spark-gap device wherein the anode is given such a radius of curvature at points where the potential gradient would otherwise be high that the gradient is more equally distributed over the anode surface and arc concentration is eliminated.

Another object of the present invention is the provision of a spark-gap device wherein the anode is devoid of sharp points and edges, thus eliminating a high potential gradient at any point on the anode surface with accompanying arc concentration and preventing the wearing of holes in the adjacent cathode surface which eventually may cause destruction of the device.

A further object of the present invention is the

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provision of a spark-gap device wherein the electrodes are maintained in accurate alignment with each other and the anode thereof is so shaped as to prevent localization of the arc due to concentration of a high potential gradient at any point on the anode surface.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing wherein:

Fig. 1 is a sectional view of a spark-gap device constructed in accordance with the present invention;

Fig. 2 is a fragmentary view in cross section showing a slight modification which the device of Fig. 1 may take;

Fig. 3 is a plan view of the anode of the device shown in Fig. 1, and

Fig. 4 is a sectional view taken on the line IV—IV of Fig. 3.

Referring now to the drawing in detail, the device as shown in Fig. 1 comprises a vitreous envelope 5 closed at each end by cup-shaped members 6 and 7 formed of a metal having substantially the same coefficient of expansion as that of the vitreous envelope, such as that commercially known as "Kovar," which forms an hermetic seal with the vitreous envelope.

As will be obvious from the drawing, the electrodes are supported by the end closure members 6 and 7 and are assembled thereon prior to sealing the closure members to the vitreous envelope, with the latter being accomplished so as to accurately and precisely align the electrodes, such as in the manner shown and described in the copending application of Ward W. Watrous, Serial No. 521,807, filed February 10, 1944, and assigned to the same assignee as the present invention.

For example, the anode 8, which may be formed from an iron or carbon-steel rod, as hereinafter explained, is provided with a threaded end 9 passing through an opening in the closure member 6 and exteriorly of the latter a threaded terminal 10, simulating a nut, is screwed upon the threaded anode end 9, thus securing the anode 8 to the closure member 6. After the terminal 10 has been tightened, it is then fastened to the "Kovar" closure member 6, as by welding or brazing 12. Preferably the terminal 10 is first welded or brazed to the cup 6 and the anode then screwed therein, since this facilitates manufacture.

The cathode 13 constituting a cylinder of metal, such as aluminum or the like, is somewhat similarly secured to the "Kovar" closure member 7. As will be noted, the cathode is closed at one end except for a small opening through which

passes a threaded bolt or the like 14 having a washer 15 disposed between the head of the bolt and the closed end of the cathode 13. Exteriorly of the "Kovar" closure member 7 the bolt is provided with a terminal in the form of a nut 16 which, after tightening upon the bolt, is brazed or welded at 17 to the closure member 7, or preferably it is assembled in the same manner as the terminal 10 by first brazing the latter to the cup 7 and screwing the bolt 14 therein. The bolt 14 and terminal nut 16 are provided with a longitudinal passageway 18 for the purpose of evacuating the device and filling with the desired gaseous environment such as a mixture of about 80% hydrogen and 20% argon at about 680 mm. pressure, after which such passageway is sealed-off by an exhaust tip 19.

By reference now more particularly to Fig. 2 it will be noted that the inner end of the anode 8 is elliptically rounded instead of hemispherically. It has been found, as hereinbefore mentioned, that in instances where the radius of a hemispherical end is equal to that of the anode 8, an edge results at the point where the anode end begins to round off. Tests have shown that after a comparatively few hours' life the high potential gradient at this point on the anode surface causes a concentration of the arc which wears a hole in the adjacent surface of the cathode at the points X and Y.

By shaping the anode in such a manner as to eliminate edges on the surface of the anode, the potential gradient is more or less uniformly distributed over the entire surface eliminating any concentration of the arc. For example, with an anode of one-quarter inch diameter, by giving the extreme end of the anode 8 a rounded contour having a radius of about three thirty-seconds of an inch joining with the periphery of the one-quarter inch diameter anode by a curvature having a one-inch radius, an end is provided having no sharp edge or abrupt change in radius of curvature which may be termed parabolical or elliptical, where the potential gradient increases to a high value with attendant concentration of the arc. Similarly the anode, as shown in Figs. 1 and 3, is given a curvature having a one inch radius where the diameter of the anode 8 reduces from its one-quarter inch diameter to about three-sixteenths inch adjacent the open end of the cathode 13, or the anode may be made of uniform diameter and the inner end of the cathode 13 be given a curved surface 20 of a similar radius of curvature as that of the anode as shown in Figs. 1 and 3.

The spark-gap devices as shown in Fig. 1, when provided with elliptically or parabolically curved surfaces in lieu of hemispherical surfaces, have operated for a useful life of 1500 hours without the wearing of holes at the points X and Y in the cathode or at any other points and during such useful life the whole anode surface sustained the arc indicating there was no concentration of a high potential gradient. Moreover, by supporting the electrodes directly from the end closure members which are in turn sealed to the vitreous cylindrical container not only is a rigid construction thus provided, but in addition the electrodes are accurately and precisely aligned and maintained concentrically to within .005 inch during the entire useful life of the device.

It should thus become obvious to those skilled in the art that a spark-gap device operable at relatively high potentials and particularly applicable to pulsing of electrical wave energy is herein provided which is of rigid yet precise construction. Furthermore, such device has a long useful life since the electrodes are provided with a surface of such contour that the potential gradient is distributed substantially uniformly over the entire surface of the anode, thus eliminating arc concentration which otherwise causes puncturing of the adjacent surface of the cathode and destruction of the device.

Although several embodiments of the device have been herein shown and described, it is to be understood that other modifications thereof may be made without departing from the spirit and scope of the appended claims. Moreover, the dimensions herein given are illustrative only and electrodes of other shapes and sizes may be employed with equal facility so long as sharp edges and points are eliminated in the manner herein disclosed.

We claim:

1. A spark-gap device comprising opposite end caps and an interposed glass sleeve between said end caps sealed to each, one of said end caps having a rod-like electrode secured thereto and the other end cap having a hollow cylindrical electrode secured thereto, said rod-like electrode projecting coaxially into said hollow cylindrical electrode.

2. A spark-gap device comprising a vitreous sleeve, oppositely disposed end caps having their peripheral edge hermetically sealed to said sleeve, a rod-like anode rigidly secured to one of said end caps, and a hollow cylindrical cathode coaxially disposed relative to said anode and rigidly secured to the other of said end caps.

3. A spark-gap device comprising a vitreous sleeve, oppositely disposed metallic end caps having their peripheral edge hermetically embedded in the respective peripheral edges of said sleeve, a hollow cylindrical cathode rigidly secured to one of said end caps, and a rod-like anode projecting coaxially into said cathode with parallel adjacent surfaces of said anode and cathode spaced uniformly from each other.

4. A spark-gap device comprising an envelope, an anode and a cathode rigidly supported in said envelope and concentrically and telescopically disposed relative to each other, said anode being provided with an end devoid of sharp edges or abrupt change in radius of curvature at its inner extremity and one of said electrodes having a similar surface of curvature adjacent the inner extremity of said concentrically disposed cathode to prevent concentration of the arc discharge due to a high potential gradient at any point on the anode surface.

5. A spark-gap device comprising a vitreous sleeve, oppositely disposed end caps hermetically sealed to said sleeve, a hollow cylindrical cathode rigidly secured to one of said end caps, and a rod-like anode projecting coaxially into said cathode and provided with an end devoid of sharp edges or abrupt change in radius of curvature at its inner extremity and one of said electrodes having a similar surface of curvature adjacent the inner extremity of said concentrically disposed cathode to prevent concentration of the arc discharge due to a high potential gradient at any point on the anode surface.

6. A spark-gap device comprising a vitreous sleeve, oppositely disposed end caps hermetically sealed to said sleeve, a hollow cylindrical cathode rigidly secured to one of said end caps, a rod-like anode projecting coaxially into said cathode and

provided with an end devoid of sharp edges or abrupt change in radius of curvature at its inner extremity, and said cylindrical cathode having a surface of curvature devoid of an abrupt change in radius adjacent the inner extremity thereof to prevent concentration of the arc discharge due to a high potential gradient at any point on the anode surface.

7. A spark-gap device comprising a vitreous sleeve, oppositely disposed metallic end caps having their peripheral edge hermetically embedded in the respective peripheral edges of said sleeve, a hollow cylindrical cathode rigidly secured to one of said end caps, and a rod-like anode projecting coaxially into said cathode and provided with an end devoid of sharp edges or abrupt change in radius of curvature at its inner extremity and having a similar surface of curvature adjacent the inner extremity of said concentrically disposed cathode to prevent concentration of the arc discharge due to a high potential gradient at any point on the anode surfaces.

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