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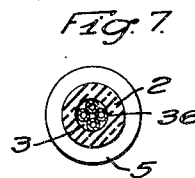
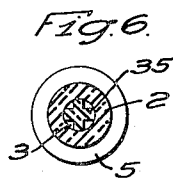
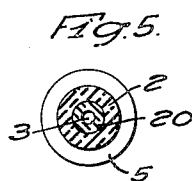
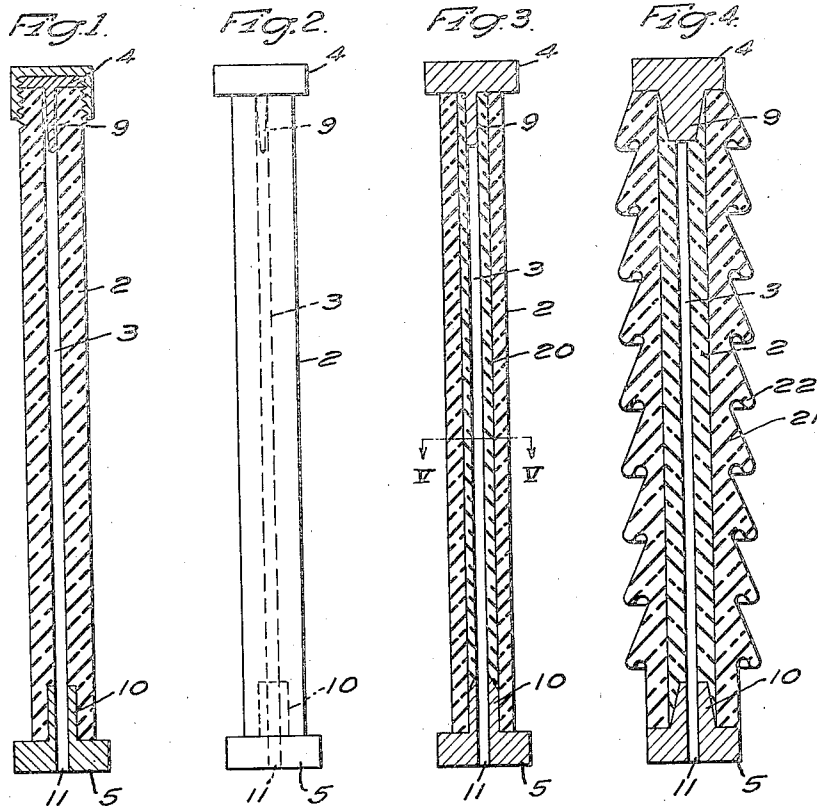
J. J. TOROK

2,050,397

ELECTRICAL DISCHARGE DEVICE

Filed Feb. 20, 1932

2 Sheets-Sheet 1



WITNESSES:

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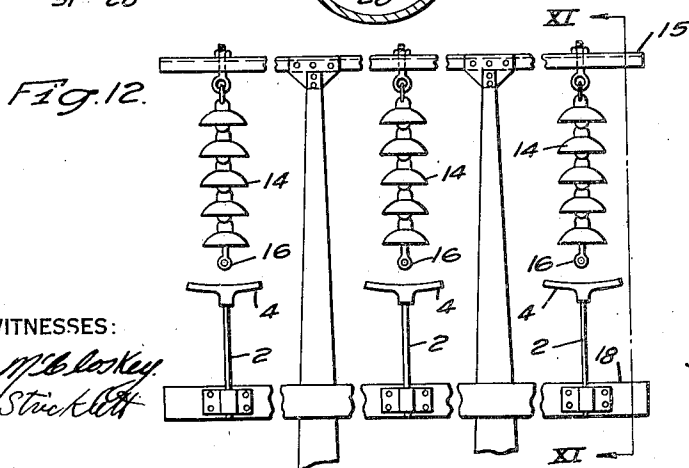
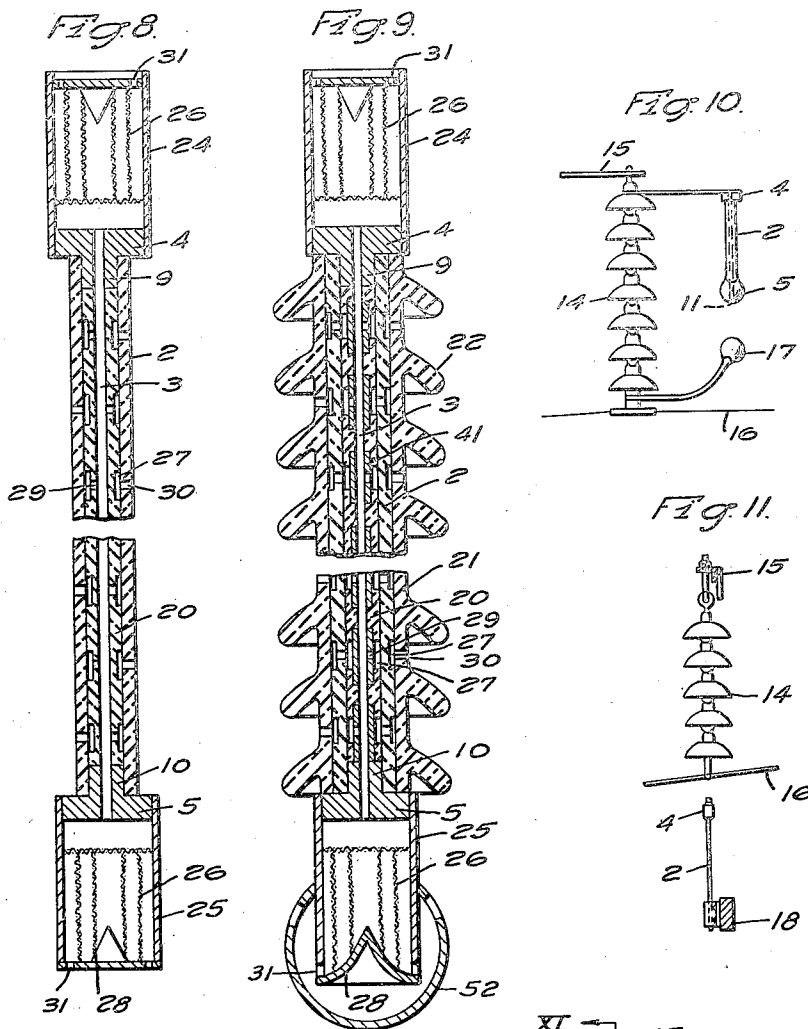
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ELECTRICAL DISCHARGE DEVICE

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2 Sheets-Sheet 2



WITNESSES:

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2,050,397

ELECTRICAL DISCHARGE DEVICE

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pany, a corporation of Pennsylvania

Application February 20, 1932, Serial No. 594,193

17 Claims. (Cl. 175—30)

My invention relates to an electrical discharge device and particularly to a space discharge device for draining excess voltages from transmission lines. This application is a continuation in part, of application Serial No. 406,831, filed November 13, 1929.

Electrical transmission lines are subject to excess voltages, which are usually caused by lightning or atmospheric disturbances, but may be caused by switching or other manipulation of the electrical circuits. These high-potential surges frequently cause severe damage to the transmission line or its connected apparatus.

Many devices have been used to drain off or dissipate these over-potential surges on transmission lines.

The first devices used for removing over-potential from transmission lines were ordinary arc gaps, the gaps being set to begin operation or to "break down" at a voltage somewhat above the highest normal operating voltage on the line. These gaps were very effective in reducing over-voltages on the lines, but introduced a further disadvantage in that once having been broken down the gaps continued to carry current at normal line voltage. In order to extinguish the arc following a discharge through such a gap, it was frequently necessary to completely disconnect the line before service could be reestablished. As interruptions of service are highly undesirable, many attempts have been made to provide drainage devices having a self-quenching or valve action which would interrupt the arc flowing because of normal potential in the lines.

It was found that if a fusible element is placed in series with the drainage gap, the dynamic current flowing in the arc would "blow" the fuse and extend the length of an arc sufficiently to extinguish the same. However, such a fuse-protected gap could act only once, and it was necessary to re-fuse the gap before protection was again provided for the line. As a consequence, in the event of recurrent surges during a sustained storm, the lines or attached apparatus were frequently damaged by surges occurring on the lines between the destruction of the fuse and the replacement of the same.

Attempts have been made to improve such fused gaps by providing a magazine of fuses and automatic machinery for inserting a new fuse after each fuse operation. Attempts have also been made to provide self-extinguishing drain devices by inserting resistance elements in series with the gap which were intended to limit the current so that the gap can interrupt it at current zero.

All of these devices proving unsatisfactory in service, various valve-type drainage devices or so called lightning arresters have been developed for application to transmission lines. Many of these devices were complicated in structure, sometimes unsatisfactory in action, besides being expensive to install and maintain.

It is an object of my invention to provide a self-extinguishing space-discharge device for removing excess-potential from transmission lines.

My device comprises essentially a pair of spaced electrodes, one of which is connected to the line to be protected and the other to a suitable ground, as was the usual procedure in so-called spill-over gaps. My drainage gap is made self-extinguishing by providing a dielectric structure enclosing at least the major portion of the arc space, and so confining the arc space as to maintain a high arc voltage. In order to further expedite the deionization of the arc, the dielectric structure is composed of material capable of evolving large quantities of substantially non-ionized gas when in close proximity to an arc discharge.

In the normal operation of an ordinary open-air gap device after the gap has broken down, an arc discharge ionizes the gases in the arc space and so establishes a comparatively low-resistance conducting medium by which the arc reestablishes each half cycle after current zero. According to the device of my invention, the non-ionized gas evolved from the dielectric structure by the arc drives away, or mixes turbulently with, the ionized gases left by the arc and carries them to the side walls where they recombine. Thus the insulating properties of the arc space are restored (by the recombination or neutralization of the ionized gaseous particles of the arc-stream) so rapidly that the increase of potential after current zero will not cause the arc to reestablish itself on the system recovery voltage.

I have found that it is not necessary to confine the entire arc length, but that a portion may be unconfined, and if desired, the unconfined portion may be also de-ionized by directing a flow of relatively non-ionized gas into the unconfined arc space.

Other objects and advantages of my invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings in which,

Figure 1 is a sectional elevation of a space discharge device according to my invention,

Fig. 2 is a normal elevation of my device,

Fig. 3 is a modification showing a laminated dielectric structure according to my invention,

Fig. 4 is a modification showing a ceramic casing enclosing a gas-evolving dielectric tube.

Fig. 5 is a section taken on line V—V of Fig. 3.

Figs. 6 and 7 are cross sections similar to Fig.

5 showing the insertion of a dielectric gas-evolving material to provide a large gas-evolving surface in the vicinity of the arc passage.

Figs. 8 and 9 show modifications of my device having vent means for relieving excessive internal pressure in my dielectric structure and deionizing screens for preventing the ionized gases expelled from the tube from coming in contact with any structure outside of my improved spark gap.

Fig. 10 is a diagrammatic view showing my device applied to a transmission line, and

Figs. 11 and 12 are views showing a further method of applying my device to a transmission line.

The device of my invention comprises a suitable hollow insulator or dielectric structure, such as a tube 2 having a relatively small bore or hollow 3. Preferably, the tube 2 is comprised of a dielectric material, such as hard fiber, or an insulating composition of the type hardened under heat and pressure, or compressed boric acid, or other suitable dielectric, capable of evolving substantially non-ionized gas in the presence of an arc discharge. Suitable conducting electrodes 4 and 5 are provided at the respective ends of the dielectric structure, each of said electrodes 4, 5 having a portion 9, 10 extending into the dielectric structure so that the spark-gap distance inside of the structure is sufficiently less than the spark-gap distance outside of the structure so that the sparkover or breakdown voltage in the confined opening 3 is less than the sparkover or breakdown voltage in the unrestricted space outside of the tube 2. While any suitable conducting material may be used for the electrodes 4, 5, I have found that, in service, electrodes of steel or other ferrous alloys give most satisfactory performance.

One or both of the electrodes is provided with an opening 11, preferably coaxial with the bore of the dielectric structure for permitting the escape of gas evolved within the dielectric structure.

As stated in the aforementioned parent application, I have found it desirable in commercial practice, by reason of certain difficulties and expense in providing extremely small-diametered holes of appreciable length, to make the holes of the order of one-quarter to one-half inch in diameter, and to suit the lengths of the tubes in accordance with the necessary sparkover voltage. With such sizes of holes, it is evident that the restriction of the arc in the bore cannot of itself, apart from the material of its walls, exert a substantial effect on the power-arc current which normally follows a sparkover between the electrodes in the bore; as will be evident from the work of Dr. Joseph Slepian on "The Extinction of a Long A. C. Arc," published in the American Institute of Electrical Engineers Transactions, April, 1930, pages 420-430, particularly page 426, first column; and as explained also in my paper entitled "An Experimental Lightning Protector for Insulators," presented at the Winter Convention of the A. I. E. E., January 26-30, 1931, particular reference being made to the digest appearing in Electrical Engineering, July 1931, page 500, top of the second column. As stated at the outset of this specification, I produce a swiftly acting arc-extinguishing effect by the uti-

lization of gas-evolving wall-material lining the restricted arcing path within the bore of my hollow insulator. While I have stated one practical size of bore, it is to be distinctly understood, however, that my invention is not limited, in its broadest aspects, to any particular dimensions.

In the modification shown in Figs. 3 and 5, the dielectric structure is composed of a plurality of telescoped dielectric tubes, the innermost tube 20 of which is composed of gas-evolving material. The use of such a laminated structure permits the choice of a gas-evolving material best suited to extinguishing an arc substantially independently of mechanical strength requirements which may be supplied by the outer dielectric tube or tubes, it only being necessary to provide sufficient strength in the entire laminated structure, considered as a whole, to withstand the pressures developed in the restricted bore 3.

It will be noted, in Fig. 3, that the electrode 10 extends within the outer tube 2 and is provided with a beveled or tapered end or arc-terminal, whereby the arc will be prevented from forming between the outer tube 2 and the inner insulating gas-evolving body 3, as will be obvious from the drawings.

In the modification shown in Fig. 4, the exterior dielectric member 21, which may be of ceramic material, is provided with suitable skirts 22 for maintaining a long creepage distance over the outside of the dielectric structure.

In some cases, it is desirable to increase the surface area exposed to the arc without materially increasing the arc space. This may most easily be done by inserting filler strips or inserts of gas-evolving material into the bore of the dielectric structure. Thus, as shown in Fig. 6, the inserts may be in the form of ribbed or cruciform rods or strips 35 which divide the arc space 3 into a plurality of parallel arc paths, or if it is desired to maintain a single arc path, a plurality of rods or tubes 36 may be inserted as shown in Fig. 7.

In some cases, particularly in tubes of great length, for high-voltage lines, it is sometimes desirable to vent the tubes 2 intermediate of their length in order to reduce the internal pressure to a safe value. The unguarded venting of the tubes might permit the flow of ionized gases around the exterior of the tube, thereby greatly increasing the danger of an unconfined sparkover between the terminals or electrodes externally of the tube. In order to overcome such a danger, I have provided deionizing passages through the dielectric structure. Preferably, the deionizing passages comprise an annular groove 27 (Fig. 8) in the outer surface of the inner telescoped dielectric member and offset, communicating, radially extending passages 29, 30 by which gas is delivered from the inner bore 3 through a passage 29 in the inner dielectric member and thence to the annular groove 27, and from the annular groove through a diametrically opposite passage 30 in the outer or surrounding dielectric member and thence to atmosphere.

This construction has several advantages, chief of which are its deionizing ability and its equalization of stress between the inner and outer tubes. The gas, under considerable pressure, forces its way between the two tubes, reducing the effective pressure on the inner tube and increasing it on the outer tube.

As shown in Fig. 9, the inner gas-evolving tube is not necessarily continuous, but may comprise a series of gas-evolving tubes 20 and metallic tubes 41 suitably enclosed in a confining non-

gas-evolving exterior dielectric member 21. This structure breaks up the internal arc into a series of arcs and relieves the internal pressure on the device. This construction further assists in retaining the arcs within the device.

In some instances, particularly where a plurality of conductors are in close proximity to each other, it is highly undesirable to have ionized gases expelled in the vicinity of the conductors.

In order to prevent this, I have devised suitable deionizing devices, such as the shields shown in Figs. 8 and 9. Suitable casings 24, 25 are attached to the vented electrodes 4, 5 to receive the discharged gases. Inside the casing suitable screens 26 are positioned to intersect the gas blast and collect any charges on the gas particles. Suitable baffles 28 are provided for directing the gas to vents 31 for exhausting the deionizing gases to atmosphere.

As shown in Fig. 9, one of the terminal electrodes, as 5, may be surrounded by a suitably vented hollow conducting sphere or inclosing structure 52.

In the application of my device, the terminal electrodes 4, 5 of the dielectric member may be directly connected, respectively, to the line to be protected and to a suitable ground connection or vice versa. However, in order to avoid leakages through the dielectric material, it is desirable to provide a third electrode 17 suitably spaced from one of the terminal electrodes, so that a portion of the arc discharge will be substantially unconfined, and another portion, preferably the major portion, will be confined in the dielectric structure.

A practical installation of my device is shown in Fig. 10, in which the external-gap electrode 17 is connected to the line 16 to be protected, and one of the terminal electrodes, as 4, is connected to ground by means of the grounded supporting tower. This connection places my discharge device in parallel with the usual supporting insulator 14 for the power line. In the installation shown in Fig. 10, the gases discharged from the dielectric structure flow across the unconfined or external arc space between electrodes 5 and 17, and deionize not only the gases in the confined arc space in the dielectric structure but also in the unconfined arc space between the intermediate terminal 5 and the free terminal 17 connected to the line 16.

In the operation of my device as shown in Fig. 10, the insulator-string 14 is protected against excess-voltages by two gaps, one confined in my hollow insulator or tube 2, and the other in the open air between the electrodes 5 and 17. It is obvious that the over-all break-down or spark-over voltage of my two arcs must be less than the flashover voltage of the insulator-string, in order to protect the latter. On the other hand, in order to extinguish my arcs, the maintenance-voltage required by my hollow-insulator device must be great enough so that the normal alternating-current voltage of the system is insufficient to sustain an arc for any substantial length of time, and in general, so that the arc will not restrike in my hollow-insulator device after the first current-zero.

In Figs. 11 and 12, a further connection is disclosed in which the discharge devices, instead of being connected in parallel with the supporting insulators 14, are supported from a suitable arm 18 on the tower structure, and the intermediate electrode 4 is so shaped as to maintain a uniform

external arc distance, even though the line might sway because of atmospheric disturbances.

In the foregoing description and in the appended claims, when I refer to the electrodes as being electrically insulated, spaced, normally spaced, normal insulated, or as providing a spark-gap space therebetween, or similar language, I mean to refer to electrodes which are spaced in all normal operating positions or conditions of the device.

While I have shown and described specific embodiments of my invention, it is apparent that changes and modifications can be made therein without departing from the spirit and scope of my invention. I desire, therefore, that only such limitations shall be imposed as are necessitated by the prior art or as may be embodied in the accompanying claims.

I claim as my invention:

1. An electrical discharge device comprising 20 primary spaced terminal electrodes, a substantially tubular structure in which a space discharge occurs between said electrodes, said space having gas-evolving wall-material therein, said tubular structure being insulating along its outer 25 surface between the electrodes, and an auxiliary electrode in said tubular structure intermediate the primary electrodes in space-discharge relation thereto.

2. An excess-voltage protective device for an 30 alternating-current system, comprising a hollow-insulator device having electrically insulated conducting electrodes at the respective ends thereof, said hollow-insulator device including structural means for providing a long restricted arc-path 35 between said electrodes within said hollow and for causing sparkover between said electrodes to occur within a long restricted arc-path between said electrodes within said hollow rather than between said electrodes externally of the insula- 40 tor, the restriction of said arc-path being insufficient of itself apart from the material of its walls, to exert a substantial effect on a power-arc current following said sparkover, said restricted-path means including gas-evolving wall-material 45 for extinguishing said arc, said device including means for limiting the gas-pressure built up therein.

3. An excess-voltage protective device for an alternating-current system, comprising a hollow 50 insulator, electrically insulated conducting electrodes at the respective ends thereof, structural means for causing the spark-gap distance between the electrodes within the hollow of the insulator to be sufficiently less than the spark- 55 gap distance between the electrodes externally of the insulator to insure that a sparkover shall occur within said hollow under the conditions of operation, said device including means responsive to an arc following said spark for evolving gas in 60 close, intimate relation to the arc path, and means for limiting the gas-pressure built up in said device.

4. An excess-voltage protective device for an alternating-current system, comprising a hollow- 65 insulator device having electrically insulated conducting electrodes at the respective ends thereof, said hollow-insulator device including structural means for providing a long restricted arc-path between said electrodes within said hollow and 70 for causing sparkover between said electrodes to occur within a long restricted arc-path between said electrodes within said hollow rather than between said electrodes externally of the insulator, the restriction of said arc-path being insufficient 75

of itself, apart from the material of its walls, to exert a substantial effect on a power-arc current following said sparkover, said restricted-path means including gas-evolving wall-material for extinguishing said arc, said device including means for venting said evolved gas.

5. An excess voltage protective device for an alternating-current system, comprising a hollow insulator, electrically insulated conducting electrodes at the respective ends thereof, structural means for causing the spark-gap distance between the electrodes within the hollow of the insulator to be sufficiently less than the spark-gap distance between the electrodes externally of the insulator to insure that a sparkover shall occur within said hollow under the conditions of operation, said device including means responsive to an arc following said spark for evolving gas in close, intimate relation to the arc path, and means for venting said evolved gas.

6. An electrical discharge device comprising a tubular dielectric structure comprising gas-evolving wall-material therein, and electrically insulated conducting electrodes at the respective ends thereof, at least one of said electrodes being vented, the structural arrangement of said device being such as to cause sparkover between the electrodes to occur within the tubular dielectric structure rather than externally thereof.

7. An electrical discharge device comprising a tubular dielectric structure comprising gas-evolving wall-material therein, spaced electrodes both terminating within said tubular dielectric structure to provide a spark-gap therewithin, means for venting said tubular dielectric structure, and means for deionizing the vented gases.

8. A protective device comprising a tubular dielectric structure comprising gas-evolving wall-material therein, a plurality of electrodes therein, and means for initiating an arc between the electrodes within the tubular dielectric structure rather than externally thereof, said tubular dielectric structure comprising concentric cylindrical tubes, means for providing an annular space therebetween, and a plurality of offset venting means for said annular space for communicating respectively with the bore of the inner tube and the outside of the outer tube.

9. An electrical discharge device comprising a tubular dielectric structure comprising gas-evolving wall-material therein, and electrically insulated conducting electrodes at the respective ends thereof, said device including means for limiting the gas-pressure built up in said device, the structural arrangement of said device being such as to cause sparkover between the electrodes to occur within the tubular dielectric structure rather than externally thereof.

10. An arc interrupter comprising a hollow tube of insulating material having one end closed and the other end open, electrodes spaced apart internally of said insulating tube and normally insulated from each other, and the material of said insulating tube being adapted for volatilizing on the occurrence of an arc to extinguish the arc and expel the gases from the open end of the tube.

11. An arc interrupter comprising a hollow tube of insulating material, and an electrode at each end of said tube, said electrodes being normally insulated from each other and arranged to provide a preferential discharge path between them through said tube, and there being material arranged for exposure to an arc within the tube and adapted for volatilizing on the occurrence of

the arc to extinguish it and expel the gases from the tube.

12. The combination of an upper support, a suspension type insulator depending from said support, a high voltage conductor secured to the lower end of said insulator, a lower support below said conductor, a hollow tube of insulating material with one end secured to said lower support, said insulating tube extending from said lower support toward said high voltage conductor, the upper end of said insulating tube being spaced from the conductor, and an electrode at each end of said tube, said electrodes being normally insulated from each other and arranged to provide a preferential discharge path between them through said tube, there being material arranged for exposure to an arc within the tube and adapted for volatilizing on the occurrence of the arc to extinguish it and expel the gases from the tube, and said electrode farthest from said high voltage conductor being grounded.

13. An arc-interrupter comprising a tubular insulating casing member, electrodes extending within said tubular insulating casing member to provide a spark-gap space between said electrodes within said casing member, a separate interior insulating gas-evolving member disposed within said tubular insulating casing member between said electrodes, said interior insulating gas-evolving member being perforated from end to end to provide a discharge-space of limited width for the discharge of an arc between said electrodes, said interior insulating gas-evolving member comprising material, in the walls of said discharge-space, capable of emitting gas in the presence of an arc, at least one of said electrodes having a beveled end whereby the arc is directed towards the perforated portion of said interior insulating gas-evolving member and away from the annular space between said interior insulating gas-evolving member and the tubular insulating casing member, and means for venting the arcing space, the construction and arrangement being such that an arc forms interiorly of said tubular insulating casing member rather than exteriorly thereof.

14. An arc-interrupter comprising a tubular insulating casing member comprising gas-evolving material capable of emitting gas in the presence of an arc, normally spaced and insulated electrodes extending within said tubular insulating casing member to provide an arcing space between said electrodes within said tubular insulating casing member, a telescoping tubular outer-casing member closely surrounding said gas-evolving tubular insulating casing member, said telescoping tubular member being of greater mechanical strength than said gas-evolving tubular member, and means for venting the arcing space, the construction and arrangement being such that an arc forms interiorly of said tubular insulating casing member rather than exteriorly thereof.

15. An arc-interrupter comprising an insulator forming a long, narrow arcing-space, said insulator comprising arcing-space wall-material of compressed boric acid for evolving arc-extinguishing gases in response to the play of an arc, and normally spaced and insulated electrodes extending into the ends of said long, narrow arcing-space, the construction and arrangement being such that an arc forms between said electrodes interiorly of said insulator, within said long, narrow arcing-space, rather than exteriorly of said insulator, at least one of said electrodes having venting-means associated therewith for venting

its end of the arcing-space to provide a blast of gases for extinguishing the arc.

16. An arc-interrupter comprising a tubular insulating casing member of fiber, normally spaced and insulated electrodes extending within the fiber tubular casing member to provide an arcing-space between said electrodes within said fiber tubular casing-member, a telescoping tubular outer-casing member closely surrounding said fiber tubular casing-member, said telescoping tubular member being of greater mechanical strength than said fiber member, and means for venting the arcing space, the construction and arrangement being such that an arc forms interiorly of said tubular insulating casing member rather than exteriorly thereof.

17. An arc-interrupter comprising a tubular insulating casing-member composed essentially of compressed boric acid, normally spaced and insulated electrodes extending within the boric-acid tubular casing-member to provide an arcing-space between said electrodes within said boric-acid tubular casing-member, a telescoping tubular outer-casing member closely surrounding said boric-acid tubular casing-member, said telescoping tubular member being of greater mechanical strength than said boric-acid member, and means for venting the arcing-space, the construction and arrangement being such that an arc forms interiorly of said tubular insulating casing member rather than exteriorly thereof.

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