

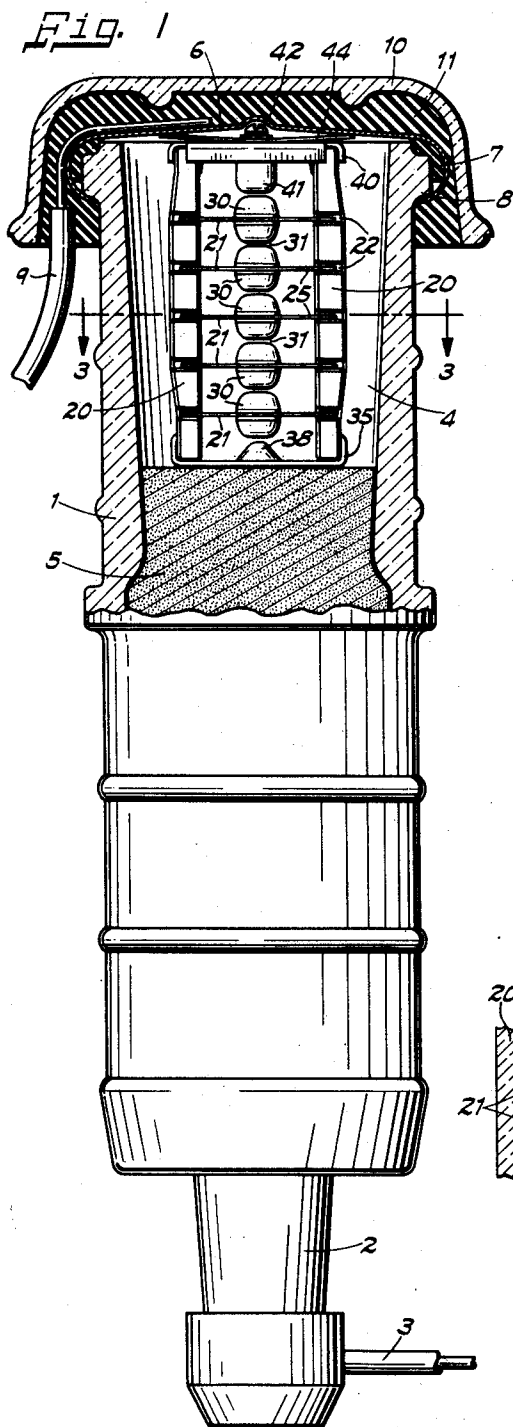
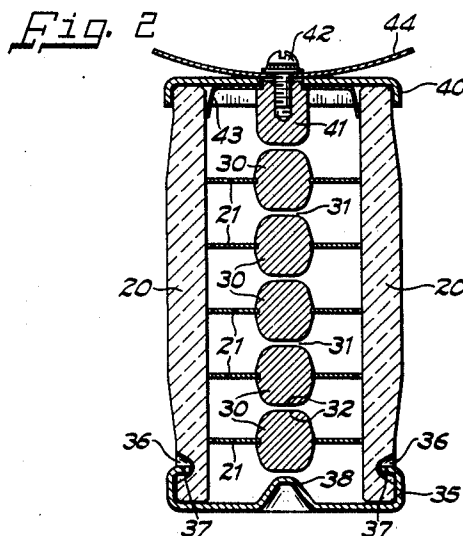
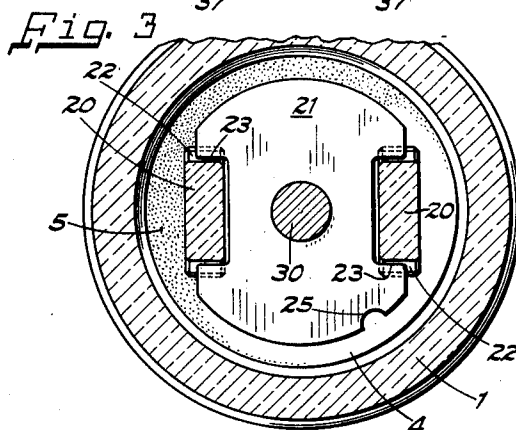
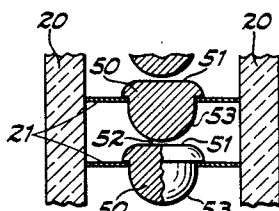
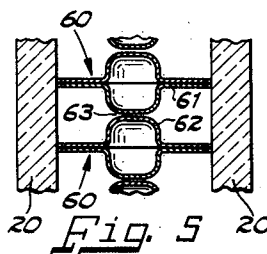
June 16, 1959

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2,891,193

SPARK GAP ASSEMBLY

Filed March 14, 1956



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2,891,193

SPARK GAP ASSEMBLY

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Application March 14, 1956, Serial No. 571,543

10 Claims. (Cl. 315—36)

The present invention relates to an improved gap assembly for a lightning arrester or the like.

Spark gap assemblies are designed so that under normal voltage conditions, the gap will insulate an electric line from ground when the assembly is connected therebetween. When a lightning disturbance, or other voltage surge of sufficient magnitude occurs on the line, the surge will spark over the gap and the current will be discharged to ground.

In valve type lightning arrester applications the gap assembly and the valve material are interrelated. The valve material is conventionally provided as a cylindrical plug or a series of stacked blocks of comminuted silicon carbide molded in solid form with a suitable bonding agent such as sodium silicate. This valve material is non-linear in its electrical resistance characteristics, and until the spark gap assembly sparks over, the valve material resistance is very high and acts as an insulator. On sparkover due to a lightning or other high voltage surge, the valve resistance decays rapidly and the material then more readily resembles a conductor. On subsidence of the over-voltage the inherent high resistance characteristic of the valve material reasserts itself to limit the 60-cycle power follow current to a magnitude that the spark gap assembly is capable of interrupting.

It will therefore be apparent that the IR voltage drop of valve type lightning arresters must be maintained at a level which will limit power follow currents to a value which the series spark gap structure can safely interrupt. It will be obvious that it becomes desirable to consistently strive for reduction in the IR discharge voltage to provide an adequate margin for increased factor of safety in protecting equipment. This is especially true when it is recognized that the insulation of equipment to be protected, such as transformers, tends to decrease in strength as the equipment ages.

Proper arrester design requires a well balanced selection of materials to provide an IR drop amply low for protection of equipment, discharge capacity sufficiently high that the arrester easily handles all surges normally encountered in service even when repeated, and the limiting of follow current to such low values that no disturbance is produced on the power line and interruption of follow current is assured at first current zero.

Because of the interrelation of the spark gap assembly and the valve material, the trend towards decreased IR drops has led to reconsideration in the design of conventional series gap structures. A typical series gap assembly which has proven to be successful in its operation over a substantial period of years is illustrated in Patent No. 2,032,566, granted to Ralph H. Earle on March 3, 1936, and assigned to the same assignee as is the present invention. However, with constant improvement in arrester design and valve material, certain problems have arisen with the structure therein disclosed. Higher power follow currents incident to reduction in the IR voltage discharge have caused arc switching on the ladder gap structure. The power follow current arc, on occasion,

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switches out of the small gaps confined between gap electrodes. A hot ionized gas blast created within the gaps by the surge and power follow current arc forces the follow current arc out of the gap confines.

The result is an arc loop stretching out from the gap electrodes. Magnetic action causes instant elongation of the arc. Great masses of ionized gases are created which effectively short out the gap structure. Under certain conditions a complete flashover occurs over the structure, permitting a continuous flow of power follow current until interrupted by a backup device such as a fuse or circuit breaker.

It is therefore an object of the present invention to provide a spark gap assembly capable of operating effectively to interrupt power follow current over a larger range of values following a sparkover resulting from an over-voltage surge on an electric line protected by said assembly.

It is another object of the present invention to provide a spark gap assembly for a lightning arrester preferably including a series of spaced apart electrode members having opposed arcing surfaces.

Specifically, it is an object of the present invention to provide a spark gap assembly including spaced apart electrodes, at least one of which includes a gas baffle plate portion intermediate its ends and extending laterally relative thereto, and further which electrode includes a diverging arcing surface for directing arcs of relatively large magnitude outwardly away from the electrode portion to terminate on the baffle plates.

Various embodiments of the invention are possible, and a few of these are illustrated in the drawing, in which:

Fig. 1 is a vertical view in partial section through a lightning arrester which includes a spark gap assembly according to the present invention;

Fig. 2 is a vertical section of a preferred embodiment of the spark gap assembly taken through the opposing spacer members supporting the assembly;

Fig. 3 is a cross section of the spark gap assembly taken on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary vertical section taken through an alternative spark gap assembly;

Fig. 5 is a fragmentary vertical section taken through another form of the spark gap assembly.

The spark gap assembly may be accommodated to a variety of conventionally known lightning arresters, or to other suitable equipment, and is preferably mounted in a totally enclosed arrester housing as shown in Fig. 1.

The preferred embodiment of the present invention is shown in Fig. 1 assembled in operating position in a conventional distribution, valve-type lightning arrester. The arrester of Fig. 1 includes a cylindrical insulating housing 1 which may be of glass or porcelain. As illustrated, the upper end of the housing is open and lower end is substantially closed, except for an aperture (not shown) communicating with a circuit interrupter 2. The circuit interrupter may be of the type shown in the patent to R. H. Earle, No. 2,315,320, granted March 30, 1943, for Automatic Circuit-Interrupting Device, owned by the assignee of the present invention. The interrupter is generally provided as accessory equipment and is merely illustrated for convenience in description, and may be eliminated if so desired, forming no part of the present invention.

The interrupter includes a rupturable auxiliary spark gap in series connection with the arrester, which, upon the occurrence of a flow of current exceeding a predetermined value across the auxiliary gap during a predetermined period of time, is adapted to extend the gap between the arrester and ground. As a practical embodiment the interrupter includes an explosive cartridge which

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is thermally responsive to excess current conditions caused by failure of the valve material, or for some other reason, which cartridge acts to release the attached ground wire 3, and as a result, an extended gap is produced which interrupts the circuit through the arrester.

The bore 4 of the housing 1 contains the valve material 5, which has been stated previously to be preferably of silicon carbide compacted and bonded with a binder such as sodium silicate.

The open end of the housing 1 is preferably sealed by means of a metallic sealing cap 6 including a marginal portion which may be crimped over a resilient sealing gasket 7 and engaging the undershoulder 8 of the housing 1. A line lead wire 9 is positioned to electrically contact the cap 6, and the entire assembly is covered by an insulating cap 10 which may be of glass or porcelain, and filled with any suitable insulating material 11, such as asphalt.

The preferred gap assembly is illustrated in operating position in the arrester of Fig. 1, and is shown in greater detail in Figs. 2 and 3. It will be apparent, however, that in certain instances the assembly may be provided as a unit mounted independently of arrester valve material. In addition, the assembly operates effectively when mounted at the lower end relative to Fig. 1 for certain installations, such as direct transformer mounting; and in certain applications, an assembly may be provided at both ends of an arrester without departing from the scope of the present invention.

The assembly includes laterally spaced insulating support members 20, which are of an insulating material, such as a ceramic or plastic material, or the like. The support members 20 are slotted at predetermined spaced intervals to receive the conducting baffle plates 21 as required. As shown, the slots 22 are provided at opposed sides of each support member, although it is conceivable that they may be provided at one side internally of the assembly (not shown). The baffle plates are each notched out at opposed sides to provide shoulder portions 23 (see Fig. 3) engageable with the slots 22 of the support members 20. Each of the baffle plates may be notched at 25 to provide a means for indexing during assembly in order that the plates may be assembled in the same relative position to insure substantially identical gap spacing between each electrode.

It will be apparent from Fig. 3 that the baffle plate 21 extends laterally outwardly from its center, to substantially fill the cross section of the chamber 4. Thus, each plate acts as a resistance to any gases tending to rise from therebelow. The plates 21 are preferably stamped from sheet metal and are arranged with their respective indexing notches 25 in alignment in order to insure that the series arrangement of the plates provides substantially equal gap spacing between the respective conducting electrode members 30.

As illustrated in the preferred embodiment of Figs. 1, 2 and 3, the gap electrodes 30 are preferably staked or simply pressed from endwise, similar to riveting, into mounting position relative to the baffle plates 21 to protrude from opposed sides thereof. This provides an inexpensive item of manufacture and a convenient means for maintaining an equal gap distance 31. It is also to be noted that the preferred structure provides a relatively small surface 32 on opposed electrodes 30 which permits an equal gap distance independent of any lateral shifting or movement of the electrode with respect to the support members 20 and with respect to each other.

It will also be noted that the electrode members 30 are provided with arcing surfaces divergent relative to the opposed flat surfaces 32. Thus, when operating at relatively small currents, such as below 75 peak amperes, the arc will tend to terminate on the electrodes in the small gap areas. Currents of this magnitude cause negligible damage or burning of the electrodes. However,

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greater currents can cause burning, melting, and fusing of gap electrodes if the current should remain in the small gap areas, and especially if the arc termini tend to remain at one spot. Such damage does not occur in the present gap structures, since the gas pressures created by the arcs themselves force the arc out of the small gap areas, and such lateral dispersion is aided by the divergent arcing surfaces. Current loops are formed, and magnetic effects further force the arcs away from the gap electrodes. Thus, the individual arcs will often finally terminate on the baffle plates rather than on the gap electrodes. Damage to the electrodes and to the baffles is negligible since the arc ends are constantly moving along the metal surfaces during the flow of power follow current and are therefore not concentrated in a particular area.

As ionized gases are created during operation of the spark gap, these gases are prevented from rising in the chamber 4 of the arrester by the laterally extending baffle plates 21, and thus are restricted from short circuiting the entire assembly and permitting the arcs to switch over and short out the structure.

It will also be apparent from Figs. 1 and 2 that the present spark gap assembly has been constructed in accordance with economical manufacturing practice to provide a mechanically strong assembly. The opposed support members 20 are forced towards one another by the crimped flange 37 of the lower electrode plate 35. Each support is provided with a notched portion 36 for receiving the flange 37. The lower electrode plate 35 is also preferably formed during its manufacture to provide the electrode portion 38 substantially at its center and having the same operating characteristics as the remaining electrodes 30.

The upper portion of the gap assembly is held together by means of a transverse retainer plate 40 having downwardly formed end flanges embracing the sides of the opposed support members 20. The upper gap electrode member 41 is fastened in place by means of a machine screw 42 in threading engagement with a tapped hole therein. The electrode 41 and the screw 42 also act to retain an outwardly biased leaf spring 43 and a compressible leaf spring 44. The spring 43 forces the support members outwardly against the flanges of the retainer plate 40 to provide a frictionally held assembly. It will be apparent, however, that the upper electrode member 41 may be formed with a protruding stud (not shown) and riveted over to retain the springs 43 and 44 and the plate 40 to replace the screw 42 and tapped hole.

When the entire spark gap assembly is placed within the chamber 4 of the lightning arrester, and the conducting cap 6 is forced downwardly relative thereto, the compressible leaf spring 44 is relatively flattened and maintains a tight engagement of the relative parts of the assembly, in addition to maintaining excellent electrical contact with the cap 6 and the line lead 9 contacting the cap.

The embodiment of Fig. 4 operates in substantially the same manner as the preferred embodiment, but utilizes an "acorn" shaped gap electrode 50. This electrode provides a relatively flat surface 51 at its uppermost portion to define a fixed gap 52 with the convex arcing surface 53 of the adjacent electrode member in the series. Substantially identical baffle plates 21 are used to support the electrodes 50 and for the other purposes outlined in connection with the embodiment of Figs. 1-3. It will be apparent that the embodiment of Fig. 4 also permits lateral shifting of the electrodes without materially affecting the gap dimension 52. The electrodes 50 may also be staked to the stamped baffle plates 21 under conventional manufacturing practices.

It will be apparent that in both the embodiments of Figs. 1-3 and Fig. 4, the electrodes may be fastened to the baffle plates according to other well-known manu-

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facturing techniques without departing from the scope of the invention. That is, the members may be joined by means of brazing, induction soldering or spot and projection welding. However, the staking or swaging techniques outlined are believed to be most expedient and less costly.

The embodiment of Fig. 5 utilizes an integrally formed electrode member 60 which is formed to provide laterally extending baffle plate portion 61 and electrode portion 62. The plates are formed under conventional punch press practice and may be arranged in back-to-back relationship to provide the structure shown. Each pair of opposed plates is inserted in the spaced-apart slots of the opposed support members 20 in the same manner as previously outlined in connection with the first embodiment. The arrangement of adjacent electrodes 60 provides fixed gap dimensions 63 having divergent arcing surfaces terminating in a relatively flat portion to permit lateral movement of the units without departing from a predetermined gap dimension.

The members 60 may be projection welded together to minimize relative lateral shifting, and it is preferred to make them of relatively thick sheet stock to provide similar heat transfer properties as the solid members 30 and 50 forming a part of the embodiments of Figs. 1-3 and 4, respectively. The heavier material tends to minimize the creation of vaporized metal by rapid conduction of the heat of arcing. It will also be apparent that the solid members 30 and 50 may be fashioned in other forms than cylindrical (not shown) from commercially supplied bar stock, such as hexagonal or rectangular cross-section material.

It will be apparent from the construction that power follow current arcs that are of such magnitude tending to switch out of the gap confines, will be terminated on the baffle plates. Ionized gases created will be confined to individual chambers between baffle plates so that flashovers cannot occur. This obtains because of the large dimension of the baffle plates which serves to prevent vertical movement of the ionized gases. However, horizontal circulation of the ionized gases is encouraged by the relatively open periphery of the baffle plates since the support members 20 occupy little of the area around the baffles. This structure encourages cooling of the created ionized gases upon mixing with a large volume of air in the relatively larger bore 4. However, the area of the baffle plates is such that the ionized gases which are needed for current flow do not reach the outer edges of the baffle plates because they have already been cooled and de-ionized by contact from air in the bore 4 prior to movement of that total distance to the periphery from the electrodes, the de-ionization taking place rapidly enough so that the arc is extinguished at the first current zero. Higher currents can be carried since the arc switching process keeps the arc terminals moving, thereby preventing excessive gap electrode surface erosion. In addition, the construction permits a simplified and inexpensive manufacture of various components, wherein lateral mechanical movement may be permitted between parts without disturbing a predetermined gap dimension.

I claim:

1. In an insulating housing containing a bore, a relatively open spark gap assembly spaced from the defining surfaces of said bore comprising a series of spaced apart electrodes, relatively narrow laterally spaced support members for maintaining said electrodes in spaced relation to one another, an opposed pair of said electrodes jointly defining a predetermined spark gap therebetween, at least one of said electrodes including an arcing surface divergent relative to said gap, said one of said electrodes including a surrounding baffle plate portion disposed intermediate the ends of said one electrode and defining an auxiliary arcing surface laterally extending relative to and in a plane spaced from said

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spark gap, said baffle plate portion engaging said relatively narrow spaced support members at only spaced intervals in a manner to afford a relatively open spark gap assembly.

2. In an insulating housing containing a bore, an open spark gap assembly spaced from the defining surfaces of said bore comprising a series of spaced apart electrodes, narrow laterally spaced support members for maintaining said electrodes in spaced relation to one another, an opposed pair of said electrodes jointly defining a predetermined spark gap therebetween and each including an arcing surface divergent relative to said gap, and each of said electrodes including a surrounding baffle plate portion disposed intermediate the ends of said one electrode and defining an auxiliary arcing surface laterally extending relative to and in a plane spaced from said spark gap, only portions of said baffle plate engaging said narrow support members.

3. In a generally vertically disposed insulating housing containing a vertical bore, a vertically arranged spark gap assembly horizontally spaced from the defining surfaces of said bore comprising a series of vertically spaced apart electrodes, relatively narrow laterally spaced vertically arranged support members for maintaining said electrodes in horizontally spaced relation to one another, an opposed pair of said electrodes jointly defining a predetermined horizontal spark gap therebetween, at least one of said electrodes including an arcing surface comprising a relatively flat portion defining the minimum horizontal dimension of said gap and extending laterally outwardly therefrom in a surface divergent relative to said gap, said electrodes each including a relatively large surrounding baffle plate portion disposed in the horizontal plane intermediate the ends of said one electrode, and defining an auxiliary arcing surface laterally extending relative to and in a plane spaced from said spark gap, said baffle plate portions engaging said support members at spaced portions of the periphery thereof to provide a relatively open spark gap assembly.

4. A relatively open spark gap assembly including relatively narrow laterally spaced support members, and a conducting electrode structure comprising a plate-like member including an aperture and being transversely supported at opposed edges by said narrow support members, an electrode member seated in said aperture and having a portion protruding from at least one side of said plate-like member, fastening means for maintaining mechanical and electrical engagement of said electrode member and said plate-like member, said electrode member having a contour delineated by an arcing surface divergent relative to the said protruding portion.

5. A relatively open spark gap assembly including relatively narrow laterally spaced support members, and a conducting electrode structure comprising a plate-like member including an aperture and being transversely supported at opposed edges by said narrow support members, an electrode member seated in said aperture and having a portion protruding from at least one side of said plate-like member, fastening means for maintaining mechanical and electrical engagement of said electrode member and said plate-like member, said electrode member having a smooth surface and a contour delineated by an arcing surface divergent relative to said protruding portion, the extremity of said protruding portion being further delineated by a relatively flat surface intersecting said divergent surface.

6. A relatively open spark gap assembly including relatively narrow laterally spaced support members, and a conducting electrode structure comprising a relatively large plate-like member transversely supported at opposed edges by said support members, a relatively small smooth cylindrical electrode member having a portion axially protruding from at least one side of said plate-like member, fastening means for maintaining mechani-

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cal and electrical engagement of said electrode member and said plate-like member, said electrode member having a smooth contour delineated by an arcing surface divergent relative to the said protruding portion, the extremity of said protruding portion being further delineated by a relatively flat surface intersecting said divergent surface.

7. A relatively open spark gap assembly including a pair of narrow laterally spaced vertically extending support members, and a conducting electrode structure comprising a relatively large horizontally disposed plate-like member including an aperture and being transversely supported at opposed edges by said narrow support members, an electrode member seated in said aperture and having a portion protruding from at least one side of said plate-like member, fastening means for maintaining mechanical and electrical engagement of said electrode member and said plate-like member, said electrode member having a general acorn-shaped contour delineated by an arcing surface divergent relative to the said protruding portion.

8. A vertically aligned relatively open spark gap assembly including vertically disposed relatively narrow laterally spaced support members, and a conducting electrode structure comprising a relatively large horizontally disposed plate-like member including an axial aperture and being transversely supported at opposed peripheral edges by said narrow vertical support members, a relatively small electrode member seated in said aperture and having a portion vertically protruding from at least one side of said plate-like member, fastening means for maintaining mechanical and electrical engagement of said electrode member and said plate-like member, said electrode member having a general acorn-shaped contour delineated by an arcing surface divergent relative to said protruding portion, the extremity of said protruding por-

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tion being further delineated by a relatively flat surface intersecting said divergent surface.

9. A relatively open spark gap assembly including a pair of narrow laterally spaced support members, and a conducting electrode structure comprising a plate-like stamping transversely supported at opposed edges by said narrow spaced support members, a small electrode portion formed integrally of said stamping and protruding from one side thereof, said electrode portion having a contour delineated by an arcing surface divergent relative to the protruding end thereof.

10. A relatively open spark gap assembly including a pair of narrow vertically extending laterally spaced support members, and a conducting electrode structure comprising a horizontally disposed plate-like stamping transversely supported at opposed edges by said narrow vertical support members, an electrode portion formed integrally of said stamping and protruding from one side thereof, said electrode portion having a contour delineated by an arcing surface divergent relative to the protruding end thereof, the extremity of said protruding electrode portion being further delineated by a relatively flat surface intersecting said divergent surface.

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