April 12, 1966 E. SARBACH 3,246,199

ARC ARRESTING SPARK GAP ASSEMBLY FOR LIGHTNING ARRESTERS

Filed July 14, 1961 2 Sheets-Sheet 1

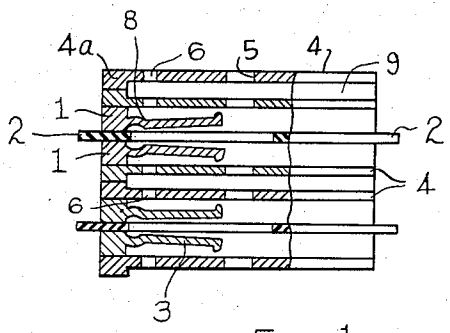


Fig. 1

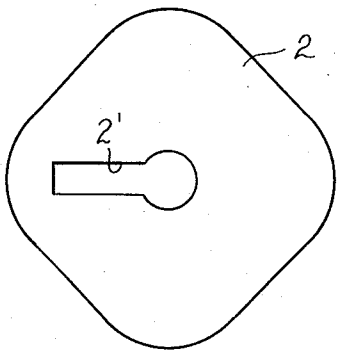


Fig. 3

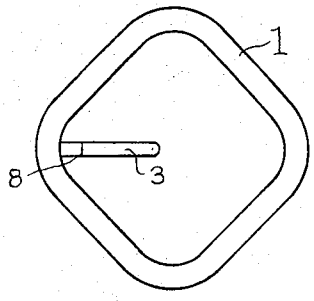


Fig. 2

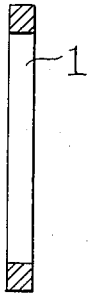


Fig. 2a

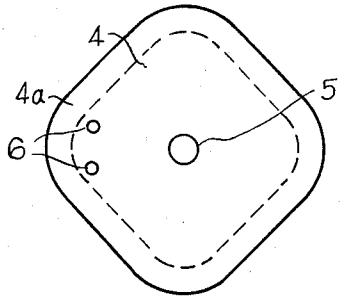


Fig. 4

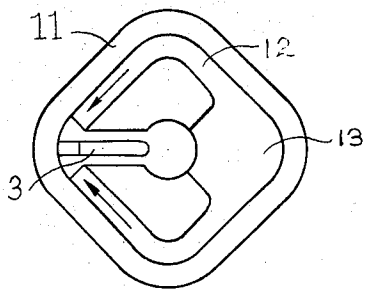


Fig. 5

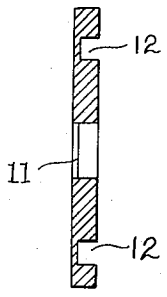


Fig. 6

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ARC ARRESTING SPARK GAP ASSEMBLY FOR LIGHTNING ARRESTERS

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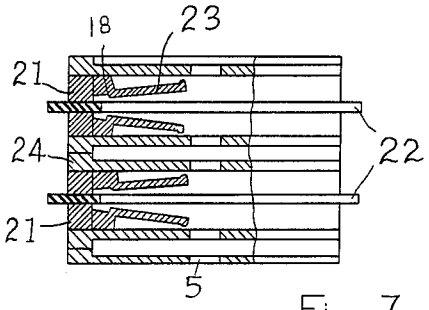


Fig. 7

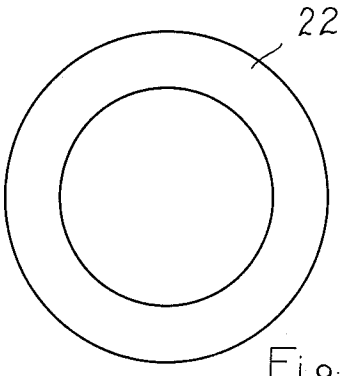


Fig. 10

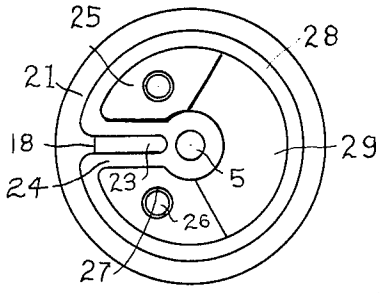


Fig. 8

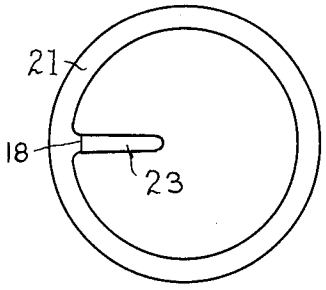


Fig 11

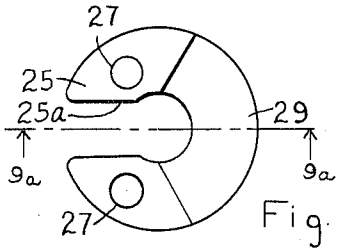


Fig. 9

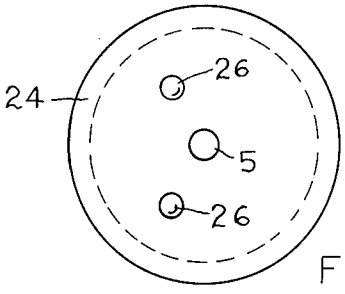


Fig. 12

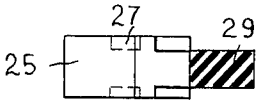


Fig. 9a

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3,246,199

ARC ARRESTING SPARK GAP ASSEMBLY FOR LIGHTNING ARRESTERS

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Claims priority, application Switzerland, July 15, 1960, 8,076/60
5 Claims. (Cl. 315—36)

The present invention relates to an improved arc arresting spark gap assembly for use in the construction of lightning arresters.

For lightning arresters having multiple spark gaps and voltage-dependent resistances connected in circuit with each other, lower and lower residual voltages are required, depending upon the particular specifications of different countries. Through the lower residual voltage, the protection level is reduced and consequently the insulation of the arresters is made at reduced costs. The lower residual voltage can be achieved through improvement of the voltage-dependent resistance material and through a reduction in height of the resistance. Through this latter measure, however, the follow current is increased and thereby quenching of the arc made more difficult. Plate type spark gaps of the kind previously used can therefore no longer meet those increased requirements. As a suitable expedient, more and more reliance is placed on shifting or displacing the electric arc which is accomplished by means of a magnetic field. This magnetic field can be produced by the electrodes themselves by suitably guiding the follow current in the electrodes, or it can be produced by using a separate magnet or by using special blast coils through which part of the follow current flows.

In the case of large follow currents, however, quenching by mere shifting of the electric arc is still not assured. Care must be taken that at the response point ionized gases no longer exist, because otherwise upon a subsequent rise in the recovery voltage backfiring will occur.

The present invention is thus concerned with an improved construction for a spark gap assembly for lightning arresters for use with voltage-dependent resistances, and extinction of the arc with the aid of self-produced magnetic fields which corresponds to the previously mentioned requirements and, at the same time, has a most simple and low cost spark gap which functions without any great lengthening of the arc. According to the the invention, the desired results are achieved by a multiple, series arranged, spark gap structure comprised of a plurality of pairs of electrodes stacked in superposed manner, each electrode pair being formed by two electrode disks each of which includes a tongue directed radially inward, these tongues being radially aligned and spaced from one another to form a gap therebetween, and the electrode disks themselves being spaced from each other by an intermediate disk of insulating material. In addition, each pair of electrodes is essentially enclosed between two cover plates to establish spark chambers individual thereto, these spark chambers communicate with each other through central openings in the cover plates, and the cover plates are further provided with cooling surfaces and guide channels which effect a circulation of gas such that cold gas again reaches the response point of the arc gap between the electrode tongues.

The invention will become more apparent from the following detailed description of representative embodiments of the improved spark gap construction and from the accompanying drawings. In these drawings:

FIG. 1 is a view partly in elevation and partly in central vertical section of a stack of spark gaps according to one embodiment of the invention;

FIG. 2 is a plan view of one of the electrode disks used in the FIG. 1 structure;

FIG. 2*a* is a view of the electrode disk in vertical section taken on line 2*a*—2*a* of FIG. 2;

FIG. 3 is a plan view of one of the insulator disks used in the FIG. 1 structure;

FIG. 4 is a plan view of one of the shut-off plates used in the FIG. 1 structure;

FIG. 5 is a plan view of a modified construction for an electrode disk usable in the FIG. 1 structure;

FIG. 6 is a view of the electrode disk of FIG. 5 in vertical section taken on line 6—6 of FIG. 5;

FIG. 7 is a view partly in elevation and partly in central vertical section similar to FIG. 1 of another embodiment of the invention;

FIG. 8 is a plan view of an assembly of one of the electrode disks with a special insulating plate combined therewith as used in the FIG. 7 structure;

FIG. 9 is a plan view of the special insulating plate shown in FIG. 8;

FIG. 9*a* is a transverse section view of the special insulating plate taken on line 9*a*—9*a* of FIG. 9;

FIG. 10 is a plan view of one of the insulating disks used in the FIG. 7 assembly to space the electrode disks of each pair;

FIG. 11 is a plan view of one of the electrode disks used in the FIG. 7 structure; and

FIG. 12 is a plan view of one of the shut-off plates used in the FIG. 7 structure.

With reference now to the embodiment of the invention illustrated in FIGS. 1–4 of the drawings, it will be seen from FIG. 1 in particular that the stack of spark gaps are arranged electrically in series from the top to the bottom as is customary. The complete lightning arrester would contain more than the two spark gap units which have been illustrated but these two are deemed sufficient to illustrate the inventive concept which is defined in the appended claims. Each spark gap unit is comprised of a pair of electrodes 1, 1 which are spaced from each other by means of an insulating disk 2. As shown in FIGS. 2 and 2*a*, each electrode 1 is constituted by a ring-like member of electrically conductive material having an essentially square configuration with rounded corners and is provided with a tongue portion 3 projecting radially inward toward the center from one of the corner portions. The tongue portion 3 is generally sloped in a direction away from the plane of the electrode ring but includes a re-entrant-like portion 8 which constitutes the response point for each spark gap defined by the tongues 3 of each pair of electrodes 1, these tongues being in alignment one above the other and divergent at their outer ends as indicated in the FIG. 1 assembly. The re-entrant-like portions 8 of adjacent tongues of each pair converge to establish the response point of the gap, i.e. the place where the arc strikes. The insulating disk 2, as shown in FIG. 3 is also a generally square plate of insulating material with rounded corners and is somewhat larger than the electrodes 1 so as to provide a peripheral insulating flange when assembled with the electrodes, as shown in FIG. 1. Each insulating disk 2 is generally imperforate, planar and provided with a key-hole shaped slot 2′ with the narrow portion of the slot in alignment with the tongue portions 3 of the electrodes so as to permit the arc to be struck therebetween. The rounded portion of the keyhole slot is located centrally of the disk and serves to permit the arc to pass through the same. In contact with each of the electrodes 1 is a shut-off or closure plate 4 which is made from electrically conductive material. As shown in FIG. 4, each of these plates is of the same size and configuration as the elec-

trodes 1 and is generally planar except for a thickened rim portion 4a. Each plate 4 includes a conmparatively large central opening 5 and two smaller openings 6 located adjacent one of the rounded corner portions which are provided for circulation of gas. These holes 6 are so located that gas passing through the same will be directed upon the response points 8 on the electrode tongues. Thus, as shown in the assembly view of FIG. 1, each spark gap unit includes a pair of electrodes 1 held in spaced relation by an insulator disk 2 and upper and lower closure plates 4 which establish an arc chamber for each pair of electrodes. The closure plates 4 of adjacent spark gap units also establish intermediate chambers 9 due to their raised rim portions.

The spark gap assembly shown in FIG. 1 operates in the following manner.

As soon as the voltage on the spark gap rises sufficiently, the arrester responds at the points 8 of the several electrode pairs in the assembly. Thus, there arises a plurality of partial arcs which, driven by their own self-produced magnetic fields, pass rapidly along the divergent tongue portions 3 and through the central holes 5 in plates 4 and combine into a single electric arc. The combined electric arc will now have only two roots, one of such roots being located at the uppermost plate 4 of the assembly, and the other root being located at the lowermost plate 4 of the assembly. As a result of the movement of the electric arc there arises, at the same time, a circulation of gas, whereby comparatively cold gas from the intermediate chambers 9 formed by adjacent plates 4 passes through the holes 6 and is directed upon the response points 8 of the partial arcs in the arc chambers to thus favor quenching of the after or follow currents.

A somewhat modified construction for the spark gaps is illustrated in FIGS. 5 and 6. Here it will be seen that the electrode 11 has the same general external configuration as electrode 1 but is provided with cooling channels 12 leading back to the response point 8 from a cooling surface 13. On response of the arrester, the hot gases, generated as the arc strikes, flow over the surface 13 and along the channels 12 in the directions indicated by the arrows and pass thus in a cooled condition again to the response points 8. With this type of construction, the holes 6 which were provided in plates 4 of the previously described embodiment for gas circulation are omitted.

A somewhat different embodiment of the invention is illustrated in FIGS. 7–12. It will be appreciated from these views that the various elements which make up the assembly shown in FIG. 7 have a generally circular configuration.

As seen in FIGS. 7 and 11, the electrodes 21 of each electrode pair are seen to be of ring shape and are provided with aligned, divergent tongues 23 extending radially inward and with re-entrant-like response points 18 similar to the tongues 3 and response points 8 of the electrodes 1 of the embodiment shown in FIGS. 1–4. The electrodes 21 of each pair are spaced from each other by intermediate planar insulator disks 22 which, as shown in FIG. 10, are seen to have an annular configuration.

For guiding and cooling the hot gases, special insulator members 25 are used and these are detailed in FIGS. 9 and 9a. A sub-assembly of such an insulator member with the associated electrode ring 21 and shut-off plate 24 is illustrated in FIG. 8, and FIG. 12 illustrates the detailed structure of the shut-off or closure plate 24. It will be seen from the assembly view in FIG. 8 that the insulator member 25 has a generally circular peripheral configuration and the external diameter of the same is somewhat less than the internal diameter of the electrode ring 21 so as to establish arcuate gas guide channels 28 therebetween when the insulator member 25 is placed inside of the opening in the electrode ring 21. The insulator member 25 is also provided with a comparatively broad cooling surface 29 for cooling the gases before they are passed to the channels 28, and it is further provided with a key-hole slot 25a, the narrow part of which is aligned with the tongues 23 and the circular part of which is concentric with the hole 5 in plate 24. The insulator member 25 is also generally plate-like, it is concentric with electrode ring 21, and it is centered and supported within electrode 21 by an adjacent circular shut-off plate 24. For this purpose the insulator member 25 is provided with circular recesses 27 which receive centering pins 26 upstanding upon the face of plate 24.

The spark gap structure shown in the embodiment of FIGS. 7–12 operates generally in accordance with the same principles as has been described in connection with the operation of the embodiment of FIGS. 5 and 6. That is to say, hot gases reaching the surface of the insulator member 25 through hole 5 in the shut-off plate 24 flow across the cooling surface 29, thence into and around the channels 28 in the directions indicated by the arrows and thence are directed onto the response points 18 of the electrodes 21 to assist in the quenching of after currents.

In conclusion, the spark gap structure in accordance with the invention has a very high resistance to back-firing even at high follow currents, i.e. the relation of the recovery voltage to the response voltage at which certainly no back-fire will occur. The partial electric arcs which arise upon response, i.e. upon arcing over of the gaps between electrodes of each pair, very quickly leave the electrodes as a result of the narrow shaping of the tongues, and these partial arcs are combined into a single arc which possesses root points only on the uppermost and lowermost electrodes. Consequently, the consumption of the electrodes by burning off is very slight, so that even severe quenching tests have no influence upon the response voltage. Finally, through the special shaping of the spark gaps is achieved also in a very simple manner the desired supply of de-ionized gases to the response points of the partial electric arcs.

I claim:

1. In an arc arresting spark gap assembly for lightning arresters for use in conjunction with voltage-dependent resistances and wherein arc extinction is facilitated through a self-produced magnetic blow-out effect, the combination comprising a plurality of pairs of electrodes stacked in superposed relation, each pair of electrodes being constituted by a pair of disks spaced from each other by an intervening disk of insulating material, the electrode disks of each pair including substantially radially aligned tongues extending inward from the periphery of said disks toward the center of and spaced one above the other to establish a spark gap therebetween having a response point, a cover plate on each electrode disk of each electrode pair to thereby establish a separate spark chamber for each electrode pair, said cover plates and said intervening insulator disks being provided with aligned apertures to establish an axially extending communication between said spark chambers of sufficient size to enable a single arc to be established across a plurality of said spark gaps, adjacent cover plates appertaining to adjacent electrode pairs including wall portions spaced from each other to establish intervening cooling chambers which serve to cool gases developed by the arcs across said spark gaps, and means for directing the flow of gas from each cooling chamber to the response point of the electrode tongue in an adjacent spark chamber.

2. A spark gap assembly as defined in claim 1 wherein said means for directing the flow of gas from each said cooling chamber formed between adjacent cover plates to the response point of the electrode tongue in an adjacent spark chamber is constituted by an aperture through the wall of the cover plate in the vicinity of said response point.

3. A spark gap assembly as defined in claim 1 wherein

said means for directing the flow of gas from each said cooling chamber formed between adjacent cover plates to the response point of the electrode tongue in an adjacent spark chamber is constituted by gas flow channels formed in the surface of the electrode disc of which said tongue forms a part.

4. A spark gap assembly as defined in claim 1 wherein said electrode disks are ring-shaped and said means for directing flow of gas from each said cooling chamber formed between adjacent cover plates to the response point of the electrode tongue in an adjacent spark chamber is constituted by a disk-like member of insulating material located in the space within said electrode rings and the periphery of which is spaced from said electrode rings to establish flow channels for the gas to the response point.

5. A spark gap assembly as defined in claim 4 wherein

said disk-like member of insulating material located in the space within said electrode rings is supported upon the adjacent cover plate, and which further includes means centering said disk-like member comprising pins upstanding from the faces of adjacent cover plates which enter correspondingly positioned recesses in the opposite faces of said disk-like member.

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