Sept. 24, 1957 E. NILSSON 2,807,751

SPARK GAP STACK, PREFERABLY FOR VALVE TYPE LIGHTNING ARRESTERS

Filed July 7, 1955

Fig.1a

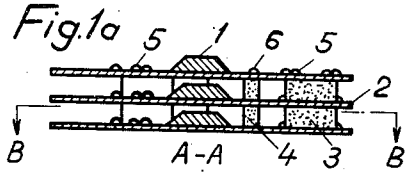


Fig.2

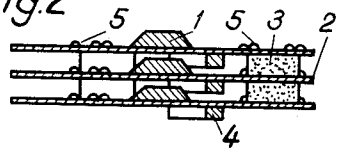


Fig.1b

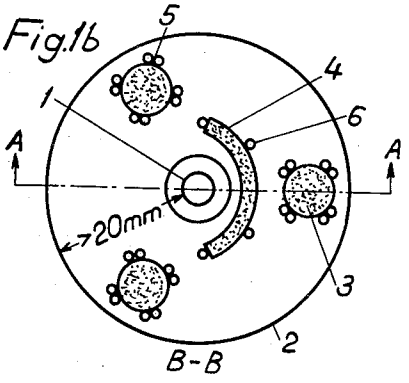


Fig.3

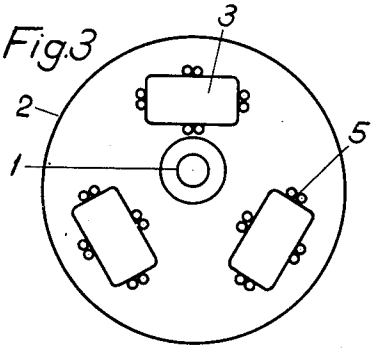


Fig.4a

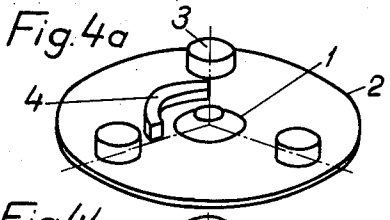


Fig.4b

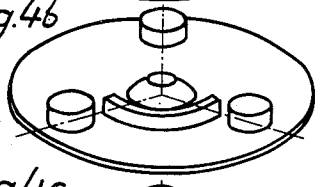


Fig.4c

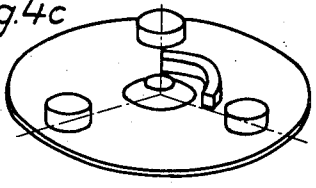


Fig.5a

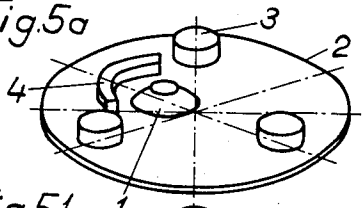


Fig.5b

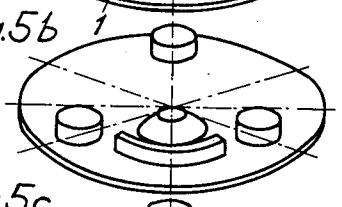
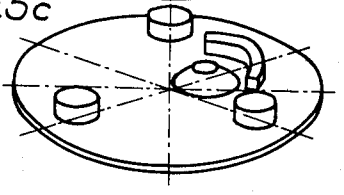


Fig.5c



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United States Patent Office 2,807,751 Patented Sept. 24, 1957

2,807,751

SPARK GAP STACK, PREFERABLY FOR VALVE TYPE LIGHTNING ARRESTERS

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Application July 7, 1955, Serial No. 520,564

Claims priority, application Sweden February 18, 1955

14 Claims. (Cl. 315—36)

This invention relates to spark gap stacks consisting generally of a plurality of disc-shaped metallic electrodes between which a number of series-connected spark gaps are formed.

The function of the spark gap stack in the lightning arrester is in the first place to insulate when only the normal power voltage—usually an alternating current voltage—lies across the arrester, in the second place to arc over when an over-voltage of a certain amplitude is superposed upon this alternating current voltage, and in the third place to quench the arc and to again insulate when the over-voltage has passed and only the normal power voltage remains. The quenching normally takes place at the first zero passage of the power voltage, when the over-voltage has passed. The quenching capacity of a gap having a given structural design is related partly to the peak and the wave shape of the surge-current caused by the over-voltage and partly to the value of the follow-current driven by the power voltage during the time between the passing of the surge-current and the quenching of the arc at a following zero passage of the power voltage. It may be noted that the practically occurring over-voltages mainly are known in respect to their magnitude and frequency, whereas the magnitude of the follow-current is a constructive variable. A characteristic tendency in the development of modern valve type arresters is to give the follow-current higher and higher values, which means improved protective properties of the device regarding the non-linear resistances of the arrester. A presumption for this development, however, is that the embodied spark gaps have an adequate quenching capacity.

The quenching capacity of a single gap between metallic surfaces arranged at a short distance from each other depends on whether the gas volume and the arc foot points on the electrodes, heated up by the arc, are rapidly deionized and cooled by carrying away the heat in the electrode metal. Experiments indicate that it is advantageous if the gas volume between two electrodes has the possibility of expanding, which implies that the outer edge of the gap electrode is not used for arranging a ring-shaped insulating supporting member (compare for example the stack type shown in U. S. Patent No. 2,234,108).

The present invention relates more particularly to spark gap stacks with electrode plates open at the periphery, and one object of the present invention is to further increase the quenching capacity.

It has been found that a shortcoming of the earlier used arrangement is that the arc, during the follow-current interval, may travel from the spark-over path to the free edge of the electrode. If the follow-current then is higher than that used earlier, the burning at the electrode edge will be very great and may cause a successive flash-over to adjacent electrodes in the stack. It has further been found that there is a maximum value for the path of travel which the arc covers for different follow-currents within the whole current range occurring in practice. An increase of the follow-current from low values results initially in an increasing tendency of the arc to travel, but

when considerably higher values are obtained, the arc burns itself into the electrode surface, with the result that its travel is limited.

According to the present invention the spark gap stack is therefore designed with its electrode plates stacked on each other and having their profiles shaped to form spark-over gaps between successive plates, in such a way that the shortest possible path of travel for the arc foot points along a free electrode surface is at least 20 mm. between a spark-over gap and a free electrode edge. A long path of travel towards a free electrode edge is obtained according to a modification of the invention by an arrangement in which the arc is given for its travel a predetermined direction which is other than that towards the nearest edge. This predetermined direction is not caused by magnetic blowing but is obtained by means of screens which reflect or deflect the pressure waves in the gas, which are caused by the suddenly occurring surge-current arc. Alternatively or in combination with this measure the spark-over gap may be designed with an eccentrically arranged protuberance, the pressure waves being asymmetrically reflected by the inner side of the container in which the stack is inserted. By symmetrically displacing in an angular direction successive spark-over gaps or screen devices or both of them in the stack, the said predetermined direction in successive gaps can be directed towards different points of the periphery of the gap stack. The possibility of the uniting of the arcs round the electrode edges and the risk of series flash-overs between several electrodes is thus decreased. By designing the spark-over gap as an eccentrically arranged frusto-conical or wart-shaped protuberance, which is angularly displaced in relation to corresponding protuberances on adjacent electrode plates, the added advantage is gained that the protuberances can be made by stamping elements of thin sheet metal without the need of filling up the resulting cavities.

Further objects and advantages of the invention will appear more fully from the following description, especially when taken in conjunction with the accompanying drawings which form a part thereof.

In the drawings:

Figs. 1*a* and 1*b* are respectively cross-sectional and plan views according to the lines A—A and B—B and showing one form of the invention;

Fig. 2 is a cross-section showing another form of the device;

Fig. 3 is a plan view showing still another modification;

Figs. 4*a*, 4*b*, and 4*c* show, in perspective, still another form with three similar electrode plates separated from each other and shown in positions displaced from each other through three equal angles, and

Figs. 5*a*, 5*b*, and 5*c* are views corresponding to Figs. 4*a*, 4*b*, and 4*c*, but showing a slightly modified arrangement.

In the form shown at Figs. 1*a* and 1*b* the electrode stack comprises three electrode plates **2** each provided with a frusto-conical or wart-shaped protuberance **1**, which together with the plane part of the adjacent electrode plate forms a spark-over gap for the arc. The distance of the plates from each other is determined by spacers **3** which may be made of high ohmic insulation material or of resistance material for the control of the voltage distribution between the electrode plates. The spacers **3** are fixed by small protuberances **5**, which may be made, for example, by stamping the electrode plates. A screen **4** of insulating material is provided for each electrode plate and may have the form of a ring segment as shown in the drawing. The screen **4** may advantageously be fixed by small protuberances **6** on the plate. The distance between the plane part of the protuberance **1**

and a free electrode edge along a free electrode surface is at least 20 mm. and the screen device **4** gives the arc a predetermined direction, in the present case (Fig. 1*b*) to the left.

The device according to Fig. 2 differs from that shown in Fig. 1 in that the screen device **4** in Fig. 2 consists of a protuberance on the electrode plate and is arranged on the side of the plate opposite to that having the spark-over protuberance **1**. The screen protuberance **4** may favorably consist of electrically conducting material and need not span the whole distance between two adjacent electrode plates.

As mentioned above, a predetermined or preferred direction of the arc can be obtained by arranging the spark-over gap eccentrically, and such an arrangement may be employed either separately or in combination with a suitable arrangement of a screen device. In Fig. 3 the electrode plate **2** is provided with an eccentric spark-over protuberance **1**. The predetermined arc direction obtained by the eccentricity is further accentuated by the arrangement of the spacers **3**, one of which is located in close proximity to the spark-over wart **1** and serves as a screen device. In this example the spacers **3** are given a mainly rectangular form, and they or part of them may also consist of grading impedances for the control of the voltage distribution or may consist of pre-ionizing bodies which produce a radiation and thereby pre-ionize the spark-over gap.

Fig. 4 shows an example of systematic angular displacement of the screen devices on successive electrode plates. In Figs. 4*a*, 4*b*, and 4*c* three successive electrode plates **2** have concentrically arranged spark-over protuberances or warts **1**. The screen devices **4** have the shape of ring segments, and have angular displacements of 120° in relation to the adjacent screen devices and thus give the arcs, formed in the different spark-over gaps of the stack, different directions of travel. The plates are correctly spaced from each other by means of the spacer members **3** which may also serve as grading resistors or ionizing devices or as both grading resistors and ionizing devices.

A systematic angular displacement is also found in the stack shown in Fig. 5. The Figs. 5*a*, 5*b*, and 5*c* show three successive electrode plates **2** with eccentrically arranged spark-over protuberances or warts **1**. In this example also the screen devices **4** are in the form of ring segments and are located in corresponding positions in relation to the spark-over warts **1** in the three electrode plates. The screen devices **4** and the warts **1** are both angularly displaced in relation to each other on successive electrode plates, in this example through 120°. By thus angularly displacing the spark-over gaps as well as the screen devices, the arcs between the electrode plates obtain distinct predetermined directions, angularly displaced in relation to each other.

As shown in Fig. 5, the plates in this example also are correctly spaced by means of spacer members **3**, which may also serve as grading impedances or ionizing devices or as both grading impedances and ionizing devices. The number of spacers **3** for each plate is suitably chosen in such a relation to the angular displacements of the plates that the spacers on successive plates will be in alignment with each other so that they form supporting pillars through the spark gap stack. As a result the mounted stack will obtain a desirable mechanical strength. With this arrangement the number of elements **3** for each plate is equal to, or a multiple of, the number of angular displacement steps in the cycle. In the example shown three elements on each plate correspond to three displacement steps of 120° each for the electrode plates. Also in the arrangement according to Fig. 5 the spacers **3** themselves may serve as screen devices, in which case the ring segment shaped screen **4** may be omitted. In such a case the spacers **3** are all suitably displaced 60°

in relation to the shown position, so that one of the elements **3** will then be located between the spark-over wart and the nearest free electrode edge and thus will cause the arc, after spark-over in the spark-over gap, to travel in a mainly opposite direction. The relative position of the spacers **3** and the spark-over warts **1** is maintained so that they together are angularly displaced in relation to the corresponding arrangement of the adjacent electrode plate, suitably by angular displacement of the electrode plate.

In all the arrangements above described the protuberances on the electrode plates, including the spark-over warts **1**, the protuberances **4** and the fixing devices **5** and **6**, may be made by stamping electrode plates of thin sheet material. The cavities thus formed in the opposite sides of such protuberances are not inconvenient if the electrode plate on this point need not necessarily be plane. In this respect the systematic displacement of eccentrically arranged spark-over warts has the additional advantage that the spark-over wart on each electrode plate will be facing a plane part of the adjacent plate.

As above explained the invention is not limited to screen devices of ring segment shape, and in most of the forms the screen device may consist of either insulating or conducting material. In all the forms also the other elements arranged between the plates, including the spacers, grading resistors and ionizing devices, may form screen devices for obtaining a predetermined direction for the travelling arc.

While suitable embodiments of the invention have been described herein, it is to be understood that they are not intended as limitations except within the scope of the claims hereto or hereinafter appended.

I claim as my invention:

1. A spark gap stack of the character described, comprising a plurality of substantially circular electrode plates stacked upon and in spaced relation to each other with the spaces between adjacent plates in free communication with each other at their peripheral edges, means on said plates designed to form spark-over gaps for an arc between adjacent plates and so arranged that the shortest possible free-horizontal path of travel of the arc from the foot points of said gap to the peripheral edges of the plates along the plate surface is greater than the distance between said foot points and the geometrical center of the plates and is at least 20 mm.

2. A spark gap stack according to claim 1, in which each plate has an eccentrically arranged protuberance forming the said spark-over gap.

3. A spark gap stack according to claim 1, comprising a screen device arranged between adjacent plates and in proximity to the spark-over gap to influence the direction of an arc.

4. A spark gap stack according to claim 1, in which the means forming the spark gap are eccentrically arranged and angularly displaced in relation to each other in the adjacent spaces between the electrode plates.

5. A spark gap stack according to claim 1, comprising screen devices eccentrically arranged in the spaces between the plates and angularly displaced with respect to the screen devices in adjacent spaces.

6. A spark gap stack according to claim 1, comprising screen devices arranged between adjacent electrode plates and serving as spacing means therefor.

7. A spark gap stack according to claim 1, comprising means forming the spark-over gaps eccentrically arranged and angularly displaced in relation to each other in the adjacent spaces between the electrode plates, and screen devices eccentrically arranged in the spaces between the plates and angularly displaced with respect to the screen devices in adjacent spaces.

8. A spark gap stack according to claim 1, comprising screen devices arranged between adjacent electrode plates and serving as grading impedances.

9. A spark gap stack according to claim 1, comprising screen devices arranged between adjacent electrode plates and serving as pre-ionizing bodies.

10. A spark gap stack according to claim 1, comprising screen devices arranged between adjacent electrode plates and formed by protuberances in the electrode plates.

11. A spark gap stack according to claim 1, comprising spacers arranged in the spaces between the electrode plates and angularly displaced with respect to each other in successive spaces through such an angle that individual spacers in successive spaces are in alignment with each other and form a plurality of supporting pillars extending through the stack.

12. A spark gap stack according to claim 1, in which each electrode plate consists of a thin metal sheet stamped to the required form to locate the spacing means and to form the spark-over means.

13. A spark gap stack according to claim 1, in which the electrode plates are so displaced angularly with respect to each other that, in the adjacent spaces between the electrodes, the said arc-travel paths are disposed in angular relation to each other.

14. A spark gap stack of the character described, comprising a plurality of substantially circular electrode plates stacked upon each other in spaced relation, with the intervening spaces in free communication with each other at the peripheral edges of the plates, and spacing, screening and spark-gap members so disposed between adjacent plates that each arc is given a predetermined direction towards the periphery of the plate, and in which the electrode plates are angularly disposed with respect to each other progressively so that the said predetermined arc directions are directed to different points in the periphery of the stack, and in which the shortest possible free horizontal path of travel of the arc from the foot points of said gap to the outer peripheral edges of the plates along the plate surface is greater than the distance between said foot points and the geometrical center of the plates and is greater than 20 mm.

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