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3,378,722

SERIES SPARK GAPS ARRANGED TO PRODUCE A MAGNETIC FIELD

Filed Oct. 13, 1965

2 Sheets-Sheet 1

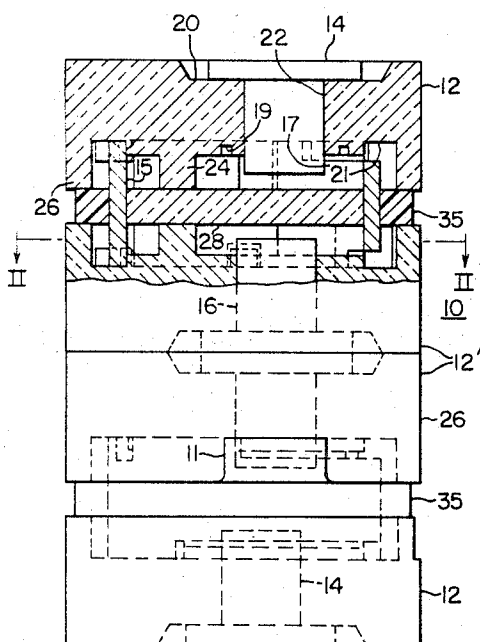


FIG. 1.

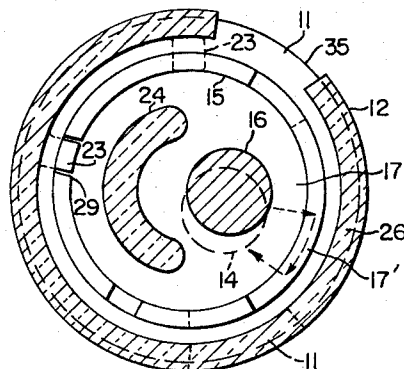
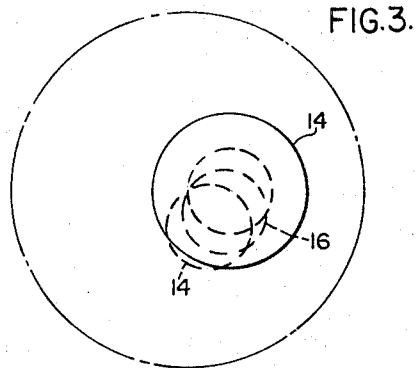


FIG. 2.

WITNESSES

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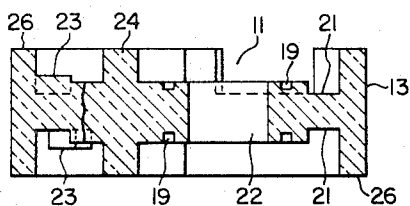
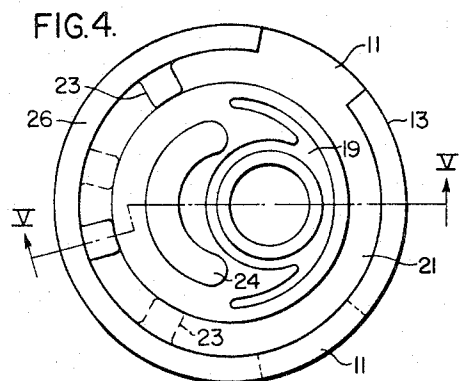


FIG. 5.

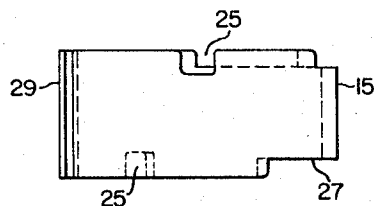
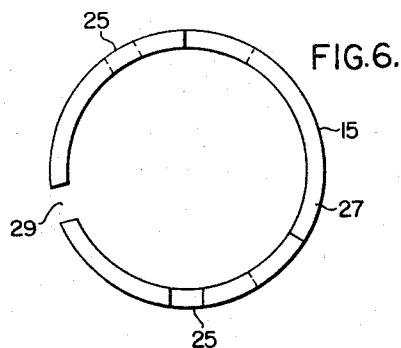


FIG. 7.

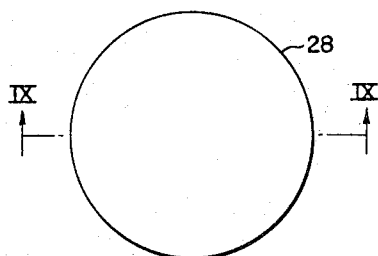
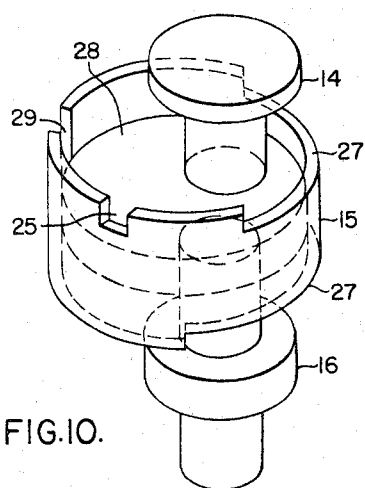


FIG. 8.



FIG. 9.

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SERIES SPARK GAPS ARRANGED TO PRODUCE A MAGNETIC FIELD

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ABSTRACT OF THE DISCLOSURE

A lightning or voltage surge arrester is so constructed that upon breakdown, the arc discharge generates its own magnetic field for moving the arc from the point of sparkover and to finally interrupt it.

The present invention relates to improvements in low voltage spark gap devices, and particularly to a unique construction of a series gap device particularly but not exclusively useful in lightning arresters such as are provided on electric power lines.

The low voltages herein referred to lie generally in the range of the distribution voltages which run from about 3 kv. to 27 kv., for example, though the present invention is not limited thereto.

There is presently needed in the low voltage arrester art a small, inexpensive and highly efficient spark gap structure. One approach to this objective in arrester design is to stretch the arc in the gap over an extended area by use of an axial magnetic field provided by magnets or coils physically disposed in a stacked gap assembly or at the ends thereof. By stretching and moving the arc it is brought into contact with the cool surfaces of the insulating material. Otherwise, if the arc is allowed to remain only in the sparkover area, burning and pitting of the gap electrodes will occur thereby changing the electrical characteristics of the gaps. This in turn causes inconsistent sparkover behavior since the gaps have been electrically changed. Further, the heat generated in the gap electrodes in the sparkover area with little or no arc movement can cause projections to form on the electrode surface that can result in static sparking and the consequent generation of radio noise and interference.

With the use of magnets physically disposed in the stack assembly means must be provided to protect or shield the magnets from high current and voltage surges; with magnet coils, means must be provided, such as a spark gap device electrically connected across each coil, to protect the coil from over voltages. Thus, such magnetic arc stretching means can become damaged and demagnetized. In addition, the original cost of the magnetic structures and their protecting means add greatly to the cost of the arrester device.

The character of the gap structure and the operation and effect of a magnetic field are thus key factors in the overall arrester efficiency and economy sought, and it is the unique and novel improvements in this character and operation that embody the principles of the present invention.

It is, therefore, the principal object of the present invention to provide an efficient and low cost spark gap structure that has ample arc elongation and interruption ability using a magnetic field developed by its own arc discharge.

Another object of the invention is to provide an improved spark gap assembly that is compact, simple and economical to assemble and which utilizes a minimum of parts and connections so that an increase in stack com-

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ponents and higher ratings can be obtained with a minimum increase in the size of the arrester.

Still another object of the present invention is to provide a rugged spark gap structure that effectively resists bursting pressures.

A further object of the invention is to provide a means to rapidly move the arc from the point of sparkover so that the electrodes that form spark gaps are kept clean and burr free for consistent sparkover voltage level and minimum radio noise generation.

Briefly, the present invention employs a stack of ceramic (or other suitable material) gap plates each having an external peripheral raised portion supporting a tubular or ring type electrode in the center thereof between adjacent plates. Each tubular electrode has a longitudinal slit extending its entire length so as to prevent current flow in both directions around the tubular ring. At a point almost diametrically opposite the ring slit is located an internal pin or rod type electrode (formed from elongated brass rod stock or other suitable types of material) that provides the second electrode for the spark gap that is located off stack center. Each rod electrode is supported in place by a hole provided in each ceramic plate. Each rod extends beyond the surface of its respective ceramic plate into an arc chamber formed by adjacent plates and near one portion of the ring electrode to form a spark gap therewith. Adjacent rods in the stack assembly are supported by their heads above an insulating disc or plate physically secured in the center of the tubular ring electrode. Each succeeding rod electrode and each tubular slit is displaced about the axis of the stack by a small angle so that current from the inner (rod) electrode breaks down the gap between the inner electrode and outer (ring) electrode and then is forced to move about and along the external (ring) electrode to the next rod electrode where it again flashes the gap. Thus, a current path is formed in each arc chamber from the rod electrode around the tubular electrode for the distance of the angular displacement, and this current path forms an arc motive magnetic field that acts on the portion of the arc between the inner electrode and tubular electrode to force one foot of the arc toward the slit in the tubular electrodes, while the other foot moves along and around the inner electrode away from the sparkover point. The rod electrode, being off center, allows the arc to be stretched for a longer distance and provides a loop between the electrodes. Further, the arc will always move in the same direction regardless of polarity.

For a better understanding of the nature and objects of the invention, reference may be had to the following detailed description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a side elevation of an assembled stack of gap plates constructed in accordance with the principles of the present invention;

FIG. 2 is a cross-sectional view taken along lines II-II of FIGURE 1;

FIG. 3 is a top plan view of the assembly shown in FIGURE 1 with center electrodes shown in phantom;

FIG. 4 is a top elevation view of an insulating plate that may be employed in the assembly shown in FIG. 1;

FIG. 5 is a cross-sectional view taken along lines V-V of FIG. 4;

FIGS. 6 and 7 respectively are top and side elevation views of a tubular electrode structure employed in the assembly of FIG. 1;

FIGS. 8 and 9 respectively are top elevation and side cross-sectional views of an insulating plate disposed in the tubular electrode structure of FIGS. 6 and 7; and

FIG. 10 is a perspective view of the electrode structures employed in the assembly shown in FIG. 1.

More specifically, there is shown in FIG. 1 and arrester gap assembly 10 which includes top and bottom insulating gap plates 12 and two intermediate insulating gap plates 12' supported therebetween. Plates 12 and 12' may be machined or molded of ceramic or other suitable insulating material such as glass bonded mica. The two gap plates 12' are disposed in back to back relationship and are identical to end plates 12 both of which are employed to support electrode structures 14, 15 and 16, as shown in FIGS. 1 and 10, the purpose of which will be explained hereinafter. Electrode 16 is best shown in FIG. 10. The number of insulating gap plate pairs 12' depicted in FIG. 1 are shown for purposes of illustration only. Any suitable number of gap plates may be used to obtain the desired voltage rating for an arrester. Gap plates 13, shown in FIGS. 4 and 5, may be used to further increase the voltage rating of arrester assembly 10.

Each of the gap plates 12 and 12' is provided with a vent port 11 in the outer wall structure 26 as shown in FIG. 2. When a high surge current is discharged by the arrester gas pressure can rapidly build up within the arc chamber. Vents 11 allow the built up pressure to escape from the arc chamber. Insulating gap plates 13 (FIGS. 4 and 5) have two such vents 11, one in the upper wall portion 26 and one in the lower wall portion 26, since both portions can form an arc chamber with contiguous gap plates. The vents are located so that the power follow current arc will be driven to the side of the plate where wall 26 is solid to prevent power follow current from being blown out of the sparkover and arc elongation chamber.

The electrodes 14 are terminal electrodes for the spark gap assembly 10. The electrodes have essentially a T-shaped configuration with the top portion of the T seated in an eccentrically located depressed area 20 provided in the face of end plates 12. The shank portion of electrode 14 extends through plate 12 through a hole 22 provided in the plate and centrally located in relation to the eccentrically disposed depressed area 20, see FIG. 3. Each insulating gap plate in the stack is provided with an eccentrically located hole like that depicted in FIGS. 1, 4 and 5.

The shank portion end of electrode 14 extends into an arc chamber formed by an annular outer wall structure 26 of the insulating plate 12 and a second insulating plate or disc 28 supported in the center of tubular electrode 15 and on a semicircular raised or shoulder portion 24 of plate 12. The relationship of the electrode 15 and disc 28 to the electrodes 14 and 16 is best shown in FIG. 10. The lower end of the shank portion of electrode 14 and that part of electrode 15 closest to electrode 14 form a spark gap region 17 between them. Substantially diametrically opposite the spark gap 17 and concentric with the wall structure 26 is the semicircular, raised portion 24 provided on the face of plates 12 and 13 as best shown in FIGS. 2 and 4. (Throughout the figures like numerals designate like parts, and insulating gap plates 12, 12' and 13 are substantially identical insofar as they form the arc chambers between them that support the gap electrodes and confine the arc discharge when it develops.) Semicircular raised portions 24 assist in spreading or splitting the arc discharge in the arc chamber formed by insulating plates 12, 12' and 13 and insulating discs 28. When an arc is struck in the chamber it moves from originating gap 17 around pin electrodes 14 and 16 to areas of tubular electrode 15 far removed from the rod electrodes in a manner to be more fully explained hereinafter. Raised portions 24 split and cool the arc as it moves towards the outer regions of tubular electrodes 15.

The outer wall structures 26 partially enclose electrodes 15 as best seen in FIG. 1. However, electrodes 15 are seated in plates 12, 12' and 13 in circular grooves or recesses 21 provided in the face surfaces thereof. With the plates 13, the grooves 21 and the wall structures 26 are

formed on both faces thereof as shown in FIG. 5. Similarly, both faces of plates 13 are provided with circular recesses 19 of a smaller dimension than recesses 21; in plates 12 and 12' only one face is provided with circular recesses 19 and 21. Recesses 19 provide extra creepage distance between discharge electrodes 14 and 16 and 15.

In FIGS. 4 and 5 circular depression 21 is shown provided with small raised portions or projections 23 angularly spaced from each other on the same side of the plate 13 by a distance somewhat less than 90 degrees. Two projections 23 near the horizontal center line (FIG. 4) of the plate are angularly spaced from each other by an angle of approximately 30 degrees. Projections 23 serve to key the adjacent gap plates and electrodes in about a 30 degree offset manner so that spark gap regions 17 form a somewhat spiralling configuration along the stack assembly 10 which can be seen in FIG. 1 in the lateral displacement of electrodes 14 and 16. In the same manner, FIG. 2 shows pin electrode 14 (in cross section) offset from the next pin electrode 16 (in phantom) by a small angle. Similarly FIG. 3 shows pin electrodes in the stacked plate assembly angularly displaced in phantom beginning with electrode 14 in top end plate 12. The approximate 30 degree angular displacement of adjacent rod electrodes and spark gaps as shown in the drawings is given by way of example only. The lateral displacement is employed to provide a current loop path between adjacent spark gaps that will establish a self-driving magnetic field when an arc is struck. With an arrester device having a larger radius a smaller angle could be used to provide the displacement distance required to establish such a path.

Tubular electrodes 15 are keyed in adjacent gap plates by a small notch portion 25 provided in both ends or edges of the electrode as best seen in FIG. 7, and by a longitudinal slit 29 extending the entire length of the electrode, see FIG. 6. The notch portions 25 in the ends of the tubular electrode are angularly displaced from each other as best seen in FIGS. 6 and 7. Projections 23 in the gap plates fit into notches 25 and slit 29 in electrode 15 and are strategically located so that slit 29 is always disposed substantially diametrically opposite spark gap 17. In the same manner, semicircular raised portion 24 is formed in the gap plates substantially opposite the spark gap 17 so that it (raised portion 24) is always located substantially across slit 29.

When an overvoltage is applied across assembly stack 10, a relatively short arc discharge is produced between the tubular electrodes 15 and the pin electrodes 14 and 16 in the spark gap regions 17. Current flows through the arc discharge and around the ring electrode 15 via path 17' to a point adjacent the next electrode 16, thence via a second series arc to the next rod electrode as best shown in FIG. 2. Current flow continues down to the bottom end of electrode structure 16 where again it flows through the discharge to another ring electrode, and so on until the surge current caused by the overvoltage has traveled the entire assembly 10. When the arc is struck in gap 17, the magnetic field created by current loop 17' drives the arc away from the area of gap 17 so that one end of the arc moves around electrode 15 towards slit 29 while the other end of the arc moves around inner (rod) electrodes 14 and 16 from the sparkover point. Thus the arc is stretched from the rod electrode to the extremity of the tubular electrode (slit 29). The arc is further stretched and cooled by semicircular shoulder portion 24 that is disposed between slit 29 and the shank portions of rod electrodes 14 and 16.

Slit 29 prevents current flow in both directions around the ring electrodes which would produce opposing magnetic fields; such opposing fields would in turn extremely limit movement of the arc. Thus, the unidirectional flow of current in ring electrodes 15 conveniently provides a self-driving magnetic field in each spark gap chamber that stretches the arc in the chamber without the use of externally disposed magnets. This unique and efficient

stretching of the arc carries it into contact with the cool insulating material of the gap plates and thus prevents the burning of the electrodes in the sparkover area and facilitates interruption of the arc.

Ring electrodes 15 may be formed from a piece of flat stock in which case slit 29 would be formed when the electrode is shaped and formed. The stock may be brass, copper or other suitable material. Similarly, the rod electrodes may be formed of brass or copper rod or tubular stock, or from other suitable materials and stock.

In order to increase the creepage distance between rod electrodes 14 and 16 and their associated ring electrodes 15, both edges of each electrode 15 are provided with an extensive slot 27 in an area substantially opposite to that of slit 29 so that when electrodes 15 are placed in the stack they will have a reduced surface area adjacent the rod electrodes. Slots 27 are of the approximate depth of positioning slots 25 and are best shown in FIGS. 7 and 10. As with slots 25 and keying notches 23 in the gap plates, slots 27 are angularly disposed on opposed edges of electrode 15 by an angle of about 30 degrees.

Insulating disc 28 (FIGS. 8 and 9) disposed in the longitudinal center of ring electrode 15, like the gap plates, is made of ceramic or other suitable type of heat resistant insulating material. Discs 28 may be fixed therein so that stack assembly 10 is easily and quickly assembled by simply placing gap plates together so as to enclose a ring electrode between each adjacent pair except for the back to back plate pair 12'. Annular raised portions or grooves may be provided in the faces of disc 28 to give additional creepage distance.

The stack assembly 10 shown in FIG. 1 is provided with back to back gap plates 12' that support a back-to-back T-shaped electrode 16 that may take the form of the unitary structure shown in FIG. 10. Such a structure considerably reduces the tendency of stack assembly 10 to produce radio noise and interference. Plates 12' and electrode 16 tend to evenly distribute the voltage stress on the assembly among the insulating gap plates; uneven voltage stresses on the plates of such an assembly can cause the generation of radio noise.

On the outside of ring electrodes 15, and between adjacent gap plates is disposed an insulating ring 35 that may be made of fiberglass, epoxy or other heat resistant materials of suitable mechanical strength. Such a ring adds mechanical strength to stack assembly 10 by keeping ring electrode 15 (which has the slit 29 along its entire length) from spreading out under force of high surge currents and causing the ceramic plates 12, 12' or 13 to break. Ring 35 is designed and dimensioned to simply fit over electrode 15 and between adjacent gap plates when the stack is assembled. All of the components in stack assembly 10 are simply designed to provide a quick and easy method of assembly, yet the structure of the present invention provides a highly efficient self-driving spark gap that rapidly stretches the arc so that power follow current is effectively interrupted.

From the foregoing description, it should be readily apparent that the applicants have disclosed a highly advantageous spark gap device heretofore unavailable in the prior art. Applicants' unique combination of simple and inexpensive components provides a very efficient magnetic field in an arc chamber without the use of magnetic devices such as permanent magnets or coils. In addition, the disclosed combination is compact, rugged and easily assembled. Applicants' novel combination provides a small, compact spark gap device that can withstand extreme bursting pressures caused by high current surges.

Though the invention has been described with a certain degree of particularity, it should be understood that the present disclosure has been made by way of example only and that changes in details of construction and arrangement of parts may be made by those skilled in the

art without departing from the spirit and scope of the invention.

What is claimed is:

1. A spark gap device comprising means defining at least two arc chambers, a tubular electrode extending from one chamber into the other chamber, the tubular electrode having a narrow slit extending the length thereof, a second electrode in each chamber forming a spark gap therein with the tubular electrode, the second electrodes being angularly displaced from each other to form a current loop when an arc is struck between the tubular electrode and the second electrodes.

2. The spark gap device of claim 1 in which the second electrodes are disposed adjacent the tubular electrode at points radially spaced from the narrow slit.

3. The spark gap device of claim 1 in which the second electrodes are disposed inside the tubular electrode.

4. The spark gap device of claim 1 including at least two insulating plates, the electrodes being held in place between the insulating plates and spaced apart by the insulating plates.

5. The spark gap device of claim 1 in which an insulating ring means is disposed around the tubular electrode.

6. The spark gap device of claim 4 in which each of the insulating plates has an annular recess on at least one side near the periphery thereof for receiving an end of the tubular electrode therein.

7. The spark gap device of claim 4 in which the insulating plates have an eccentrically placed hole for holding the second electrode therein.

8. The spark gap device of claim 4 in which the insulating plates have a substantially semicircular raised portion provided on at least one side thereof and disposed substantially between the second electrode and the narrow slit in the tubular electrode.

9. A spark gap device comprising
a stack of insulating plates,
a tubular shaped electrode supported between two adjacent plates, said tubular shaped electrode having a narrow slit extending the length thereof,
each of said plates axially supporting a rod shaped electrode in an area bounded by said tubular shaped electrode,
said rod shaped electrodes being further radially spaced from the narrow slit in said tubular shaped electrode, each of said plates having means for engaging said tubular shaped electrodes in such a manner that the rod shaped electrodes are maintained in an angularly displaced manner from each other,
the rod shaped electrodes and the tubular shaped electrode forming a pair of spark gaps between them.

10. The spark gap device of claim 9 wherein adjacent rod electrodes in the stack are separated by an insulating disc means secured substantially in the longitudinal center of the tubular electrode.

11. The spark gap device of claim 9 wherein the stack of insulating plates has two end insulating plates and at least one intermediate insulating plate, the intermediate insulating plate having annular recesses on both sides thereof for receiving the ends of the tubular electrodes therein.

12. The spark gap device of claim 9 wherein an insulating ring means is disposed between adjacent insulating plates and around the tubular electrodes.

13. The spark gap device recited in claim 9 in which the insulating plates have an annular recess provided on at least one side thereof, said annular recess having at least one raised portion formed therein, and

at least one notch portion provided in each end of the tubular shaped electrode for engaging said raised portions, the notch portions in the tubular shaped electrode being angularly displaced.

14. The spark gap device recited in claim 9 in which the insulating plates disposed intermediate of the ends

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of the stack have recesses provided on both sides thereof with angularly displaced raised portions formed in the recesses, and

angularly displaced notch portions provided in the ends of the tubular shaped electrode for engaging said raised portions.

15. The spark gap device recited in claim 9 in which each of the insulating plates is provided with a raised portion on at least one side thereof,

said raised portion being radially disposed between the slit in the tubular shaped electrode and the rod

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shaped electrode when the spark gap device is assembled.

References Cited

UNITED STATES PATENTS

5 3,069,589 12/1962 Cunningham ----- 315—36
3,287,588 11/1966 Lee et al. ----- 315—36 X

FOREIGN PATENTS

158,215 3/1940 Austria.

10 DAVID J. GALVIN, *Primary Examiner.*