June 30, 1953 A. A. OLSEN ET AL 2,644,116

AIR-GAP CONSTRUCTION

Filed Sept. 21, 1950 3 Sheets-Sheet 1

Fig. 1.

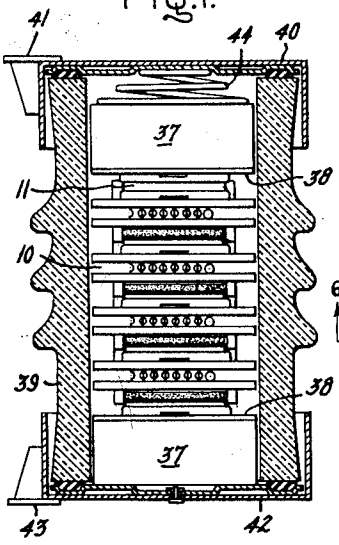


Fig. 2.

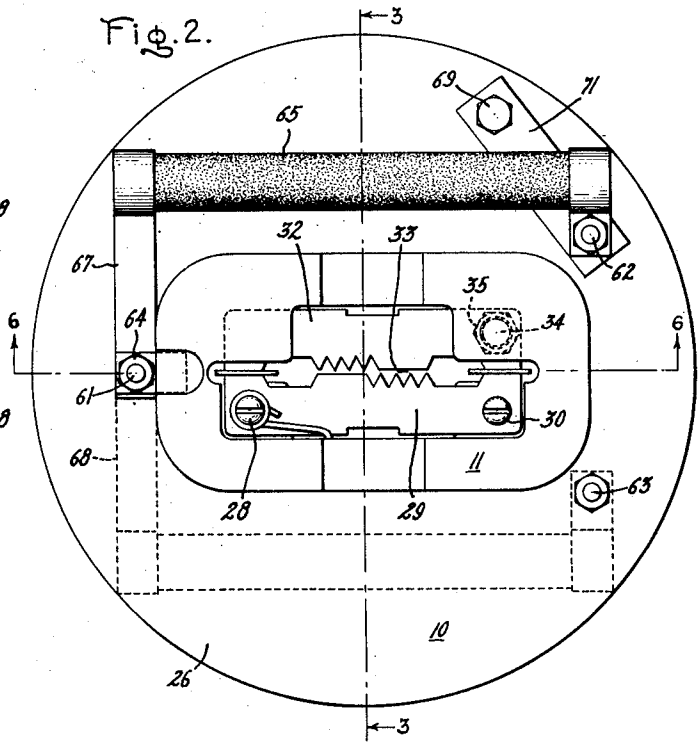


Fig. 3.

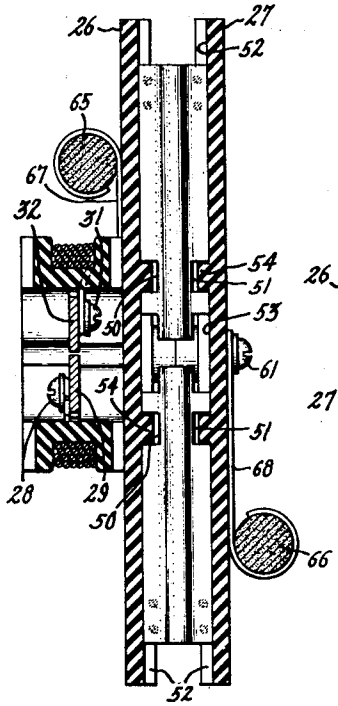
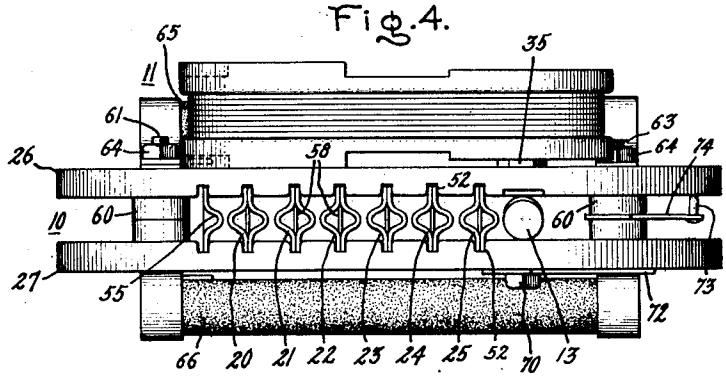


Fig. 4.



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Filed Sept. 21, 1950 3 Sheets-Sheet 2

Fig. 5.

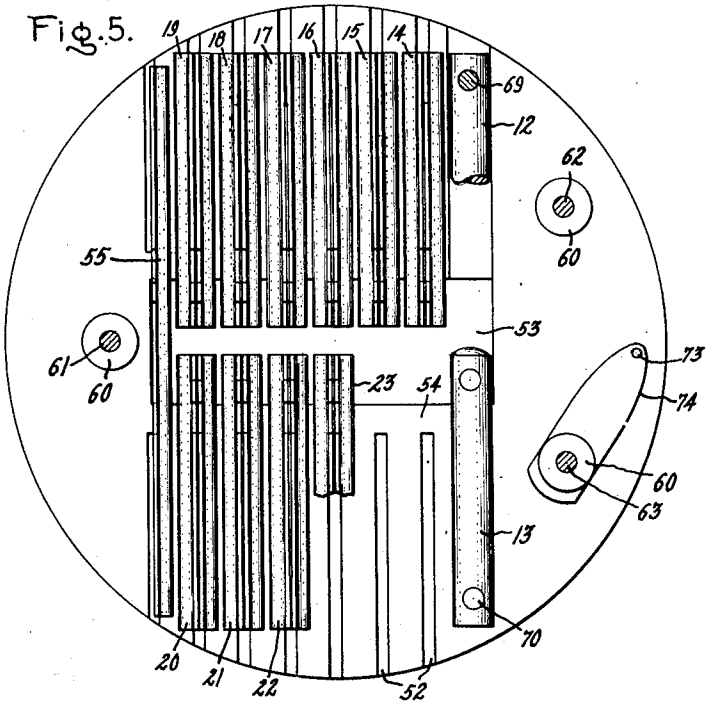


Fig. 6.

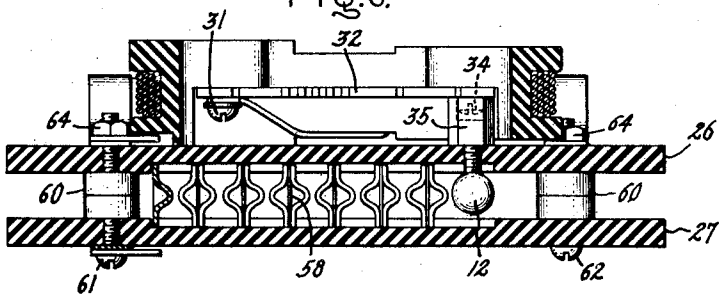


Fig. 7.

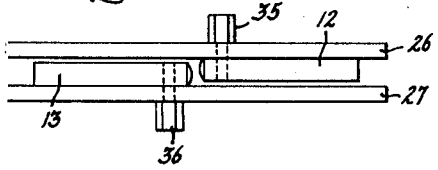
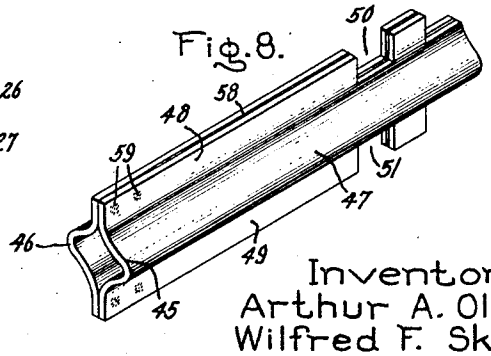


Fig. 8.



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Filed Sept. 21, 1950 3 Sheets-Sheet 3

Fig. 9.

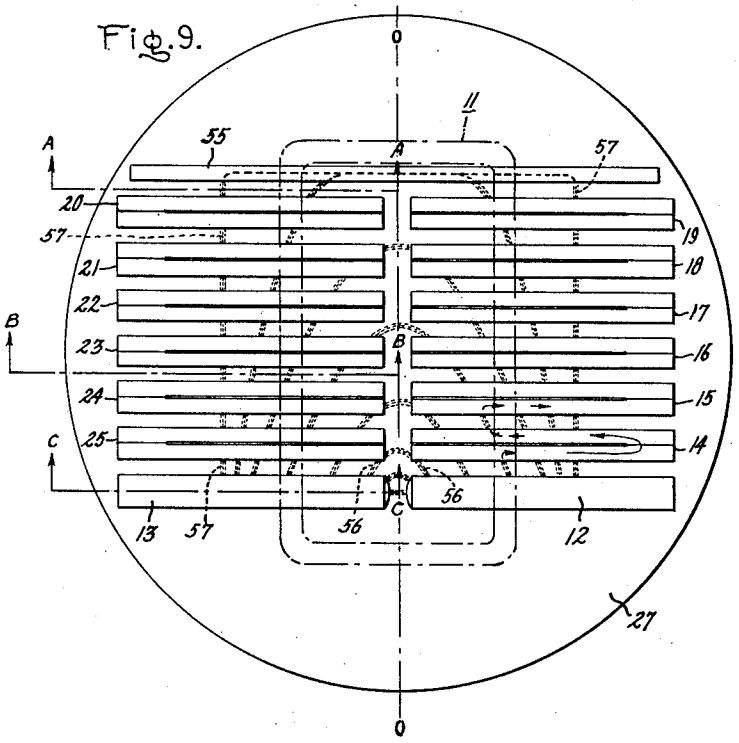
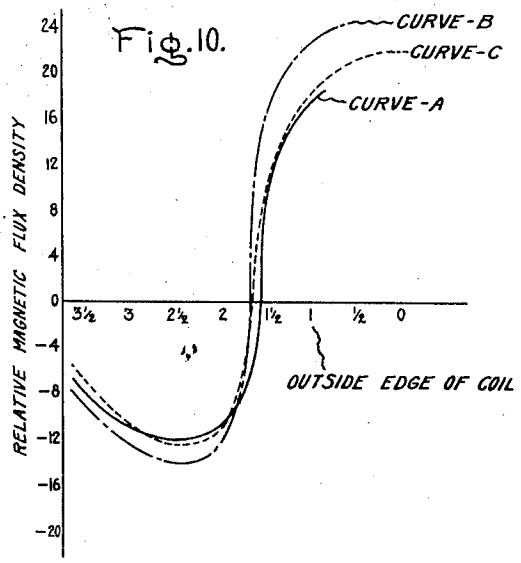


Fig. 10.



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UNITED STATES PATENT OFFICE

2,644,116

AIR GAP CONSTRUCTION

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Application September 21, 1950, Serial No. 185,994

16 Claims. (Cl. 317—70)

1

This invention relates to an air gap construction suitable for incorporation in lightning arresters for the interruption of higher power follow currents than is possible with conventional valve type arrester gaps. More particularly, the invention is an improvement on the invention disclosed and broadly claimed in the copending application of John W. Kalb, Serial No. 184,925, filed September 15, 1950, now Patent No. 2,614,232, issued October 14, 1952, and assigned to the same assignee as the instant application.

In valve type lightning arresters comprising a fixed gap or gaps in series with a non-linear resistance, a practical combination of a single fixed gap of small spacing for low sparkover value and many gaps of larger aggregate spacing for high current interrupting ability is most desirable to permit the use of a relatively low resistance valve element and thereby realize the advantages of greater strength and better protection. It is also desirable to have a device which breaks an initial arc up into a plurality of arcs without any appreciable elongation of the arc and without permitting recombination of the plurality of arcs into a single arc. Although an embodiment of the aforementioned Kalb invention has all of these features plus the additional feature of an unusually large number of gaps with aggregate spacings larger than the initial gap in a relatively small space, the embodiment of that invention is rather complicated and costly in that the gap electrodes are each mounted on a separate insulating support which is in turn mounted on barriers of insulating material. Moreover, after being extinguished, the arc, which is dependent upon the current, applied voltage and the main gap spacing, sometimes tends to restrike across the main gap electrodes. This is probably caused by pent up high temperature or ionized gases drifting back into the main gap space.

It is therefore an object of our invention to provide an improved air gap construction incorporating a gap of small spacing for low sparkover value together with a plurality of gaps of larger aggregate spacing for high interrupting ability all arranged within a relatively small space considering the number of gaps.

It is also an object of our invention to provide such a construction with improved features therein whereby its reliability is at all times assured.

It is a further object of our invention to provide an improved air gap construction which is relatively simple with a minimum of elements and therefore one which can be produced at a relatively reasonable cost.

2

It is still a further object of our invention to provide a configuration of electrodes together with a method of support which in combination provide a relatively simple arrangement and at the same time presents a relatively long creepage path between adjacently disposed electrodes.

In accordance with our invention, a pair of electrodes defining a surge or impulse spark gap is positioned adjacent a plurality of spaced and improved auxiliary electrodes each of which comprises a pair of elongated and adjacently positioned opposed plates of conductive material having respectively a longitudinal corrugation therein intermediate opposite longitudinally extending edges of the plates which are respectively engageable with grooves in the opposing faces of a pair of plates of insulating material whereby the auxiliary electrodes are maintained in spaced relationship without otherwise being fixed to the insulating plates.

The electrodes defining the surge gap and the auxiliary electrodes defining auxiliary gaps are so spaced and positioned relative to each other and to a magnetic means that a force is produced between the magnetic field of the magnetic means and an arc across the urge gap to move the arc into the auxiliary gap area where it is broken up into a plurality of arcs which are moved to a predetermined region in the auxiliary gap area beyond which further movement is arrested or restrained either by a portion of the field produced by the magnetic means reacting in a reverse direction or by additional magnetic means providing a field acting in the reverse direction.

As a modification, the pair of plates comprising an auxiliary electrode are electrically connected together at the outer ends toward which the auxiliary arcs are moved but otherwise suitably insulated from each other whereby current will flow from a terminal of one arc through one half of the electrode to its outer end then across to the other half and flow back in an opposite direction through the other half to the terminal of another arc. The resulting magnetic field set up by these current loops reacts with the reverse field of the magnetic means to arrest movement of the auxiliary arcs toward the outer ends of the electrodes and thus reinforces the effect of the return or reverse field in carrying out this function.

The invention will be better understood from the following description when taken in connection with the accompanying drawings and the scope of the invention will be pointed out in the appended claims. In the drawing, Fig. 1 is a sectional view of a lightning arrester embodying

improved gap and coil units of the invention; Fig. 2 is a plan view of a single gap and coil unit embodying the invention; Fig. 3 is a sectional view of the unit taken on the line 3—3 of Fig. 2; Fig. 4 is an elevation or side view of the Fig. 2 unit; Fig. 5 is a plan view of the unit with a top plate or slab of insulating material, the coil winding and some of the electrodes removed so as better to illustrate the internal structure of the device; Fig. 6 is a sectional view taken on the lines 6—6 of Fig. 2; Fig. 7 is a side elevation view of the main gap portion of the unit more or less stripped of external elements to better illustrate the position of the main electrode terminals employed; Fig. 8 is a perspective view of one of the auxiliary electrodes of the device; Fig. 9 is a diagrammatic arrangement of the electrodes illustrating the progression or movement of an arc to be interrupted and Fig. 10 shows a plot of the relative magnetic flux intensities in different parts of the gap structure on one side of the center line thereof.

Referring now to the various figures of the drawings, we have illustrated an air gap construction generally comprising a gap unit 10 and a coil unit 11. The gap unit 10 comprises a pair of spaced main electrodes 12 and 13 defining a main gap and a plurality or group of spaced auxiliary electrodes 14 to 19 inclusive arranged side by side parallel with electrode 12 and defining a plurality of auxiliary arc gaps therebetween transverse or normal to the gap between electrodes 12 and 13. Another group of spaced auxiliary electrodes 20 to 25 inclusive positioned respectively opposite electrodes 14 through 19 inclusive are arranged side by side parallel with electrode 13 and define a plurality of auxiliary arc gaps therebetween transverse to the gap between electrodes 12 and 13 and a plurality of arc gaps with oppositely disposed electrodes 14 to 19 parallel to the gap between electrodes 12 and 13. All of the electrodes are interposed between a pair of plates or slabs 26 and 27 of any suitable insulating material.

The coil unit 11 is removably positioned on the outside surface of insulating plate 26 and is so mounted that the area within the periphery of the coil winding is opposite the gap between electrodes 12 and 13 and opposite the gaps between the auxiliary electrodes adjacent the respectively opposing ends thereof. One end of the coil winding is electrically connected by a clamping screw 28 to one end of a conducting bar of metal 29 which is mounted on insulating supports comprising a pair of ledges constituting part of the spool of insulating material upon which the coil is wound. A pin 30 of conducting material is mounted at the opposite end of bar 29. The other end of the coil winding is electrically connected by a clamping screw 31 to one end of another bar of metal 32 similarly mounted on ledges of the spool opposite to and spaced from bar 29 so as to define a gap space 33 therebetween. At the opposite end of bar 32 and on the underside thereof is also mounted a pin of conducting material 34 similar to pin 30. Main gap electrode 12 is electrically connected, as most clearly illustrated by Figs. 6 and 7 with a hexagonal-shaped terminal 35 of conducting material mounted on the outside surface of insulating plate 26 while gap electrode 13 is similarly electrically connected to a similar terminal 36 mounted on the outside surface of insulating plate 27. Terminal 35 is provided with a depressed or hollowed-out portion which accommodates pin 34 of coil unit 11 as illustrated by Fig. 6 while terminal 36 is also provided with a similar hollowed-out portion for the accommodation of a pin similar to pin 30 or 34 of another coil unit, not shown in the interest of simplicity, and which may be positioned on the outside surface of insulating plate 27. On the other hand, pin 30 of coil unit 11 may be electrically connected to another gap unit similar to gap unit 10 and other coil and gap units thus alternately stacked in series with each other and with resistances or valve elements 37 as illustrated by Fig. 1. For good electrical contact between the stack of coil and gap units and the resistances 37, circular disks 38 of conducting material each having a terminal similar to terminals 35 and 36 fixed thereto may be interposed respectively between the top coil unit and the adjacent valve element and between the bottom coil unit and the valve element adjacent thereto with the pin 30 of the top coil unit and the pin 34 of the bottom coil unit respectively in engagement with the terminals.

As shown in Fig. 1, the complete assembly may be enclosed within a weatherproof housing 39 of insulating material such as porcelain which may be sealed by closures or covers of conducting material one of which 40 includes a terminal 41 for connection of the assembly to a source of electrical power to be protected while the other 42 includes a terminal 43 for connection to ground. Instead of connecting terminal 41 to a source of power and terminal 43 to ground, it will be apparent that this arrangement may be reversed so that terminal 43 is connected to the power source while terminal 41 is connected to ground. A coil spring 44 of conducting material is interposed between the top valve element and housing cover to electrically connect the assembly wtih the line terminal 41 and maintain the coil, gap and resistance elements in good electrical contact. It will be obvious that good electrical contact pressure is assured between the end of a terminal 35 or 36 and the bars of conducting material 29 or 32 since the overall thickness of a coil spool at the right-hand end as viewed in Figs. 4 and 6 is less than the thickness at the left-hand end.

Thus it will be seen that coil winding 11 is electrically connected in series with electrodes 12 and 13 and the gap therebetween while gap 33 provides a bypass or shunt around the winding for its protection during the passage of a transient having components with rapid rates of current change. Following the breakdown of the gap or establishment of an arc between main electrodes 12 and 13 and dissipation of the transient, the power follow current path to ground will include winding 11 so that the magnetic field produced thereby and within the periphery of the coil will react with the magnetic field produced by the current in the arc on a motor principle to move the initial arc between the main electrodes 12 and 13 toward the left, as viewed in Fig. 5 into the vicinity of the auxiliary electrodes where it will be broken up into a plurality of arcs.

Both the structure of the device, insofar as the relative position of the electrodes is concerned, and the partial operation thereof as thus far described is substantially identical to an embodiment of the invention disclosed in the copending application of Kalb referred to hereinbefore and thus constitutes no part of this invention. However, in order to carry out our invention it should

first be observed that each of the auxiliary electrodes 14 to 19 and 20 to 25 is relatively long so that the outer ends thereof opposite to the respectively opposing inner ends as well as a considerable portion of the length of the electrodes adjacent the outer ends are positioned outside the periphery of winding 11 as better illustrated by Figs. 3 and 9. In addition, the auxiliary electrodes are made up of simple and easily made punch press parts. To be more specific and referring particularly to Fig. 8 of the drawings, each auxiliary electrode comprises a pair of identical and elongated plates 45 and 46 of conducting material each of which has a longitudinally extending corrugation or furrow 47 therein positioned intermediate opposite longitudinally extending flanges or edges 48 and 49 respectively. A pair of notches 50 and 51 are oppositely positioned respectively in the opposite edges for a purpose which will be explained hereinafter.

The inner or opposing faces of plates 26 and 27 of insulating material are provided with a plurality of spaced and parallel depressions or grooves 52 and a centrally disposed depression 53 as shown in Fig. 5 which together define a pair of ridges 54 in each of the plates of insulating material as more clearly illustrated by Fig. 3.

Each electrode comprising a pair of plates 45 and 46 is mounted with the corrugations therein opposed so that opposite longitudinally extending flanges or edges thereof are respectively received in oppositely disposed grooves 52 in plates 26 and 27 and so that oppositely disposed ridges 54 in the insulating plates will respectively engage the oppositely disposed notches in the electrodes. The grooves serve properly to space and prevent lateral displacement of the electrodes while the ridges serve to prevent axial displacement thereof. Although notches 50 and 51 are illustrated as positioned adjacent the inner or opposing ends of the auxiliary electrodes, we have found that radio noise or interference is reduced as the distance of these notches from the inner ends of the electrodes is increased. It should be observed that the auxiliary electrodes are thus very simply mounted without the employment of individual separate supports of any kind and since all gap spaces are completely vented to the atmosphere the possibility of arcs restriking across the main gap due to a buildup of unequal gas pressure is eliminated. It should also be noted that because of the combination of the particular configuration of the auxiliary electrodes and the slotted structure of the insulating plates, the creepage distance over the surface of the plates of insulating material between adjacent electrodes is relatively long.

To better control the auxiliary arcs in the region of the auxiliary electrodes, a long auxiliary electrode 55 having the configuration of half an electrode or a single plate thereof but having a length approximately twice as long is positioned in oppositely disposed grooves in the plates 26 and 27 so as to be spaced from oppositely disposed electrodes 19 and 20 and so as to span the space between all of the oppositely positioned electrodes at the end of the space opposite main electrodes 12 and 13. Like the other auxiliary electrodes, electrode 55 is also provided with notches in the flanges thereof which engage the ridges of plates 26 and 27.

As previously pointed out, after the establishment of an arc between electrodes 12 and 13, the magnetic field produced by winding 11 within the periphery thereof will be effective to move the

arc into the region of the auxiliary electrodes. The arc will first be broken up into an arc, substantially transverse to the initial arc, between electrodes 13 and 25, a second arc substantially parallel to the initial arc, between opposed auxiliary electrodes 25 and 14 and a third arc, also substantially transversed to the initial arc, between electrodes 14 and 12 as indicated by the dotted lines 56 in Fig. 9. Arcs are moved progressively by the internal magnetic field in somewhat the manner illustrated by Fig. 9 with the arcs between opposed electrodes and parallel to the initial arc moving away from the main electrodes and the arcs between adjacent auxiliary electrodes and substantially transverse to the initial arc moving towards the far or outside ends of the auxiliary electrodes where they would obviously tend to reunite or recombine into single objectionable long arcs if this were permitted to happen. However, since the auxiliary electrodes extend for a substantial distance beyond the periphery of winding 11, the relative positions of which are most clearly illustrated by Fig. 9, the return magnetic field traversing the electrodes in an opposite direction in this outer region will exert a force on the arcs between adjacent electrodes tending to force them back toward the inner ends of the electrodes. Thus the progression of the arcs between adjacent electrodes towards the outer ends thereof will be arrested at points some distance short of the outer ends approximately as illustrated by dotted arc lines 57 in Fig. 9.

We have illustrated by Fig. 10 a plot of the relative magnetic flux intensities in different parts of the gap structure on one side of the long center line of the winding 11. Since the actual distance from the center line 0—0 of the winding to the outside edge of the coil is about one inch, it will be seen from the curves that the effect of the magnetic field tending to move the arcs toward the outer ends of the electrodes is most concentrated at the center region of the winding and gradually falls off to zero approximately one-half inch beyond the outer edge of the winding where the return magnetic field becomes effective and increases in intensity until the region approximately two and one-half inches from the center line 0—0 is reached. Curves A, B and C illustrate the variation in the flux pattern along section lines A—A, B—B and C—C respectively of the gap structure as indicated at Fig. 9.

In the absence of long electrode 55, it will be apparent that the termini of an arc between electrodes 19 and 20 would not only be forced toward the outer ends of these electrodes but the arc proper would be elongated and forced outwardly beyond the periphery of the winding 11 in a direction away from the main pair of electrodes. Such a relatively long arc would be difficult to deionize or extinguish and might lead to sparkover to other points in the structure which, of course, cannot be tolerated.

To reinforce the effect of the return magnetic field in arresting the arc movement, we provide, as a modification, insulation between the two plates 45 and 46 of each auxiliary electrode which may be in the form of mica strips 58, for example, so that these parts will be electrically insulated from each other with the exception of the outer ends thereof which are spot welded or otherwise suitably fixed together electrically as indicated by the numeral 59 in Fig. 8. Thus it will be apparent that when the arcs between adjacent and parallel aligned electrodes, are near

the center of the gap structure, the current in each electrode will flow from the terminal of one arc through one half of the electrode to its outer end and then cross over to the other half and flow back through the length of this half to the next arc as shown by the arrow headed lines in Fig. 9. The resulting magnetic field set up by these current loops will react on a motor principle with the return field of the winding 11 to force the arcs away from the outer ends of the electrodes and thus tends to reinforce the effect of the return field outside the periphery of the winding 11 in carrying out this function.

To more positively space insulating plates 26 and 27 as illustrated and maintain the insulating plates and electrodes therebetween securely fastened together spacers 60 together with bolts 61, 62 and 63 with nuts 64 threaded thereon are employed. When a plurality of gap and coil units are employed in series as illustrated by Fig. 1, the voltage distribution between successive units is controlled by resistors 65 and 66 connected in series by conducting bolt 61 together with conducting strips 67 and 68. The resistors are in turn connected in shunt across the main gap between electrodes 12 and 13 by conducting screws 69 and 70, threaded respectively into electrodes 12 and 13, together with conducting strips 71 and 72 electrically interconnecting bolts 62 and 63, electrically connected at corresponding ends of the resistors, to screws 69 and 70 respectively. A gap illumination button 73 spring biased against the inner surface of one of the insulating plates at a point opposite the main gap by resilient arm 74 upon which it is mounted serves to facilitate sparkover of the main gap. As illustrated, arm 74 is mounted between a pair of spacers 60 and electrically connected through bolt 63 and copper strip 72 to one of the main gap electrodes.

In addition to the improved operation and reliability of our device, it will be apparent that the improved structure is not only simplified by virtue of identical and simple plates comprising auxiliary electrodes but is also simplified by virtue of the fact that the plates of insulating material are also identical. Moreover, because of the employment of the return magnetic field to arrest outward progress of the auxiliary arcs and the use of long electrode 55, it will be apparent that the establishment of long arcs has been eliminated. Furthermore, because of the particular configuration and simple mounting of the auxiliary electrodes contact of the arcs with insulation has also been eliminated.

While we have, in accordance with the patent statutes, shown and described a particular embodiment of our invention it will be obvious that changes and modifications can be made without departing from the invention in its broader aspects and, we, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In an air gap construction, the combination of an arcing electrode comprising a pair of elongated and adjacently positioned plates of conducting material, each of said plates having a single corrugation therein positioned intermediate opposite longitudinally extending edges thereof and extending longitudinally the entire long length of said plates, said plates being disposed with the corrugations therein opposed and magnetic means to move the terminal of an arc longitudinally along each of said corrugations.

2. In an air gap construction, the combination of an arcing electrode comprising a pair of elongated plates of conducting material, said plates being adjacently positioned in parallel alignment and shaped so as to define portions respectively protruding transversely in opposite directions from the faces of said plates and extending longitudinally the entire long length of said plates intermediate opposite longitudinally extending edges thereof and magnetic means to move the terminal of an arc longitudinally along each of said extending portions.

3. In an air gap construction, the combination of an arcing electrode comprising a pair of elongated and adjacently positioned plates of conducting material, each of said plates having a single corrugation therein positioned intermediate opposite longitudinally extending edges thereof and extending longitudinally the entire long length of said plates, said plates being electrically connected together at one end and disposed with the corrugations therein opposed and magnetic means to move the terminal of an arc longitudinally along each of said corrugations.

4. In an air gap construction, the combination of an arcing electrode comprising a pair of elongated and spaced plates of conducting material, each of said plates having a single corrugation therein positioned intermediate opposite longitudinally extending edges thereof and extending longitudinally the entire long length of said plates, said plates being electrically connected together at one end and disposed in parallel alignment with the corrugations therein opposed and magnetic means to move the terminal of an arc longitudinally along each of said corrugations.

5. In an air gap construction, the combination of an electrode support plate of insulating material having a groove and a depression spaced therefrom and defining a ridge between said groove and depression and an arcing electrode comprising a pair of elongated plates of conducting material adjacently disposed in parallel alignment, each of said plates having a longitudinally extending corrugation therein intermediate opposite longitudinally extending edges thereof and a notch in at least one of said opposite edges, said plates being disposed with the corrugations therein opposed and with a pair of adjacent longitudinally extending edges disposed in said groove to prevent lateral displacement of said electrode, said ridge portion of said plate of insulating material engaging said notch in said electrode to prevent axial displacement thereof.

6. In an air gap construction comprising a pair of spaced and parallel plates of insulating material, an arcing electrode interposed between said plates, said electrode comprising a pair of elongated plates of conducting material adjacently disposed in parallel alignment, each of said plates having a longitudinally extending corrugation therein intermediate opposite longitudinally extending edges thereof, a notch in each of said opposite edges, a groove and a depression spaced therefrom in the face of one of said plates of insulating material, a groove and a spaced depression respectively opposite said first mentioned groove and depression in the adjacent face of the other of said plates of insulating material, said grooves and depressions respectively defining oppositely disposed ridge

portions of said plates of insulating material, said plates of conducting material being disposed with the corrugations therein opposed and with opposite corresponding edges respectively disposed in said grooves to prevent lateral displacement of said electrode, said ridge portions of said plates of insulating material respectively engaging the notches in the opposite edges of said electrodes to prevent axial displacement thereof.

7. In an air gap construction, mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of spaced main electrodes mounted on said mounting means and defining a main arc gap, a first group of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned adjacent one of said pair of main electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of main electrodes, a second group of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of main electrodes and disposed side by side with an end of each auxiliary electrode spaced from and disposed opposite an end of one of the electrodes of said first group of auxiliary electrodes, said second group of auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of main electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely disposed ends of said first group of electrodes parallel to said gap between said pair of main electrodes, and magnetic means positioned adjacent said electrodes defining a magnetic field transversely traversing the gap between said pair of main electrodes and the gaps between said oppositely disposed ends of said first and second group of electrodes in one direction and transversely traversing in the opposite direction the gaps between said auxiliary electrodes adjacent the ends thereof remote from said oppositely positioned ends.

8. In an air gap construction, mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of spaced electrodes mounted on said mounting means and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned side by side adjacent one of said pair of electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed side by side with an end of each auxiliary electrode spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned auxiliary electrodes parallel to said gap between said pair of electrodes, each of said auxiliary electrodes comprising a pair of adjacently positioned and spaced plates each of which has a centrally disposed longitudinally extending corrugation therein, said pair of plates being disposed with the corrugations therein opposed and magnetic

means positioned adjacent said electrodes defining a magnetic field transversely traversing in one direction the gap between said pair of electrodes and the gaps between said oppositely positioned ends of said first and second mentioned auxiliary electrodes and transversely traversing in the opposite direction the gaps between said auxiliary electrodes adjacent the ends thereof remote from said oppositely positioned ends.

9. In an air gap construction, mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of spaced electrodes mounted on said mounting means and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned side by side adjacent one of said pair of electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed side by side with an end of each auxiliary electrode spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned auxiliary electrodes parallel to said gap between said pair of main electrodes, each of said auxiliary electrodes comprising a pair of adjacently positioned and spaced plates each of which has a centrally disposed longitudinally extending corrugation therein, said pair of plates being disposed with the corrugation therein opposed and with the ends thereof remote from said oppositely positioned ends being connected electrically together and magnetic means positioned adjacent said electrodes defining a magnetic field transversely traversing in one direction the gap between said pair of electrodes and the gaps between said oppositely positioned ends of said first and second mentioned electrodes and transversely traversing in the opposite direction the gaps between said auxiliary electrodes adjacent said remote ends thereof.

10. In an air gap construction, mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of spaced electrodes mounted on said mounting means and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned side by side adjacent one of said pair of electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed side by side with an end of each auxiliary electrode spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned auxiliary electrodes parallel to said gap between

said pair of electrodes, each of said auxiliary electrodes comprising a pair of elongated plates each having a longitudinally extending corrugation therein disposed intermediate opposite longitudinally extending edges thereof, said pair of plates being disposed with the corrugation therein opposed and magnetic means positioned adjacent said electrodes defining a magnetic field separate portions of which have opposite directions relative to said gaps, said portions of said field being transverse to and traversing in one direction the gap between said pair of electrodes and the gaps between portions of said auxiliary electrodes adjacent said oppositely positioned ends thereof and traversing in the opposite direction the gaps between said auxiliary electrodes adjacent the ends thereof remote from said oppositely positioned ends.

11. An air gap construction comprising mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of spaced electrodes mounted on said mounting means and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned side by side adjacent one of said pair of electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed side by side with an end of each electrode spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned auxiliary electrodes parallel to said gap between said pair of electrodes, and a coil winding connected electrically in series with said pair of electrodes and the gap therebetween, the axis of said winding being transverse to all of said gaps with the area within the periphery of said winding being disposed opposite said pair of electrodes and said oppositely positioned ends of said auxiliary electrodes, the remote ends thereof being disposed opposite the area outside the periphery of said winding.

12. An air gap construction comprising a pair of spaced and parallel plates of insulating material, a plurality of spaced and parallel grooves in the face of one of said plates, a plurality of the spaced and parallel grooves respectively opposite said first mentioned grooves in the adjacent face of the other of said plates, a pair of spaced electrodes positioned between said plates and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes positioned between said plates and defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes, a plurality of elongated and spaced auxiliary electrodes positioned between said plates with an end of each spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned electrodes parallel to said gap between said pair of electrodes, each of said auxiliary electrodes comprising a pair of elongated plates each having a longitudinally extending corrugation therein disposed intermediate opposite longitudinally extending edges thereof, said pair of plates being disposed with the corrugations therein opposed and with a pair of corresponding longitudinal edges disposed in one of said grooves in one of said plates of insulating material and the opposite longitudinal edges disposed in an oppositely disposed groove in the other of said plates of insulating material and magnetic means positioned adjacent said electrodes defining a magnetic field transversely traversing in one direction the gap between said pair of electrodes and the gaps between portions of said auxiliary electrodes adjacent said oppositely positioned ends thereof and transversely traversing in the opposite direction the gaps between portions of said auxiliary electrodes adjacent the ends thereof remote from said oppositely positioned ends.

13. In an air gap construction, mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of main spaced electrodes mounted on said mounting means and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned adjacent one of said pair of electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween transverse to said gap between said pair of electrodes and in series circuit relationship with said one electrode, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed with one end of each spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrode, said second mentioned auxiliary electrode defining a plurality of auxiliary arc gaps therebetween transverse to said gap between said pair of electrodes and in series circuit relationship with the other of said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned electrodes parallel to said gap between said pair of electrodes, an elongated electrode spaced respectively from a pair of said oppositely disposed auxiliary electrodes and spanning the space between said respectively opposed first and second mentioned electrodes at the end thereof opposite said pair of main electrodes and magnetic means positioned adjacent said electrodes defining a magnetic field separate portions of which have opposite directions relative to said gaps, said field being transverse to and traversing in one direction the gap between said pair of electrodes and the gaps between portions of said auxiliary electrodes adjacent said oppositely positioned ends thereof and traversing in the opposite direction the gaps between portions of said auxiliary electrodes adjacent the ends thereof remote from said oppositely positioned ends.

14. In an air gap construction, mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of main spaced electrodes mounted on said mounting means and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned adjacent one of said pair of electrodes,

said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween transverse to said gap between said pair of electrodes and in series circuit relationship with said one electrode, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed with one end of each spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween transverse to said gaps between said pair of electrodes and in series circuit relationship with the other of said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned auxiliary electrodes parallel to said gap between said pair of electrodes, each of said auxiliary electrodes comprising a pair of elongated plates each having a longitudinally extending corrugation therein disposed intermediate opposite longitudinally extending edges thereof, said pair of plates being disposed with the corrugations therein being opposed, an elongated electrode spaced respectively from a pair of said oppositely disposed auxiliary electrodes and spanning the space between said respectively opposed first and second mentioned electrodes at the end thereof opposite said pair of main electrodes and magnetic means positioned adjacent said electrodes defining a magnetic field separate portions of which have opposite directions relative to said gaps, said field being transverse to and traversing in one direction the gap between said pair of electrodes and the gaps between portions of said auxiliary electrodes adjacent said oppositely positioned ends thereof and traversing in the opposite direction the gaps between portions of said auxiliary electrodes adjacent the ends thereof remote from said oppositely positioned ends.

15. In an air gap construction, mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of spaced electrodes mounted on said mounting means and defining a main arc gap, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned adjacent one of said pair of electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween transverse to said gap between said pair of electrodes, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed with an end of each electrode spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned auxiliary electrodes parallel to said gap between said pair of electrodes, and a coil winding positioned adjacent said electrodes with the axis thereof transverse to all of said gaps, said winding being disposed with the area within the periphery thereof opposite the gap between said pair of electrodes and the gaps between portions of said auxiliary electrodes adjacent said oppositely positioned ends thereof, the gaps adjacent the remote ends of said auxiliary electrodes being disposed opposite the area outside the periphery of said winding.

16. In an air gap construction comprising mounting means for positioning electrodes in spaced relation to define arc gaps therebetween, a pair of spaced electrodes mounted on said mounting means and defining a main arc gap, a coil winding connected electrically in series with said pair of electrodes and the gap therebetween, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means and positioned adjacent one of said pair of electrodes, said auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween normal to said gap between said pair of electrodes, a plurality of elongated and spaced auxiliary electrodes mounted on said mounting means adjacent the other of said pair of electrodes and disposed with one end of each spaced from and positioned opposite an end of one of the electrodes of said first mentioned auxiliary electrodes, said second mentioned auxiliary electrodes defining a plurality of auxiliary arc gaps therebetween transverse to said gaps between said pair of electrodes and a plurality of auxiliary arc gaps respectively between said ends thereof and said oppositely positioned ends of said first mentioned auxiliary electrodes parallel to said gap between said pair of electrodes, the axis of said winding being transverse to all of said gaps with the area within the periphery of said winding disposed opposite said pair of electrodes and said oppositely positioned ends of said auxiliary electrodes, the ends of said auxiliary electrodes remote from said oppositely positioned ends being disposed opposite the area outside the periphery of said winding, each of said auxiliary electrodes comprising a pair of plates each of which has a centrally disposed longitudinally extending corrugation therein, said plates being adjacently disposed in parallel alignment with the corrugations therein opposed and with said remote ends thereof being electrically connected together, the balance of said plates being electrically insulated from each other.

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