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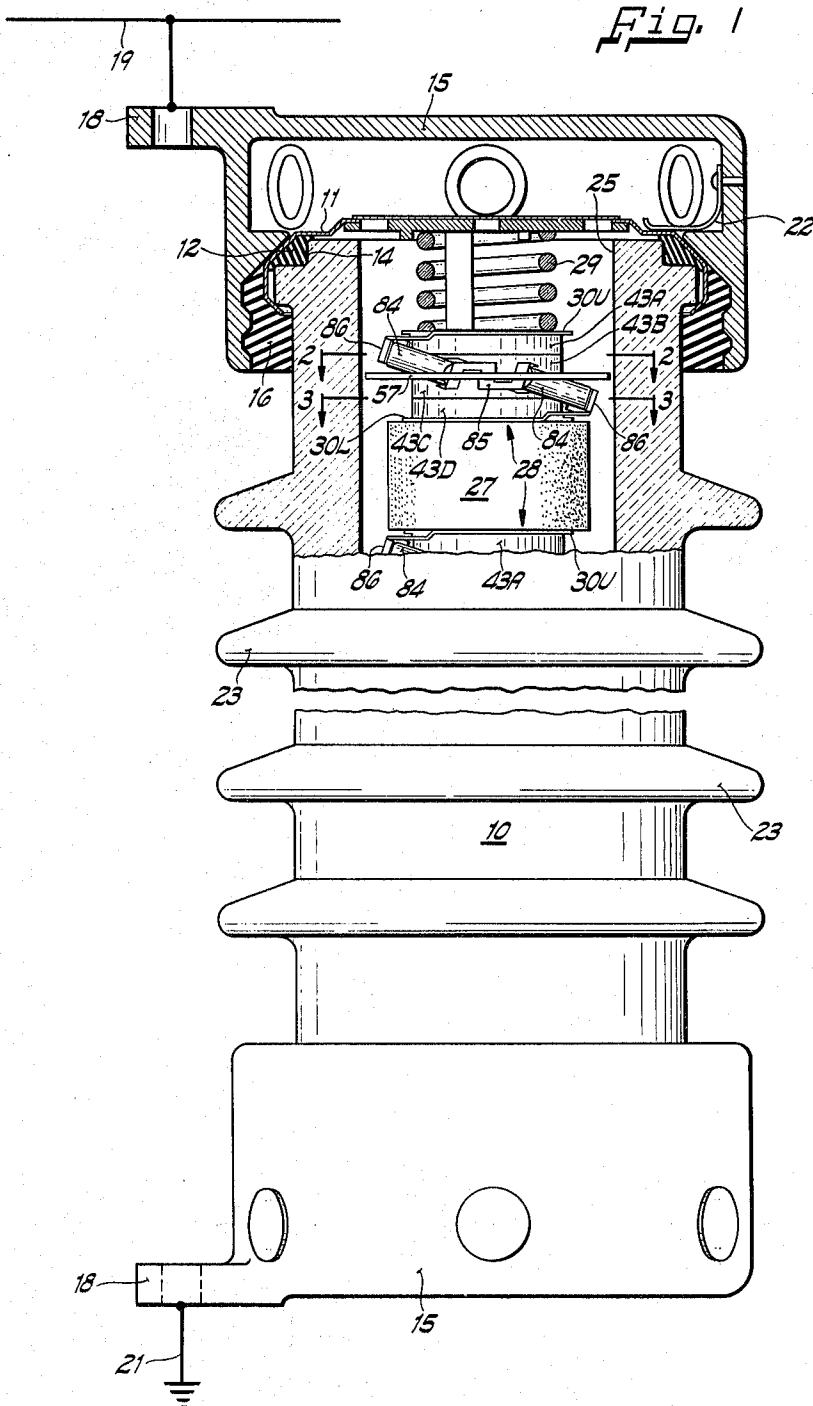
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LIGHTNING ARRESTER SPARK GAP

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LIGHTNING ARRESTER SPARK GAP

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This invention relates to lightning arresters and, in particular, to a spark gap construction for valve type lightning arresters.

A conventional valve type lightning arrester has a spark gap, or a series of spark gaps, connected in series with a current limiting resistor between an electrical power line conductor and ground. The series spark gap normally insulates the arrester from the power line to which it is connected, and the length of the gap is such that the voltage between the power line conductor and ground is insufficient to sparkover the gap and permit current to flow through the current limiting resistor to ground. The gap becomes conducting by sparking when lightning strikes the power line conductor or a high frequency transient voltage of a magnitude greater than the sparkover potential of the gap appears on the power line, thereby providing a path to ground for the lightning current through the current limiting resistor. The resistor has valve, or non-linear, characteristics, i.e., very high apparent resistance under normal voltage conditions but sharply reduced resistance under a predetermined overvoltage, thereby permitting the lightning surge to be discharged to ground with low discharge voltage. Sixty cycle power current follows the lightning current, and the resistor, or valve element, reduces the power follow current, which tends to flow due to the normal line voltage, to a small magnitude which is interrupted by the series gap. The arc in the spark gap tends to migrate across the face of the gap electrodes when the power follow current is of moderate magnitude, thereby preventing localized overheating of the electrodes and facilitating interruption of the arc. However, the trend in the industry is toward lower lightning arrester discharge voltages which require spark gaps of higher follow current interrupting ability, and on such higher magnitude follow current the arc tends to remain concentrated for an appreciable time at the initial arcing spot on the electrodes, thereby heating the metallic electrodes above their melting temperature and causing burning of the initial arcing points and deformation of the electrodes. Such deformation or burning of the initial arcing point may cause a sufficient change in the configuration of the electrode surface to vary the spacing between the electrodes and to decrease the follow current interrupting ability by making it more likely for the arc to restrike after a current zero.

Spark gap devices are known having magnetic means to elongate the arc by moving it across the electrodes and between a plurality of spaced auxiliary gaps wherein the initial arc is broken up into a plurality of smaller arcs. The field of the magnetic means reacts with the magnetic field of the arc, in accordance with the well known electric motor principle, to elongate, constrict, split up the arc into a plurality of arclets, or to keep the arc in continuous motion in order to develop high arc voltage and thus facilitate interruption of the follow current. Such magnetic means usually comprise either permanent magnets or coils which occupy substantial space within the lightning arrester housing. The coils of such magnetic arc-elongation means are connected in series with the valve elements and present such high impedance to the high frequency lightning current that suitable protective means are necessary within the arrester housing to shunt the coils. The permanent magnets may be demag-

netized by large magnitude surge currents and thus lose their effectiveness.

It is an object of the invention to provide a lightning arrester with a spark gap having improved means for moving the arc away from the initial sparking point and into the auxiliary gap electrodes. Another object is to provide such a spark gap construction which does not require coils or permanent magnets within the lightning arrester housing in order to move the arc. Still another object is to provide such a spark gap construction which does not utilize permanent magnets or coils and yet produces a magnetic field of high flux density for moving the arc even at low magnitudes of power follow current.

Other objects and advantages of the invention will be readily apparent from the following detailed description when taken in conjunction with the accompanying drawing in which:

FIG. 1 is an elevation view partly in section of a valve type lightning arrester having spark gaps in accordance with the invention;

FIGS. 2 and 3 are views taken on lines 2—2 and 3—3 of FIG. 1 respectively;

FIGS. 4 and 5 are views schematically illustrating movement of the arc from the main gap into the auxiliary electrode gaps;

FIG. 6 is a front elevation view partly in section of a spark gap unit of the arrester of FIG. 1 illustrating the current path through the spark gap unit;

FIGS. 7, 8 and 9 are partial views taken respectively on lines 7—7, 8—8 and 9—9 of FIG. 2;

FIG. 10 is a schematic view illustrating the direction and density of the lines of magnetic flux adjacent the main gap; and

FIG. 11 is a view schematically illustrating the increase in magnetic flux density in the main gap resulting from the cladding pieces on the main electrodes.

Referring to the drawing, a valve type lightning arrester incorporating the invention has a tubular housing 10 of suitable insulating material such as porcelain. The open ends of tubular housing 10 may be sealed by metallic caps 11 which are spun thereon and hold annular gaskets 12 of suitable resilient material such as synthetic rubber against annular seats 14 provided in the outer periphery adjacent the ends of housing 10. Cup-shaped metallic castings 15 of suitable material such as aluminum alloy are secured to the ends of housing 10 by suitable means such as cement 16.

The end castings 15 are provided with metallic terminals 18 for connection of the upper end of the arrester to a conductor 19 of the power line system to be protected and the lower end to ground 21. Spring members 22 electrically connect the end castings 15 and the metallic caps 11. The porcelain housing 10 may be provided with a plurality of deep skirts 23 which provide long creepage distance over the external surface of the arrester and thus keep external leakage current to a minimum.

The axial compartment 25 in tubular porcelain housing 10 contains a column of alternate current limiting valve block resistors 27 and spark gap units 28 maintained in electrical conductive relation between upper and lower metallic end caps 11 by a metallic compression spring 29 which at its upper end engages the upper end cap 11 and at its lower end engages the top metallic plate 30U of the uppermost spark gap unit 28. The valve block resistors 27 are cylindrical in configuration and are preferably composed of granulated valve material such as silicon carbide and an essentially non-conductive binding material and preferably have a metallic surface (not shown) sprayed on the ends thereof to assure good electrical contact between valve blocks 27 and end plates 30U and 30L of the spark gap units 28.

Spark gap unit 28 includes upper and lower arc extinction chambers 31U and 31L (see FIGS. 2, 3 and 7) each of which encloses a pair of spaced main electrodes 33 and 34 defining a main air gap 35 therebetween and three spaced apart auxiliary electrodes 36, 37 and 38 defining, together with main electrodes 33 and 34, four auxiliary gaps 39, 40, 41 and 42 (see FIGS. 4 and 5). Spark gap unit 28 may comprise upper and lower thin metallic circular end plates 30L and 30U integral with four hollow insulating discs 43A, 43B, 43C and 43D arranged in a stack (see FIGS. 6 and 7). The insulating discs 43A-43D are identical and each has a transverse wall portion 44 and a generally keyhole-shaped, diametrically extending cavity 45 defined by a peripherally continuous vertical wall 46. The insulating discs 43A-43D are preferably of a glass-bonded mica insulating material commercially available under the mark "Mycalex" or may be of a gas evolving insulating material such as horn fiber. The discs 43A-43D are arranged with the cavities 45 in the pair of uppermost adjacent discs 43A and 43B facing each other to form upper arc chamber 31U and with the cavities 45 in the pair of lowermost adjacent discs 43C and 43D facing each other to form lower arc chamber 31L.

Upper and lower arc chambers 31U and 31L are identical and only upper arc chamber 31U will be described. Insulating discs 43A and 43B are preferably affixed together with suitable cement such as epoxy resin (not shown). Each disc 43A and 43B has a pair of shallow, generally U-shaped depressions 51 (see FIGS. 4, 5 and 7) in the confronting face thereof on opposite sides of cavity 45. The main electrodes 33 and 34 are of horn shape, or generally J-shape, with the longer legs 53 thereof diverging and maintained back-to-back within arcing distance in the same horizontal plane and positioned within the upper arc chamber 31U defined by the registering cavities 45 in the discs 43A and 43B and with the shorter current carrying legs 54 thereof disposed within the depressions 51. Upper disc 43A is secured to metallic upper plate 30U by a metallic rivet 56 which extends through a clearance aperture in transverse wall 44 in upper disc 43A and through a clearance aperture in the shorter leg 54 of main electrode 33 to affix main electrode 33 to upper disc 43A and to also provide the electrical path to the interior of upper arc chamber 31U.

A circular disc 57 of suitable insulating material such as fiber and of larger diameter than the discs 43A-43D is disposed between and affixed to discs 43B and 43C and centers the spark gap unit 28 within the axial compartment 25 within porcelain housing 10. Insulating disc 43B is secured to insulating disc 43C, main electrode 34 in upper chamber 31U is secured to insulating disc 43B, and main electrode 34 in lower arc chamber 31L is secured to disc 43C by a metallic rivet 59 (see FIGS. 6 and 7) which extends through clearance apertures in members 43B, 57 43C and the electrodes 34. Rivet 59 also provides the electrical path between the main electrode 34 in upper chamber 31U and the main electrode 34 in lower arc chamber 31L.

The short leg 54 of the U-shaped, or horn-shaped, main electrodes 33 and 34 adjacent the bight thereof has a U-shaped cutout portion 61 (see FIGS. 4 and 5) defined by edges which abut against two spaced apart, vertically extending bosses 62 molded in horizontal wall portions of discs 43A and 43B and prevent main electrodes 33 and 34 from turning about rivets 56 and 59. The longer legs 53 of the back-to-back, horn-shaped main electrodes 33 and 34 are divergent at one end and converge intermediate their ends to a minimum spacing forming main air gap 35. The end portions 65 of longer legs 53 on the side of the main gap opposite the diverging ends constitute current carrying portions to and from the arc in the main gap and are approximately at right angles to, or transverse to, said arc, thereby subjecting the arc to mag-

netic forces tending to move the arc toward the divergent ends of main electrodes 33 and 34. The current flowing in end portions 65 is at right angles to the arc in the main gap 35 and the magnetic flux generated by such current reinforces the magnetic flux generated by the arc current in the region below the arc, as seen in FIG. 10, thereby tending to move the arc toward the diverging ends of the main electrodes 33 and 34. The length of end portions 65 between the main gap 35 and the bight of the U-shaped main electrodes 33 and 34 is of appreciable length in order to assure that sufficient "reinforcing" magnetic flux is generated by the current flow therein to rapidly move the arc.

One end of a thin, metallic, pre-ionizing electrode 67 (see FIGS. 4, 5 and 7) is disposed against the short leg 54 of main electrode 33 and is secured to insulating disc 43A by rivet 56. Pre-ionizing electrode 67 has an off-set portion (see FIG. 7) and a relatively pointed tip 68 at the free end thereof which touches disc 43A adjacent the path 35 of minimum dimension between main electrodes 33 and 34 and in spaced relation to main electrode 34. Pre-ionizing tip 67 is capacitively coupled to main electrode 34. When a high frequency surge appears on power line 19, the pre-ionizing electrode 67 emits corona or photons into the minimum gap path 35 to ionize its dielectric gap and help break down the main gap 35 at low and consistent impulse levels. The mica-glass material of disc 43A has relatively high dielectric constant and provides relatively high capacitance between the pre-ionizing electrode 67 and main electrode 34, in comparison to the capacitance between these members utilize air as a dielectric, with the result that the air adjacent the pre-ionizing tip 67 is highly stressed and emits corona into the main gap 35.

When the main gap 35 arcs over, as schematically illustrated in FIG. 4, the current follows a path through rivet 56, along the shorter leg 54 of main electrode and up the portion 65 of longer leg 53 disposed transversely to the arc, across the gap 35, down the portion 65 of longer leg 53 disposed at right angles to the arc and up shorter leg 54 of main electrode 34, and out of the upper arc chamber 31U through rivet 59 as shown in FIG. 6. The direction of the current in the main gap 35 is thus transverse to the direction of the current in the current carrying portions 65 of the main electrodes 33 and 34, and the magnetic field of the arc reacts with magnetic field of the current in the main electrodes 33 and 34 in accordance with the well known electric motor principle to move the arc toward the ends of the longer legs 53 which diverge relative to each other. Since the direction of the main gap 35 at the point of minimum spacing between main electrodes 33 and 34 is transverse, and in the preferred embodiment substantially normal, to the direction of current flow in the current carrying portions 65 of main electrodes 33 and 34, the magnetic field of the arc is in the same direction as and reinforces the magnetic field generated by the current flowing in the portions 65 in the region "below" the arc as seen in FIG. 10. Consequently, the magnetic flux density is appreciably greater "below" than "above" the arc as seen in FIG. 10. Since the force of an arc is always in a direction away from the region of greater flux density toward the region of lower flux density, the arc is moved from the main gap 35, as schematically illustrated in FIG. 4, toward the diverging ends of the main electrodes 33 and 34 and is ultimately broken up into arclets in the auxiliary gaps 39, 40, 41 and 42 as illustrated in FIG. 5.

U-shaped, flux-field reinforcing cladding pieces, or yokes, 69 of high permeability ferromagnetic material such as mild steel are clamped on the longer leg 53 of each of the main electrodes 33 and 34 adjacent the point of minimum dimension 35 between the main electrodes 33 and 34. Spacers 76 of suitable insulating material such as fiber are disposed between the main elec-

trodes 33 and 34 and the ferromagnetic yokes 69. The ends of the legs of the U-shaped cladding pieces 69 are positioned as close as possible to the confronting sides of main electrodes 33 and 34 without affecting the spark-over potential between main electrodes 33 and 34. The cladding pieces 69 surround a portion of the cross-sectional periphery of the main electrodes 33 and 34, i.e., the three sides of the main electrodes other than the confronting sides thereof, and lower the reluctance of the path of the magnetic flux generated by the flow of follow current in the portions 65 of the main electrodes, thereby causing a substantial increase in the magnetic flux density per ampere of follow current in the region between main electrodes 33 and 34 as schematically illustrated in FIG. 11.

The ferromagnetic yokes 69 provide a low reluctance circulating flux path around the main electrodes 33 and 34. Only the magnetic flux in the region between the arching electrodes 33 and 34 is utilized to move the arc, and consequently the magnetic flux density in this region should be as high as possible. The high permeability of the yokes 69 offers low reluctance to the flow of flux in the path around the main electrodes as schematically illustrated in FIG. 11, thereby increasing the concentration of magnetic flux tending to move the arc.

The insulating spacers 76 between main electrodes 33 and 34 and the ferromagnetic yokes 69 prevent the arc from terminating on the steel yokes. If the arc were to terminate on the ferromagnetic yokes 69, these members would be eliminated as paths for the magnetic flux surrounding the main electrodes 33 and 34 and consequently the paths for the magnetic flux would be entirely through the air and its density would be substantially diminished. Even if the arc does not terminate on the yokes 69, these members 69 would tend to carry current if they were not insulated by spacers 76 from the main electrodes 33 and 34, and the result would be that the greater portion of the magnetic flux path would be in air and the concentration thereof would be materially reduced.

The high magnetic flux density provided by the cladding pieces 69 causes the follow current arc in main gap 35 to rapidly move away from the initial arching point toward the diverging ends of the horn shaped main electrodes 33 and 34. The cladding pieces 69 increase the magnetic flux density adjacent the cathode and the anode arc spots to a sufficiently high magnitude to assure movement of the arc away from the initial arcing points (illustrated schematically in FIG. 4) toward the diverging ends of the main electrodes 33 and 34 over the entire range of follow currents that the arrester is required to interrupt. After the arc has been moved beyond the cladding pieces 69, the arc is of sufficient column length so as to be propelled by the reaction between its magnetic field and that of the current flowing in the main electrodes 33 and 34 even at the lower magnitude range of follow currents. Stable and consistent sparkover potential is maintained because the initial arcing points on the main electrodes 33 and 34 are not overheated by stationary arcs, and consequently the spacing of the main gap 35 remains unchanged. The main electrodes 33 and 34 will not burn even on the highest magnitudes of follow current because the velocity of movement of the arc away from the main gap 35 increases in proportion to the magnitude of the follow current.

A large brass button 70 affixed to the diverging end of each main electrode 33 and 34 functions as a heat sink conducting heat away from the portion thereof defining the main gap 35, thereby providing additional means to prevent burning and deformation of the main electrodes 33 and 34.

Five slots 71-75 in the peripherally continuous wall 46 of the discs 43A and 43B extend inwardly into upper arc chamber 31U and register with the greater-width

portion of the keyhole-shaped cavities 45, the slots 71-75 in the two discs 43A and 43B being in register. A flat, metallic, radially extending auxiliary electrode 37 is disposed in the registering central slots 73 in the discs 43A and 43B and is held in position by upwardly extending bosses 78 molded in the transverse wall portions 44 of the discs 43A and 43B. A generally J-shaped metallic auxiliary electrode 36 has the ends thereof disposed in slots 71 and 72 in the discs 43A and 43B and is held in position by bosses 80 molded in the transverse wall portion 44 of the discs 43A and 43B. Similarly a generally J-shaped metallic auxiliary electrode 38 has the ends thereof disposed in slots 74 and 75 in the discs 43A and 43B and is held in position by bosses 83 molded in the transverse wall 44 of the discs 43A and 43B.

The center auxiliary electrode 37 and the brass buttons 70 affixed to the diverging ends of main electrodes 33 and 34 define a pair of auxiliary gaps which are first presented to the arc as it is moved outwardly. Upon further movement of the arc, the J-shaped auxiliary electrodes 38 and 39 together with the center auxiliary electrode 37 and the brass buttons 70 form four auxiliary gaps 39-42 in series which divide the arc into four arclets, as illustrated in FIG. 5, thereby increasing the total voltage drop in the arc and facilitating rapid extinction of the arc. It will be appreciated that the arc between main electrodes 33 and 34 in the lower arc extinction chamber 31L is also broken into four parts by a similar arrangement of auxiliary electrodes 37, 38 and 39.

A pair of nonlinear grading resistors 84 are connected at one end to a metallic terminal clip 85 mounted on circular insulating disc 57 and at their other end to axially extending terminal portions 86 formed respectively on the upper plate 30U and lower plate 30L. The two grading resistors 84 shunt the main gaps 35 in the upper and lower arc chambers 31U and 31L and assure uniform distribution of sixty cycle voltage across the entire stack of valve blocks 27 and spark gap units 28 and thus contribute to consistent sparkover voltages under both wet and dry conditions.

It will be appreciated that the disclosed invention accomplishes rapid movement of the arc even on low magnitudes of follow current without bulky coils and protective gaps for the coils or permanent magnets within the lighting arrester housing, and the stretching of the power-follow-current arc to many times its original length and breaking it up in many arclets within the auxiliary gaps coupled with the rapid cooling by the heat sinks 70 develops exceptionally high arc voltage which rapidly exceeds the potential of the power system and extinguishes the arc.

While only a single embodiment of the invention has been illustrated and described, many modifications and variations thereof will be readily apparent to those skilled in the art, and consequently it is intended in the appended claims to cover all such modifications and variations which fall within the true spirit and scope of the invention.

What is claimed is:

1. An air gap construction comprising a pair of spaced metallic main electrodes converging to a minimum spacing therebetween and defining a main air gap, said main electrodes having divergent ends on one side of said main air gap and each main electrode having a portion on the opposite side of said main gap carrying all of the current of an arc formed in said main gap and being disposed transverse to the direction of minimum spacing and to the arc in said main gap, a plurality of spaced auxiliary electrodes in the plane of said main electrodes defining auxiliary air gaps therebetween and having the end auxiliary electrodes disposed adjacent to but spaced from the diverging ends of said main electrodes and defining additional auxiliary gaps therebetween, ferromagnetic members surrounding a portion of the periphery of said main

electrodes adjacent said minimum spacing and decreasing the reluctance of the magnetic flux path surrounding said main electrodes but leaving free the confronting portions of said main electrodes, and insulating means between said ferromagnetic members and said main electrodes, whereby the magnetic flux density in said main gap is increased and the arc therein is rapidly moved toward the diverging ends of said main electrodes and broken up into smaller arcs formed in said auxiliary gaps.

2. An air gap construction comprising the combination of a pair of metallic main electrodes maintained within arcing distance for a portion of their length to define a main gap therebetween and being provided with divergent ends and with portions carrying all of the current to and from said main gap disposed at an angle to the arc in said main gap, a plurality of spaced auxiliary electrodes in the plane of said main electrodes defining auxiliary gaps therebetween and being disposed adjacent said diverging ends, and ferromagnetic members surrounding a portion of the periphery of said main electrodes adjacent said main gap but leaving the confronting faces thereof free, whereby the magnetic flux density in said main air gap is increased and the arc in said main gap is rapidly moved toward said diverging ends and broken up into smaller arcs formed in said auxiliary gaps.

3. An air gap construction comprising, in combination, a pair of horn-shaped main electrodes defining a main air gap therebetween, a plurality of spaced auxiliary electrodes in the plane of said main electrodes defining first auxiliary air gaps and having the end auxiliary electrodes spaced from the diverging ends of said horn-shaped main electrodes and defining additional auxiliary gaps in series with said first auxiliary gaps, ferromagnetic members surrounding a portion of the cross sectional periphery of said main electrodes adjacent said main air gap and decreasing the reluctance of the magnetic flux path surrounding said main electrodes but leaving the confronting faces thereof free, and insulating means between said ferromagnetic members and said main electrodes, whereby the magnetic flux density in said main air gap is increased and the arc formed therein is rapidly moved toward the diverging ends of said main electrodes and broken up into smaller arcs in said auxiliary gaps.

4. A lightning arrester spark gap assembly comprising a plurality of stacked discs of insulating material arranged in pairs of adjacent discs having mating hollow portions defining an arc extinction chamber, a pair of horn-shaped main electrodes in said chamber defining a main air gap therebetween, metallic means for affixing one of said main electrodes to each of said pair of discs and constituting terminal means carrying current to said one main electrode within said chamber, a plurality of auxiliary electrodes mounted in spaced apart relation within said chamber adjacent the diverging ends of said horn-shaped electrodes and forming auxiliary gaps therebetween, ferromagnetic members surrounding a portion of the cross-sectional periphery of said main electrodes adjacent said main air gap but leaving free the confronting faces of said main electrodes, and insulating means between said ferromagnetic members and said main electrodes, whereby the magnetic flux density in said main gap is increased and an arc formed therein is rapidly moved toward said auxiliary electrodes and broken up into smaller arcs in said auxiliary gaps.

5. In a lightning arrester, a plurality of stacked insulating discs arranged in pairs of adjacent discs, said discs of each pair having mating hollow portions defining an arc extinction chamber, a pair of metallic main electrodes within said chamber maintained within arcing distance for a portion of their length to define a main gap and being provided with diverging ends and portions disposed on the opposite side of said main gap from said diverging ends and at an angle to the direction of the arc in said main gap, said portion of each said main electrode disposed at an angle to the direction of the arc in

said main gap carrying all of the current in said arc, the main gaps in all of said pairs of adjacent discs being connected in series, a plurality of auxiliary electrodes mounted in spaced apart relation within said chamber adjacent said diverging ends defining auxiliary gaps therebetween, and ferromagnetic members surrounding a portion of the cross sectional periphery of said main electrodes adjacent said main gap but leaving the confronting faces thereof free, whereby the magnetic flux density in said main gap is increased and an arc therein is rapidly moved toward said diverging ends and broken up into smaller arcs in said auxiliary gaps.

6. A lightning arrester comprising an elongate ceramic housing having an axial opening, metallic closure means for the ends of said housing, a stack of superimposed arrester elements including a valve block and a gap unit in said axial opening connected in series between said metallic closure means, said gap unit including a plurality of superimposed insulating discs arranged in pairs of adjacent discs, each disc of said pair having the surface thereof configured to form an arc chamber with the other disc of said pair, a plurality of pairs of spaced horn-shaped main electrodes converging to a minimum spacing and forming a main air gap and having diverging ends, each pair being disposed in one of said arc chambers and all of said pair of electrodes being connected in series, metallic means for affixing one of said main electrodes to each disc of said pair of discs and constituting means for carrying current to said one main electrode within said arc chamber, said insulating discs of each pair having registering grooves extending inwardly into said arc chamber adjacent the diverging ends of said main electrodes, a plurality of spaced metallic auxiliary electrodes defining auxiliary gaps therebetween within each arc chamber mounted in said inwardly extending grooves, the end auxiliary electrodes also defining auxiliary gaps with the diverging ends of said main electrodes, ferromagnetic members surrounding a portion of the cross sectional periphery of said main electrodes adjacent said main air gap but leaving free the confronting faces of said horn-shaped main electrodes, and insulating means between said ferromagnetic members and said main electrodes, whereby the magnetic flux density in said main air gap is increased and an arc therein is rapidly moved toward said diverging ends and broken up into smaller arcs in said auxiliary gaps.

7. A lightning arrester comprising an elongate ceramic housing having an axial opening, metallic closure means for the ends of said housing, a stack of superimposed arrester elements including a valve block and a gap unit in said axial opening connected in series between said metallic closure means, said gap unit comprising four superimposed insulating discs, the upper and second disc having the confronting surfaces thereof configured to form an upper arc chamber and the lower and the bottom discs having the confronting surfaces thereof configured to form a lower arc chamber, pairs of spaced horn-shaped main electrodes in said upper and lower arc chambers converging to a minimum spacing and forming a main air gap and having diverging ends, upper and lower metallic plates adjacent said upper and bottom discs, metallic rivet means for affixing said upper and lower plates to one main electrode within said upper and lower chambers respectively, second metallic rivet means for affixing the other main electrode in said upper chamber to said second disc and said other main electrode in said lower chamber to said third disc and providing electrical connection between said other main electrodes, a plurality of spaced auxiliary electrodes in each of said upper and lower chambers defining auxiliary gaps therebetween mounted adjacent the diverging ends of said horn-shaped electrodes, the end auxiliary electrodes defining additional auxiliary gaps with the diverging ends of said main electrodes, ferromagnetic members surrounding a portion of the cross sectional periphery of said main electrodes

adjacent said main air gap but leaving free the confronting faces of said horn-shaped main electrodes, and insulating means between said ferromagnetic members and said main electrodes, whereby the magnetic flux density in said main air gap is increased and an arc formed therein is rapidly moved toward said diverging ends and broken up into smaller arcs in said auxiliary gaps.

8. An air gap construction comprising, in combination, a pair of spaced electrodes converging to a minimum spacing and defining an air gap therebetween, the portions of said electrodes on one side of said air gap diverging relative to each other and the portions thereof on the other side of said air gap carrying all of the current of an arc formed in said air gap and being disposed transverse to the direction of minimum spacing and to the arc in said gap, whereby the magnetic field generated by the current in said portions on the other side of said air gap reinforces the magnetic field generated by said arc and tends to move said arc toward said diverging portions, ferromagnetic members surrounding a portion of said main electrodes adjacent said minimum spacing and decreasing the reluctance of the magnetic flux paths surrounding said main electrodes but leaving free the confronting portions of said main electrodes, and insulating means between said main electrodes and said ferromagnetic members.

9. A lightning arrester spark gap construction comprising, in combination, a plurality of stacked discs of insulating material arranged in pairs of adjacent discs having mating hollow portions defining an arc extinction chamber, a pair of spaced horn-shaped electrodes in each said chamber diverging relative to each other and de-

fining an air gap therebetween and having portions carrying all of the current to an arc formed in said air gap disposed transverse to the arc in said air gap, metallic means for affixing one of said horn-shaped electrodes to each of said pair of discs, said metallic means engaging said portion disposed transverse to the arc in said air gap and constituting terminal means carrying current to said one main electrode within said chamber, whereby the magnetic flux generated by the current flowing in said current-carrying portions is additive to the magnetic flux generated by said arc and tends to move said arc away from said air gap, U-shaped cross section ferromagnetic members surrounding three sides of the cross-sectional periphery of said electrodes adjacent said air gap and decreasing the reluctance of the magnetic flux paths surrounding said electrodes but leaving the confronting faces of said electrodes free, and insulating means between said ferromagnetic members and said main electrodes.

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