July 31, 1962 B. C. HICKS ET AL 3,047,769

SPARK GAP DEVICES

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FIG.1.

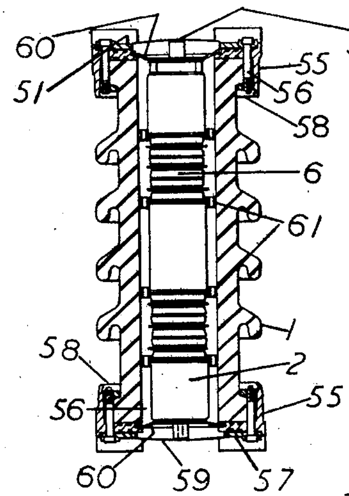


FIG.2.

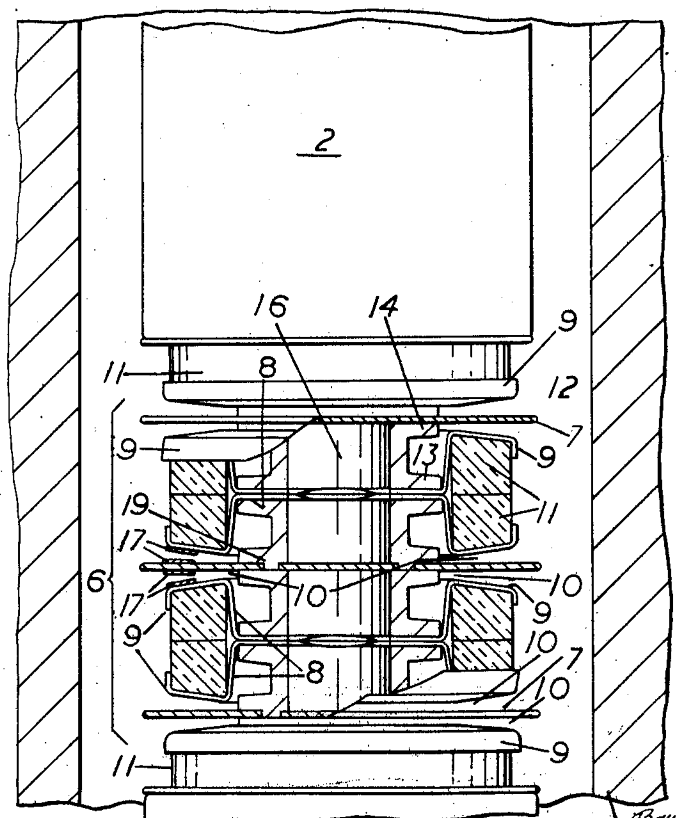


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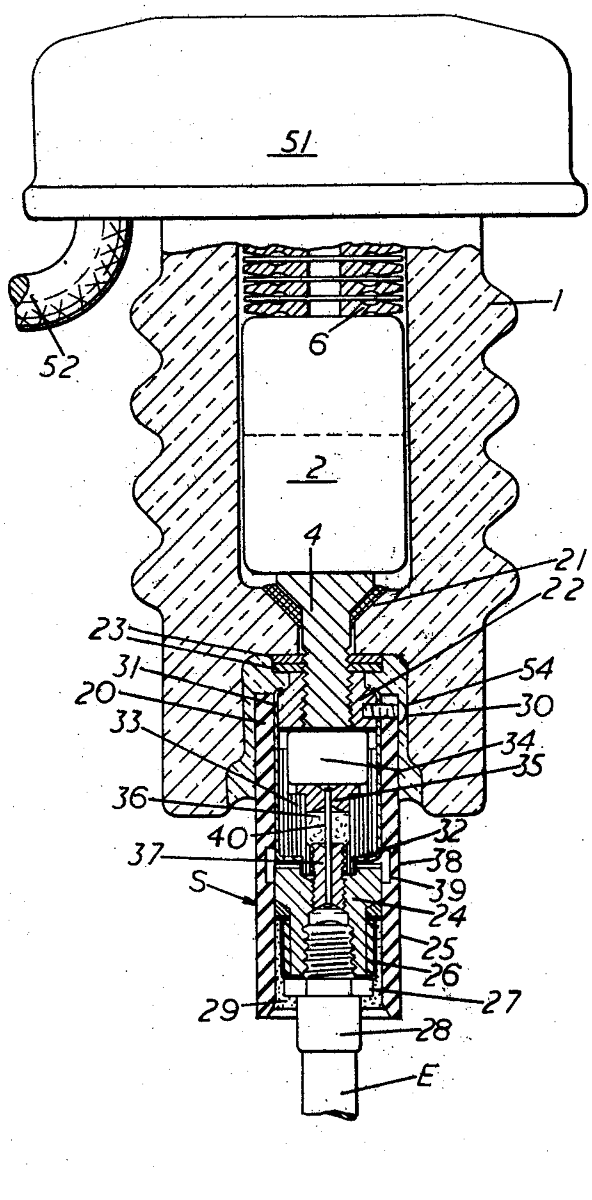
FIG.3.

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# SPARK GAP DEVICES

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The present invention relates to improvements in surge diverters and lightning arresters for electric power distribution systems and is concerned with improved forms of spark gap devices for incorporating in such equipment and also to an improved form of isolator device designed to minimise liability to damage to the operative elements of such equipment resulting from transient currents.

Iightning arresters and surge diverters are used on power lines normally comprise a series of non-linear resistor blocks with one or more spark gap units in series therewith, the gap units having the function of flashing over on the occurrence of a surge and under these conditions the non-linear resistor blocks provide a comparatively low resistance path to earth for the surge current but they then provide a path to earth for power current. It is necessary to terminate the resulting power current as rapidly as possible. Comparatively substantial power currents may be involved because, for other considerations, it is desirable that the resistor blocks shall have a comparatively low resistance under surge conditions.

The ability to terminate the flow of power current is a function of the properties of the non-linear resistor blocks and of the characteristics of the spark gap, and it is important that the gap components shall not be permanently affected under operating conditions, for example the current should be interrupted at the spark gap electrodes without causing any permanent damage to the surface of said electrodes so that the diverter or arrester shall be capable of repeated operation without any change in its characteristics.

The primary object of the present invention is to provide a spark gap unit capable of fulfilling these requirements and which more specifically is adapted to interrupt a comparatively heavy flow of power current through the arrester following the clearance of a surge to earth through the non-linear resistor blocks, while a further object is to provide a construction which involves susbtantially no deterioration of the spark gap components as a result of its action in terminating the flow of power current through the gap.

It has been proposed heretofore to utilise a ring-shaped magnet adjacent a circular gap structure for the purpose of imparting a circular motion to the discharge between the electrodes and thus preventing arcing being concentrated at one point of the peripheral gap, and a more specific object of the invention is to provide a compact, efficient and generally improved construction utilising a permanent magnet adjacent the gap.

In accordance with the present invention a gap unit of the character referred to comprises spaced electrodes of circular formation, one of which is of cupped shape and is surrounded by a ring magnet, said electrode being flanged outwardly over one radial face of the magnet and having a ridged formation in section to define a circular spark gap between said electrode and a second electrode spaced substantially uniformly from the raised edge part of the first electrode by means of a centrally positioned spacer of arc-resisting insulating material, said spacer extending to a point adjacent the peripheral gap between the electrodes so as to render the electrostatic field distribution substantially uniform in the spark gap zone between the electrodes.

Preferably the second electrode is of flat or disc-like form and the spacing between the electrodes is divergent outwardly from the circular spark gap surrounding the cupped formation of the first electrode and the spacer is arranged concentrically within said spark gap and has a peripheral portion extending to a point close to said spark gap.



A similarly polarised ring magnet is preferably provided on each side of the circular spark gap or of a pair of such spark gaps disposed on the two sides of the second electrode.

The spacer may have an outwardly directed flange extending nearly to said spark gap zone, the physical positioning or geometry of the two electrodes and of the said flange being chosen to produce a uniform electrostatic field within the spark gap zone.

In the preferred arrangement the spacer member is of reel shape, that is to say, it compriss a tubular body with outwardly directed flanges at each end and is accommodated within the cupped formation of the first electrode, one flange thereof seating and fitting within the cupped base of the electrode while the flange at the other end extends to a point close to the peripheral gap as already referred to.

Non-linear grading resistor blocks may be located within the spacer member so as to assist in producing a predetermined electrostatic field between the two electrodes.

By the arrangement described a highly efficient spark gap unit is provided which can be made very compact, but which nevertheless is satisfactory and reliable in operation, securing rapid quenching of the arc and termination of the power current flow without damage to the surfaces of the electrodes between which the arc is formed, due to the rapid circular motion of the arc and providing efficient cooling of the electrode surfaces. Further, the grading resistors are cooled by contact with the electrodes which serve as cooling fins for the resistors and the latter may thus be made more compact.

In general terms a lightning arrester or surge diverter is designed to allow the flow of momentarily heavy surges which pass to ground through the spark gap units and through the non-linear resistor elements disposed in series with said spark gap units and both of which function in co-operation to provide a path to ground for such surge current or transients, but normally function to prevent the flow of power follow current. Under certain circumstances, however, there may be an excessive amount of power follow current which may damage the arrester and may cause line fuses or switch gear equipment in the network to interrupt the supply of power, with perhaps a widespread service interruption, and a further object of the present invention is to provide an improved form of isolator device which serves to detach one lead, generally the ground lead connection, to the arrester under these exceptional circumstances thereby preventing damage to the arrester itself and avoiding damage to other line equipment and minimising the danger of a service interruption.

The features of the present invention are shown in somewhat diagrammatic form and by way of example on the accompanying drawings in which:

FIG. 1 is a general view of a surge diverter or lightning arrester suitable for connection to a power distribution network, and

FIG. 2 is an enlarged detail view showing the arrangement of the spark gap assembly, and

FIG. 3 is a sectional view showing a different type of arrester including a safety device or isolator for the arrester in the event of an excessive flow of power follow current.

As shown in FIG. 1 a lightning arrester comprises an outer casing **1** preferably of heat-resisting ceramic material having terminal cap structures **51**. The casing **1** houses a plurality of non-linear resistor blocks **2** such as have been proposed heretofore in this art, and also a spark gap unit **6** shown in conventional form on FIG. 1 of the drawings, the details of the novel structure of such gap unit being explained hereinafter in greater detail with reference to FIG. 2. The spark gap unit **6** and the non-linear resistor blocks **2** provide a path to ground for surge currents and co-operate functionally to prevent the flow of any substantial amount of power follow current along the path to ground provided for the surge currents, in a manner well-known in this art.

The terminal cap structures **51** each comprise an inwardly flanged metal ring **55** held to outwardly flanged ends of the casing **1** by set screws **56** the heads of which engage a clamp ring **57** seating against the outer face of the ring **55** while the threads engage a divided junk ring **58** seating beneath the casing flange. Concentric grooves in the flanges of rings **55** house deformable O-rings giving an effective seal for the casing **1**. Located beneath the clamp ring **57** is the flanged rim of a frangible pressure relief diaphragm **59**. The assembly of resistor blocks **2** and gap units **6** is located by concave washers **60** seating against the inner rim of the ring **55**. Tubular spacer members **61** conveniently of a polypropylene composition, are located between the members **2**, **6** and the inner wall of the casing **1** to minimise danger of damage in handling the equipment. This construction, involving the use of the frangible diaphragms **59**, is adopted so that in the event of a through short-circuit fault there shall be no danger of fracture of the casing **1** since the diaphragms will fracture first. In this connection it should be noted that the sprak gap units **6** described in detail below are so efficient in operation that through short-circuit currents can traverse the units without permanent damage to the gap units.

The spark gap unit **6** forms one important feature of the present invention and is shown in detail on FIG. 2 of the drawings, in which the unit is positioned between two non-linear resistor blocks **2**. The unit shown comprises flat metal disc electrodes **7** and metal cup-shaped electrodes **8** having a flange **9** which extends outwardly and divergently relatively to the adjacent disc electrode **7**, so that an outwardly diverging spark gap zone **10** between the flange **9** and the electrode **7** lies peripherally around the centrally cupped part of the electrode **8**. A ring-shaped permanent magnet **11**, which may be a ceramic magnet and may be formed in one or more sections, has a divergently inclined face congruent with the flange **9** and is radially polarised (e.g. N in the bore and S around periphery); this magnet surrounds the cupped part of the electrode **8**. The outer rim extremity of the flange **9** may run parallel to the axis for a short distance.

Each magnet **11** provides a series of radially directed lines of force across the respective gap zone **10** which result in causing any spark or arc between the electrodes **7**, **8** to travel in a circular path comprised by the spark gap zone **10**, providing rapid cooling of the arc and rapid quenching of the power current flow following the discharge of a surge through the arrester.

In the arrangement shown on the drawing it will be seen that a spark gap zone **10** is formed on each side of each electrode **7**. In this case, or even if there is a single spark gap zone on one side only of an electrode **7**, said gap zone, or both said zones, have a magnet **11** on each side thereof. Since all the magnets are similarly polarised compression of the leakage flux of the magnets is secured in the spark gap zone or zones **10** by the mutual interaction of the flux of the magnets **11**. The end magnets of the unit **6** are in electrical contact with the resistor blocks **2**.

The electrodes **7** and **8**, which are conveniently of copper, are maintained in correctly spaced pairs by means of spacer members **12** consisting of a suitable refractory insulator material, for example that known as Micalex. Each spacer is shaped so that a part thereof



extends peripherally almost to the gap zone **10**, so as to produce a uniform electrostatic field pattern in the gap zone **10** between the electrodes. It may be of tubular form and flanged at each end, there being a base flange **13** adapted to seat within the cupped electrode **8** and a flange **14** which provides the part extending nearly to the spark gap zone **10**.

Preferably a non-linear grading resistor block **16**, or a series of separate resistor blocks, is provided within the spacer **12**, being in contact with the electrode **7** at one end and the electrode **8** at the other end, so as to provide a linear voltage gradient between the electrodes, so as to determine the electrostatic field pattern between them, said pattern being substantially uniform at the central axis and, considered in the radial direction, being bunched up into the spark gap zone **10**, the distribution of the field being made substantially uniform in said zone by the part of the spacer member **12** which is disposed in the field of the electrodes and extends almost to the spark gap zone **10**. In the preferred arrangement this edge part of the spacer is formed by the flange **14**.

The formation of the spacer **12** with flanges at each end assists in securing mechanical stability of the gap construction by positively locating the electrodes **7** and **8** one in relation to the other and the insulation of the surface of the spacer **12** is improved by the peripheral channel left between the flanges, providing an insulating zone which is to some extent at least shadowed by the flange **14** from the effects of the power arc in the zone **10**. A further feature of the spacer is that it limits the possible inward movement of the arm and keeps it in a correct position where it is subjected to the maximum magneto-motive reaction with the leakage flux from the opposed pairs of magnets **11**.

It will be appreciated that in the preferred arrangement the thickness and radial positioning of the flange **14** is related to the spark gap spacing and geometry so as to secure a uniform field distribution across the spark gap zone **10**. Further, the flange **14** serves to screen the centrally recessed portion of the spacer from radiation from the arc which further assists maintenance of high insulation.

If desired, channels may be cut through the tubular central part of the spacer **12** so as to expose a part of the edges of the resistor block or blocks **15** to radiation from the gap zone **10**. This irradiation of the resistor blocks tends to reduce the impulse spark-over properties and is believed to ensure a supply of ions in the gap and thereby provides a low and reproducible impulse spark-over characteristic.

In the construction shown on the drawings the gap unit **6** comprises a number of successive gap units and includes three disc electrodes **7** and six cupped electrodes **8**, each disc **7** being common to two spark gap zones **10**. The nearest magnets **11** of adjacent pairs are arranged in physical contact one with the other while the cupped parts of the two intermediate pairs of electrodes **8** are arranged back to back as shown. Conveniently, and for the purpose of obtaining proper location of the electrodes **7**, the spacer elements **12** are provided with depending lugs **19** which engage corresponding apertures in the electrodes **7**. The various components of the complete arrester including the resistor blocks **5** and the one or more spark gap units **6** are held in compression by suitable spring means in the outer casting **1**.

By the particular arrangement of the electrode structure shown, particularly the cupped formation of the electrodes **8** with down-turned rims, each spark gap zone **10** lies adjacent the centrally cupped part of an electrode **8**. This ensures the initiation of the arc towards the inner edge of the space defined between the flanged part **9** of the electrode **8** and the disc electrode **7**. This arrangement permits the physical size of the gap assembly to be brought to a comparatively small figure so that the gap unit can be fitted into relatively small casings 1, since the arc occurs at a point some distance away from the inner walls of the housing. It also provides for a satisfactory mechanical design and, coupled with the function of the permanent magnets, avoids the need for accurate parallelism between the electrode surfaces since any arc occurring is immediately caused to move in a circular path around the cupped part of the electrode and is very rapidly quenched by the cooling action of the electrodes.

To minimise the possibility of outward excursions of the arc the edge parts of the flanges 9 may be covered with an arc resisting insulating material 17 and likewise the adjoining edge and face surfaces of the disc electrodes 7 may be similarly coated. Such insulation 17 may be for example an epoxy resin coating and experience has shown that such materials are not liable to be damaged by being comparatively close to the arcing zone 10 but nevertheless they are effective in confining the arc to the desired zone adjacent the cupped inner part of the electrode 8.

An important characteristic of this feature of the invention is that due to the particular shape of the electrodes the configuration of the spark gap components adjoining the gap zone 10 permits such arc resisting insulating material to be employed without such material being present in that part of the gap zone where the field is most concentrated. Furthermore, even if such insulating material 17 is damaged there would be no appreciable modification of the field pattern between the electrodes so that the performance of the gap remains unaltered.

In this way the restriction of the area of the two opposed electrodes liable to be traversed by the arc has the effect of reducing the liability to re-striking of the arc and permits an increase in the permissible voltage gradient across the gap. Furthermore, this result is achieved without altering the dimensions of the magnet as between its opposed poles, i.e. radial dimension in the present case, so that a high field concentration is maintained in the spark gap zone 10.

It will be realised that the structural design of the gap provides for the electrodes 7 and 8 to act as cooling members or fins for the grading resistors 11 permitting a more compact construction to be obtained.

FIG. 3 illustrates the construction of another form of lightning arrester which incorporates an isolator device S to detach one lead, the ground lead E in this case, in the event of an excessive flow of power follow current. In this case the gap units 6 are shown in the casing 1 in conventional form, as well as the resistor blocks 2. The casing 1 has a terminal cap 51 at one end from which extends a lead 52 for connection to a power line. It will be noted that the lower end of the outer casing 1 is deeply recessed as shown at 54 and that the terminal member 4 seats against a cone-shaped washer 21. The upper end of the isolator device is provided with a threaded metal connector socket 22 which screws on the lower end of the terminal 4 and seats against sealing washers 23. The isolator device itself comprises an outer sleeve 20 of insulating material the lower end of which slidably accommodates a lower terminal member 24 to which the ground lead E is suitably connected. An O-ring seal 25 is provided around a recessed lower part of the terminal member 24 and is held in position by means of a sleeve 26 engaged by an outwardly directed flange part 27 of the ground lead terminating member 28 screwing into the base of the terminal member 24. By these means the O-ring seal 25 is held under compression, maintaining a tight seal at this point while permitting ejection of the terminal 24 and of the ground lead E under exceptional fault conditions as explained hereinafter. The lower end of the sleeve 20 is filled with a resinous insulating material as indicated at 29.

Fixedly mounted in the upper part of the sleeve 20 and held therein by means of a grub screw 30 traversing the side wall of the sleeve 20 and entering the upper terminal socket 22, is a metal sleeve 31 the lower edge of which is flanged inwardly as shown at 32. A sleeve of insulating material 33 is fixed within the metal sleeve 31, the upper end of the sleeve 33 being recessed to house a block 34 of a suitable grade of linear resistor material, the lower end of which seats against a plug member 35 entering the upper end of a chamber formed within the insulating material 33 and housing a charge 36 of gas-producing material, for example a suitable grade of explosive such as black powder. The lower end of the sleeve 33 is of reduced diameter and has a threaded bore to house a plug 37 screwing both into the end of the sleeve 33 and the terminal member 24, and thus serving to keep these parts in the normal assembled position.

The lower face of the inturned flange portion of the sleeve 31 forms one element of a by-pass spark gap and is positioned comparatively close to the upper face of the terminal member 24, a mica washer being conveniently interposed between these parts, as shown at 38. Preferably the radial spark gap faces on the two sides of the mica washer 37 are formed of or coated with substances which provide desired operating properties. Preferably one surface is formed of a refractory metal and the other of a more fusible metal or both surfaces may be formed of a refractory metal. For example, one surface may be coated with or formed of molybdenum while the other face may be formed of or coated with copper or tin. If desired, the outer sleeve 20 may be formed with a peripherally enlarged portion adjacent the spark gap, as shown at 39.

A heater or igniter wire 40 consisting of surge-resistant material is provided between the plug 35 and the screw plug 37. This surge-resistant material will, in general, consist of a metal having a relatively low conductivity and therefore of comparatively large cross-sectional area, and it consists of a metal having a relatively high melting point which is not liable to oxidation. Suitable materials consist of nickel-iron alloys having a relatively high proportion of nickel, these materials being desirable because they can be readily soldered to the parts to which they are attached. If, however, non-soldering assembly methods are adopted other refractory metals such as nickel-chrome alloys can be used.

In operation any currents having surge characteristics which may seek a path to ground through the arrester assembly as a whole produce a voltage across the resistor block 34 which appears across the spark gap defined by the mica washer 38 so that such currents pass harmlessly to ground through the lead E. In the exceptional event of a dangerously prolonged flow of power follow current the path through the resistor block 34 and the igniter wire 40 provides a path which is preferably taken by said power follow current, and if it is dangerously excessive and of such a nature as would damage the arrester or cause a supply interruption the igniter wire 40, being so chosen that under these conditions the charge of gas-producing material 36 is fired, now becomes operative and a high pressure is suddenly produced in the chamber housing the charge 36 of gas-producing material. The result is that the ground lead E together with the lower terminal 24 are forcibly ejected from the outer casing 20, the threaded joint between the plug 36 and the insulating sleeve 33 being readily stripped to permit ejection of the ground lead E. The sleeve 33 and the outer sleeve 20 are, however, sufficiently strong to resist fracture and therefore the terminal 24 and lead E are forcibly ejected to secure an extremely rapid disconnection of the arrester and termination of the power follow current before any line fuses can interrupt the feed of power into the network.

It will be realised that the resistor block 34 has the function of providing a measure of discrimination as between high voltage surges which pass to ground mainly through the path provided by the spark gap, whereas power follow current flows mainly through the path provided by the igniter wire **40** and it thereby becomes possible so to grade the wire **40** that, in conjunction with the operating properties described, the ground lead is ejected and the path to ground through the arrester is lifted before the flow of power follow current is able to cause fusing of any fuse links in the line circuit.

What we claim is:

1. Spark gap unit for installation in a lightning arrester casing for electric power lines in a surge current path within an arrester casing comprising a plurality of nonlinear resistor blocks, said unit comprising spaced pairs of circular electrodes one electrode of each pair being of disc shape and the other of cupped shape, a spacer of arc-resisting insulating material positioned between said electrodes to define a circular gap between the cupped portion of said other electrode and the said disc electrode, a radially polarized ring magnet surrounding the central cupped portion of said other electrode and the spacer member within it, said electrode being flanged outwardly over one radial face of the magnet to define a circular spark gap between said electrodes, said spark gap being peripherally divergent in the outward direction, and means on said spacer member extending to a point adjacent the peripheral gap between the electrodes to regulate and make uniform the electro-static field distribution in said spark gap.

2. A spark gap unit as claimed in claim 1 wherein the second electrode is of flat or disc-like form and the spacing between the electrodes is divergent outwardly from the circular spark gap surrounding the cupped formation of the first electrode and wherein the spacer is arranged concentrically within said spark gap and has a peripheral portion extending to a point close to said spark gap.

3. A spark gap unit as claimed in claim 1 wherein a similarly polarised ring magnet is provided on each side of the circular spark gap or of a pair of such spark gaps disposed on the two sides of the second electrode.

4. A spark gap unit as claimed in claim 2 wherein the spacer has an outwardly directed flange extending nearly to said spark gap zone, the physical positioning or geometry of the two electrodes and of the said flange being chosen to produce a uniform electrostatic field within the spark gap zone.

5. A spark gap unit as claimed in claim 1 wherein the outwardly flanged edge part of the cupped electrode is of outwardly divergent formation as seen from the second electrode so that a spark gap zone is formed between the electrodes in a peripheral zone closely surrounding the cupped part of the first electrode and the spacer has a flange portion extending nearly to said spark gap zone so as to produce a uniform electrostatic field in said zone.

6. A spark gap unit as claimed in claim 1 wherein the radial face of the magnet lying beneath the outwardly flanged part of the electrode is of congruent shape to said part of the electrode.

7. A spark gap unit according to claim 1 wherein the spacer is of flanged formation at both ends, one flange serving to seat within the cupped part of the first electrode while the other extends radially to a point adjacent the spark gap zone between the two electrodes.

8. A spark gap unit according to claim 5 wherein the spacer has a centrally channelled portion the surface of which is at least partially sheltered from the spark gap zone by means of the flange of the spacer extending towards the spark gap zone.

9. A spark gap unit according to claim 1 comprising grading resistors located within the spacer and adapted to provide a uniform electrostatic field distribution between the two electrodes adjacent the axis, said field being uniform in the spark gap zone by the provision of the spacer extending nearly to the spark gap zone.

10. A spark gap unit as claimed in claim 9 wherein the electrodes, being in physical contact with the grading resistors, are adapted to serve as cooling fins for such resistors.

11. A spark gap unit according to claim 9 wherein openings are provided in the spacer so that the edges of the grading resistors are exposed to the spark gap zone and subjected to radiation therefrom.

12. A spark gap unit as claimed in claim 1 wherein external peripheral portions of the electrodes are covered or coated with arc-resisting insulating material.

13. A spark gap unit as claimed in claim 2 wherein outer peripheral portions of the electrode and adjoining face portions are coated or covered with an arc-resisting insulating material.

14. A spark gap unit according to claim 2 wherein the arc-resisting insulating material is applied to peripheral portions of both electrodes which are separated from the spark gap zone so that such material is without substantial effect on the field in the spark gap zone.

15. A lightning arrester for electric power lines comprising an arrester casing, a terminal cap at one end of said casing supporting a lead for connection to a power line, a terminal member at the other end of said casing for attachment to a ground lead, a plurality of non-linear resistor blocks housed within said casing and disposed in a surge current path from said first lead to said ground lead, and a spark gap unit in said path, said unit comprising spaced electrodes of circular shape, one being of disc form and another being of cupped form, a radially polarised ring magnet surrounding said cupped electrode which extends outwardly over one radial face of the magnet and having an outwardly divergent formation in relation to the disc electrode to define a circular spark gap between said electrodes, said spark gap being of progressively greater width in the outward direction, and a centrally positioned spacer of arc-resisting insulator material positioned between the two electrodes, said spacer including a peripheral portion extending to a position adjacent the peripheral gap between the electrodes to modify the electrostatic field distribution in the spark gap zone.

16. A lightning arrester for electric power lines comprising an arrester casing, a terminal cap at one end of said casing supporting a lead for connection to a power line, a terminal member at the other end of said casing, an isolator device connected to said terminal member to provide a mounting for a ground lead terminal and to detach the latter and isolate the arrester in the event of an excessive flow of power follow current, said isolator device comprising an outer sleeve, a lower terminal member slidably mounted in said outer sleeve and attachable to the ground lead, a threaded connector member accommodated at the upper end of said outer sleeve for connection to the terminal member of the arrester, a further sleeve of insulating material fixedly connected to said outer sleeve, said further sleeve having a recess, a charge of gas-producing material in said recess, a plug closing said recess at one end and electrically connected to said connector member, a threaded plug closing said recess at its other end, said plug further threadingly engaging the ground lead terminal, and a heater wire of surge resistant material extending between the plug members closing the two ends of the recess housing the charge of gas-producing material, and adapted to activate the charge of gas-producing material when heated by a dangerously excessive flow of power follow current thereby to eject the ground lead terminal forcibly from the base of the sleeve and providing rapid arc extinction.

17. A lightning arrester as claimed in claim 16 further comprising a block of linear resistor material fitted in a recess in the upper end of the further sleeve in the path between the connector member and the first plug closing the chamber housing the gas-producing material, a metallic sleeve surrounding said further sleeve within the first sleeve and connected to the upper terminal, the lower end

of said metal sleeve being flanged inwardly to form a first by-pass spark gap component, the upper face of the lower terminal providing the second gap component, being held in spaced relation from said first component thereby providing a path for high voltage surges across said gap and by-passing the path to ground through the heater wire, said heater wire being traversed mainly by power follow currents and being effective against excessive values of such current to activate the said charge and eject the ground lead terminal.

18. A lightning arrester for electric power lines comprising an outer casing, terminal members on said casing, a plurality of non-linear resistor blocks within said casing, and a spark gap unit within said casing, said resistor blocks and said spark gap unit being electrically in series in a surge current path through said casing between said terminal member, said spark gap unit comprising spaced circular electrodes one electrode being of disc shape and the other of cupped shape, a radially polarised ring magnet surrounding said cupped electrode, the latter being flanged conversely outwardly over one radial face of the magnet to define a circular spark gap between said electrodes, said spark gap being peripherally divergent in the outward direction, a centrally positioned spacer of arc-resisting insulating material between said electrodes to hold them fixedly in spaced relation and means on said spacer member extending to a point adjacent the peripheral gap between the electrodes to regulate and make uniform the electro-static field distribution in said spark gap.



19. A lightning arrester for electric power lines comprising an outer casing, terminal members at the two ends of said casing, an end cap hermetically closing said casing, said end cap including a frangible diaphragm adapted to fracture under conditions involving excessive gas pressure in said casing, a plurality of non-linear resistor blocks in said casing and a plurality of spark gap units in said casing, said blocks and said gap unit being in series in a surge current path through said casing between the terminal members.

20. A lightning arrester according to claim 19 wherein said end cap comprises an inwardly flanged metal ring seating against the end face of the casing, a clamp ring on the outer face of the flanged ring, a junk ring seating beneath a flange on the casing, screw operated fastening means bearing on said clamp ring and threadingly engaging the junk ring to hold the flanged ring against the end of the casing, and deformable sealing rings fitted in grooves in the faces of the flanged ring engaged by the end of the casing and the clamp ring respectively, the said diaphragm being interposed by a flanged edge part thereof between the clamp ring and the flanged ring to serve as a closure for the casing.

**References Cited** in the file of this patent

UNITED STATES PATENTS

2,906,910 Dyer ------------------ Sept. 29, 1959