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LIGHTNING ARRESTERS

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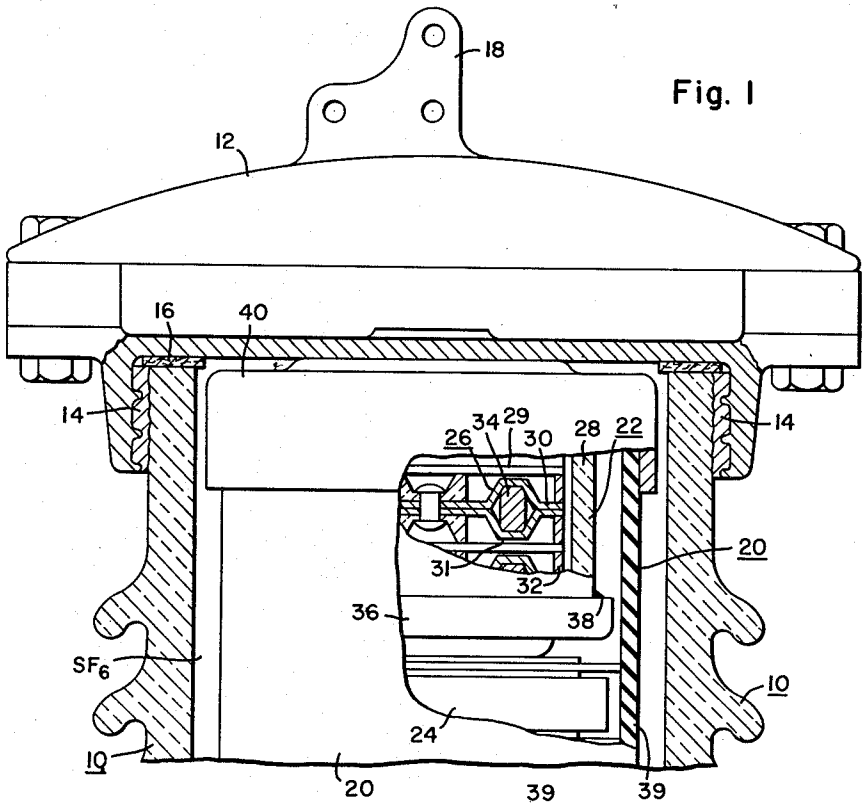


Fig. 1

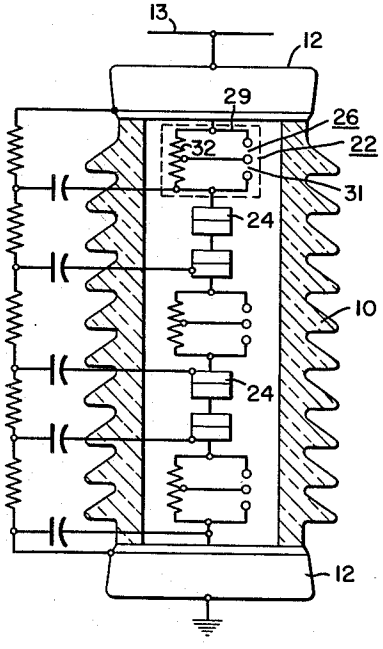


Fig. 2

WITNESSES

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LIGHTNING ARRESTERS

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This invention relates to lightning arresters and, more particularly, to improved corona suppressing structures therefor.

When a lightning arrester becomes contaminated on the surface of the outer housing, a noticeable reduction in the internal sparkover voltage may be observed. The reduction of internal sparkover voltage results from an upset in the voltage gradient on the internal parts. When the surface of a lightning arrester outer housing becomes contaminated, in essence, the arrester becomes a large capacitor, one plate of which is formed by the contaminated surface and the other plate of which is formed by the internal parts of the arrester. The upset in the voltage gradient of the internal parts is the result of capacitive currents which flow through the porcelain wall between the contaminated surface and the internal parts.

The amount of sparkover reduction is related to the amount of capacitive current. Under normal clean and dry conditions the resistance over the porcelain surface is very high, approaching infinity. When the arrester surface becomes contaminated the resistance will drop and may go down to a short circuit. In other words, the resistance of the porcelain surface may vary anywhere between the limits of infinite resistance and zero resistance. To further upset the voltage gradient the surface resistance may not vary evenly over the entire surface. One part of the surface may be at near zero resistance while another part is still near infinity. The voltage at any point on the arrester surface will vary with the resistance of the surface contamination. Thus, it can be seen that due to this variation in resistance along the surface of the porcelain housing, a potential difference is established between the contaminated outer surface and the internal parts along the length of the arrester.

The amount of capacitive current which will flow through the porcelain wall is dependent among other things on the distance between the two plates, the area of the plates, and the potential difference existing between the two plates. Due to the flow of capacitive current corona builds up around the internal arrester parts. The amount of corona present depends directly on the amount of current flow. This corona in effect brings the two plates closer together. This shortening of the distance between the two plates will cascade with the build up of more corona. The process may continue until some of the internal arrester parts flash over or spark over causing an arrester operation. If contamination is severe enough the arrester will be unable to valve off and will result in an arrester failure.

The area of the plate formed by the surface contamination depends upon the severity of the contamination. The area of the other plate, formed by the internal arrester parts, may vary with the amount of corona present. The formation of corona discharge effectively increases

the size of the plate presenting an effectively larger area. As the corona discharge builds up, the effective distance between the two plates is also decreased. Both of these conditions lead to an increased capacitive current flow. The increased current flow causes more corona discharge. If these conditions exist for a relatively long period of time, the arrester may experience a low voltage sparkover and add to the possibility of an arrester failure. Depending upon the severity of the surface contamination this corona effect may progress to a point where a reduction in arrester sparkover of 20% to 30% is produced. Thus the complex problem of the contamination effect on lightning arresters resolves itself into the control of internal corona discharge.

The principal object of the present invention is to provide a lightning arrester embodying an electronegative gas whereby corona discharge due to surface contamination is suppressed.

Another object of the present invention is to provide a lightning arrester in which the effect of surface contamination is minimized by reducing the build up of corona discharge in the internal parts of the arrester which utilizes an electronegative gas for corona suppression.

Other objects and advantages of our invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a partial sectional view of an arrester embodying this invention; and

FIG. 2 is a diagrammatic view illustrating the invention.

Briefly, the invention comprises a valve-type lightning arrester which includes a plurality of electrodes forming a spark gap enclosed in a sealed spark gap assembly housing, and a plurality of non-linear resistor blocks arranged in columnar disposition with the spark gap assembly. One or more columns of spark gap assemblies and non-linear resistor blocks may be disposed in side-by-side relationship. Each column may include all resistor blocks, or all gap assemblies, or a combination of both. The entire column of internal elements is disposed within an insulating tube which in turn is disposed within an outermost insulating hollow cylinder which may be of porcelain or other suitable material. The spark gap assembly housing is a sealed housing to prevent entrance of moisture or other contaminants within the spark gaps thereby preventing any change in sparkover characteristics of the gap. The outermost housing is also sealed against entrance of moisture and other contaminants which might injure or affect the non-linear resistance blocks. The free space within the outer porcelain hollow cylindrical housing not occupied by arrester parts is filled with an electronegative gas having an extremely heavy molecule, as for example sulfur hexafluoride (SF_6). The electronegative gas employed for corona suppression is excluded from the spark gap assembly itself by the sealed spark gap housing.

In a preferred embodiment of the invention shown in the drawings for the purpose of illustration, the arrester comprises a generally cylindrical housing **10** which is preferably made of porcelain but any suitable weather resistant insulating material may be used. The housing **10** is provided at each end with a metal end fitting **12**

which may be of any suitable design. The end fittings 12 are secured to the housing 10 by cement as indicated at 14, or in any other desired manner. A gasket 16 is interposed between each of the end fittings 12 and the housing 10 to seal the interior of the housing 10. A terminal connector 18 may be provided on upper end fitting 12 for connecting the arrester to a line 13 or other device to be protected. A lower terminal connector, not shown, is provided for connecting the arrester to ground.

The lightning arrester assembly which is contained in the outer housing 10 includes one or more columns 20 of lightning arrester elements, additional columns being connected, preferably, in series and disposed within the housing. If more than one column 20 of arrester units are provided, the columns may be disposed either in linear relation or side-by-side within the outer porcelain housing. The arrester elements comprise spark gap assemblies 22 and valve blocks or non-linear resistance elements 24. The non-linear resistance elements may be of any usual or desired type as for example silicon carbide blocks. Each column may consist of any combination of spark gap assemblies 22 and valve blocks 24 arranged in a series stack in any desired manner.

The gap assembly 22 may be of any suitable type as for example, the type disclosed in Patent No. 2,858,476 by E. F. W. Beck and Otto Ackermann, issued October 28, 1958, and assigned to assignee of the present invention. The spark gap assembly 22 is shown as comprising a plurality of gap devices 26 arranged in a column in a porcelain tube 28. Each of the gap devices 26 consists of a flat electrode plate 29 and a formed electrode 30 having an annular ridge which cooperates with the electrode 29 to form an annular gap space 31, the electrodes 29 and 30 being spaced apart by an annular spacer 32 of high resistance material. An annular permanent magnet 34 may be disposed in the space formed by the ridges of adjacent electrodes 30, if desired, to provide a magnetic field in the gap space to effect movement of the arc to facilitate its extinction. Any necessary number of sparkgap devices 26 may be provided, depending on the desired voltage rating, and they may be disposed in the tube 28 in a vertical column with conducting spacers, not shown, being provided if necessary at the top and bottom of the column. The ends of the porcelain tube 28 may be closed by metal end caps 36, which are sealed to the porcelain in any suitable manner, as by soldering to a metallic glaze on the porcelain as indicated at 38. Means are provided to hold the gap devices 26 firmly in contact with each other and with the end caps 36 so that the gaps are electrically in series between the end caps 36 which serve as contact means for the gap assembly.

The valve blocks 24 may be any suitable type of valve or non-linear resistance element, and are preferably made of granular silicon carbide molded to the desired size and shape with a binder of sodium silicate, or other binder, and baked to provide valve elements of a usual type. The column of arrester elements shown in the arrangement of FIG. 1 consists of a spark gap assembly 22 and a plurality of valve blocks 24 disposed in a series column in a tube 39 of any suitable rigid insulating material. One end of the tube 39 is closed by a cap member 40.

The free, unoccupied space within the insulating housing 10 and the insulating tube 39 is filled with a good corona suppressing material. Sulfur hexafluoride gas has been found to be a good corona suppressor and is employed in the illustrated embodiment. Other gases or mixtures of gases or other materials exhibiting corona suppressing properties equivalent to sulphur hexafluoride may be employed. Electro-negative gases or other electron absorbing materials having a heavy molecule are relatively good corona suppressing material.

The sulfur hexafluoride gas is provided to suppress corona build-up when the outer surface of the housing 10 has become contaminated. This prevents a reduction of contaminated sparkover voltage. It is essential, however, that the sulfur hexafluoride or other electro-negative gas or material be excluded from the sparkgap assembly housing 28 inasmuch as sulfur hexafluoride, and other electro-negative gases, serve as arc suppressors and have the ability to extinguish or interrupt electrical arcs as well as to suppress the formation of arcs. Sulphur hexafluoride (SF_6) gas in the gap space would tend to alter the normal sparkover voltage and other electrical characteristics of the gap. It is desired that the electrical characteristics of the gap not be affected by the corona suppressor. The electron attracting qualities of the SF_6 gas are employed in this invention to prevent or greatly reduce corona in the arrester and thereby to prevent resulting undesirable effects of contamination. It is desirable to accomplish this without changing the sparkover characteristics of the gap. When an arrester becomes contaminated on the surface, a radical reduction in the internal sparkover may be observed.

The following table shows the effect of contamination on the lightning arrester. It can be seen that there is a substantial reduction in sparkover in a contaminated arrester.

Arrester rating, kv.	Clean and dry 60 cycle sparkover voltage, kv.	Contaminated 60 cycle sparkover voltage, kv.	Percent reduoctin
37	85	63	26
60	132	99	25
121	252	178	29
[1] 121	258	227	12
182	310	200	35

[1] 121 kv., SF_6 filled.

It should be noted that the table of experimental results above indicates a considerable improvement in consistency of the sparkover characteristics when the arrester is filled with SF_6 gas. Note particularly the data on the arrester rated at 121 kv.

The process by which reduction in sparkover of a contaminated arrester occurs may best be understood by referring to FIG. 2. Under normal (clean and dry) conditions the resistances over the porcelain surface, represented in FIG. 2 by R1, R2, R3, R4, and R5, are very high approaching infinity. When the arrester surface becomes contaminated the resistance will droy and may go to a short circuit. In other words, the resistance of the porcelain surface may vary anywhere between the limits of infinite resistance and zero resistance. To further complicate the process the surface resistances may not vary evenly over the entire surface. One part of the surface may be at near zero resistance while another part is near infinity. The voltage potential at any point on the arrester surface will vary directly with the resistance of the surface contamination.

The actual mechanism of the reduction of internal sparkover results from an upset in the voltage gradient of the internal parts. This upset is the result of capacitive currents which flow through the porcelain wall between the contaminated surface and the internal parts. Referring again to FIG. 2, the capacitance between the surface contamination and the internal parts is represented by C1, C2, C3, C4, and C5. Capacitive current is represented by *i*1, *i*2, *i*3, *i*4 and *i*5. The amount of capacitive current which will flow is dependent among other things on

(1) The dielectric constant of the medium separating the two plates.

(2) The potential difference existing between the two plates.

(3) The area of the two plates.

(4) The distance separating the two plates.

By individual consideration of the four preceding factors it is evident that some of the factors are fixed and beyond control, while others are controllable con-

ditions. Once the arrester is built and sealed, the dielectric constant of the materials separating the two plates is fixed. The potential difference between the two plates depends upon the amount of surface contamination and at any instant in time may be considered as a fixed value. The area of the one plate formed by the surface contamination depends on the severity of the contamination and may also be considered as fixed. The area of the other plate, formed by the internal parts, may vary with the amount of corona present. The formation of corona effectively increases the size of the conductor presenting an effectively larger area. The distance separating the two plates will also vary with the amount of corona. As the corona builds up, the effective distance between the plates is decreased.

From these considerations it is evident that the two most logical areas of control are in the area of the internal plate as determined by corona, and in the distance separating the two plates once again controlled by corona. The major percentage of the sparkover reduction results from corona build up around the internal parts. The amount of corona present depends directly on the amount of capacitive current flow and in this case the amount of current flow depends directly on the corona. As the corona builds up around the internal parts the effective plate area of the capacitor is increased and the effective distance between the two plates is decreased. Both of these conditions lead to an increased capacitive current flow. The increased current flow causes more corona.

Depending upon the severity of the surface contamination, this corona effect may progress to a point where a reduction in arrester sparkover of 20 to 30% is produced. If these conditions exist for a relatively long period of time, the arrester may experience a low voltage sparkover and add to the possibility of an arrester failure. Working with this theory of electronegative gases, sulfur hexafluoride has been introduced into the arrester housing. Sulfur hexafluoride gas has long been known for its insulating and arc interrupting qualities. However, sulfur hexafluoride also has the unique characteristic of acting as a corona suppressor. The characteristics which contribute to its corona suppressing qualities are the very large heavy SF_6 molecule and its electron absorbing ability.

The buildup of corona on the internal parts of the arrester has been controlled by utilization of SF_6 for corona suppression while at the same time the sparkover characteristics of the arrester gap have not been altered.

A particular embodiment of the invention has been shown and described for the purpose of illustration, but it will be apparent that various other embodiments are possible within the scope of the invention. Thus, for example, in a folded type arrester construction the invention herein described may be utilized as well as in an arrester with a multiple piece porcelain outer housing. In either case the effect of contamination is squally serious and control of the effect is equally well accomplished in any of these units. Two or more of the arrester assemblies described could be placed in series within a single housing or two assemblies may be secured together. Similarly, numerous other modifications and embodiments will be apparent to those skilled in the art and all such modifications and embodiments are within the scope of the invention.

We claim as our invention:

1. A lighting arrester adapted to be connected across points having different electrical potential including an insulating outer housing, the outer surface of the outer housing being subject to adherence of contaminating conductive substances thereby establishing a capacitor effect between the outer surface and internal arrester parts causing sufficient capacitive current flow to initiate corona discharge about said arrester parts resulting in reduction in internal sparkover potential, a sparkgap assembly within said outer housing comprising a plurality of electrodes forming one or more sparkgaps enclosed within a sealed gap assembly housing, a plurality of other arrester elements, said sparkgap assembly and said other arrester elements arranged in one or more columns within said outer housing, and corona suppressing material filling the free space within said outer housing exteriorly of said sealed gap assembly housing.

2. A lightning arrester adapted to be connected across points having different electrical potential including an insulating outer housing, the outer surface of the outer housing being subject to adherence of contaminating conductive substances thereby establishing a capacitor effect between the outer surface and internal arrester parts causing sufficient capacitive current flow to initiate corona discharge about said arrester parts resulting in reduction in internal sparkover potential, a sparkgap assembly within said outer housing comprising a plurality of electrodes forming one or more sparkgaps enclosed within a sealed gap assembly housing, a plurality of other arrester elements, said sparkgap assembly and said other arrester elements arranged in one or more columns within said outer housing, and corona suppressing fluid material filling the free space within said outer housing exteriorly of said sealed gap assembly housing.

3. A lightning arrester adapted to be connected across points having different electrical potential including an insulating outer housing, the outer surface of the outer housing being subject to adherence of contaminating conductive substances thereby establishing a capacitor effect between the outer surface and internal arrester parts causing sufficient capacitive current flow to initiate corona discharge about said arrester parts resulting in reduction in internal sparkover potential, a sparkgap assembly within said outer housing comprising a plurality of electrodes forming one or more sparkgaps enclosed within a sealed gap assembly housing, a plurality of other arrester elements, said sparkgap assembly and said other arrester elements arranged in one or more columns within said outer housing, and a corona suppressing electronegative gas filling the free space within said outer housing exteriorly of said sealed gap assembly housing.

4. A lightning arrester adapted to be connected across points having different electrical potential including an insulating outer housing, the outer surface of the outer housing being subject to adherence of contaminating conductive substances thereby establishing a capacitor effect between the outer surface and internal arrester parts causing sufficient capacitive current flow to initiate corona discharge about said arrester parts resulting in reduction in internal sparkover potential, a sparkgap assembly within said outer housing comprising a plurality of electrodes forming one or more sparkgaps enclosed within a sealed gap assembly housing, a plurality of other arrester elements, said sparkgap assembly and said other arrester element arranged in one or more columns within said outer housing, and the free space within said outer housing exteriorly of said sealed gap assembly housing including corona suppressing, electron absorbing gas having a relatively heavy molecule.

5. A lightning arrester adapted to be connected across points having different electrical potential including an insulating outer housing, the outer surface of the outer housing being subject to adherence of contaminating conductive substances thereby establishing a capacitor effect between the outer surface and internal arrester parts causing sufficient capacitive current flow to initiate corona discharge about said arrester parts resulting in reduction in internal sparkover potential, a sealed spark gap assembly within said outer housing, and the free space within said outer housing exteriorly of said sealed gap assembly including a gas composed principally of sulfur hexafluoride.

6. A lightning arrester adapted to be connected across points having different electrical potential including an insulating outer housing, the outer surface of the outer

housing being subject to adherence of contaminating conductive substances thereby establishing a capacitor effect between the outer surface and internal arrester parts causing sufficient capacitive current flow to initiate corona discharge about said arrester parts resulting in reduction in internal sparkover potential, a sparkgap assembly within said outer housing comprising a plurality of electrodes forming one or more sparkgaps enclosed within a sealed gap assembly housing, a plurality of other arrester elements, said sparkgap assembly and said other arrester elements arranged in one or more columns within said outer housing, and the free space within said outer housing exteriorly of said sealed gap assembly housing including a gas composed principally of sulfur hexafluoride.

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