Sept. 16, 1969 E. NASSER 3,467,936

LIGHTNING ARRESTOR AND METHOD OF USING THE SAME

Filed March 28, 1966 2 Sheets-Sheet 1

Fig. 1

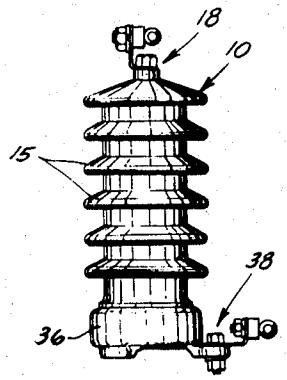
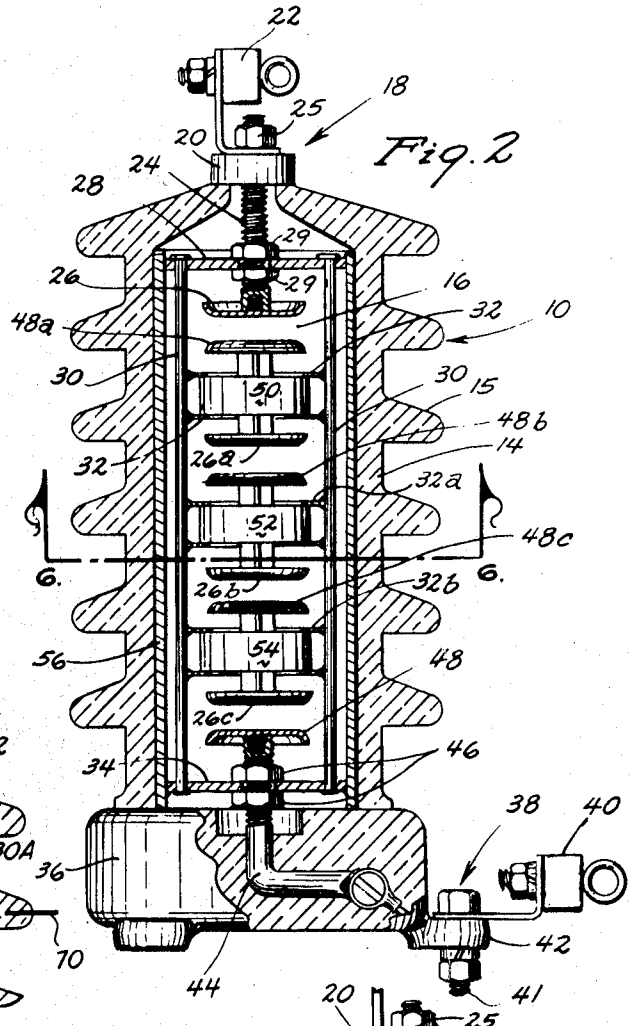


Fig. 2



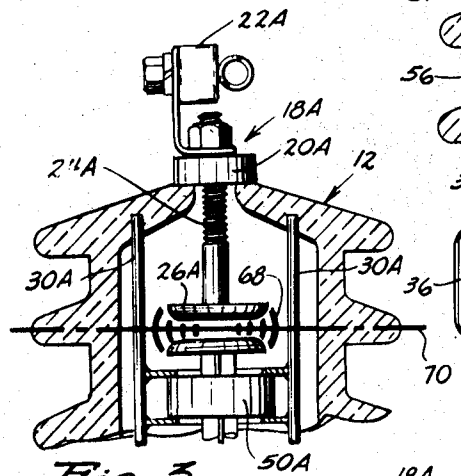


Fig. 3

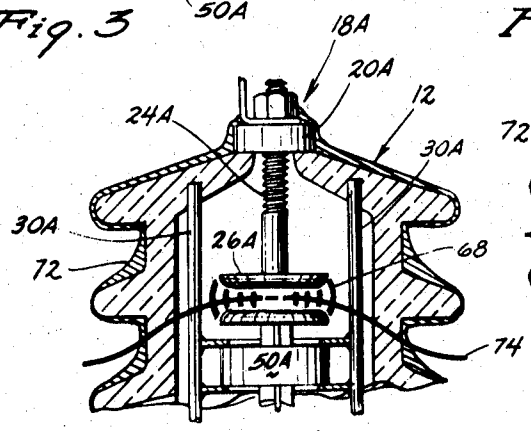


Fig. 4

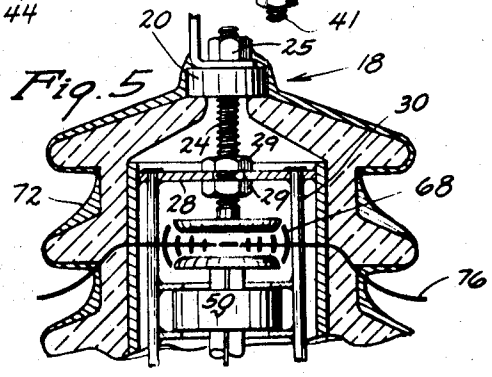


Fig. 5

INVENTOR.
ESSAM NASSER
BY
Dick, Zorby, McKee & Thomte
ATTORNEYS

Sept. 16, 1969 E. NASSER 3,467,936

LIGHTNING ARRESTOR AND METHOD OF USING THE SAME

Filed March 28, 1966 2 Sheets-Sheet 2

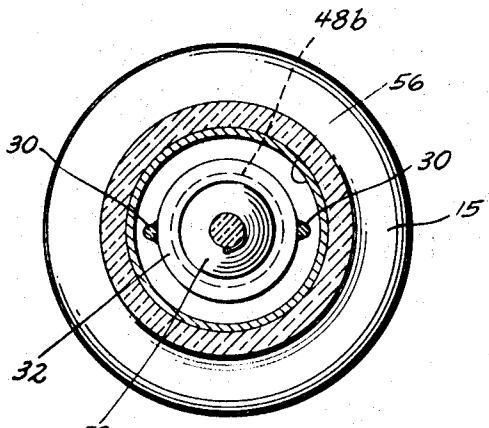


Fig. 6

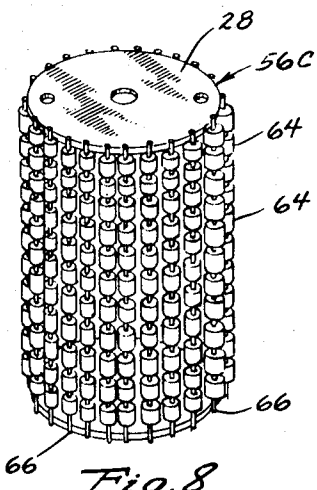


Fig. 8

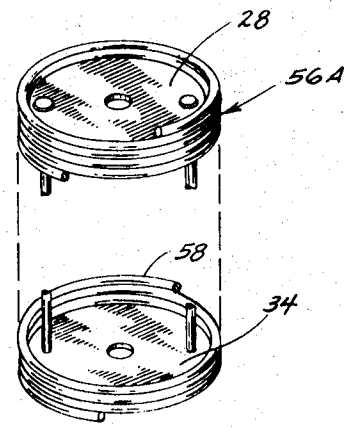


Fig. 7

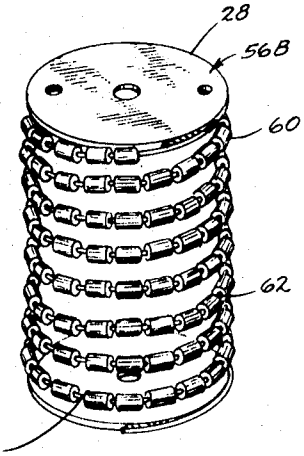


Fig. 9

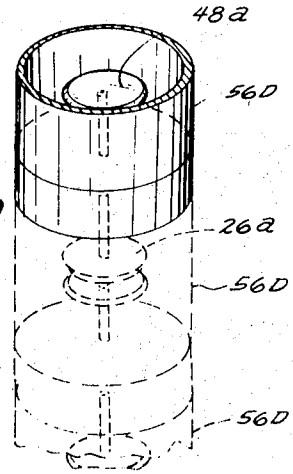


Fig. 10

INVENTOR.
ESSAM NASSER
BY
Dick, Zarley, McKee & Monte
ATTORNEYS

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LIGHTNING ARRESTOR AND METHOD OF USING THE SAME

Essam Nasser, Ames, Iowa, assignor to Iowa State University Research Foundation, Ames, Iowa, a corporation of Iowa

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Int. Cl. H01c 7/12
U.S. Cl. 338—21 14 Claims

ABSTRACT OF THE DISCLOSURE

A lighting arrestor for use with high potential lines having an insulative housing, a top terminal adapted to be connected to a source of high potential, a bottom terminal adapted to be connected to ground, a plurality of spaced apart electrodes located between said terminals, and a shield means of high electrical resistance and low electrical conductivity located in spaced relation around said electrodes and electrically connected to said terminals. The method of maintaining constant equipotential planes between electrodes in a lightning arrestor by passing a current of constant value through a high resistance element located in the area surrounding the space between such electrodes.

Lightning arrestors are used in transmission systems as protective devices against high-voltage surges caused by lightning. They are designed to be nonconductive below a certain maximum allowable voltage. As soon as the voltage exceeds this value, a sparkover will take place across accurately designed spark gaps making the arrestor conductive, and the excessive charge is conducted to ground. This voltage is known as the sparkover voltage and should never change in service. It is a function of a spark gap configuration and the electric field intensity at the electrodes.

However, conductive films or contaminants of different materials often are deposited on the outside of the porcelain housing of such arrestors. Such a conductive film is created when, for instance, fertilizer dust is deposited on the arrestor housing, and the dust becomes highly conductive when dew or the like causes it to become moist. Coal dust, residue from chemical manufacturing plants, and ocean salt are other kinds of contaminant that have a detrimental effect on lightning arrestors. The lightning arrestors consist of a number of air gaps connected in series with non-linear resistors, and such an arrestor is placed in a porcelain or glass housing or housings. The complete electric breakdown of air between electrodes which are separated by the air gaps depends only on the electric field intensity and its variation along the gap, provided all other factors such as gas pressure, external radiation and impurities remain unchanged. The sparkover voltage of an arrestor will therefore, only be affected if the electric field intensity within the gap is changed. The conductive contaminant on the surface of the arrestor can lower its sparkover voltage only by changing the field intensity at one or more locations of the air gaps. The conductive contaminant on the outside of the housing changes the shape and location of equal potential surfaces between the electrodes. For instance, if the contaminant is electrically connected to the potential of the line, it tends to move this equal potential plane downward as the equipotential surface seeks points of the same potential as the contaminant on the outside. The bending of this equipotential surface by the contaminant creates areas of higher field intensity between the electrodes in the air gaps, and sparks may take place within these areas of high field intensity.

The conductive contaminant not only reduces the sparking voltage by deformation of the electric field between the gap electrodes, but the sparking voltage can also be reduced through the contaminant creating a nonuniform voltage distribution between units. Either cause may lead to the breakdown of one single gap or more, at service voltages, and this can persist for hours. This is accompanied by corona discharges within the arrestor which may lead to the complete deterioration of the unit insulation and to failure of the arrestor.

It is therefore a principal object of this invention to provide a lightning arrestor which can resist the adverse affects of a conductive contaminant on the outside surface thereof, and which can maintain the predetermined and desired configuration of the equipotential surfaces and electric field lines between electrodes even when such contaminant is present.

A further object of this invention is to provide a lightning arrestor which is economical of manufacture, durable in use, and versatile in application.

These and other objects will be apparent to those skilled in the art.

This invention consists in the construction, arrangements, and combination of the various parts of the device, whereby the objects contemplated are attained as hereinafter more fully set forth, specifically pointed out in the claims, and illustrated in the accompanying drawings, in which:

FIG. 1 is a side elevational view of the lightning arrestor of this invention;

FIG. 2 is a partial sectional view at an enlarged scale of the simplified device shown in FIG. 1;

FIG. 3 is a partial sectional view through a conventional simplified lightning arrestor which has no contaminant on the outer surface thereof. This figure illustrates the electric field lines and equipotential surfaces which should exist between the electrodes of a lightning arrestor;

FIG. 4 is a partial sectional view of a conventional arrestor of the type shown in FIG. 3, but with a contaminant film on the outer surface thereof. This figure illustrates the deformation in the equipotential surface which is caused by the contaminant and which leads to a reduction of the sparkover voltage;

FIG. 5 is a partial sectional view of the device of this invention and is identical to the upper portion of FIG. 2, but this figure illustrates the condition of the equipotential lines of the arrestor of this invention when a contaminant film does exist on the outer surface of the arrestor housing;

FIG. 6 is a sectional view of the device of this invention taken on lines **6—6** of FIG. 2;

FIG. 7 is a perspective view of an alternate form of shield used within the housing of the arrestor of this invention;

FIG. 8 is a perspective view of a second alternate form of shield which is also used within the housing of the arrestor of this invention;

FIG. 9 is a perspective view of even a third alternate form of shield which is used within the arrestor housing as an alternate to the shields shown in FIGS. 2, 7 and 8; and

FIG. 10 illustrates a fourth alternate form of shield similar to that of FIGURE 2 but being comprised of a plurality of sections.

The numeral **10** generally designates the arrestor of this invention and the numeral **12** designates a conventional arrestor. The arrestor **10** includes a conventional housing **14** of porcelain, glass or the like with a plurality of spaced apart ribs **15** which extend laterally outwardly from the body of the housing. The housing **14** is generally hollow to create an inner compartment **16**. A terminal

means **18** is positioned on the upper end of housing **14** and includes a terminal cap **20** which can be positioned on a suitable shoulder (not shown) on the upper end of the housing. Terminal connecting element **22** is secured to the upper end of threaded shaft **24** which extends through terminal cap **20**. Nut **25** on the upper end of shaft **24** serves to interconnect the cap **20**, the connecting element **22**, and the shaft **24**. The lower end of shaft **24** extends downwardly through a suitable opening in the top of housing **14** and terminates in a conventional cup-shaped electrode **26**. An electro-conducting cap **28** is mounted on shaft **24** intermediate its length by the two nuts **26**. Rods **30** of nonelectro-conducting material have their upper ends secured to the upper electro-conducting cap **28**. A plurality of spaced apart pairs of washers **32**, **32A** and **32B** are secured in any convenient fashion between the rods **30**. An electro-conducting cap **34** identical to the upper cap **28** is secured to the lower ends of rods **30**.

A base **36** of housing **14** is also comprised of glass or porcelain material and serves to close the lower end of compartment **16**. A ground terminal means **38** is secured to base **14** and includes a ground terminal element **40** which is secured to terminal bracket **42** by means of nut and bolt assembly **41**. An L-shaped threaded shaft **44** is imbedded in base **36**, and the upper threaded end of shaft **44** extends through the lower cap **34**. Nuts **46** serve to connect the threaded shaft to the cap **34**. The upper end of shaft **44** terminates in a conventional cup-shaped electrode **48**.

Non-linear resistors **50**, **52** and **54** are supported in pairs of washers **32**, **32A** and **32B**, respectively. Cup-shaped electrodes **48A** and **26A** are supported by and interconnected through resistor **50**; electrodes **48B** and **26B** are similarly connected through resistor **52**; and electrodes **48C** and **26C** are similarly connected through resistor **54**.

A cylindrical shield **56** of adequately high electrical resistance covers the entire side wall area of the compartment **16** so as to surround all of the aforementioned electrodes. Shield **56** can be comprised of carbon or similar materials of high electrical resistance, and it can be either prefabricated and inserted into compartment **16** in the fabrication of the arrestor, or it can be coated or painted on the walls of compartment **16** without being prefabricated. Carbon has the further characteristic of having low electrical conductivity.

An alternate shield **56A** is shown in FIG. 7. Shield **56A** is comprised of a helical wire **58** of high electrical resistance. Wire **58** is electrically connected to the upper cap **28** and the lower cap **34**. The helical turns of wire **58** should be as close as possible to each other, or at least much smaller than the distance between opposing pairs of electrodes, such as the electrodes **26** and **48A**, for example.

A further shield **56B** is shown in FIG. 9 and is comprised of a chain of helically disposed resistors **60** which are disposed upon a helical electrode **62**. Again, the helical coils of electrode **62** should be as close as possible to each other, or at least much smaller than the distance between opposing electrodes. The opposite ends of the electrode **62** are electrically secured to the caps **28** and **34**.

A further shield **56C** is illustrated in FIG. 8. Shield **56C** utilizes a plurality of vertically disposed electrodes **66** which have their opposite ends electrically connected to caps **28** and **34**. A plurality of resistors **64** are electrically connected to each of the electrodes **66**. The resistors **60** and **64** in shields **56B** and **56C**, respectively, should be of equal value in each arrestor so as to form a uniform resistance gradient from cap **28** to cap **34**.

It should be understood that the shields **56**, **56A**, **56B** and **56C** would assume the precise position of shield **56** as illustrated in FIG. 2 so as to completely surround the electrodes within the compartment **16**. They can also be subdivided into partial shields with each one surrounding a spark gap. The electrically connected partial shields **56D** are shown in FIG. 10.

The essential difference between the arrestor **10** of this invention and the conventional arrestor **12** of FIGS. 3 and 4 is that the conventional arrestor does not utilize any type of shield within the compartment **16** to surround the electrodes, nor does the conventional arrestor utilize the electro-conducting caps **28** and **34** to electrically connect the upper and lower ends of the shield to the upper and lower terminal means, respectively. The components of the conventional arrestor **12** in FIGS. 3 and 4 which are common to the components of the arrestor of this invention as previously described have been given the same reference numerals as those numerals assigned to the same components in the arrestor **10**, except that the letter A has been added thereto.

The numeral **68** has been used in FIGS. 3, 4 and 5 to designate the electric field lines between opposing electrodes in both the conventional arrestor **12** and the arrestor **10** of this invention. Under ideal conditions with no contaminant on the outside of the arrestor housing, the equipotential line between opposing electrodes should assume the straight position shown by the equipotential lines **70** in the noncontaminated conventional arrestor shown in FIG. 3. Thus, under these circumstances, the equipotential surfaces are horizontal planes when no conductive contamination is present at the surface of the arrestor since the surface does not have any specific potentials. However, when a contaminant of adequate conductivity is present, such as the contaminants **72** shown in FIG. 4, various points of the outer surface of the arrestor assume different potentials. Since the contaminant **72** is in electrical contact with the upper terminal means **18** of high electrical potential, the equipotential surfaces between electrodes are bent downwardly as these planes of equipotential seek points of the same potential on the contaminant on the outside of the arrestor. The bending of the equipotential surfaces by the contaminant create areas of high electrical field intensity between the electrodes, as illustrated by the curved equipotential line **74** in FIG. 4, and sparkover at lower voltage values take place in these areas of high field intensity.

When the shields **56**, **56A**, **56B**, or **56C** are used to surround the electrodes of the arrestor, as shown in FIGS. 2 and 5, the contaminant is prevented from having an adverse affect on the equipotential surfaces. A current of constant value flows through the shield being used at all times, and this circuit is completed from the upper terminal means to the upper cap **28**, thence through the shield being used, thence the lower cap **34**, and thence to an electrical ground through the lower terminal means **38**. The equipotential surfaces within the spark gaps between opposing electrodes will retain their configuration regardless of all potential distortions created by a contaminant on the outer surface of the arrestor housing. Similarly, the field lines between opposing electrodes will also retain their configuration without interference. The sparkover voltage will therefore remain constant and will allow for the designed protection to take place only when a voltage surge of adequate value appears on the arrestor terminals.

Therefore, from the foregoing, it is seen that by placing a shield of high electrical resistivity around the electrodes of a lightning arrestor, distortion of the equipotential surfaces between electrodes by an electroconductive contaminant on the outside of the arrestor is prevented. This in turn eliminates the creation of areas of high field intensity between the electrodes, which in turn prevents sparkover between the electrodes at lower and undesirable voltages. The device of this invention is therefore seen to accomplish at least all of its stated objectives.

Some changes may be made in the construction and arrangement of my lightning arrestor without departing from the real spirit and purpose of my invention, and it is my intention to cover by my claims, any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope.

I claim:

1. In a lightning arrestor,
an elongated housing of insulative material and having a hollow interior,
a first conductive means in one end of said housing and being adapted for electrical connection to a high potential source,
a second conductive means in the other end of said housing and adapted to be connected to an electrical ground,
at least a pair of spaced electrodes mounted within said housing between said first and second conductive means and defining a space therebetween,
and an electro-conductive shield means of high electrical resistance and low electrical conductivity within said housing extending completely around the space between said electrodes in spaced condition with said electrodes, said electro-conductive means being in electrical contact with said first and second conductive means so that when an electrical current is passed through said cylindrical electro-conductive means when said first conductive means is connected to a high potential source, the equipotential planes in between said electrodes will remain constant and will avoid distortion by an accumulation of any electro-conductive material on the outside of said housing.

2. The device of claim 1 wherein said electro-conductive shield means is disposed adjacent the inner walls of the interior of said housing.

3. The device of claim 1 wherein said electro-conductive shield means is comprised of carbon material of high resistivity.

4. The device of claim 1 wherein said electro-conductive shield means is a coating material on the inner walls of the interior of said housing.

5. The device of claim 1 wherein said electro-conductive shield means is a prefabricated hollow cylinder.

6. The device of claim 1 wherein said electro-conducting shield means is an elongated resistance wire disposed in a helix in spaced relation around said electrodes, said helix comprised of a plurality of convolutions tightly and closely wound on each other to present a continuous cylindrical shield comprised of helically wound wire.

7. The device of claim 1 wherein said electro-conducting shield means is an elongated wire disposed in a helix in spaced relation around said electrodes, with a plurality of resistors on said wire.

8. The device of claim 1 wherein said electro-conducting shield means is an elongated wire disposed in a helix in spaced relation around said electrodes, with a plurality of resistors of equal electrical resistance on said wire.

9. The device of claim 1 wherein said electro-conducting shield means includes a plurality of substantially parallel spaced apart electro-conducting elements with a plurality of resistors electrically connected to each of said electro-conducting elements.

10. The device of claim 1 wherein said electro conducting shield means includes a plurality of substantially parallel spaced apart electro-conducting elements with a plurality of resistors of equal electrical resistance electrically connected to each of said electro-conducting elements.

11. The device of claim 6 wherein the distance between the adjacent convolutions of said helically disposed wire is less than the distance between said electrodes.

12. The device of claim 7 wherein the distance between the adjacent convolutions of said helically disposed wire is less than the distance between said electrodes.

13. The device of claim 1 wherein a plurality of pairs of spaced electrodes are mounted within said housing, and said shield means includes separate shield elements extending around each pair of electrodes.

14. The method of stabilizing the sparkover potential of a lightning arrestor in contact with a source of high potential and having an elongated arrestor housing of insulative material and having a hollow interior, a first conductive means on one end of said housing and in electrical connection with a high potential source, and a second conductive means on the other end of said housing and in connection with an electrical ground, and at least two spaced apart electrodes mounted within said housing between said first and second conductive means and defining a space therebetween; comprising, placing an electro-conductive shield means of high electrical resistance within said housing completely around the space between said electrodes and in spaced condition with respect to said electrodes, passing a constant current through said cylindrical electro-conductive means to stabilize the intensity of the electric field between said spaced electrodes to prevent deviations in said electric fields that might be created by the presence of an electro-conductive contaminant on the outside of said arrestor housing.

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REUBEN EPSTEIN, Primary Examiner

U.S. Cl. X.R.

313—333; 317—2, 61