United States Patent

Nagai et al.

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[54] LIGHTNING ARRESTER

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.**.....**317/68,** 315/36, 317/70
[51] **Int. Cl.**.....**H02h 9/06**
[58] **Field of Search**.....317/70, 61, 68; 313/DIG. 5; 315/36

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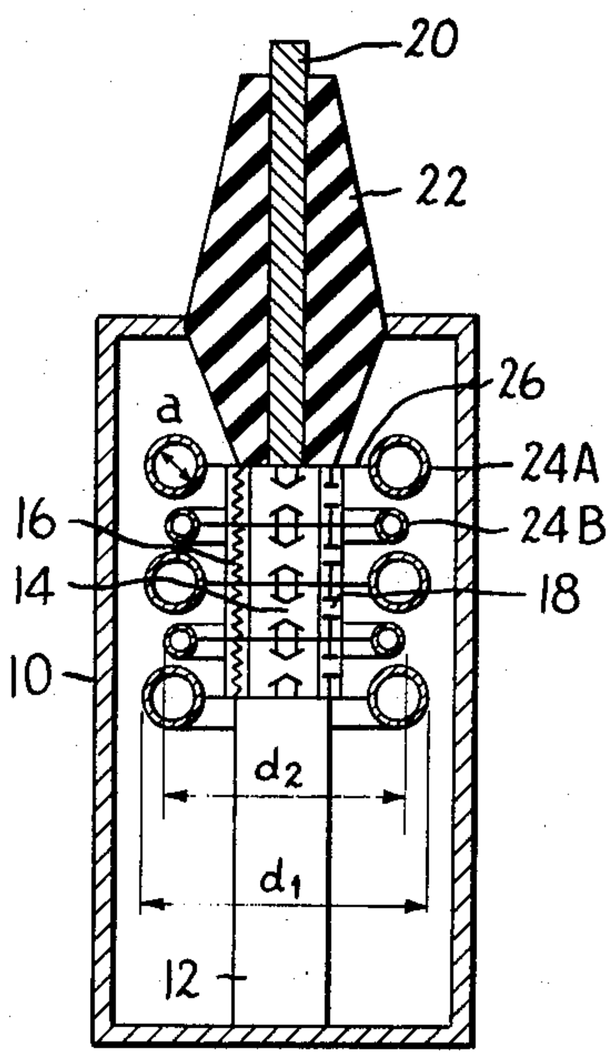
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[57] **ABSTRACT**

Serially connected discharging gaps are shunted by resistors and capacitors and disposed between a characteristic element and a line terminal within a grounded housing. At least one shielding ring encloses each gap and includes a disc connected to one end of an electrode forming each gap.

8 Claims, 4 Drawing Figures



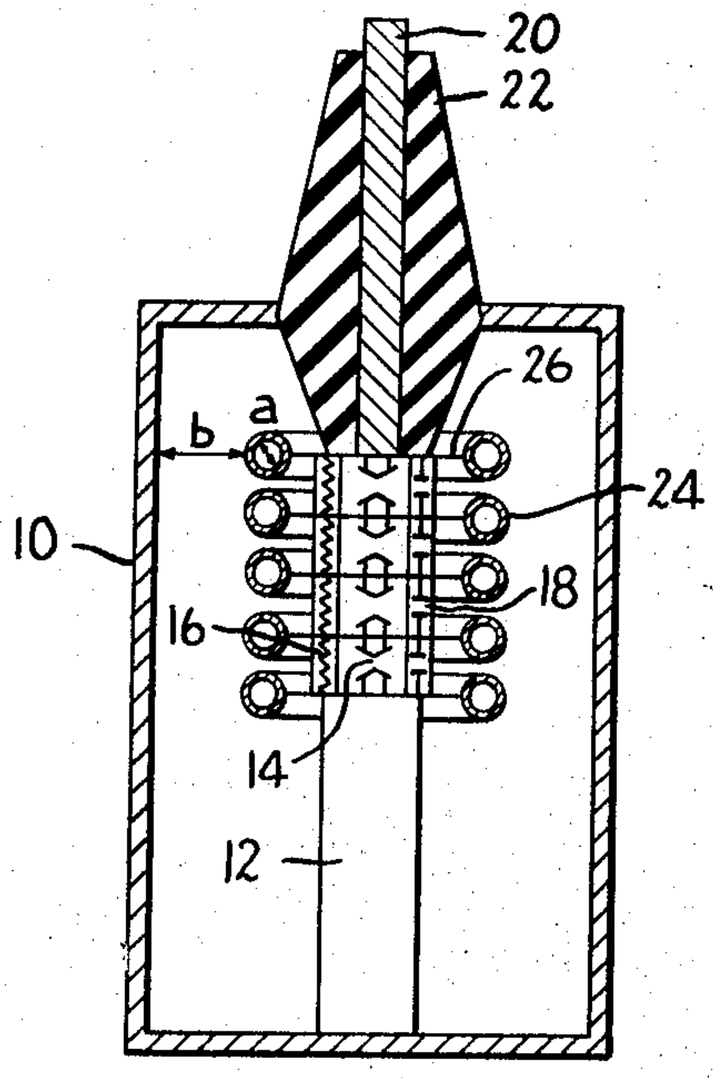


FIG. 1

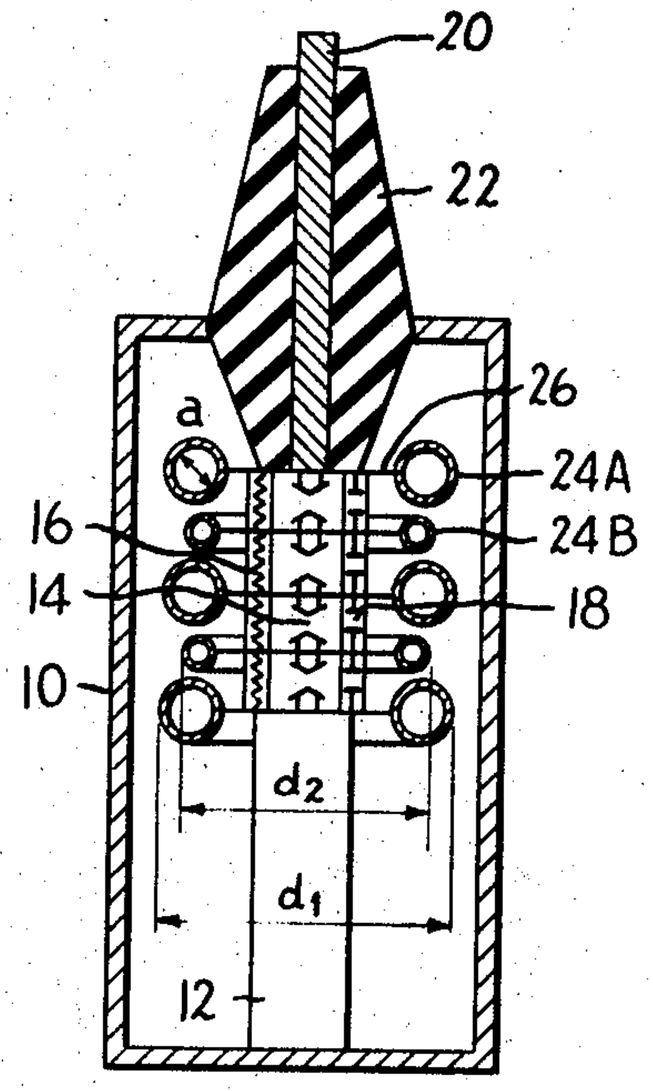


FIG. 2

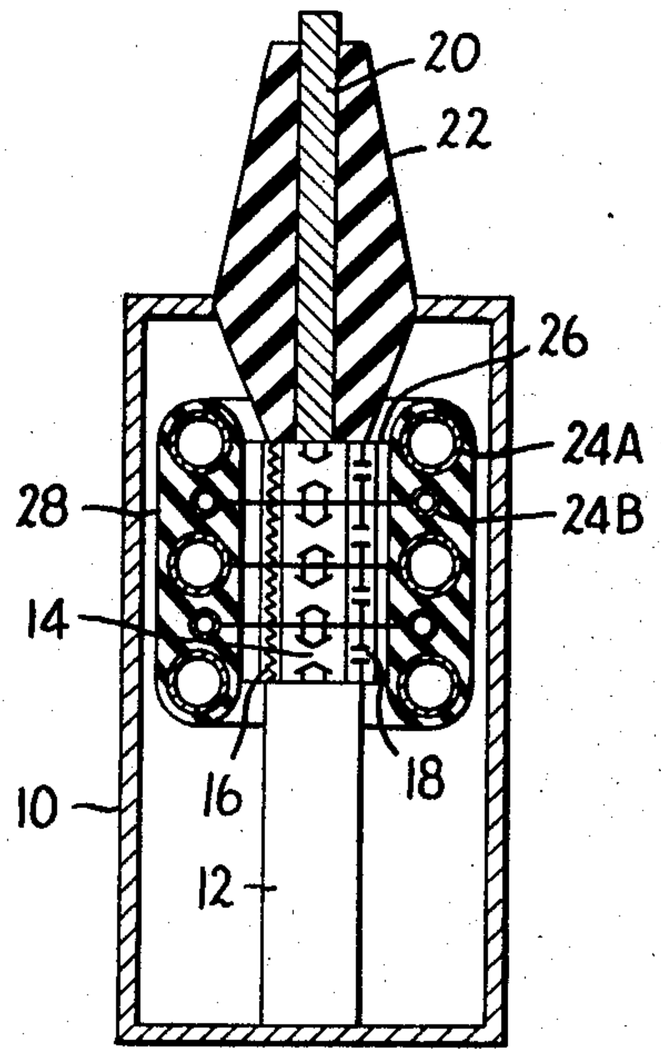


FIG. 3

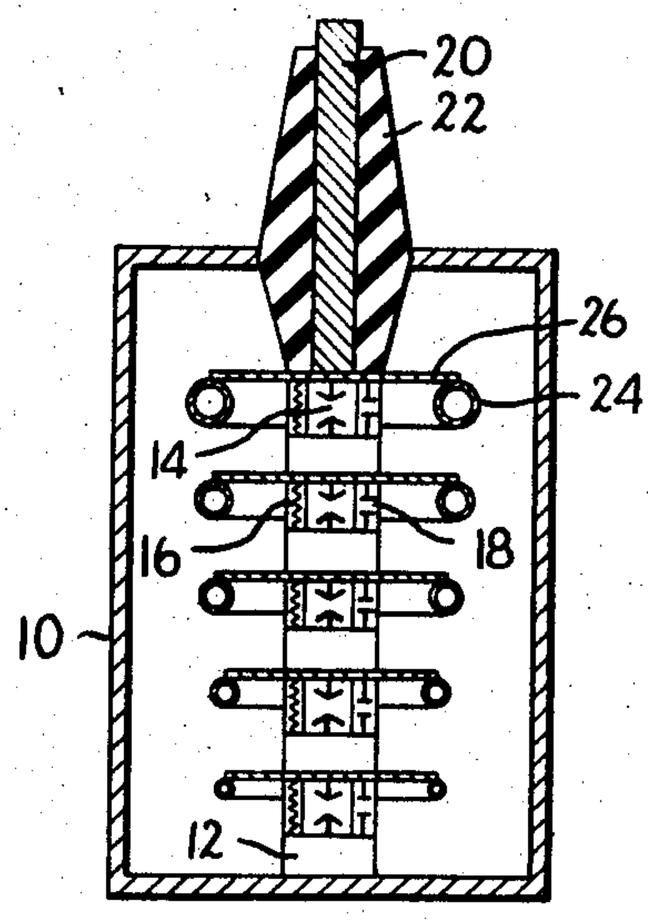


FIG. 4

LIGHTNING ARRESTER

BACKGROUND OF THE INVENTION

This invention relates to improvements in a lightning arrester including an arrester element disposed within a grounded housing.

There have been already known lightning arresters of the type including an arrester element disposed within a grounded housing filled with an electrically negative gas such as sulfur hexafluoride (SF_6) for the purpose of safely effecting the maintenance and inspection thereof. Such lightning arresters have included voltage dividing elements consisting of resistors and capacitors in order to uniformly distribute any electric surge across discharging gaps involved. The surface of the voltage-dividing element is affected by a potential due to the grounded housing to cause the equipotential lines to obliquely penetrated into the surface of the element. This causes a decrease in voltage with which a corona discharge is initiated and also a decrease in withstand-test voltage required between the voltage-dividing element and the grounded housing. Although the voltage-dividing element can increase in longitudinal dimension to increase the withstand-test voltage required between the same and the grounded housing this measure is undesirable in that the resulting lightning arrester increases in overall dimension.

SUMMARY OF THE INVENTION

Accordingly it is an object of the invention to provide a new and improved lightning arrester increased in withstand-test voltage required between a voltage-dividing element involved and a grounded housing for the arrester while making it difficult to cause any corona discharge along the surface of the voltage-dividing element.

It is another object of the invention to provide a new and improved lightning arrester including a minimum number of voltage-dividing elements for controlling the electric discharge characteristics thereof.

The invention accomplishes these objects by the provision of a lightning arrester comprising a grounded housing and an arrester element disposed in the grounded housing characterized by a plurality of shielding rings for encircling the arrester element.

The adjacent shielding rings may be preferably different from each other in dimension of an electrical conductor forming the ring.

Advantageously at least one of a diameter of the electrical conductor forming the shielding ring and the outside diameter of the shielding ring may progressively decrease from the side of the application of voltage toward the grounded side.

BRIEF DESCRIPTION OF THE DRAWING

The invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawing in which:

FIG. 1 is a schematic longitudinal sectional view of a lightning arrester constructed in accordance with the principles of the invention; and

FIGS. 2, 3 and 4 are views similar to FIG. 1 but illustrating different modifications of the invention.

Throughout the Figures like reference numerals designate the corresponding or similar components.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawing and FIG. 1 in particular it is seen that an arrangement disclosed herein comprises a grounded housing **10** filled with any suitable electrically negative gas high in electrically insulating property, for example, sulfer hexafluoride (SF_6), a characteristic element **12** disposed on the bottom of the housing **10**, and a discharging gap unit **14** disposed on the characteristic element **12**. The characteristic element **12** comprises a nonlinear resistor formed essentially of silicon carbide (SiC). Even if high electric surges resulting

from lightning strokes reach the characteristic element to cause flows of high current therethrough the element is operative to limit a voltage across the associated lightning arrester to a low magnitude while decreasing a current continuously flowing from the associated source of electric power into the arrester after the discharge of the surges to a magnitude sufficient to be readily interrupted by the discharging gap unit **14**. The discharging gap unit includes a plurality of discharging gaps interconnected in series circuit relationship. Each gap has connected thereacross a resistor **16** and a capacitor **18** forming a voltage-dividing element for the discharging gap unit. Both end gaps of the unit **14** are connected respectively to the characteristic element **12** and a line terminal **20** extending through the surface of the grounded housing **10** and hermetically surrounded by an electric insulation **22** sealed through that top surface.

The voltage-dividing element formed of the resistors and capacitors **16** and **18** respectively is effective for uniformly distributing electric surges resulting, for example, from lightning strokes across the discharging gaps but the surface thereof are affected by a potential due to the grounded housing **10** so that equipotential lines are obliquely penetrated into the surface of the voltage-dividing element. This leads to a decrease in a voltage with which a corona discharge is initiated along the surface of the voltage-dividing element and/or a decrease in a withstand-test voltage required between the voltage-dividing element **16–18** and the grounded housing **10**. If it is desired to increase that withstand-test voltage, the voltage-dividing element should increase in longitudinal dimension. This results in a disadvantageous increase in the overall dimension of the lightning arrester.

According to one aspect of the invention, those disadvantages are climinated by the use of a plurality of shielding rings disposed outside the voltage-dividing element and around the discharging gap unit and therefore around an arrester element formed of the voltage-dividing element and the discharging gap unit. More specifically, as shown in FIG. **1**, a plurality of shielding rings **24** are disposed in axially aligned, spaced relationship outside and slightly spaced away from the voltage-dividing element **16–18** while they encircle the discharging gap unit **14**. The shielding rings **24** are of the same construction and the same dimension. Each of the shielding rings **24** comprises a length of circular, electrically conductive pipe bent into a closed circle and an electrically conductive disc **26** connected at the outer periphery to the inner periphery thereof in the central plane. The disc **26** is sandwiched on the central portion between each pair of adjacent electrodes forming the discharge gaps except for both end discs **26** having the central portions sandwiched between the line terminal **20** and the adjacent electrode and between the characteristic element **12** and the adjacent electrode respectively. Thus the disc **26** and therefore the shielding ring **24** is maintained at the same potential as the gap electrode connected thereto. In FIG. **1** the four discharging gaps and the five shielding rings **24** are shown so that each discharge gap is operatively coupled to at least one shielding ring.

The shielding ring and disc **24** and **26** respectively permit the equipotential lines to be penerated substantially perpendicularly into the surface of the voltage-dividing element **16–18** to establish a desirable electric field around that element. This makes it difficult to cause a corona discharge along the surface of the voltage-dividing element **16–18** while much increasing a withstand-test voltage required between the voltage-dividing element and the grounded housing. This results in a small-sized lightning arrester.

For lightning arresters including the shielding rings as above described the withstand-test voltage required between the shielding rings and the grounded housing is one of the important factors for determining the capability of the arrester. It has been found that the larger the diameter "*a*" (see FIG. **1**) of the circular conductor or the metallic pipe forming the ring **24** the more the established electric field will be alleviated and therefore the higher the withstand-test voltage.

In the arrangement of FIG. 1 the diameter "*a*" of the ring's pipe can not sufficiently increase because the rings **24** are axially close to one another. As a result it is required to increase a distance between the grounded housing **10** and each of the shielding rings **24** designated by reference character "*b*" representing a minimum spacing therebetween, for the purpose of increasing the withstand-test voltage required therebetween. This inevitably leads to an increase in lateral dimension of the arrester.

This increase in lateral dimension of the arrester can be avoided by an arrangement as shown in FIG. 2. As shown, a plurality of larger shielding rings **24A** formed of an electrically conductive pipe of larger diameter "*a*" alternate smaller shielding rings **24B** formed of a conductive pipe of smaller diameter. The rings **24A** and B have the outside diameters of d_1 and d_2 respectively while they are substantially equal in inside diameter. In other respects the arrangement is identical to that shown in FIG. **1**.

Since the alternating rings **24A** are of a larger diameter "*a*," the withstand-test voltage required between the rings **24** and the grounded housing **10** can be sufficiently high even for the housing small in lateral dimension. Further a voltage applied across each of the discharging gaps can be controlled by varying the diameters of the pipes forming the rings with the magnitudes of the voltage-dividing resistors and capacitors remaining unchanged. Therefore the resulting arrester is possible to be improved in discharge characteristics.

FIG. **3** shows a modification of the arrangement illustrated in FIG. **2**. The arrangement of FIG. **3** is different from that illustrated in FIG. **2** only in that, in FIG. **3**, the shielding rings **24A** and B are embedded in any suitable electrically insulating material **28** such as an expoxide resin into a unitary structure. This measure causes an increase in withstand voltage required between each pair of adjacent rings to permit a further increase in diameter of the pipe for the larger ring **24A** and therefore a further increase in withstand-test voltage required between the rings **24** and the housing **10**.

FIG. **4** illustrates another modification of the invention. As shown in FIG. **4** the discharging gaps **14** alternate the characteristic elements **12** and have operative coupled thereto the respective shielding rings **24** one for each gap. The rings **24** are formed of electrically conductive pipes progressively decreased in diameter from the upper side as viewed in FIG. **4** or the side of the application of voltage toward the lower side or the grounded side. It is seen that the rings **24** have respective outside progressively decreased from the upper side to the lower side while the inside diameters thereof remain substantially unchanged. The shielding rings **24** each have the conductive disc **26** connected at the outer periphery to the upper end thereof and sandwiched on the central portion between the associated electrode for gap and the adjacent characteristic element.

The shielding rings **24** as shown in FIG. **4** serve to progressively decrease the stray capacitances between the same and the grounded housing **10** as the rings is near to the grounded side with the result that any electric surge is allowed to be more uniformly distributed across the discharging gaps **14**. Therefore the arrangement of FIG. **4** is advantageous in that the discharge characteristics can be controlled without the necessity of increasing the number of the voltage-dividing elements.

If desired, only one of the pipe's diameter and the outside diameter of the ring may changed in the manner as above described.

What is claimed is:

1. A lightning arrester comprising a grounded housing, a plurality of gap units serially disposed within said grounded housing and defining gaps between successive gap units, voltage-dividing means interconnecting said gap units and a shielding ring encircling and disposed radially outwardly of each said gap unit, and means electrically connecting each said shielding ring with the respective gap unit.

2. A lightning arrester as claimed in claim **1** wherein the adjacent shielding rings are different from each other in diameter of an electrical conductor forming the ring.

3. A lightning arrester as claimed in claim **1** wherein said shielding rings are embedded in an electric insulation.

4. A lightning arrester as claimed in claim **1** wherein at least one of a diameter of an electrical conductor forming said shielding ring and the outside diameter of the said shielding ring progressively decreases from the side of the application of voltage toward the grounded side.

5. A lightning arrestor as claimed in claim **1**, wherein said shielding rings are formed of tubular conductors.

6. A lightning arrestor as claimed in claim **1**, wherein each said shielding ring comprises a toroidal member and said connecting means comprises a disc extending out from said gap unit and united at its periphery with said toroidal member.

7. A lightning arrestor as claimed in claim **6**, wherein said disc is tangential to said annular member.

8. A lightning arrestor as claimed in claim **1**, wherein a resistor and a capacitor are connected in parallel with one another across each gap.

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