

LIGHTNING PROTECTION FACILITY

TECHNICAL FIELD

[0001]

The present invention relates to a lightning protection facility that dissipates ions into the air to decrease an electric field in the air for protecting a structure from lightning strokes and, more particularly, it relates to a charge dissipater of such a lightning protection facility.

BACKGROUND ART

[0002]

The proximity of an electrically charged thundercloud causes an electric field to be generated between the thundercloud and the ground. The electric field intensity grows gradually until causing an electric breakdown in the air to generate an electric discharge between the thundercloud and the earth's surface. This is a lightning stroke. There have been known lightning protection facilities each having a charge dissipater (also referred to as an ion dissipater or an ionizer) installed on or around a structure (a building or the like) to be protected from lightning strokes and constructed to dissipate, into the air, ions of an opposite polarity to that of a lower part of the thundercloud to decrease an electric field generated over the structure and thereby delay occurrences of the lightning strokes (see Patent Documents 1 and 2).

[0003]

Examples of conventional charge dissipaters include umbrella-shaped charge dissipaters, ball-shaped charge dissipaters, and dissipation wires. Such dissipaters make use of a point discharge phenomenon, which is a natural phenomenon, at a time of

a thunder stroke in order to dissipate charges induced at a structure to be protected, the ground or the like for decreasing the electric field, thus preventing abrupt transfer of the charges and preventing damages due to direct lightning strokes.

RELATED ART DOCUMENT

PATENT DOCUMENTS

[0004]

Patent Document 1: Japanese Laid-Open Patent Application,

Publication No. S53-39450

Patent Document 2: US Patent No. 5043527

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005]

These charge dissipaters are composed of thin wires of small diameter, that is, protruding rods, however, and therefore there is a risk that these charge dissipaters may be damaged due to occurrences of self-induced vibrations when used in an environment in which swept areas of the charge dissipaters are increased by icing, snow accretion or the like or in an environment in which strong wind blows.

[0006]

Embodiments of the present invention seek to provide a lightning protection facility that can prevent damages due to self-induced vibrations.

MEANS TO SOLVE THE PROBLEM

[0007]

According to an aspect of the present invention, there is provided a lightning protection facility comprising:

a pole erected on a structure or on the ground;

a plurality of needle-like conductive objects disposed on a tip of the pole and extending radially therefrom;

a reinforcement member disposed to cross two or more of the plurality of needle-like conductive objects and fixed to the needle-like conductive objects; and a cylindrical-shaped tube through which base ends of the plurality of needle-like conductive objects are inserted, the base ends of the plurality of needle-like conductive objects being joined to the tip of the pole, the cylindrical-shaped tube covering a joint portion between the base ends of the plurality of needle-like conductive objects and the tip of the pole and having a tapered top end portion with an increasing diameter toward a top end of the cylindrical-shaped tube.

EFFECT OF THE INVENTION

[0008]

Embodiments of the present invention provide a lightning protection facility which, even when used in an environment in which swept areas of a plurality of needle-like conductive objects are increased by icing or the like or in an environment in which strong wind blows, can prevent damages of the needle-like conductive objects due to self-induced vibrations to stably contribute to preventing damages due to direct lightning strokes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a schematic diagram showing a lightning protection facility according to an embodiment of the present invention.

FIG. 2 is a diagram showing a charge dissipater viewed from above in FIG. 1.

FIG. 3 is a diagram showing a charge dissipater viewed laterally in FIG. 1.

FIG. 4 is a perspective diagram of a fastener shown in FIG. 3.

FIG. 5 is a diagram showing a state of a pole and a plurality of protruding rods just joined by thermite welding.

FIG. 6 is a partially broken enlarged diagram of a nugget and a wrapper tube of FIG. 5, viewed from an X direction.

FIG. 7 is a diagram showing a resin-coating region of the charge dissipater, the charge dissipater in FIG. 1 being viewed from a direction orthogonal to the axis of the pole.

FIG. 8 is a diagram showing the resin-coating region of the charge dissipater, the charge dissipater in FIG. 1 being viewed from a top end side of the pole.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0010]

Now, an embodiment of the present invention will be described with reference to the drawings. Like constructions will be denoted by like reference numerals and detailed descriptions thereof will be omitted.

[0011]

<Lightning protection facility>

First, a lightning protection facility according to an embodiment of the present invention will be described. FIG. 1 is a schematic diagram showing the lightning protection facility according to the embodiment of the present invention. As shown in FIG. 1, the lightning protection facility 1 according to the embodiment of the present invention is a facility for preventing a lightning stroke into a structure (for example, a building) S to be protected, and includes a plurality of charge dissipaters (also referred to as ion dissipaters or as ionizers) 10, an earth 20, and a conductive wire (for example, a stranded copper wire) 30. The plurality of charge dissipaters 10 are erected obliquely upward on the sidewalls of the structure S to be protected. A plurality of protruding rods 12 of each of the charge dissipaters 10 (see FIG. 2) are connected electrically to the earth 20 via the conductive wire 30.

[0012]

A negative electric field caused by the thundercloud grows to an extreme level at the tips of the protruding rods 12 (see FIG. 2) of each charge dissipater 10, causing the air to be ionized to generate positively charged ions, which are released into the air (a point discharge phenomenon or a so-called corona discharge). Since the charge dissipaters 10 are electrically connected via the earth 20 to the ground around the structure S to be protected, so that positive charges are supplied from the ground to the charge dissipaters 10, the charge dissipaters 10 continue dissipating positive ions from the protruding rods 12 as long as the thundercloud stays in the sky and thus there is a negative electric field generated. That is, what is assumed to be happening is that positive charges, accumulated in the ground around the earth 20, are transferred via the conductive wire 30 to the charge dissipaters 10 installed on the structure S to be protected, and then, those positive charges are dissipated from the charge dissipaters 10 as positive ions. While the charge dissipaters 10 are dissipating positive ions, the electric field intensity of a space over the charge dissipaters 10 is weakened, and a space having a relatively stronger electric field intensity becomes a path for lightning strokes. Therefore, the space around the charge dissipaters 10, which has a lower electric field intensity, is less likely to become a path for lightning strokes as compared to a space around which there are not provided those charge dissipaters 10, meaning that the lightning protection facility 1 is effective for lightning prevention.

[0013]

<Charge dissipater>

Now, description will be made of a structure of the charge dissipaters 10 according to the embodiment of the present invention. FIG. 2 is a diagram showing a charge dissipater viewed from above in FIG. 1, and FIG. 3 is a diagram showing a

charge dissipater viewed laterally in FIG. 1, FIG. 4 is a perspective diagram of a fastener shown in FIG. 3. FIG. 5 is a diagram showing a state of a pole and a plurality of protruding rods just joined by thermite welding. FIG. 6 is a partially broken enlarged diagram of a nugget and a wrapper tube in FIG. 5 viewed from an X direction. FIG. 7 is a diagram showing a resin-coating region of the charge dissipater, the charge dissipater in FIG. 1 being viewed from a direction orthogonal to the axis of the pole. FIG. 8 is a diagram showing the resin-coating region of the charge dissipater, the charge dissipater in FIG. 1 being viewed from a top end side of the pole.

[0014]

As shown in FIGS. 2 and 3, each charge dissipater 10 is a so-called ball-shaped charge dissipater, and includes: a pole 11, a plurality of protruding rods 12, a plurality of latitude-direction reinforcement members 13, a plurality of longitude-direction reinforcement members 14, and a plurality of fasteners 15. Note that, in FIG. 2, illustration of the plurality of fasteners 15 is omitted.

[0015]

The pole 11 is a rod-like member made of a metal (for example, an SUS steel), and has a base end secured to the structure S to be protected by a bracket, a bolt or the like.

[0016]

The plurality of protruding rods 12 are needle-like conductive objects disposed on a tip of the pole 11 and extending radially therefrom, with at least one of the protruding rods 12 pointing upward. In the embodiment, thirty two protruding rods 12, of a diameter of 2.6mm, made of an SUS steel extend radially to be distributed evenly in a hemisphere of an outer diameter of 1.2m centered around the tip of the pole 11.

[0017]

The plurality of latitude-direction reinforcement members 13 are ring-shaped conductive members of a metal (for example, an SUS steel), extending in a latitude direction of the hemisphere centered around the tip of the pole 11. Each latitude-direction reinforcement member 13 is secured to protruding rods 12 by fasteners 15 at places where it crosses these protruding rods 12. In the embodiment, four latitude-direction reinforcement members 13 with different radii are strung with spacing from one another.

[0018]

The plurality of longitude-direction reinforcement members 14 are conductive arc-shaped members of a metal (for example, an SUS steel), extending in a longitude direction of the hemisphere centered around the tip of the pole 11. Each longitude-direction reinforcement member 14 is secured to protruding rods 12 by fasteners 15 at places where it crosses these protruding rods 12. In the embodiment, two longitude-direction reinforcement members 14 are placed to cross each other at a right angle.

[0019]

As shown in FIG. 4, the plurality of fasteners 15 are conductive cross-shaped fasteners made of a metal (for example, an SUS steel), each of which is crimped to be fixed to a protruding rod 12 and a reinforcement member 13 or reinforcement member 14 (in FIG. 4, the latitude-direction reinforcement member 13) for securing the protruding rod 12 and the reinforcement member 13 or reinforcement member 14 to each other.

[0020]

As shown in FIG. 5 and FIG. 6, the charge dissipater 10 further includes a nugget 16 and a wrapper tube 17.

[0021]

The nugget 16 is a diameter enlarged portion formed by joining the tip of the pole 11 and the plurality of protruding rods 12 to each other by thermite welding.

[0022]

The wrapper tube 17 is a cylindrical-shaped member, made of a metal (for example, copper), through which base ends of the plurality of protruding rods 12 are inserted. The wrapper tube 17 has a tapered top end portion with an increasing diameter toward its top end.

[0023]

In addition, as shown in FIG. 7 and FIG. 8, sections, of the plurality of protruding rods 12, except for top ends thereof, the plurality of latitude-direction reinforcement members 13, the plurality of longitude-direction reinforcement members 14, the plurality of fasteners 15 and the wrapper tube 17 are covered with a resin coating and a water-repellent coating (a resin-coating region C of FIG. 7 and FIG. 8).

[0024]

<Method of manufacturing the charge dissipater>

Now, description will be made of a method of manufacturing a charge dissipater 10 of the embodiment of the present invention. First, as shown in FIG. 5 and FIG. 6, the tip of a pole 11 and the base ends of a plurality of tied protruding rods 12 are jointed to each other by thermite welding. That is, a pole 11 and a plurality of tied protruding rods 12 are placed into a resin mould with the tip of the pole 11 and the base ends of the plurality of tied protruding rods in contact with each other. A thermite

agent containing, for example, copper and tin powders is heated to be melt by gunpowder and poured into the contact portion, to allow the tip of the pole 11 and the base ends of the plurality of protruding rods 12 to be joined to each other by thermite welding and thereby form a nugget 16. After the formation of the nugget 16, the welded pole 11 and plurality of protruding rods 12 are taken out of the mould, followed by inserting the plurality of protruding rods 12 through a wrapper tube 17, and securing the base end of the wrapper tube 17 to the top end of the nugget 16 with an adhesive or the like.

[0025]

Subsequently, as shown in FIG. 7 and FIG. 8, a given number of protruding rods 12 are bent at their base end sides so as to be spread open at a given angle. Then, a latitude-direction reinforcement member 13 corresponding to the spread open protruding rods 12 is placed at a given position and secured to those protruding rods 12 by fasteners 15 at places where it crosses the protruding rods 12. These steps are repeated for all protruding rods 12 and all latitude-direction reinforcement members 13 in order, starting from protruding rods 12 to be bent at a greatest angle and from a latitude-direction reinforcement member 13 to be positioned closest to the pole 11.

[0026]

After all the protruding rods 12 have been spread open so as to extend radially and all the latitude-direction reinforcement members 13 have been secured to the protruding rods 12 by crimping the fasteners, a longitude-direction reinforcement member 14 is placed at a give position and secured to protruding rods 12 by fasteners 15 at places where it crosses those protruding rods 12. These steps are repeated for all longitude-direction reinforcement members 14.

[0027]

Fixing a latitude-direction reinforcement member 13 to a protruding rod 12 and a longitude-direction reinforcement member 14 to a protruding rod 12 is achieved as follows: a protruding rod 12 and a latitude-direction reinforcement member 13 (or a longitude-direction reinforcement member 14) crossing each other are accommodated into four grooves, which are arranged in a crisscross direction, of a cross-shaped fastener 15, and then the grooves of the fastener 15 are crimped using a jig (a special purpose pressing-device) to fix the protruding rod 12 and the reinforcement member 13 or 14 for securing the protruding rod 12 and the reinforcement member 13 or 14 to each other.

[0028]

Note that desirably, each of electrical connections of the reinforcement members 13 and 14 with the protruding rods 12 is made in such a manner as to provide only a low resistance, because dissipation current flow caused by the point discharge phenomenon is very feeble. In the embodiment, the cross-shaped metal fasteners are employed as the fasteners 15 to reduce contact resistances between pressing faces derived from the crimping.

[0029]

Then, a resin coating material is poured into the inside of the wrapper tube 17, and also, with a brush, the resin coating material is applied onto: sections, of the plurality of protruding rods 12, except for top ends thereof; the plurality of latitude-direction reinforcement members 13; the plurality of longitude-direction reinforcement members 14; the plurality of fasteners 15; and the wrapper tube 17, in order to create a resin coating thereon (a resin-coating region of FIG. 7 and FIG. 8). Incidentally, in the embodiment, a water-repellent coating is applied onto the resin

coating with a brush, to form the water-repellent coating.

[0030]

In the lightning protection facility 1 according to the embodiment of the present invention, the plurality of radially extending protruding rods 12 are secured to each other by the reinforcement members 13 and 14. Even when used in an environment in which swept areas thereof are increased by an icing phenomenon or the like phenomenon, or in an environment in which strong wind blows, therefore, the lightning protection facility 1 prevents damages of the charge dissipaters 10 due to self-induced vibrations and thereby stably contributes to preventing damages due to direct lightning strokes.

Also, in the lightning protection facility 1 according to the embodiment of the present invention, since the protruding rods 12 and the reinforcement members 13, 14 are fixed to each other by crimping the cross-shaped fasteners 15, contact resistances between the pressing faces are reduced.

Further, in the lightning protection facility 1 according to the embodiment of the present invention, since the pole 11 and the plurality of protruding rods 12 are joined to each other by thermite welding, fixing the plurality of protruding rods 12 to the pole is facilitated.

Furthermore, in the lightning protection facility 1 according to the embodiment of the present invention, since the plurality of protruding rods 12 are covered with the resin coating and the water-repellent coating, with the top ends of the plurality of protruding rods 12 exposed therefrom, the lightning protection facility 1 can ensure dissipation performance of the charge dissipaters 10, while preventing icing and snow accretion thereon as well as erosion thereof.

[0031]

In the above, the embodiment of the present invention has been described. The present invention, however, is not limited to the above embodiment, and changes and modifications can be made without departing from the scope of the invention. The number and the radiation direction of protruding rods 12 are not limited to those mentioned above. For example, one hundred twenty (120) protruding rods 12 may extend radially so as to be arranged evenly in a whole sphere, and any other construction may be possible as long as a plurality of protruding rods 12 extend radially and three-dimensionally. Further, the number of latitude-direction reinforcement members 13 and the number of longitude-direction reinforcement members 14 are not limited to those mentioned above. Also, a reinforcement member or members which are other than the latitude-direction reinforcement members 13 and the longitude-direction reinforcement members 14, may cross two or more protruding rods 12 and to be fixed thereto. Moreover, the protruding rods 12 and the reinforcement members 13, 14 may be fixed by: fasteners other than the cross-shaped fasteners; welding; bonding; or the like. Also, the charge dissipater 10 according to the present invention may be installed: on a side face of a tower of an umbrella-shaped charge dissipater; on a roof top of a building; on the ground around a small-sized facility; or the like. In addition, the reinforcement member(s) are not limited to those made of a conductive material. Also, any number of protruding rods 12 may be secured to one another by one reinforcement member as long as the number of protruding rods 12 is two or more.

Explanations of reference numerals

[0032]

- 1 lightning protection facility
- 10 charge dissipater
- 11 pole
- 12 protruding rod (needle-like conductive object)
- 13 latitude direction reinforcement member (reinforcement member)
- 14 longitude direction reinforcement member (reinforcement member)
- 15 fastener
- 16 nugget
- C resin-coating region
- S structure to be protected (structure)

CLAIMS

1. A lightning protection facility comprising:
 - a pole erected on a structure or on the ground;
 - a plurality of needle-like conductive objects disposed on a tip of the pole and extending radially therefrom;
 - a reinforcement member disposed to cross two or more of the plurality of needle-like conductive objects and fixed to the needle-like conductive objects; and
 - a cylindrical-shaped tube through which base ends of the plurality of needle-like conductive objects are inserted
 - the base ends of the plurality of needle-like conductive objects being joined to the tip of the pole,
 - the cylindrical-shaped tube covering a joint portion between the base ends of the plurality of needle-like conductive objects and the tip of the pole and having a tapered top end portion with an increasing diameter toward a top end of the cylindrical-shaped tube.
2. The lightning protection facility of Claim 1, further comprising fasteners crimped to be fixed to the needle-like conductive objects and the reinforcement member for securing the needle-like conductive objects and the reinforcement member to each other.
3. The lightning protection facility of Claim 1 or Claim 2, wherein the pole and the plurality of needle-like conductive objects are joined to each other by thermite

welding.

4. The lightning protection facility of Claim 1 or Claim 2, wherein the plurality of needle-like conductive objects are coated with a resin, with top ends of the plurality of needle-like conductive objects exposed therefrom.

5. The lightning protection facility of Claim 3, wherein the plurality of needle-like conductive objects are coated with a resin, with top ends of the plurality of

needle-like conductive objects exposed therefrom.