Feb. 2, 1960 F. X. REES 2,923,849

LIGHTNING ARRESTOR

Filed July 10, 1958

FIG. 1.

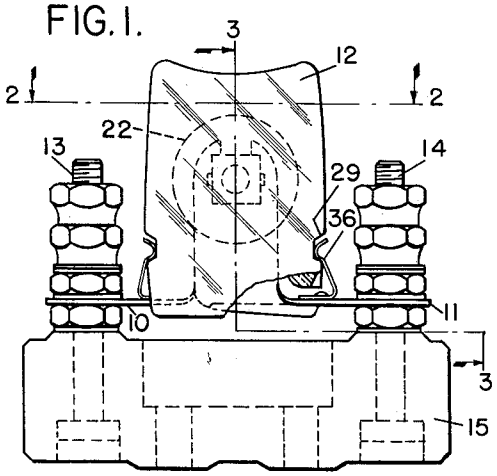


FIG. 2.

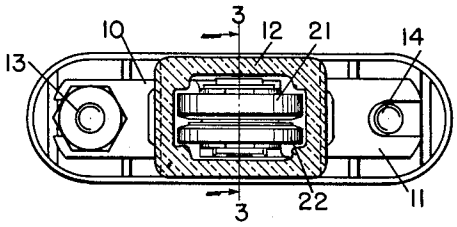


FIG. 3.

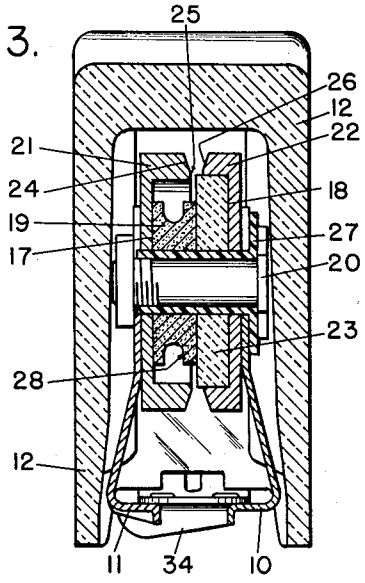


FIG. 4.

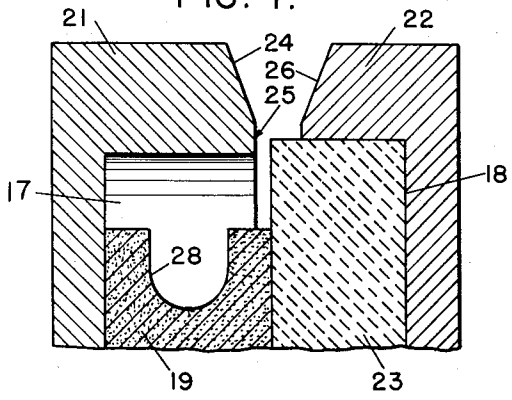


FIG. 5.

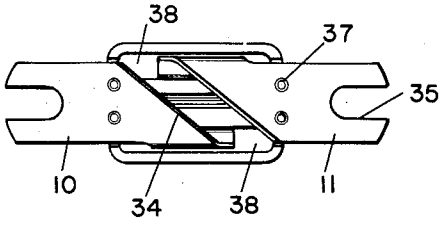
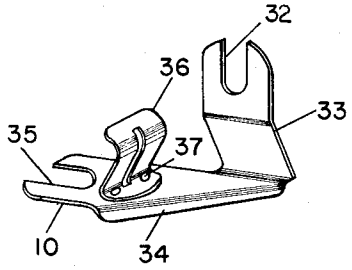


FIG. 6.



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LIGHTNING ARRESTOR

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17 Claims. (Cl. 313—311)

My invention relates to lightning arrestors.

One object of the present invention is the provision of a lightning arrestor structure which occupies a minimum of space, which is durable, which is economical to manufacture, and which at the same time is highly effective.

Another object of the present invention is the provision of a lightning arrestor structure which will effectively operate for numerous discharges encountered without burning the air-gap electrodes to thereby maintain the breakdown voltage at substantially the same value throughout its life.

Another object of the present invention is the provision of a lightning arrestor which has an air-gap structure inherently having an arc extinguishing characteristic which will minimize the time the lightning arrestor is subjected to the discharge current.

Another object of the present invention is the provision of a lightning arrestor having two metal electrodes forming a major air-gap, one of said metal electrodes having an adjacent auxiliary electrode of semiconductive material forming a minor air-gap with the other metal electrode which is effective to initially ionize said major air-gap at a relatively low critical potential to allow the main disruptive discharge to pass through such major air-gap between said metal electrodes.

Another object of the present invention is the provision of a lightning arrestor structure having a substantial confined internal air space between the metal electrodes to provide adequate internal compression of the air upon a disruptive discharge to tend to move ionized air outwardly from the base of the major air-gap to assist in the early extinguishing of that disruptive discharge.

Another object of the present invention is the provision of a lightning arrestor which is securely held in its mounting position requiring very little maintenance for an indefinite period of time.

Other objects, purposes and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference will be made to the accompanying drawings, in which like reference characters designate corresponding parts throughout the several views, and in which:

Fig. 1 is a side elevational view of the present invention comprising electrodes enclosed in a housing with associated metallic connectors extending to terminal posts of a terminal block;

Fig. 2 is a cross sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a cross sectional view taken on lines 3—3 of Figs. 1 and 2;

Fig. 4 is an enlarged view of a portion of the electrodes of Fig. 3;

Fig. 5 is a bottom plan view of Fig. 3 and shows the lightning arrestor connectors held in their housing by metal springs; and

Fig. 6 is a perspective view of one of the metallic connectors shown in Fig. 5 and used to electrically connect the electrodes to their respective terminal posts of the arrestor.

In general, the lightning arrestor of the present invention comprises a terminal block **15**, a transparent hollow glass housing **12**, and the electrodes **21**, **22** and **23** which are held in position by the hollow housing **12** and are electrically connected to the terminals **13** and **14** of the terminal block.

The circular metallic electrode **22** (see Fig. 3) has a circular recess **18** for receiving a disc **23** of a suitable semiconductive material such as "Carborundum," "Everohm," or the like. The material having the trade name "Carborundum" is essentially a silicon carbide type of material. "Everohm" is a trade name applied to a semiconductive product particularly adaptable for use in lightning arrestors, and comprises powdered graphite or mineral black combined with a finely ground Portland cement binder as fully described in Pat. No. 1,818,184, dated August 11, 1931. The circular electrode **22** is preferably made of brass and has an axial hole or bore for receiving the stem of insulating material **27** as seen in Fig. 3. This insulating material **27** has an axial bore for receiving the shaft of a bolt **20** and is preferably made of Bakelite type insulating material.

The circular disc **23** of semiconductive material has an outside diameter such as to securely fit into the recess **18** of electrode **22** with a portion protruding therefrom. This disc **23** is an auxiliary electrode so that its tight fit in the recess **18** establishes good electrical connection with the metal electrode **22**.

The spacer **19** is in the form of a circular disc with a recess or groove **28** around its periphery. The other metallic electrode **21** is mounted on the stem of insulating material **27** and is provided with an inner circular recess **17** having a diameter less than the diameter of the circular recess **18** of the circular electrode **22**. In other words, the two metal electrodes **21** and **22** are positioned like two cups facing each other separated by a spacer and all having axial bores. The inside of the electrode **21** is smaller so that the inner edge of its rim forms a flat ring **25** adjacent the inner flat surface of the auxiliary electrode **23**. This flat ring **25** extends slightly beyond the outside diameter of the auxiliary electrode **23** so as to be directly opposite a flat portion of electrode **22**. These flat portions of electrodes **21** and **22** form what might be termed a major air-gap, from which their sides **24** and **26** slant outwardly or away from each other at an angle of approximately forty degrees to form the sides **24** and **26** of a horn type gap. This horn-shaped air-gap extends circularly around the periphery of these two electrodes **21** and **22**. The air-gap between the inner flat edge **25** of the rim of electrode **21** and the flat inner surface of the auxiliary electrode **23** may be conveniently termed the minor air-gap.

The stem of insulating material **27** extends through the axial bores of the electrodes **21**, **22**, **23** and the spacer **19** with a small portion extending out of the electrodes **21** and **22** on both ends of the stem when assembled. An axial bore is provided in the stem of insulating material for receiving the shaft of a bolt **20**. The extended portions of the stem of insulating material receive the cut-out portions **32** of the metal connectors **10** and **11** which are held tightly in their positions by a bolt **20** provided with a nut at one end. The assembled unit is held in the glass housing **12** by the recesses **29** in the lower portion of the housing **12** which cooperate with the resilient mounting springs **36** to form an integral whole which is mounted on the terminals **13** and **14**.

Electrical connection is made between the metallic electrodes **21** and **22**, and the terminals **13** and **14** through the metallic connectors **10** and **11**, one of which is shown

in perspective in Fig. 6. Each of these metallic connectors is provided with a base portion having at one end a cut-out portion 35 and at the other end a diagonally flanged portion 34 with a resilient mounting spring 36 attached adjacent thereof by means of metal rivets 37. The cut-out portion 35 at the end of the tail portion provides an opening for receiving the terminal bolt and against which a lock nut can be tightened. An arm 33 adjacent the flanged portion 34 is bent at an angle from the base and has a cut-out portion 32 at its other end for receiving the stem of insulating material 27. The two metallic connectors 10 and 11 are identical in form except for two portions of metal in the cut-out portion 32 of one metallic connector which are cut at their sides and bent at their bases so as to be substantially perpendicular to the upper part of the arm 33 to form a locking feature for the nut of bolt 20 and are reversibly positioned when assembled so that there is a tail portion extending outwardly in opposite directions as shown in Fig. 1. In this way, the electrode 21 is connected through connector 11 to the terminal 14; whereas, the electrode 22 and the auxiliary electrode 23 are connected through connector 10 to the terminal 13.

With the parts in the positions as above described, a space 38 is provided between the diagonally flanged portions 34 as can best be seen in Fig. 5. This space 38 allows any condensation formed on the inner walls of the glass housing 12 to be evaporated or to drop out at the bottom of the housing. This space also serves for the movement of air which may take place as a result of disruptive discharges between the electrodes.

One of the purposes of the present invention is to provide an arrestor which will be suitable for use with various communication facilities where the breakdown of the protecting arrestor should be in the order of 600 volts. To provide such an arrestor of the air-gap type means that the breakdown gap must be in the order of five thousandths of an inch. Such a small air-gap is obviously subject to the collection of particles that might well provide a short between the two electrodes.

The present invention proposes to avoid the difficulty of a small air-gap by actually providing an air-gap in the order of twenty thousandths of an inch between the metal electrodes and then have a minor air-gap between the auxiliary electrode and the other metal electrode which minor air-gap is in the order of five thousandths of an inch. With this structure any particles that collect in the minor air-gap do not provide a short between the electrodes because at the potentials normally used to operate the communication facilities the auxiliary electrode is a relatively high resistance in the order of megohms.

Although there may be several explanations as to the operation of the electrical phenomena involved in the present invention, it is believed that one explanation should be given to more clearly point out what are believed to be the advantageous characteristics of its structure.

More specifically, when the critical potential gradient exists between the metal electrode 21 and the auxiliary electrode 23, an initial limited discharge takes place. Thus, the air is ionized in the minor air-gap. The flow of the current of such limited discharge along the surfaces of the semiconductive material of the auxiliary electrode 23 also adds to the ionization of the air at the base of the major air-gap. In this way, the air at the base of the major air-gap is sufficiently ionized to allow a disruptive discharge of current to pass through the major air-gap. It is also noted that the mass of the metal electrodes 21 and 22 is relatively large so as to provide heat distributing and dissipating surfaces to avoid the melting of the electrodes in the presence of relatively heavy discharges. Also, since the surfaces 24 and 26 slant outwardly, there is a tendency for the discharge to travel outwardly and thus become more quickly interrupted when the major portion of the discharge wave has passed.

In addition, it is noted that the spacer 19 is in the form of a circular disc with a recess 28 around its periphery and is also of a smaller diameter than the inside of the cup-shaped metal electrode 21. This provides an internal space in which the air may be slightly compressed upon the occurrence of disruptive discharges.

Such internal compression of the air upon a disruptive discharge tends to move ionized air outwardly from the base of the major air-gap. This movement of the ionized air causes the discharge to move outwardly where the horn-shaped gap between the metal electrodes is constantly enlarging and thus assists in the early extinguishing of such disruptive discharge after the major peak of the discharge wave has passed. In other words, the discharge moves away from what has been termed the major air-gap into what has been termed as the horn-shaped air-gap. As can be seen from Fig. 4, there is considerable mass of metal in the electrodes 21 and 22 adjacent this horn-shaped air-gap, which mass of metal serves as heat sinks. Although the manufacture of these electrodes and their assembly may be performed fairly accurately, the discharge will be initiated at those points around the minor air-gap of the electrodes which are closest together, and the disruptive discharge will occur at corresponding points in the major air-gap. But the heat of course will be rapidly conducted by the mass of metal to all parts of the electrodes. This avoids the concentration of sufficient heat at any one point to cause the melting of the electrode.

It should also be noted that the flat portion 25 of the rim of the electrode 21 extends sufficiently below the outer periphery of the auxiliary electrode 23 as to provide a very uniform minor air-gap in spite of slight irregularities at the edge of the auxiliary electrode 23 which irregularities are hard to avoid due to its granular composition.

In the above description and in the drawings, the electrodes 21, 22 and 23 are shown as being circular in form. Such form has been particularly selected because of the feasibility of providing tools for manufacturing such a form; but it is to be understood that the electrodes could be of any other suitable configuration such as square, rectangular, triangular, or the like.

Having described one form of a lighting arrestor as embodying the present invention, it is desired to be understood that this particular form is selected to facilitate in the disclosure of the invention rather than to limit the number of forms which it may assume; and, it is to be further understood that various modifications, adaptations and alterations may be applied to specific form shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention.

What I claim is:

1. A lightning arrestor comprising, in combination, a metal electrode having a circular recess in one face and a flat edge on the periphery of said recess from which the adjoining surface of said electrode slants outwardly, an auxiliary electrode of relatively high resistance semiconductive material of such a shape to enable said recess to receive said auxiliary electrode with a portion protruding from said recess, a second metal electrode having a circular recess in one face with the periphery of said recess having a flat edge from which the surface of said second electrode slants outwardly, an insulating spacer provided to place the outer edge of said auxiliary electrode in close proximity to the said flat edge provided on said second metal electrode, and mechanical connecting means to hold the assembled said parts in a protective housing.

2. A lightning arrestor comprising, in combination, a metal electrode in the form of a circular disc having a through axial bore, a circular recess in one face, and a

flat edge on the periphery of said recess from which the adjoining surface of said electrode slants outwardly at an angle of twenty degrees, an auxiliary electrode of relatively high resistance material having a through axial bore, which said recess of said metal electrode is provided to receive said auxiliary electrode; a second metal electrode in the form of a circular disc having a circular recess of less diameter than said recess of first said metal electrode, a flat edge on the periphery of said circular recess which said flat edge is adjacent the outside edge of said auxiliary electrode when said parts are assembled, a through axial bore and the free edge adjoining said flat edge slanting outwardly at an angle of twenty degrees; an insulating spacer in the form of a circular disc with a recess around the periphery of said disc; and mechanical connecting means for holding said assembled parts together in a protective housing.

3. A lightning arrestor comprising, in combination, an auxiliary electrode of relatively high resistance semiconductive material, a metal electrode having a circular recess in one face with a diameter substantially equal to the external diameter of said auxiliary electrode of semiconductive material, said metal electrode receiving said auxiliary electrode of semiconductive material with a portion of said auxiliary electrode protruding therefrom, a second metal electrode spaced so as to form a horn-shaped air-gap with said metal electrode, said second metal electrode having a circular recess of an internal diameter less than said recess of first said electrode with the outer periphery of said circular recess having a flat edge, means for positioning said electrodes on an axis passing through the central portion of the bases thereof with said flat edge of the said second electrode presented toward the first said electrode and the said flat edge thereof substantially in the plane of the outside periphery of said auxiliary electrode of semiconductive material, said auxiliary electrode forming a minor air-gap with said second metal electrode, said minor air-gap being of a shorter dimension than the base of said horn-shaped air-gap, said auxiliary electrode being of such a high resistance in the order of megohms thereby allowing an initial limited discharge to take place in the minor air-gap when the critical potential gradient exists between the second said electrode and the said auxiliary electrode thereby ioninzing the air in the minor air-gap and at the base of the said horn-shaped air-gap allowing the disruptive discharge of current to pass through the said horn-shaped air-gap, said horn-shaped air-gap having a capacity to quickly interrupt the disruptive discharge of current when the major portion of the discharge wave has passed.

4. A metal electrode in the form of a circular disc having a circular recess and a free outer edge in one face of said electrode, said free outer edge having a flat edge on the periphery of said circular recess, said free outer edge adjoining said flat edge slanted outwardly, a through axial bore, and said electrode requiring external support.

5. A lighting arrestor comprising two metal electrodes each having the surface of one side laterally formed outward with respect to its periphery and the surface of the opposite side, said two electrodes being spaced apart so as to form a horn between the laterally formed sides with the closest surfaces of the two electrodes adjacent the throat of said horn being effective to provide a minor air-gap for allowing a discharge to be initiated, while the laterally formed sides of the two electrodes from said closest surfaces to the mouth of said horn are effective to extinguish the arc caused by the discharge.

6. A lightning arrestor according to claim 5, wherein an auxiliary electrode of relatively high resistance semiconductive material is included with and connected to one of said electrodes adjacent the throat of said horn, whereby the minor air-gap is formed between the periphery of said auxiliary electrode and the closest surface of the other electrode for allowing a discharge to be initiated.

7. A lightning arrestor according to claim 6, wherein the surface of said other electrode adjacent the periphery of said auxiliary electrode is normal to the periphery of said other electrode, whereby the minor air-gap is formed between the periphery of said auxiliary electrode and said surface for allowing a discharge to be initiated.

8. A lightning arrestor comprising, at least two electrically conductive electrodes having respective opposing faces closely spaced in part to form a major air gap and also diverging in part to provide an air gap of increasing size as compared to said major air gap, and auxiliary electrode of semi-conductive material being electrically connected to one of said conductive electrodes and partially bridging said major air gap to thereby form a minor air gap with the other of said conductive electrodes, whereby an arc discharge initiated in said minor air gap is quickly transferred to said major air gap and is extinguished in said air gap of increasing size and whereby a short circuit across said minor air gap produces only a high resistance connection through said auxiliary electrode between said two conductive electrodes.

9. The lightning arrestor as defined in claim 8 wherein said minor air gap has a length corresponding substantially to the air gap breakdown length for the amplitude of voltage at and above which said arrestor is desired to provide a discharge path through said auxiliary electrode between said two conductive electrodes.

10. The lightning arrestor defined in claim 8 wherein said respective opposing faces are parallel plane surfaces over that part forming said major air gap.

11. The lightning arrestor according to claim 8 wherein the diverging portions of said opposing faces are linear.

12. The lightning arrestor according to claim 8 wherein said electrically conductive electrodes are both cup-shaped and said respective opposing faces are the respective lips thereof.

13. The lightning arrestor according to claim 12 wherein said cup-shaped electrodes are circular.

14. The lightning arrestor according to claim 12 wherein said auxiliary electrode closely fits within the cavity of one of said cup-shaped electrodes and protrudes at least at its outer edge slightly above the lip of said one cup-shaped electrode to thereby partly bridge said major air gap betwen said one electrode and the other of said conductive electrodes.

15. The lightning arrestor according to claim 14 wherein the innermost edge of the lip of said other electrode lies within the outermost edge of said auxiliary electrode.

16. The lightning arrestor defined in claim 14 wherein an insulating member fits within the cavity of said other cup-shaped electrode and abuts against said auxiliary electrodes to thereby space said facing lips of said two cup-shaped electrodes, said insulating member having its periphery spaced from the inner surface of the cavity of said other electrode wherefore said insulating member and said cavity together define an annular air space wherein the air is compressed upon the occurrence of an arc discharge between said opposing faces to thereby aid in forcing said arc out along said air gap of increasing size.

17. A lightning arrestor comprising, at least two electrically conductive electrodes having respective surfaces opposing each other, said opposing surfaces being sufficiently closely spaced in part to form an arc discharge air gap from one electrode to the other, said opposing surfaces diverging outwardly from the region of said arc discharge air gap to thereby form an outwardly flaring horn between said opposing surfaces with said horn having its throat substantially at said arc discharge air gap, whereby an arc initiated across said arc discharge air gap is extinguished as it travels along the outwardly flaring sides of said horn.

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