

Nov. 23, 1943.

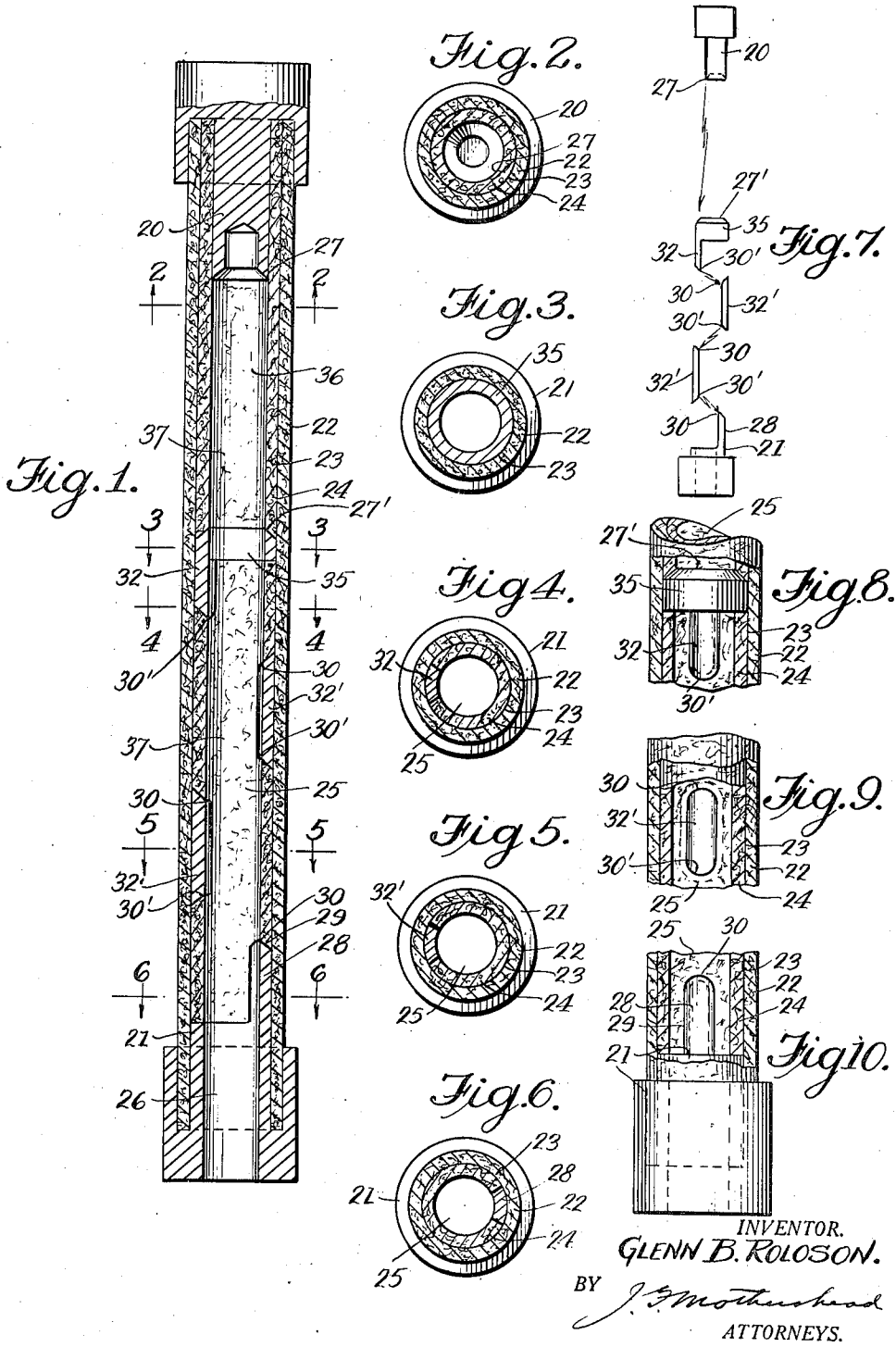
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LIGHTNING ARRESTERS, ARC INTERCEPTING TYPE

Filed July 25, 1941

2 Sheets-Sheet 1



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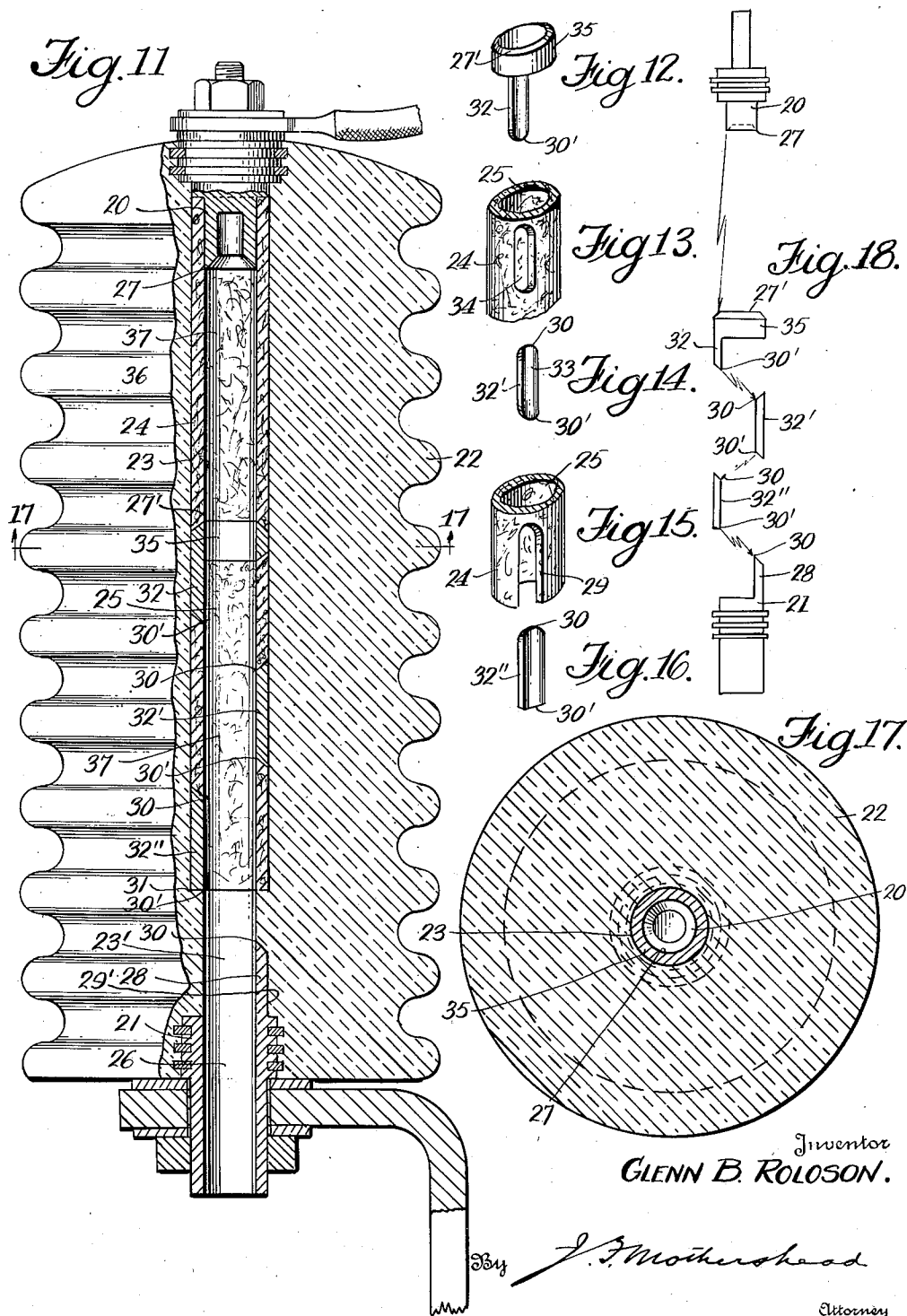
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UNITED STATES PATENT OFFICE

2,334,727

LIGHTNING ARRESTER, ARC INTERCEPTING
TYPE

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Application July 25, 1941, Serial No. 403,950

3 Claims. (Cl. 175—30)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the act of April 30, 1928 (Ch. 460, 45 Stat. L. 467).

My invention pertains to lightning arresters for the prevention of interruptions to service and damage to connected apparatus due to surges produced by lightning or other causes.

The functions of lightning arresters connected to electric transmission and distribution lines are, as known in the art, first, to discharge heavy surge currents produced by lightning or other causes and, second, to interrupt the power follow up currents in the shortest possible time, both without destruction of the arrester.

Difficulty has been experienced however in providing lightning arresters which will satisfactorily accomplish both functions. In other words, lightning arresters designed to discharge heavy lightning currents fail to interrupt small follow up currents; while, on the other hand, lightning arresters designed to interrupt small follow up currents fail to discharge heavy lightning currents or are destroyed by lightning striking on the line in the vicinity of the arrester.

On extended transmission or distribution lines or lines where the capacity of the source of power is small, the follow up currents will be small. For this reason lightning protective devices are frequently used with different follow up current interrupting capacities, depending upon the distance from the device to the source of power. This practice is a compromise but which sacrifices the capacity to discharge high current surges for the ability to interrupt the follow up current at the point where the device is located.

Many expedients have been adopted in expulsion tube type lightning arresters to increase the ability of the devices to interrupt small follow up currents. One of the methods consists in placing one or more plugs of gas evolving material in the bore or chamber of the expulsion tube and causing the arc to pass through a comparatively long channel of minute cross sectional area. The evolved gases are also compelled, in such devices, to pass through extremely restricted channels causing the gases to build up extreme pressures which frequently cause a bursting of the arrester. Another expedient is to almost fill the bore of the expulsion tube with a rod of insulating material. It is obvious that such obstructions to the rapid passage of gas, such as the aforementioned plugs and rods as well as the restricted passageways,

reduce the capacity to discharge heavy lightning currents.

Having in mind such experienced failures in the performances of conventional arresters, applicant's invention aims to provide a lightning arrester which will discharge the largest surge current and interrupt the smallest follow up current and contemplates the accomplishment thereof by providing an arrester of the expulsion tube type having an open unrestricted passageway for the free flow of the column or body of gases, which accumulate in the arresters, to prevent bursting and an arrangement of electrodes whereby arcs therebetween must traverse, or be traversed by, the column of gas passing through the arrester. An object of this improved arrangement is to more positively lengthen the arcs to a breaking point, as well as to more positively non-ionize all paths through which the arcs may be maintained.

From one viewpoint the present improvement may be considered a reversal of the principle of the operation of the improved arrester claimed in my copending application Serial No. 354,327, patented December 15, 1942, No. 2,304,343, in that the arc in the present arrangement is caused to traverse the column of gases passing through the arrester, whereas in the improvement of the aforesaid copending application the gases are directed along paths traversing the arc paths.

The foregoing and other objects of the invention will become apparent from a reading of the following specification and appended claims. Certain embodiments having characteristics of my invention and by which the same may be practiced are illustrated in the accompanying drawings in which

Figure 1 illustrates, in vertical cross section, one embodiment of my invention;

Figures 2, 3, 4, 5 and 6, cross sectional views taken at lines 2—2, 3—3, 4—4, 5—5, and 6—6, respectively, of Figure 1;

Figure 7, a schematic illustration of an arrangement of electrodes showing the paths of the arcs therebetween;

Figure 8, a sectionalized view of the arrester to illustrate, in elevation, an intermediate electrode and the manner of mounting the same within the arrester;

Figure 9, a view similar to that of Figure 8, except that it is illustrative of a modified intermediate electrode;

Figure 10, a fragmentary view in elevation illustrating the inner face of the ground terminal electrode;

Figure 11, a sectionalized view in elevation illustrative of a modified embodiment of my invention wherein a porcelain insulator body is employed as distinguished from one of fibrous material;

Figure 12, a perspective view of an intermediate electrode of the character shown in Figure 8;

Figure 13, a view in perspective of a section of an inner tube of gas evolving material, illustrating the formation by which an intermediate electrode of the character shown in Figure 9 may be mounted within the arrester;

Figure 14, a perspective view of an intermediate electrode of the character shown in Figure 9;

Figure 15, a perspective view of the lower end portion of a tube of gas evolving material illustrating the formation by which the lowermost intermediate electrode of the Figure 11 embodiment or the ground terminal electrode of the Figure 1 embodiment may be mounted within the arrester;

Figure 16, a perspective of an intermediate electrode comparable with that of the Figure 14 embodiment except for its base formation;

Figure 17, a cross sectional view taken at line 17—17 of the Figure 11 assembly; and

Figure 18, a schematic view illustrating the staggered relationship of the electrodes when mounted in the arrester and also illustrating exemplary arc paths angularly disposed with respect to the axis of the arrester passageway.

By reference to the drawings, shown for the purpose of illustrating applications of the invention and by which the same may be practiced, the embodiments will be seen as including a line terminal electrode 20 and a vented ground terminal electrode 21 suitably maintained, in such manners as shown in Figures 1 and 11, in fixed spaced relation by a suitable insulator body 22, of fiber, glass, porcelain, or other compound, having a passageway 23 of considerable cross sectional area and with which at least the inner extremities of the terminal electrodes 20 and 21 communicate and by which arrangement an arc chamber is provided between the terminal electrodes. A layer of suitable gas evolving material 24 is mounted within the passageway 23 and in contiguous relationship with the wall thereof to provide a liner for the wall of the passageway 23 and to provide within the lined area an unrestricted passageway 25 of considerable and substantially uniform cross sectional area for the free flow of a column of accumulated gases through the passageway toward and from the vent 26 of the ground electrode 21 before such gases can build up sufficient pressure as would cause a bursting of the arrester. The vent 26 of the ground electrode is preferably of a cross sectional uniform area comparable with that of the passageway 25 within the lined portion of the arrester.

The end of the line terminal electrode 20 which extends into communication with the passageway 25 may be flared outwardly in order that its greatest extremity be in the form of a rim 27 terminating on a plane with that of the outer surface of the end portion of the electrode 20 and immediately adjacent the inner surface of the liner 24.

The ground terminal electrode 21 is provided with a portion 28 which projects into the passageway 23 of the insulator body beyond other portions of the electrode, with its inner face slightly concave and on a plane with the inner surface of the liner 24. For thus mounting and positioning the ground electrode the lower end of the liner 24, in the Figures 1-10 embodiment, is notched

out as at 29 to receive the projection 28 and permit the remaining end portions of the liner to rest on the rim of the electrode. The projection 28 is beveled incliningly inward and somewhat apexed in order that the extremity thereof or tip 30 may be on a plane with or immediately adjacent the inner surface of the liner 24. The side walls of the notch 29 in the liner may also be sloped or beveled to snugly fit about the edges of the projection 28 and to hold the liner in position.

In the Figure 11 embodiment the walls of the passageway 23 of the insulator body 22 are provided with a ledge 31 above which the cross sectional area of the passageway 23 exceeds that of the cross sectional area of the passageway 23' below the ledge sufficiently to accommodate the liner 24 and provide a liner passageway 25 of cross sectional area in uniformity with the unlined portion of the body passageway 23'. As distinguished from the Figure 1 embodiment wherein the liner contacts or rests upon the ground electrode, the ledge 31 of the Figure 11 embodiment serves as a support for the liner 24 and as means for maintaining a space between the terminal electrodes unabridged by a continuity of elements of less current conductivity than glass or porcelain. In this arrangement the gas evolving liner 24 cannot serve as a conductor between the terminal electrodes 20 and 21 either by itself or in combination with other current conductive elements, a feature of novelty claimed in my copending application Serial No. 295,778. Also in the Figure 11 embodiment the wall of the reduced portion of the body passageway 23' is recessed as at 29' to receive the projection 28 of the ground electrode in a manner to position the inner surface of the projection on a plane with the wall of the body passageway 23' comparable with the arrangement of the Figure 1 embodiment wherein the liner is notched, 29, to receive the projection 28.

By the arrangements described arc paths between the terminal electrodes 20 and 21 will be from a point on the rim 27 on the line electrode immediately adjacent the inner surface of the liner to the tip 30 of the ground electrode 21 which is in or on the plane of the liner. The shortest arc path between the aforesaid points on the terminal electrodes would normally be from a point on the line electrode rim 27 on the same side of the passageway 25 as that of the tip 30 of the ground electrode and an arc path between these points would be immediately adjacent the inner surface of the liner throughout the length of the path rather than diagonally across the passageway 25. While an arc flowing a path immediately adjacent the liner may have greater effect upon the liner to cause the same to evolve greater volumes of gas, the arc would not be subjected to the deflecting effect of the column of gases moving down through the passageway 25, since the arc as well as the column of gases would travel substantially parallel with each other. Such an arrangement is more or less the conventional practice in the construction of arresters most commonly used. Therefore to subject an arc flowing between the terminal electrodes to the deflecting effect of the moving column of accumulated gases, as well as to cause the arc path to be more positively non-ionized, I provide one or more auxiliary electrodes 32, 32' and 32'' intermediately of the terminal electrodes and in spaced relation with respect thereto as well as

with respect to themselves within the passageway 23 of the body insulator.

The intermediate electrodes are of such shape that they may be mounted in staggered relation angularly across the passageway 25 from each other, the lowermost one of which being positioned angularly across the passageway 25 from the projection 28 of the ground electrode 21. By this arrangement an arc flowing from a point on the rim 27 of the line electrode may flow parallel with and immediately adjacent the inner surface of the liner 24 to the first auxiliary electrode which conducts the current to the base point thereof and from which point the resumed arc must traverse the passageway 25, as well as the column of gases therein, in order to contact the uppermost point of the next auxiliary electrode, and thus on downward to the ground electrode.

The initial arc between the line electrode and the next adjacent auxiliary electrode, by being permitted to flow immediately adjacent the liner, will have the effect sought by the arrangement of other types of lightning arresters to cause the evolution of a maximum quantity of gases from the liner. This principle of operation is therefore not sacrificed in the present arrangement but the arrester improved by positively fixing the successive arc paths, i. e., after those between the line terminal and the intermediate electrode nearest thereto, traversingly of the flowing column of gases. By this arrangement, the column of gas will non-ionize the ionized diagonal arc paths and by its directional force will attenuate the arcs between the intermediate electrodes and also between the lowermost intermediate electrode and the ground electrode to points where the arcs cannot maintain themselves.

With particular reference to Figure 14, a small elongated plate-like metallic member may comprise a suitable auxiliary or intermediate electrode 32'. For mounting purposes and advantages of operation the intermediate electrode 32', as shown in Figure 14, may be of a thickness comparable with that of the liner 24 and slightly concave on its inner face to conform with the liner walls of the passageway 25, to which passageway the face of the electrode is exposed on a plane with the inner surface of the liner. Likewise, the back 33 of the electrode 32' may be slightly convex to conform with the curvature of the wall of the insulator body passageway 23 against which the electrode is positioned. It is also believed that advantages may be obtained by slightly apexing the exposed surface of the electrode at its top to provide an arc tip 30 for more or less fixing the terminus of the path of an arc to the electrode and apexing the exposed surface of the bottom of the electrode to provide a tip 30' for more or less fixing the point from which an arc will flow from that electrode to the nearest electrode therebeneath, see Fig. 7.

The intermediate electrode 32'' of Figure 16, and also Figure 11, is essentially the same as that of electrode 32' except that it may be squared off at the bottom for ease of installation and for a rigid support upon the ledge 31 in the body passageway 23. The lower end of the liner 24 of the Figure 11 embodiment is notched out at 29, as shown in Figure 15, to receive the intermediate electrode 32'' similar to the manner in which the lower end of the liner of the Figure 1 embodiment is notched at 29 to receive the projection 28 of the ground electrode 21. Likewise, for the mounting of the intermediate electrode 32' as shown in Figure 9 the liner is provided with an open-

ing 34, see Figure 13, into which the electrode may be seated. To secure the intermediate electrodes 32' and 32'' within the opening 34 and notch 29, respectively, the edges of those electrodes may be beveled, see Fig. 5, to provide lesser inner exposed surficial dimensions than that of the backs thereof and the walls of the opening 34 and notch 29 beveled to correspond therewith. By the beveling arrangement and the support of the walls of the body passageway 23 to the backs of the electrodes they may be held in fixed position, yet readily removable by the removal of the liner from the body passageway.

The intermediate electrode 32, shown in perspective in Figure 12 and in mounted position in the assemblies of Figures 1 and 11 and their associated views, is provided with a ring-like head portion 35, from which the electrode portion 32 depends, and whose opening and thickness is comparable with that of the liner 24. At the point of mounting the latter intermediate electrode within the insulator passageway, the liner is interrupted and the lower portion notched out to receive, support and retain the ring portion 35 and its depending electrode portion 32, as shown particularly in Figures 1, 8 and 11. The depending portion 32 corresponds substantially with that of the projection 28 of the ground electrode 21 and is adapted to fit into a notch in the liner 24 corresponding to the recess 29' in the insulator body 22 of the Figure 11 embodiment except for the inversion thereof. The upper edge of the ring portion 35 of the intermediate electrode may be beveled from its outer surface incliningly inward and terminating at the inner surface to provide a rim 27', as its greatest extremity, on a plane with the walls of its opening which coincides with the plane of the inner walls of the liner passageway 25 in order that the termini of arc paths, leading from the rim 27 of the electrode 20, will be on or in a plane with the liner surface in a similar manner as originating points of arc paths flowing from the rim 27 of the line electrode 20. The lowermost intermediate electrode (32' in the Figure 1 embodiment and 32'' in that of Figure 11) is positioned upwardly and diagonally across the passageway from that of the projection 28 of the ground electrode 21 and each succeeding intermediate electrode is similarly positioned with respect to the one therebeneath, the arrangement terminating by the positioning of the intermediate electrode depending portion 32 upwardly and diagonally across the passageway from the intermediate electrode next below.

In the alternate and staggered arrangement of the electrodes, the spacing and length of the intermediate electrodes, as well as the projection 28 of the ground electrode, must be such that the distance between the nearest ends or tips of adjacent electrodes on the same side of the passageway be appreciably greater than the sum of the shortest distances from those ends or tips to the nearest electrode on the opposite side of the passageway, for the intended function, i. e., for definitely fixing the shortest arc paths between succeeding intermediate electrodes across the passageway and for preventing arcs from flowing between electrodes on the same side of the passageway. By way of example reference is had to Figure 11, wherein it will be seen that the distance between the lower tip 30' of the depending portion 32 of the first intermediate electrode and the upper tip 30 of intermediate electrode 32'' on the same side of the passageway is appreciably greater than the sum of the shortest distances

from those tips, respectively, to the upper and lower tips 30 and 35' of intermediate electrode 32' on the opposite side of the passageway. Likewise, with reference to the same figure, the distance between the lower tip 33' of electrode 32' to the upper tip 30 of the ground electrode projection 23 on the same side of the passageway is appreciably greater than the sum of the shortest distances from those tips, respectively, to the upper and lower tips 30 and 35' of intermediate electrode 32' on the opposite side of the passageway. The same principle is adhered to in the showing of Figure 1 and in the event that the shortest distances from the tips of adjacent electrodes on the same side of the passageway to tips of the nearest electrodes on the opposite side of the passageway are all equal, then the distances between tips of electrodes on the same side of the passageway must be appreciably greater than twice the shortest distance from one of these tips to the nearest electrode on the opposite side of the passageway.

The space between the line electrode 23 and the ring portion 35 of intermediate electrode 32 is surrounded by fiber or gas evolving material 24 and that portion of the liner passageway forms a chamber 36 for the production of gas when an electric discharge occurs through the arrester. By the arrangement and construction of the gas chamber members a plurality of advantages and functions will be accomplished, in that by the inclusion of the ring portion 35 of the first intermediate electrode and the positioning of the extremities of that electrode and the line terminal electrode, in the form of rims 27' and 27, the shortest arc paths through the gas chamber 36, regardless of along which side of the chamber they may be established, will be immediately adjacent the liner for production of gases. Since the arc paths are not limited to a position between two definite points in the circumferences of the rims 27 and 27', but may be between any of the many circumferential points, the arrester is not limited to a single performance even if the heat of an arc may destroy the liner immediately adjacent the path along which a previous arc had been established. The heat of the arcs between the points of nearest intermediate electrodes is not apt to destroy or seriously deteriorate the liner since the shortest paths therebetween and along which the arcs will normally flow do not parallel the liner. Deterioration of the liner in the immediate vicinity of intermediate electrode tips 30 and 35' by the heat effect of the ends of the arcs therebetween will detract little, if any, from the effect of the arrester upon repeated operations since the effect of repeated arcs through the gas chamber will remain substantially uniform.

In the operation of the improved arrester, when an electric discharge occurs through the arrester, arcs are formed between each successive two of all of the various electrodes. The arc between the rims of the line electrode 23 and the rim of the first intermediate electrode will be in contact with or immediately adjacent the liner

and the succeeding arcs between the intermediate electrodes and the ground terminal electrode will each be across the arrester passageway. At the time of an electric discharge a great volume of gas is produced in the gas producing chamber 36 which almost instantaneously accumulates as a column 37 of gas. The continuing rapid accumulation of gas is forced to flow as a column down through the passageway in its rush to escape through the vented ground electrode 21. The blast of the column of gas rushing through that portion of the passageway across which arcs are established between intermediate electrodes and the ground electrode distorts and attenuates the arcs flowing traversingly of the passageway to a point where they cannot maintain themselves and simultaneously therewith the gases non-ionize the arc paths, destroying the ionized paths created by the arcs, thus breaking the arc and interrupting the electric discharge.

In my improved arrester the entire gas passageway is smooth and of substantially uniform cross sectional area and there are no obstructions to the passage of the blast of gases in the form of a column 37 to the outside air, nor is the column of gases hindered by a deflection in the flow thereof.

Having described my invention and illustrated embodiments by which the same may be practiced, what I claim is:

1. In an electric discharge device of the expulsion tube type, the combination with a tubular insulator, of a terminal electrode, of a vented tubular electrode, a tubular lining adapted to evolve gas when heated by an electric arc, one or more intermediate electrodes having end portions in diametrically opposite sides of said lining whereby arcs between adjacent electrodes are caused to cross evolved gases in said device in a zigzag course.

2. In an electric discharge device, the combination with a tubular electrode having a tubular end portion which is beveled to an edge farthest advanced from the body of the electrode at the inner surface of said tube, of a companion vented tubular electrode provided with a projecting terminal, of a tubular lining adapted to evolve gas when heated by an electric arc, and one or more intermediate electrodes arranged on diametrically opposite sides of said lining, whereby an electrical discharge passing from a power line to a ground forms a plurality of arcs crossing the passageway of said device diagonally.

3. In an electric discharge device of the expulsion tube type, the combination with a tubular insulator, a tubular gas evolving lining, a terminal electrode, a vented tubular electrode provided with a terminal portion less than semi-circular in cross-section extending in the direction of said first electrode and one or more intermediate electrodes less than semi-circular in cross-section mounted within the tubular lining at increasing distances from said vented electrode with adjacent intermediate electrode terminals located in opposite sides of said lining.

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