UNITED STATES PATENT OFFICE

2,586,285

LIGHTNING ARRESTER

Otto Ackermann, Irwin, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application May 14, 1949, Serial No. 93,261

11 Claims. (Cl. 175—30)

The present invention relates to lightning arresters, and more particularly to means for preventing shattering or explosion of valve-type lightning arresters in case of failure.

Lightning arresters of the valve type consist essentially of a plurality of spark gap devices and a plurality of valve-type resistance elements or blocks, disposed in series relation in a housing. The spark gaps normally isolate the arrester from the line to which it is connected but break down under excess-voltage conditions, such as a lightning surge, to permit the surge to be discharged to ground through the valve blocks, which have low resistance in surge voltage conditions. After discharge of the surge, the blocks, because of their valve characteristics, reduce the power follow-current to a small value which can readily be interrupted by the series gaps.

In the normal operation of lightning arresters of this type, no gas is generated, and the housing can therefore be tightly sealed to exclude moisture, which has a very detrimental effect on the electrical characteristics of the blocks and of the series gaps. If the arrester fails to interrupt the power current, however, for any reason, the blocks lose their current-limiting or valve characteristic, and the full short-circuit current of the system to which the arrester is connected flows through it to ground. This results in excessive heating and burning, and arcing over, of most of the elements of the arrester, and this is accompanied by the evolution of a large quantity of gas which is heated to a high temperature. Since the housing is tightly sealed, in the conventional construction, very high gas pressures are very rapidly built up in the housing in case of failure of the arrester, and this high pressure may cause sudden rupture or shattering of the porcelain housing, frequently with explosive force, causing parts of the housing to be violently thrown around, endangering adjacent apparatus, or persons who may be in the vicinity.

The principal object of the present invention is to provide a valve-type lightning arrester which will not shatter or exploding in case of failure of the arrester.

Another object of the invention is to provide a valve-type lightning arrester in which provision is made for venting gas from the housing in case of failure of the arrester, so as to prevent building up explosive pressures in the housing.

A further object of the invention is to provide a valve-type lightning arrester in which gas is vented from the housing in case of failure of the arrester, and in which provision is made for causing arc-over on the outside of the housing, so as to transfer the current to the outside and thus stop the evolution of gas within the housing before explosive pressures are built up, so that shattering or explosion of the arrester is positively prevented.

Other objects and advantages of the invention will be apparent from the following detailed description, taken in connection with the accompanying drawings, in which:

Figure 1 is a vertical sectional view of a lightning-arrester unit embodying the invention, the section being taken approximately on the line I—I of Fig. 3;

Fig. 2 is a diagram illustrating the effects of a block failure;

Fig. 3 is a transverse sectional view approximately on the line III—III of Fig. 1;

Fig. 4 is a view in elevation of a complete station-type lightning arrester;

Fig. 5 is an enlarged vertical sectional view of the top portion of the arrester of Fig. 4; and

Fig. 6 is an enlarged fragmentary sectional view similar to Fig. 1, showing certain spacer elements in section.

The invention is shown in the drawings embodied in a valve-type lightning-arrester unit, such as is used in high-voltage station-type lightning arresters of unit construction, although it will be obvious that the invention is not necessarily restricted to this particular type of lightning arrester. Fig. 1 shows in detail one arrester unit of a multi-unit station-type arrester.

The arrester unit is contained in a hollow, generally cylindrical or tubular housing of porcelain, or other suitable weather-resistant insulating material having sufficient mechanical strength. The arrester unit includes a plurality of valve-type resistance elements or blocks 2, and a spark-gap assembly 3 disposed in series relation in the housing.

The blocks 2 may be made of any suitable resistance material having valve, or non-linear, characteristics, that is, a material which has very high resistance, or is semi-conducting, under normal voltages, but which sharply reduces its resistance under high surge voltages to permit discharge of the surge with a low discharge voltage across the arrester, and which again increases its resistance after the discharge, so as to reduce the power current to a small value which can readily be interrupted by the gap as-
assembly 3 at the first current zero. The blocks 2 are preferably made of granular silicon carbide 4 mixed with a suitable binder, such as sodium silicate, molded to the desired size and shape, and baked. A conducting coating 5 of zinc or copper may be applied to the ends of each block to facilitate making electrical contact to the block, and an insulating coating 6 may be applied to the sides of the blocks. Such blocks are well known in themselves, and it is to be understood that any suitable type of valve blocks, or non-linear resistance elements, may be used.

The spark-gap assembly 3 is shown as a sealed, multi-gap assembly enclosed in a porcelain tube 7. The gaps themselves consist of a plurality of metal electrodes 8 spaced apart by spacers 9 of high-resistance or insulating material. The gaps are assembled in a column in the porcelain tube 7, and the ends of the tube are closed by metal end caps 10, which are sealed to the tube 7 in any suitable manner, as by soldering to a metallic glaze on the tube. The column of gaps rests on the lower end cap 10, and a compression spring 11 is placed between the top of the column of gaps and the upper end cap 10 to hold the gaps firmly in place and to effect electrical contact with the upper end cap.

The valve blocks 2 and the gap assembly 3 are disposed in series relation in a vertical column in the housing 1, the blocks 2 preferably being separated by centering and spacing washers 12, which may be made of conducting material or of stiff insulating material with a central rivet or other means for effecting electrical connection between the coatings 5 of adjacent blocks. The housing 1 is closed at the upper end by a metal end fitting or casting 13, which is cemented to the housing, as indicated at 14, with a gasket 15 to seal the housing. The end fitting 13 is provided with lugs 16 at spaced points about its periphery for mounting bolts 17, and its central portion, which extends over the open top of the housing 1, is formed as a relatively thin diaphragm 18.

An annular bottom fitting or casting 19 is cemented to the bottom of the housing 1, as indicated at 20, and the bottom of the housing is closed by a diaphragm 21 secured to the bottom fitting 19 by screws 22. A gasket 23 is provided to seal the bottom of the housing. The bottom casting 19 also has a plurality of lugs 24 for mounting bolts 25. The column of valve blocks 2 and the gap assembly 3 are supported on a metal spacer 26 which rests on the diaphragm 24, and a conducting spacer 27 and a spring plate 28 are interposed between the bottom of the column of blocks and the spacer 26. A spring plate 29 is placed on the top of the gap assembly 3 and a metal spacer 30 is disposed between the spring plate 29 and the diaphragm 18. The spring plate 29 and the column of arrester elements firmly in place, and provide sufficient pressure to insure good electrical contact between the elements, and also to hold the spacers 25 and 30 in firm contact with the diaphragms 21 and 18.

In the conventional construction of lightning arresters of this type, the housing is complete normally closed at top and bottom, and is tightly sealed to prevent the entrance of moisture. This is a desirable construction for normal operation of the arrester, since no gas is evolved in normal operation and no substantial pressure builds up inside the housing. It occasionally happens, however, that an arrester will fail to interrupt the power current which flows through the arrester following a discharge. When this occurs, the resultant heating rapidly forces the failure of one or more of the blocks 2. Such a failure occurs when one of the discharge paths through the block breaks down, or loses its resistivity, and becomes a short circuit. This quickly leads to failure of all the remaining blocks, and a high-pressure arc is formed within the blocks.

Fig. 2 shows diagrammatically the effect of such a block failure. The high concentration of energy in the arc path causes vaporization of the block material along the path, so that a hole 31 is drilled through the block and a large quantity of gas is evolved. This gas escapes through the hole 31 in both directions, and flows radially between the faulted block and the adjacent blocks, as indicated by the arrows 32 in Fig. 2. Since the blocks are held together in a vertical column, the gas escaping radially in this way tends to force the blocks apart axially, and a relatively large axial force is applied to the column of blocks in both directions, as indicated by the arrows 33. It will be understood that failure of this type occur more or less simultaneously in several different blocks in the arrester. Therefore, a large quantity of gas is evolved, and if the housing is tightly sealed, as in the conventional construction, a very high pressure is rapidly built up, which often results in rupture or shattering of the porcelain housing with explosive forces.

In accordance with the present invention, the axial force applied through the column of arrester blocks, and the high gas pressure built up in the housing, as a result of failure of the arrester, are utilized to effect venting of the gas by rupturing the diaphragms 18 and 21, so as to prevent the build-up or explosive pressures. It is necessary for this purpose that the diaphragms be made sensitive to the forces resulting from arrester failure and that they be rapidly ruptured upon failure of the arrester, to relieve the gas pressure. It is also necessary, however, that the diaphragms be capable of withstanding the forces incident to assembly and to handling and shipping of the arrester. These forces may be rather high, as when a crated arrester is dropped during shipment, for example, which subjects the diaphragms to high impact strength.

Thus, the means for rupturing the diaphragms must be designed to distinguish between the forces resulting from arrester failure and the forces resulting from handling and shipping. For this purpose, in the preferred embodiment of the invention shown in the drawings, the spacers 26 and 30 are each provided with four axially extending legs 34 which engage the respective diaphragms 18 and 21 near their peripheries. Each of the spacers 26 and 30 also has a central projection 35 (Fig. 6) which is normally spaced a small distance from the adjacent diaphragms.

With this arrangement, the normal forces resulting from handling and shipping are transmitted to the diaphragms by the legs 34 of the spacers near the peripheries of the diaphragms where they are best able to withstand these forces, and the diaphragms can readily be designed for these forces without being subjected to their peripheries. If failure of the arrester occurs in service, an axial force is applied through the column of blocks, as explained above, and this force is initially applied to the diaphragms at their peripheries through the legs 34 of the spacers 26 and 30. As this axial force rapidly increases, the legs 34 buckle and the projections...
35 of the spacers strike the diaphragms at their centers where they are most easily ruptured. At the same time, the gas generated in the arrester because of the failure fills the housing and builds up a high pressure on the diaphragms. Thus, if the diaphragms are not actually ruptured by the first contact of the projections 35, these projections deform and weaken the diaphragms because of the high localized stresses produced at the weakest parts of the diaphragms, and they are readily and quickly ruptured by the gas pressure, which builds up very rapidly. It will be understood that this all takes place very rapidly, and the diaphragms are quickly ruptured by the effects of the localized stresses caused by the axial force applied through the projections 35 and the added stresses caused by the high gas pressure applied directly to the diaphragms. Thus, the gas is vented and the internal pressure is relieved.

Where the maximum short-circuit current that can flow through the arrester in case of failure is relatively low, the internal pressure may be sufficiently relieved by rupturing the diaphragms and venting the gas as described above. In many cases, however, where high short-circuit currents may occur, merely rupturing the diaphragms at the ends of the arrester will not usually be sufficient to prevent shattering or explosion. Thus, with high concentrations of energy in the arrester, gas is evolved so rapidly that it cannot escape through the ruptured diaphragms fast enough to prevent building up of excessive internal pressure, and this effect is aggravated by the fact that the axial force tending to separate the blocks and drive them apart axially, forces the arrester parts against the diaphragms and partially blocks the openings which have been made in the diaphragms. These effects, therefore, combine to cause high internal pressures which may cause shattering or explosion in spite of the rupture of the diaphragms.

It has been found that if the arrester housing is vented, as described above, by rupture of the diaphragms at the ends, an appreciable time, which may be of the order of two cycles or more, is required to build up explosive pressures within the housing, even with very high short-circuit currents. In accordance with the present invention, means are provided for causing the internal arc in the arrester to be transferred to the outside of the arrester housing during this time interval before explosive pressures are reached, and thus to stop the further evolution of gas within the arrester housing before dangerous pressures are built up. For this purpose, baffle members are provided at both top and bottom of the arrester unit to direct the gas escaping from each end of the housing toward the opposite end, so that the two streams of hot, ionized gas coming from opposite ends of the unit cause a flashover on the outside of the housing 1, and thus transfer the arc to the outside.

The baffle members may take any suitable physical form to direct the gas escaping through the ruptured diaphragm at each end of the arrester unit toward the opposite end. In the particular embodiment of the invention shown in the drawing, which is a multi-unit station type lightning arrester, a baffle member 36 is placed between adjacent arrester units. As illustrated, the baffle member 36 has a solid central barrier portion 37 between the adjacent ends of the two units, and has a peripheral, generally cylindrical, wall portion 38 extending in both directions from the central barrier portion 37. Suitable lugs 39 may be provided on the inner surface of the wall portion 38, corresponding in number and position to the lugs 18 and 24 of the adjacent arrester units and the mounting holes pass through the lugs of the arrester units and of the baffle member to hold the assembly rigidly together, and to effect electrical connection between the adjacent units. Arcuate drain openings 40 are preferably provided in the baffle member 36 to prevent accumulation of water.

A somewhat similar baffle member 41 is provided at the bottom of the arrester. The baffle 41 is more or less cup-shaped, having a central flat surface or barrier portion and a cylindrical wall portion 42. Suitable lugs 43 are formed in and inside of the baffle member 41 for cooperation with the lugs 24 at the bottom of the arrester. The mounting screws 25 pass through the lugs 24 and 43 into a suitable base 44 on which the arrester is supported.

At the top of the arrester, a top baffle member 45 is provided. The baffle member 45, as shown in Fig. 5, preferably has a solid, curved upper portion 46 which terminates in a downwardly extending peripheral wall portion 47. The baffle member 45 is provided with lugs 48 on its inner surface for cooperation with the lugs 16 at the top of the arrester. Mounting screws pass through the lugs 16 and are threaded into the lugs 48 to secure the baffle member 45 in place on the arrester and to effect electrical contact with the baffle. Terminal means 50 of any suitable type may be secured to, or formed integrally with, the baffle member 45 for connection of a line lead.

It will be seen that each arrester unit has a baffle member at each end thereof. If failure of an arrester unit occurs, the diaphragms 18 and 24 at its ends will be ruptured, as described above, and permit escape of the gas. The gas escaping from each end of the arrester unit is directed toward the opposite end by the baffle member, so that streams of hot, ionized gas are directed toward each other from the opposite ends of the arrester unit. A conducting path is thus established on the outside of the housing, at atmospheric pressure, and since the pressures in this path is much lower than that of the internal arc path in high-pressure gas, the current flow is transferred to the outside of the housing where arcing can continue without doing serious damage until it is interrupted by operation of the line circuit breakers, or otherwise. As soon as the arc is transferred to the outside of the housing 1, evolution of gas within the housing ceases, and thus the building up of explosive pressures is prevented since the external arc can be established rapidly enough after rupture of the diaphragms to prevent the occurrence of explosive pressures within the housing.

In order to insure rupture of the diaphragms at both ends of the housing, it is preferred to provide a barrier 51 in the center of the column of blocks 2. The barrier 51 may consist of a plurality of conducting washers, similar to the washers 12, but having solid edges to prevent the passage of gas. If such a barrier were not provided, it would be possible that, if the diaphragm at one end of the arrester unit ruptured first, the pressure would be sufficiently relieved to prevent rupture of the other diaphragm, and thus the gas would escape from one end only and the arc would not be transferred to the outside as quickly as if both ends were vented. The presence of the barrier 51, however, insures that the gas in
one end of the housing cannot flow to the other end, and thus rupture of both diaphragms is assured.

The invention has been described with reference to a multi-unit lightning arrester, as shown in Fig. 4, in which two or more units are secured together in a vertical column. It will be understood, however, that each unit is a complete lightning arrester in itself and may be used alone with a baffle 41 at the bottom and a baffle 45 at the top. In a multi-unit assembly, such as that of Fig. 4, the intermediate baffle members 36 are used between adjacent arrester units. It will be noted that the baffles 36 have a central barrier portion 37 which separates the gases coming from adjacent arrester units. The purpose of this barrier is to insure rupture of the diaphragms of both adjacent arrester units. Thus, if no barrier were provided, gas escaping from the upper end of an arrester unit, for example, and striking directly against the diaphragm at the bottom of the adjacent unit, could readily apply sufficient pressure to the diaphragm to balance the pressure being applied to it internally, and thus prevent rupture of the diaphragm. In order to prevent this, the baffles are provided with the barrier portion 37 which prevents the gas from one arrester unit from striking the diaphragm of the adjacent unit.

It should now be apparent that a valve-type lightning arrester has been provided in which shattering or explosion in case of a failure is positively prevented by venting the gas generated within the housing as a result of a failure, and by inducing arc-over on the outside of the housing so as to transfer the arc to the outside and thus prevent further evolution of gas. It will be apparent that various modifications may be made within the scope of the invention. Thus, variations in the design of the spacers 25 and 39 may be possible, or other means may be utilized for rupturing the diaphragms in response to failure of the arrester. In some instances, the baffles may not be necessary, since with low short-circuit currents, it may be possible in some cases to sufficiently relieve the pressure by rupture of the diaphragms to make it unnecessary to transfer the arc to the outside, although this is a desirable, and in most cases essential, feature of the invention.

It is to be understood, therefore, that although a specific embodiment of the invention has been shown and described for the purpose of illustration, the invention is not limited to the particular details of construction shown, but, in its broadest aspects, it includes all equivalent embodiments and modifications which come within the scope of the appended claims.

I claim as my invention:

1. A lightning arrester comprising a housing of insulating material, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, means for closing the ends of the housing, means interposed between the column and the closing means for rupturing said closing means upon the occurrence of excessive gas pressure within the housing, and baffle members at both ends of the housing for directing gas escaping from each end of the housing substantially axially of the housing toward the other end.

2. A lightning arrester comprising a housing of insulating material, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, means for closing both ends of the housing, a spacer member between each end of said column and the adjacent diaphragm, said spacer members being in contact with the diaphragms and being adapted to effect rupture of the diaphragms in response to excessive axial pressure applied through said column, and baffle members for directing gas escaping from each end of the housing substantially axially of the housing toward the other end.

3. A lightning arrester comprising a housing of insulating material, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, diaphragms closing both ends of the housing, a spacer member between each end of said column and the adjacent diaphragm, said spacer members engaging the adjacent diaphragm near its periphery and having means for effecting rupture of the diaphragms in response to excessive axial pressure applied through the column, and baffle members at both ends of the housing for directing gas escaping from each end of the housing substantially axially of the housing toward the other end.

4. A lightning arrester comprising a housing of insulating material, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, diaphragms closing both ends of the housing, a spacer member between each end of said column and the adjacent diaphragm, each of said spacer members having a central projection normally spaced from the adjacent diaphragm, and baffle members at both ends of the housing for directing gas escaping from each end of the housing substantially axially of the housing toward the other end.

5. A lightning arrester comprising a housing of insulating material, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, diaphragms closing both ends of the housing, a spacer member between each end of said column and the adjacent diaphragm, each of said spacer members having axial legs engaging the adjacent diaphragm near its periphery and each of the spacer members having a central projection normally spaced from the adjacent diaphragm, and baffle members at both ends of the housing for directing gas escaping from each end of the housing substantially axially of the housing toward the other end.

6. A lightning arrester comprising a plurality of lightning-arrester units, each of said units comprising an insulating housing, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, means for closing the ends of the housing, and means interposed between the column and the closing means to permit escape of gas in response to excessive gas pressure within the housing, said lightning-arrester units being disposed in vertical end-to-end relation, baffle means between adjacent units, said baffle means being adapted to direct the escape of gas axially of the arresters toward the other end of the single unit, and baffle means at the top and bottom of the lightning arrester for directing gas escaping from the ends of the top and bottom units, respectively, substantially axially of the arresters toward the other ends thereof.

7. A lightning arrester comprising a plurality
of lightning-arrester units, each of said units comprising an insulating housing, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, means for closing the ends of the housing and means interposed between the column and the closing means for rupturing the closing means to permit escape of gas in response to excessive gas pressure within the housing, said lightning-arrester units being disposed in vertical end-to-end relation, baffle means between adjacent units, said baffle means including a central barrier portion and a peripheral wall portion adapted to direct gas escaping from the end of each unit substantially axially of the arrester toward the other end of the same unit, and baffle means at the top and bottom of the lightning arrester, said last-mentioned baffle means having peripheral wall portions adapted to direct gas escaping from the ends of the top and bottom units, respectively, substantially axially of the arrester toward the other ends thereof.

8. A lightning-arrester unit comprising: a tubular insulating housing; a valve-type arrester-block discharge-device and a spark-gap device disposed in end-to-end relation to each other within said tubular insulating housing; a frangible closure-member substantially hermetically secured to each end of said tubular insulating housing, said closure-members being frangible in response to internal forces before the bursting of said tubular insulating housing due to internal pressures, in the event of a failure of the arrester-unit in service; and gas-redirecting baffle means adjacent each of said frangible closure-members for redirecting the escaping gases from each end of the unit substantially axially of the unit toward the other end thereof, outside of said tubular insulating housing.

9. A lightning-arrester unit comprising: a tubular insulating housing; a valve-type arrester-block discharge-device and a spark-gap device disposed in end-to-end relation to each other within said tubular insulating housing; a closure-member substantially hermetically secured to each end of said tubular insulating housing; a normally closed pressure-relieving means in each of said closure-members for venting the enclosed space within said tubular insulating housing in response to internal forces before the bursting of said tubular insulating housing due to internal pressures, in the event of a failure of the arrester-unit in service; and gas-redirecting baffle means adjacent each of said closure-members for redirecting the escaping gases from each end of the unit substantially axially of the unit toward the other end thereof, outside of said tubular insulating housing.

10. A lightning-arrester unit comprising: a tubular insulating housing; a valve-type arrester-block discharge-device and a spark-gap device disposed in end-to-end relation to each other within said tubular insulating housing; a closure-member substantially hermetically secured to each end of said tubular insulating housing; a normally closed pressure-relieving means in each of said closure-members for venting the enclosed space within said tubular insulating housing in response to internal forces before the bursting of said tubular insulating housing due to internal pressures, in the event of a failure of the arrester-unit in service; and gas-redirecting baffle means adjacent each of said closure-members for redirecting the escaping gases from each end of the unit substantially axially of the unit toward the other end thereof, outside of said tubular insulating housing.

REFERENCE CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,306,285</td>
<td>of lightning-arrester units, each of said units comprising an insulating housing, a plurality of spark-gap devices and a plurality of valve-type resistance blocks disposed in a column in the housing, means for closing the ends of the housing and means interposed between the column and the closing means for rupturing the closing means to permit escape of gas in response to excessive gas pressure within the housing, said lightning-arrester units being disposed in vertical end-to-end relation, baffle means between adjacent units, said baffle means including a central barrier portion and a peripheral wall portion adapted to direct gas escaping from the end of each unit substantially axially of the arrester toward the other end of the same unit, and baffle means at the top and bottom of the lightning arrester, said last-mentioned baffle means having peripheral wall portions adapted to direct gas escaping from the ends of the top and bottom units, respectively, substantially axially of the arrester toward the other ends thereof.</td>
<td></td>
</tr>
<tr>
<td>2,422,978</td>
<td>Olsen</td>
<td>June 24, 1947</td>
</tr>
<tr>
<td>2,454,849</td>
<td>Stroup</td>
<td>Nov. 30, 1948</td>
</tr>
</tbody>
</table>

OTTO ACKERMANN.