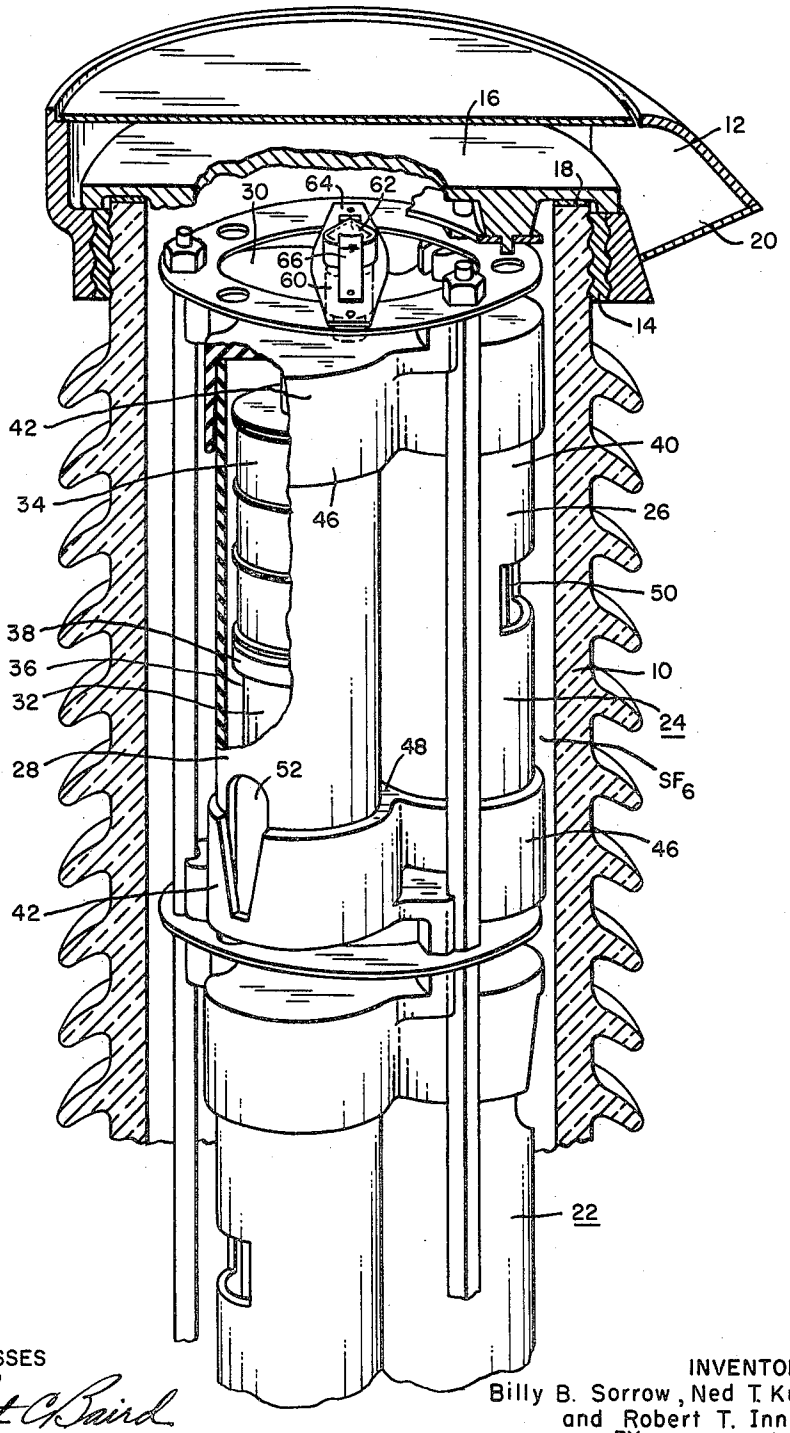
Nov. 3, 1964 B. B. SORROW ETAL 3,155,874

LIGHTNING ARRESTER

Filed Aug. 2, 1961




WITNESSES

Robert C. Baird

James F. Young

INVENTORS

Billy B. Sorrow, Ned T. Kunkle and Robert T. Innis.

BY

E. H. Liss

ATTORNEY

United States Patent Office 3,155,874 Patented Nov. 3, 1964



3,155,874

# LIGHTNING ARRESTER

Billy B. Sorrow, Ned T. Kunkle, and Robert T. Innis, Ellettsville, Ind., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Filed Aug. 2, 1961, Ser. No. 128,773
8 Claims. (Cl. 315—36)

This invention relates to lightning arresters and more particularly to an improved arc transfer means therefor.

The arc transfer device of the present invention is especially adapted for use in high voltage, station-type lightning arresters, although it may be used in other types of lightning arresters, as for example, distribution arresters. The present invention is shown for the purpose of illustration embodied in an arrester of the type disclosed and claimed in Patent No. 2,858,476, issued October 28, 1958, by Edward F. W. Beck and Otto Ackermann, and assigned to the assignee of the present invention. This is a compact, high voltage lightning arrester having columns of arrester elements disposed side by side in an insulating housing, the columns being connected in series.

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 lightning surges, permitting the surge to be discharged to ground through the non-linear resistance blocks, which have low resistance under surge voltage conditions. After discharge of the surge, the blocks because of the valve characteristics reduce the power follow current to a small value which can readily be interrupted by the series gap.

Lightning arresters of this type are usually tightly sealed to exclude moisture, which may have a very detrimental effect on the electrical characteristics of the blocks and of the series gaps. On occasion, the arrester may fail to interrupt the power follow current.

Then the full short circuit current of the system to which the arrester is connected flows through it to ground. When a lightning arrester fails, the semi-conductor blocks or non-linear valve blocks, which are usually of silicon carbide, are punctured creating a short-circuit from the line to ground. The system fault current will flow through this short-circuit, generating a large quantity of gas from the block material. The major gas generation in the arrester is a result of sublimation of the silicon carbide blocks. Since the housing is tightly sealed, in the conventional construction, very high gas pressures are rapidly built up in the housing in case of failure of the arrester, and these high pressures may cause rupture or shattering of the porcelain housing unless the pressure is promptly relieved and further gas generation is stopped or slowed. These ruptures may occur with explosive force, causing parts of the housing to be violently thrown around, endangering adjacent apparatus or persons who may be in the vicinity. These explosions vary in severity with the amount of fault current available. It, then, is evident that to prevent an explosion the fault current must be transferred from the non-linear resistance blocks.

A number of successful schemes have been devised for transferring the fault current to a path external to the non-linear resistance blocks. An example of such an arc transfer device is one in which rupturable diaphragms are provided to seal the outer housing of the arrester and baffles are provided to direct escaping gases in a direction external to and parallel to the outer housing of the arrester to produce an arc path external to the arrester housing. The current flow through the arrester blocks is transferred to the exterior of the arrester housing by this means. The rupturable diaphragms are ruptured by internal forces and the escaping gas is directed by the baffles toward the opposing end castings in order to provide an external arc.



Another scheme for arc transfer which depends upon an internal arc transfer has been proposed which comprises a fusible wire connected in series with the arrester elements and disposed within a gas evolving tube. The gas evolving tube directs the gases generated therein along the axis of the arrester. The current path is transferred from the arrester block to the path formed by the hot ionized gases evolved by the arc transfer device. When excessive fault current flows through the arrester, the fusible wire ruptures causing arcing which results in gas evolution from the tube surrounding the fusible wire. While these schemes are satisfactory in all instances where they are applied, it is sometimes necessary to provide a more rapid arc transfer means either instead of, or in addition to, the above-described arc transfer devices.

The arc transfer device of the present invention constitutes an improvement over the prior art arc transfer schemes described hereinabove, and other known schemes, in that it is simpler and more economical to manufacture, and for certain applications where faster arc transfer is required to avoid explosion, more rapid arc transfer can be accomplished by the structure of the present invention.

Briefly, the lightning arrester of this invention comprises an outer insulating housing and a plurality of arrester elements including spark gap devices and arrester blocks stacked in a column within an inner insulating tube. The inner insulating tube is provided to maintain the arrester elements in a unitary assembly and to prevent flashover between the columns of elements or other parts of the arrester. Openings are provided in the inner insulating tube and are preferably disposed near the non-linear resistance blocks but they can be disposed in any position on the insulating tube. The gas generated by the arrester blocks, particularly where silicon carbide blocks are used, is principally carbon and is highly ionized. This highly ionized gas released by the sublimation of the arrester blocks is utilized to provide the arc transfer path. These gases are released through the openings in the inner insulating tubes and flashover occurs externally of the blocks. The slots or openings in the insulating tubes are disposed in such a position that they are directed toward the inner wall of the outer housing thereby splashing the ionized gas in a direction longitudinally of the arrester and rapidly forming a complete envelope around the internal arrester parts. The presence of this highly concentrated ionized envelope provides an easy path for the internal arc transfer. The free space in the arrester housing may be filled with a mixture of gases including a high concentration of an electronegative gas as for example sulfur hexafluoride. Sulfur hexafluoride ($SF_6$) is preferable. It is known that $SF_6$ has very effective arc suppressing properties. This prevents flashover between the internal parts of the arrester which may occur due to the opening of the insulating tubes. A further precaution to prevent undesired flashover between columns of arrester elements disposed side by side is provided by an unique arrangement of the openings in that they are positioned a distance from each other sufficient to prevent flashover between columns of the arrester elements. However, upon flow of fault currents a sufficient concentration of highly ionized gas is dispersed in the sulfur hexafluoride atmosphere to permit rapid flashover.

The principal object of the present invention is to provide a simple and economical arc transfer construction for lightning arresters.

Another object of the invention is to provide a simple,

economical and effective improved arc transfer construction for a lightning arrester in which the ionized gas resulting from the sublimation of the non-linear resistance block is utilized to provide an easy path for internal arc transfer.

A further and more specific object of the invention is to provide an improved arc transfer device construction for valve type lightning arresters which permits the release of ionized carbon gases released from the block sublimation to form a complete envelope around the internal arrester parts for easy arc transfer and which is provided with means for eliminating undesired flashover between the internal parts under normal conditions.

Other objects and advantages of the invention will be apparent from the following description, taken in connection with the accompanying drawing, the single figure of which illustrates a lightning arrester partly in section embodying this invention.

In the preferred embodiment of the invention shown in the drawing, for the purpose of illustration, the arc transfer construction is embodied in a lightning arrester of the type disclosed and claimed in Patent No. 2,858,476, by E. F. W. Beck and O. Ackermann, issued October 28, 1958, and assigned to the assignee of the present invention. As more fully disclosed in the above-cited patent, the arrester comprises a generally cylindrical housing 10 which is preferably made of porcelain although any suitable weather resistant insulating material may be used. The housing 10 is provided at each end with metal end fittings 12 of any suitable design which are secured to the housing 10 by cement, as indicated at 14, or in any other desired manner. The ends of the housing 10 are closed by rupturable metal diaphragms 16 which are secured to the end fittings 12 in any desired manner, as by bolts (not shown), a gasket 18 being interposed between each of the diaphragms 16 and the housing to seal the interior of the housing. It will be understood that any suitable construction may be employed for the end fitting, the end fitting providing for electrical and mechanical connection of the unit in a column of similar units in the usual manner.

Each end fitting is provided with a directional baffle 20 with the opening of opposing end fittings directed toward each other for facilitating external arc transfer as will be hereinafter more fully explained. The arrester as disclosed includes a lower arrester unit 22 and an upper arrester unit 24 stacked thereon. The arrester assemblies 22 and 24 are identical in construction and only one such assembly will be described in detail, similar reference numerals being applied to like parts in the units 22 and 24. Each arrester assembly, which is contained in the housing 10, consists of three columns 26, 28 and 30 of lightning arrester elements connected in series and disposed side by side in the housing in a triangular arrangement. The arrester elements comprise spark gap devices 32 and valve blocks or non-linear resistance elements 34, which may be of any usual or desired type.

The gap assembly 32 may be of any suitable type, as for example, the type disclosed in Patent No. 2,858,476, by E. F. W. Beck and O. Ackermann, issued on October 28, 1958, and assigned to the assignee of the present invention. It includes a plurality of electrodes spaced apart to form gaps arranged in a column in a porcelain tube 36. Any necessary number of spark gaps may be provided depending upon the desired voltage rating and they may be disposed in a porcelain tube 36 in a vertical column. The end of the porcelain tube 36 may be closed and sealed at each end by metal end closures 38. Each of the columns 26, 28 and 30 may consist of any combination of spark gaps and valve blocks arranged in series in any desired manner. The arrester elements are disposed in a series column in a tube 40 of any suitable rigid insulating material. Each column may include either all gap assemblies or a combination of gap assemblies and resistor blocks or all resistance blocks. A different arrangement may be employed in each column. The tubes 40 are closed at their ends by generally cloverleaf-shaped end members 42 at the top and bottom. Each end member 42 includes a flange portion 46. Ribs 38 are provided which, together with flange 46 provides three relatively deep recesses of circular outline equidistantly spaced from each other to receive the ends of the tubes 40.



Each insulating tube 40 has an opening in its side wall in communication with the column of arrester elements within that tube 40. In the illustrated example, as shown in the drawing, the opening 50 in column 26 is disposed intermediate the top and bottom end caps 42 and may be of a suitable size and shape, for example the shape shown in the illustration. The opening 50 is disposed so as to face the nearest point on the interior surface of the wall of the porcelain housing 10. The insulating tube 40 of column 28 in the illustrated embodiment has an opening 52 provided adjacent the lower cap at the end of the insulating tube 40. The insulating tube 40 of the column 30 has an opening similar to opening 52 but not visible in the illustration. The opening in the insulating tube 40 of column 30 is disposed adjacent the upper cap 42. The openings 50 and 52 in tubes 40 of the columns 26, 28 and 30 all are disposed in opposing relation to the nearest point of the adjacent inner surface of the porcelain housing wall 10. The arrester unit 22 has openings in the insulating tubes disposed similarly.

It can be seen that the arrangement of the openings 50 and 52 is such that a maximum distance between the openings of adjacent columns in the insulating tube is achieved by alternate arrangement of the openings in their longitudinal position, and also in the radial disposition of the openings it can be seen that the center lines of the openings are approximately 120° apart. This disposition of the openings reduces the possibility of flashover between arrester elements of adjacent columns. Although the openings are shown in a particular position in the drawings, it should be understood that this is for purposes of illustration only and although the specific aspects of the invention is the preferable form shown and described, other locations may be employed in accordance with the broader aspects of the invention. The positions of the openings facing the nearest adjacent inner portion of the inner surface of the porcelain housing 10 is advantageous in that in case of failure of the arrester and consequent sublimation of the resistance blocks, the gases evolved escape through the openings and are projected against the wall surface, splashing in all directions, thereby completely enveloping the arrester elements with ionized gas to provide an easy path for arc transfer exteriorly of the blocks.

The entire sealed porcelain housing 10 and all the free space therein is filled with a concentrated atmosphere of an electronegative gas as for example $SF_6$ (sulfur hexafluoride). The atmosphere of sulfur hexafluoride gas serves a dual function. It serves to prevent flashover between arrester elements of adjacent columns and also serves as a corona-suppressing material. The corona-suppressing characteristic of the gas prevents changes in internal sparkover voltage due to contamination on the exterior of the housing 10. As more fully explained in copending application Serial No. 113,878, by B. B. Sorrow and N. T. Kunkle, filed May 31, 1961, now U.S. Patent No. 3,099,770, and assigned to the assignee of the present invention, an electronegative gas such as $SF_6$ prevents or greatly reduces corona discharge within the arrester thereby reducing undesirable effects of surface contamination. The $SF_6$ gas is excluded from the spark gap assembly 32 by the sealed porcelain tube 36 and end caps 38 thereby preventing any effect upon the sparkover characteristics of the gap. The end caps 38 and the porcelain tube 36 provide a sealed gap assembly.

During normal operation, the spark gaps isolate the arrester from the line to which it is connected but break down under excess voltage conditions, such as lightning surges, to permit the surge to be discharged to ground through the non-linear resistance blocks which have low resistance under surge conditions. After discharge of the surge, the blocks because of the valve characteristics reduce the power follow current to a small value which can be readily interrupted by the series gaps. On occasion when the arrester is damaged, the non-linear resistance blocks may be punctured thereby creating a short-circuit from line to ground. The system fault current will flow through the short-circuit, generating a large quantity of gas from the block material. Since the housing 10 is tightly sealed, in conventional constructions, very high gas pressures are apt to build up in the housing. In case of failure of the arrester, this high pressure may cause rupture or shattering of the porcelain housing unless the pressure is promptly relieved and further gas generation is stopped or slowed. A relatively low resistance path through the resistance blocks allows system fault current to flow almost unrestricted. The continued flow of fault current through the block causes the resistance material to sublimate. This sublimation constitutes most of the interior gas resulting in excessive pressure. The openings 50 and 52 in the insulating tubes 40 permit the gas generated by the block to escape through the aforementioned openings. The gas projected against the inner surface of the porcelain housing wall is splashed to envelop the parts of the arrester assembly. These gases are highly ionized and provide an arcing path. This path is exterior to the block and when the arc is transferred from the non-linear resistance blocks to the exterior path, sublimation and continued generation of gas is halted.

Various means are provided in addition to the arc transfer system for opening the diaphragms 16 in the end fittings of the arrester to permit escape of the gas which has already been generated. The means employed in the illustrated embodiment of this invention are described in detail in a copending application Serial No. 69,090, by B. B. Sorrow et al., filed November 14, 1960. Essentially, the device for relieving gas pressure in the illustrated embodiment comprises a hollow cylindrical tube 60 having a current sensitive element (not shown) in series with the arrester element. The end of the tube is closed by a projectile 62 held in position by a strap 64 having spring arms 66 which engage the projectile 62. Upon flow of fault current, the current sensitive element vaporizes, evolving gas and causing the projectile 62 to strike the rupturable diaphragm 16 thereby rupturing the diaphragm. The exhaust opening 20 baffles the gas toward the opposing end thereby providing an external arcing path. This external arcing path is external to the porcelain housing 10. Thus, a path is provided exteriorly as well as interiorly of the arrester housing and exteriorly of the non-linear resistance block 34. By means of openings 50 and 52 in the insulating tubes as hereinabove described, it is possible to utilize the highly ionized carbon gases released by the sublimation of the silicon carbide blocks to provide an internal arc transfer path. This results in an increased volume of ionized gas which completely envelops the internal arrester unit. The more rapidly available and increased volume of ionized gas enables the fault current rating of one type of arrester built in accordance with this invention to be increased from 25,000 amperes to 44,500 amperes.

It should now be apparent that a high voltage lightning arrester has been provided which has many advantages. The new arrester provides a more rapid and more effective means for providing an internal arc path and this enables a faulted arrester to transfer the arc from the non-linear resistance blocks to a path exterior thereto more rapidly and more positively than prior constructions. It results in increased fault current rating for a given arrester. The new construction permitting more rapid production of an envelope of highly ionized gas within the unit may include an electronegative gas such as sulfur hexafluoride which in addition to preventing reduction in internal sparkover due to the surface contamination also deters flashover between the arrester parts in adjacent columns. In its more specific aspects, the position of the openings in the insulating tubes also aid in preventing internal flashover between adjacent arrester elements. A particular embodiment of the invention has been shown and described for the purpose of illustration, but it will be apparent that various other embodiments are possible within the scope of the invention. Thus, for example, other shapes and positions of the openings in the insulating tube may be utilized and materials other than sulfur hexafluoride gas may be employed for suppressing flashover between arrester elements. Similarly, numerous other modifications and embodiments will be apparent to those skilled in the art and all such modifications and embodiments are within the scope of the invention.



We claim as our invention:

1. A lightning arrester including an outer housing, said housing being closed at its ends and sealed, a plurality of columns of lightning arrester elements including elements in each column which evolve gas when subjected to fault current, each of said columns of elements being enclosed in an insulating tube to form an arrester assembly, said tubes having closure means at the ends, said arrester assemblies being disposed side by side within said outer housing and each of said tubes having an opening in its side wall.

2. A lightning arrester including an outer housing, said housing being closed at its ends and sealed, a plurality of columns of lightning arrester elements including elements in each column which evolve gas when subjected to fault current, each of said columns of elements being enclosed in an insulating tube to form an arrester assembly, said tubes having closure means at the ends, said arrester assemblies being disposed side by side within said outer housing and each of said tubes having an opening in its side wall, said openings spaced apart a distance sufficient to effectively avoid flashover between the exposed elements of adjacent columns.

3. A lightning arrester including an outer housing, said housing being closed at its ends and sealed, a plurality of columns of lightning arrester elements including elements which evolve gas when subjected to fault current, each of said columns of elements being enclosed in an insulating tube to form an arrester assembly, said arrester assemblies being disposed side by side within said outer housing and each of said tubes having an opening in its side wall disposed in position to direct escaping gases from within said tube against the interior walls of said outer housing.

4. A lightning arrester including an outer housing, said housing being closed at its ends and sealed, a plurality of columns of lightning arrester elements including elements which evolve gas when subjected to fault current, each of said columns of elements being enclosed in an insulating tube to form an arrester assembly, said arrester assemblies being disposed side by side within said outer housing and each of said tubes having an opening in its side wall disposed in position to direct escaping gases from within said tube against the interior walls of said outer housing, said openings spaced apart a distance sufficient to effectively avoid flashover between the exposed elements of adjacent columns.

5. A lightning arrester including an outer housing, said housing being closed and sealed at its ends, one or more columns of lightning arrester elements, each column disposed within an insulating tube to form a unitary assembly, said outer housing enclosing said unitary assemblies, at least one of said insulating tubes having an opening in its side wall and the free space within said outer housing being filled with a concentrated mixture of sulfur hexafluoride.

6. A lightning arrester including an outer housing, said housing being closed and sealed at its ends, one or more columns of lightning arrester elements including a plurality of electrodes forming a spark gap structure, said column of elements disposed within an insulating tube to form one or more unitary assemblies, said outer housing enclosing said one or more unitary assemblies, at least one of said insulating tubes having an opening in its side wall and the free space within said outer housing being filled with a gaseous arc suppressing material.

7. A lightning arrester including an outer housing, said housing being closed at its ends and sealed, a plurality of columns of lightning arrester elements including elements in each column which evolve gas when subjected to fault current and a plurality of electrodes spaced apart to form a spark gap assembly, said spark gap assembly being enclosed in a sealed spark gap assembly housing, each of said column of elements being enclosed in an insulating tube to form an arrester assembly, said arrester assemblies being disposed, side by side, within said outer housing, each of said tubes having an opening in its side wall and the free space within said outer housing being filled with an electronegative gas.



8. A lightning arrester including an outer housing, said housing being closed at its ends and sealed, a plurality of columns of lightning arrester elements including elements in each column which evolve gas when subjected to fault current and a plurality of electrodes spaced apart to form a spark gap assembly, said spark gap assembly being enclosed in a sealed spark gap assembly housing, each of said columns of elements being enclosed in an insulating tube to form an arrester assembly, said arrester assemblies being disposed, side by side, within said outer housing, each of said tubes having an opening in its side wall, said openings spaced apart a distance sufficient to effectively avoid flashover between the exposed elements of adjacent columns and the free space within said outer housing being filled with an electronegative gas having arc suppressing properties.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,586,285 | Ackermann | Feb. 19, 1952 |
| 2,858,476 | Beck et al. | Oct. 28, 1958 |
| 2,891,194 | McStrack et al. | June 16, 1959 |