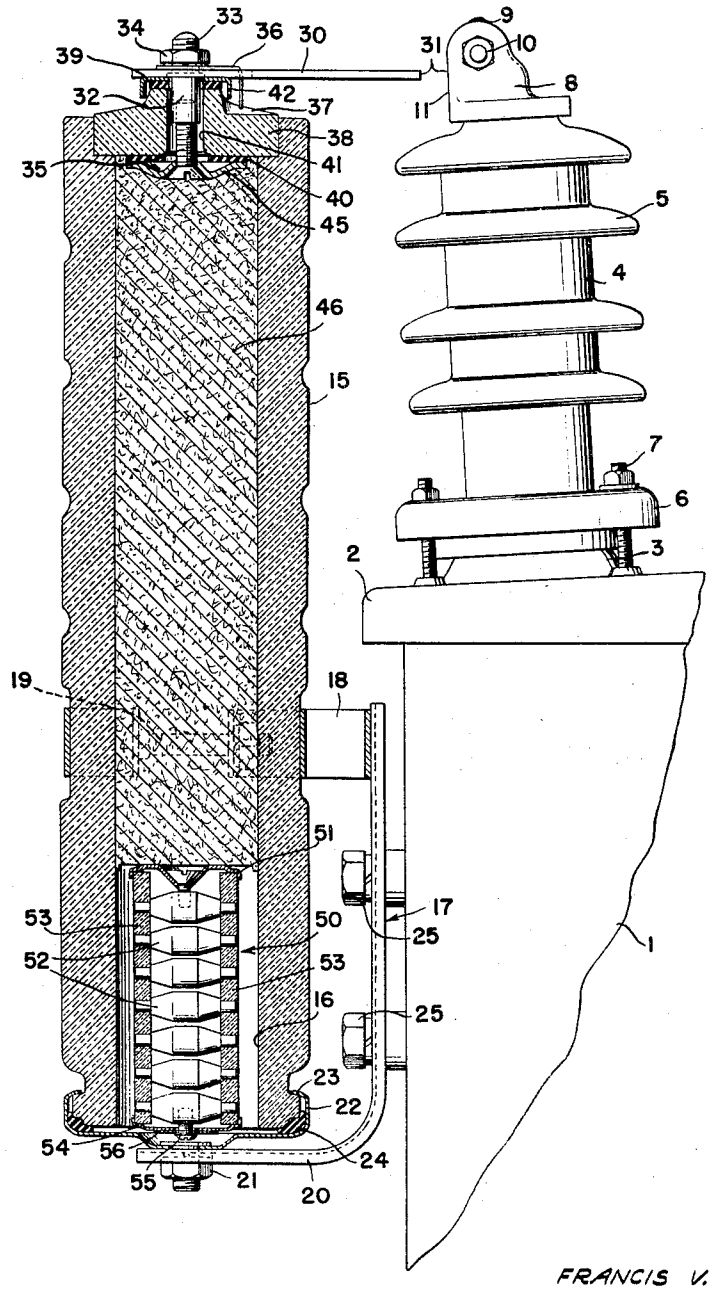
Dec. 23, 1958 F. V. CUNNINGHAM 2,866,135

LIGHTNING ARRESTERS

Filed Dec. 15, 1954 2 Sheets-Sheet 1

FIG. 1.



INVENTOR.
FRANCIS V. CUNNINGHAM
BY Gerald J. Curran
ATTORNEY

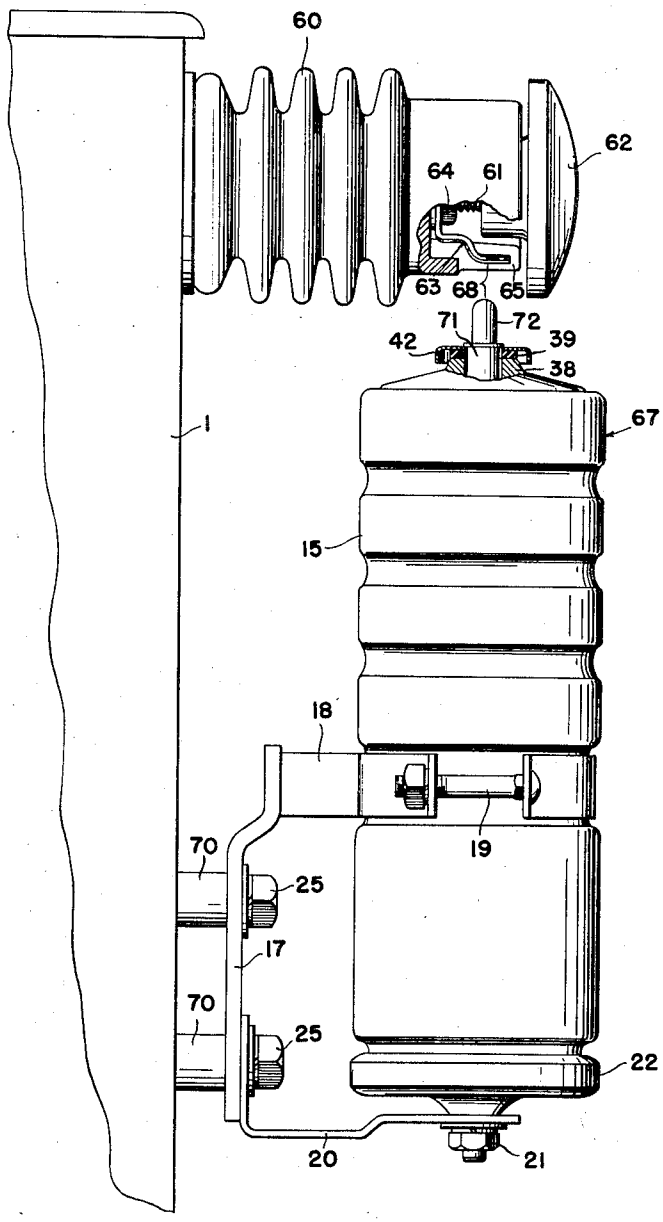
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LIGHTNING ARRESTERS

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2 Sheets-Sheet 2

FIG. 2.



INVENTOR.
FRANCIS V. CUNNINGHAM
BY Arnold J Ericson
ATTORNEY

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2,866,135

LIGHTNING ARRESTERS

Francis V. Cunningham, Milwaukee, Wis., assignor to McGraw-Edison Company, a corporation of Delaware

Application December 15, 1954, Serial No. 475,325

3 Claims. (Cl. 317—15)

The present invention relates to overvoltage protection for electrical equipment, and more particularly to an improved valve type lightning arrester and an improved mounting of such arrester on transformers, or other enclosed electrical apparatus.

Lightning arresters have long been provided for overvoltage protection of transformers, reclosing circuit breakers, and other electrical apparatus. It will be apparent that it is preferable to mount arresters close to the apparatus to be protected in order to minimize line lead impedance drop which adds to arrester impedance drop. This reduces the protective effect of the arrester, especially on apparatus in which age has reduced the insulation level. In addition, it is accepted practice to ground the arrester by connection or inter-connection to the normally grounded tank or frame of the apparatus to be protected.

When applying valve type arresters, which include totally enclosed spark gaps, it has been common practice to connect the arrester line lead directly to the primary bushing terminal of the transformer or other electrical apparatus to be protected. It will be apparent that valve type arresters mounted directly on electrical apparatus might cause line outage due to a number of possibilities. Under particularly heavy overvoltages, there have been instances of the enclosed gap electrodes being welded together to provide a continuous electrical path or short to ground. Another possibility is that should the arrester be physically broken while in service, the terminal portion connected with line current may drop down on the grounded tank or frame and short out the line. Physical breakage of arresters is well-known in the field of electric distribution, and is often caused by persons shooting or throwing stones at an arrester. In the case of expulsion type arresters, this has not been a problem, since these arresters normally require an open series gap for isolation from line voltage. Since no physical connection is made between the expulsion arrester and the line, arrester breakage cannot directly cause line outage.

It will become apparent from the above that it would often be desirable to provide valve type arresters with an open series gap for both physically and electrically isolating the arrester from line voltage prior to operation during the occurrence of a transient overvoltage or surge. The open gap, if of sufficient dimension, will prevent line outage or lockout by the arrester when the arrester is internally damaged or physically broken. It will be obvious that an open spark gap should be provided in the maximum dimension that will permit the arrester to operate effectively. The minimum dimension of the open spark gap is controlled by its performance under adverse weather conditions, such as rain, fog, ice, and snow.

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

Fig. 1 is a view, partly in elevation and partly in vertical section, showing the details of the lightning arrester mounted on the tank wall of an electrical device, such as a transformer having a protruding cover-mounted bushing.

Fig. 2 is an elevational view of the arrester, partly in section and mounted to operate in conjunction with a sidewall bushing of a transformer.

The embodiment of the present invention shown in Fig. 1 is particularly adaptable for mounting on electrical apparatus such as transformers, having cover-mounted primary bushings. The transformer is contained in a tank 1 closed by a cover 2. Although a transformer is described in connection with this embodiment, it will be understood that the arrester may be mounted on any type of electrical apparatus which is to be protected from overvoltage and of the form illustrated in either Figs. 1 or 2. In the case of the transformer, the core and coil assembly (not shown) may be of any suitable type or construction.

The cover 2 is provided with a boss 3 impressed therein for receiving the primary bushing 4. The bushing is of conventional structure and includes a plurality of spaced annular skirts 5 for increasing its effective flash-over distance. The bushing 4 may be mounted on the cover in any conventional manner, such as by means of the hold-down clamp 6 surrounding an integral annular flange on the bushing. The clamp is held in place by a plurality of bolt and nut assemblies 7 protruding from the cover 2.

The line terminal 8 positioned at the top of the bushing 4 is adapted to be engaged with a line lead (not shown) by means of a conventional connector 9 tightened in place by means of a nut 10. The terminal 8 is preferably provided with a relatively flat vertical surface 11, which acts as an isolating gap electrode surface, hereinafter described. The electrical connections from the terminal 8 to the operating members, such as the core and coil assembly, contained within the tank, are not shown, but are conventionally placed within the bore of the bushing 4.

The valve type lightning arrester, which is adapted to be mounted directly upon the tank wall 1, comprises a housing 15, which may be of porcelain or glass, as desired. The housing contains a coextensive bore 16, which is closed at both ends, and preferably hermetically sealed to keep the internal components of the arrester substantially moisture free.

The arrester is mounted on the tank 1 by means of a conductive bracket denoted generally at 17. The upper spaced-apart arms 18 of the bracket grippingly embrace the housing 15 of the arrester intermediate the ends thereof. The arms 18 are drawn together into gripping engagement by means of a nut and bolt assembly 19 engaging outwardly bent portions of the arms. The arrester is also seated on an L-shaped portion 20 of the bracket 17 and is fastened thereto by means of a nut and bolt assembly 21 protruding from the conductive cap 22 which has been inwardly spun to provide an annular flange portion 23 for engagement with the housing 15. A hermetic seal is provided between the cap and the housing by means of the resilient gasket 24. The mounting bracket 17 is fastened directly to the tank wall 1 by means of nut and bolt assemblies 25.

It is to be noted that it is conventional practice to ground the tank or frame of electrical apparatus, such as a transformer, and therefore the ground connection will be completed through the bracket 17 from the tank 1 to the conductive cap 22 which acts as a lower electrical terminal member for the arrester as will hereinafter be described.

The upper terminal of the arrester, as shown in Fig.

1, consists of an isolating gap electrode 30, which may consist of only a flat piece of conductor having an extremity cooperating with the surface 11 of the bushing terminal 8 to provide the isolating gap 31 therebetween. The electrode 30 engages an adapter member 32, which is also conductive material. The adapter member is preferably provided with a threaded stud portion 33 for receiving a nut 34 and is internally threaded at its opposite end to threadingly receive a machine screw 35. An L-shaped stop member 36 is seated in an aperture in the electrode 30 and extends downwardly to engage the sides of a slotted portion 37 of the insulating cap 38. The cap also may be porcelain and is bonded to the housing 1 to seal the upper end of the bore 16 of the housing. The stop member 36 prevents the electrode from rotating in position after the gap has been set. Gaskets 39 and 40 are provided at both ends of an aperture 41 extending through the cap 33 to act as cushioning and sealing means for clamping the various components of the upper terminal in place. An external conducting cap member 42 is fitted over the insulating cap 38 to complete the seal and act as a water shed.

The head portion of the machine screw 35 is positioned to engage the sides of an aperture in the upper electrode 45 to complete the electrical connection to the interior portions of the arrester. It is to be noted that it is preferred to manufacture the electrode 45 as shown to produce a resilient mechanical connection between the mating parts, serving to hold the cooperating members tightly together.

The upper electrode 45 is in intimate electrical contact with the valve material 46 contained within the bore 16 of the housing 1. The valve material 46 is usually a mass of granular silicon carbide, either loose or bonded into a rigid block by means of a binder of sodium silicate intermixed with the carbide and rendered desiccate by baking; and the mass of carbide, if bonded into a rigid block, may also be bonded to the housing as described in Patent No. 2,305,577, issued on December 15, 1942, to Herman O. Stoelting.

An internal spark gap assembly 50 is provided in the bore 16 at the end opposite the open spark gap and comprises a valve electrode 51 in electrical engagement with the valve material 46. The internal spark gap assembly 50 may comprise a plurality of cylindrical spark gap electrodes 52, the number of which is dependent upon the desired voltage rating and length of the arrester. The electrodes 52 are mounted between ceramic insulating posts 53. The posts are mounted between the electrode 51 and the lower cap-like electrode 54. By means of a screw 55 and a leaf spring 56 (shown here in compression), the lower spark gap electrode 52 is connected to the electrode cap 54. Electrical connection is completed by means of the leaf spring suspended across the terminal cap 22.

Attention is directed to the fact that in conventional distribution valve type arresters it is the practice to position the internal sparkover series gap in the proximity of the line terminal, whereas in the present invention the internal gap is connected directly to the ground end of the arrester. I have found that when the internal spark gap is placed adjacent to the external gap, the external gap 31 must be very short to provide a low enough front-of-wave impulse sparkover voltage to effectively protect the equipment. This relatively closed gap is insufficient to isolate the arrester from line voltage, especially when wet. The arrangement illustrated in Fig. 1, places the internal gap adjacent the ground connection and thereby permits an external gap of relatively great dimension. I have found for example, that the external gap 31 may be as much as 5/8" on a 9 kv. or 10 kv. rated arrester, which dimension will isolate an internally shorted valve arrester even under adverse weather conditions, to prevent line lockout. Tests have been conducted and indicate that a

gap of as much as 3/8" on a 10 kv. arrester will definitely spark over at line voltage under wet conditions. The particular design illustrated in Fig. 1 provides an electrically isolating external series gap, while offering a degree of overvoltage protection equal to that offered by conventional distribution valve type arresters having 3/8" external series gaps. In fact, test results have indicated a reduction of as much as 30% in the impulse sparkover level of my arrester compared to conventional arresters having the external and internal gaps in the proximity of one another at the line or upper end of the arrester.

A possible explanation of the control of sparkover through the relative position of the internal and external sparkover gap lies in the control of the magnitude of impedances shunting the various electrodes making up the internal and external sparkover gap assemblies. Assume the internal ladder gap to be positioned at the end of the arrester adjacent the open gap, and spaced remotely from the ground connection. For simplicity, assume that the impedance between each of the electrodes of these two gap assemblies and the shunting impedance between each electrode and ground to be of equal magnitude. This assumption approaches fact. Thus, since voltage distribution across a series of gaps is proportionate to impedance distribution, voltage would be equally distributed across all gaps of the two gap assemblies. The result is high sparkover.

Low and consistent sparkover may be accomplished by unequal voltage distribution through unequal impedance distribution. Thus, if the impedance of the internal gap assembly could be appreciably decreased while maintaining high impedance across the external gap, voltage would be distributed so as to greatly stress the external gap. Early breakdown of the external gap is thus assured and a noticeable arrester sparkover decrease results. My invention has accomplished this result through placement of the internal gap structure adjacent the grounded arrester cap. This greatly decreases the total impedance of the internal gap assembly. The decrease is accomplished through an increase in the electrical shunt capacitance existing between the gap electrodes and ground. This shunt capacitance is further increased through positioning the upper arms 18 of the bracket on the arrester housing adjacent to the top end of the internal gap structure. It should be remembered that these shunt capacity increases result since electrical capacitance varies inversely with distance between electrodes. Also, impedance will vary inversely with capacitance. Thus the impedance of the internal gap assembly will be considerably less when positioned, as shown in Fig. 1, than as conventional, at the upper end (not shown) adjacent the external gap electrode. This will permit a relatively larger external gap electrode.

In addition to the fact that the bracket 17 acts principally as a support member for the arrester, it is to be noted that it is conductive for grounding purposes as heretofore stated. The bracket preferably has two major portions comprising the L-shaped portion 20 at its lower end, and the embracing arms 18 arranged to graspingly engage the arrester intermediate the ends thereof. Of course, the most secure method of supporting an elongated object is to embracingly grasp it in the proximity of its center of gravity. However, it is also to be noted that since ground potential is brought to both ends of the internal ladder gap assembly 50, this will, in effect, tend to increase the stray shunt capacitance of this gap. By adding capacitive reactance to the internal gap, the external gap 31 will be under relatively greater stress. Thus, where the external gap is overstressed, or stressed relatively higher, it will tend to spark over earlier, or at least, spark over will be assured across both gaps simultaneously.

The arrester-bushing assembly illustrated in Fig. 2 provides a convenient manner of mounting of the ar-

rester for the protection of transformers having sidewall mounted bushings. It is the general practice to utilize sidewall mounted bushings on the lower kv. rating transformers, whereas cover-mounted primary bushings, as illustrated in Fig. 1, are utilized in the larger transformers. One feature of the sidewall mounted bushing, especially when combined with a lightning arrester, is that the external gap between the bushing and arrester is practically inaccessible to birds, tree frogs, or other animals that might get between and thus short out the external gap electrodes.

In both embodiments, like parts are denoted by like reference characters.

Referring now to Fig. 2, there is shown an electrical instrumentality, such as a transformer, having a tank wall **1** having a sidewall mounted bushing **60** protruding laterally therefrom. Suitable low-voltage terminal devices may also be mounted in the tank wall **1**, but are not shown herein.

The bushing preferably takes the form described and claimed in U. S. Patent No. 2,664,457 issued to Joseph Charles Joublanc on December 29, 1953, and assigned to the same assignee as is the present invention. The bushing is provided with a line terminal including a solderless connector **61** threadingly engaging a manually operated insulating knob or hand wheel **62** for graspingly receiving a primary line lead (not shown).

An external gap electrode **63** forming a part of the bushing terminal is apertured to engage the connector **61** and is held in place by means of a hexagonal nut **64** engaging the threads of the connector **61**. The insualting housing of the bushing **60** is slotted at the exterior end to provide the opening **65**, whereby the gap electrode **63** may communicate with the external gap electrode **72** of the arrester **67** to provide an external gap **68** therebetween.

The valve type arrester **67** is substantially identical in structure to the arrester previously described in connection with Fig. 1. The internal components of the arrester are identical with the structure illustrated in detail in Fig. 1. In general, the arrester **67** comprises an insulating housing **15** supported by the bracket **17**. The bracket is formed with arm-like portions **18** and L-shaped portion **20** extending laterally outwardly to receive and support the arrester. The free ends of the arms **18** are drawn towards one another by the bolt and nut assembly **19**. The entire bracket **17** is conductive and the L-shaped portion **20** is securely electrically connected to the lower terminal cap **22** of the arrester by means of the bolt and nut assembly **21**, as heretofore described. The bracket **17** is mounted directly on the tank wall **1** by means of bolt and nut assemblies **25**, being spaced therefrom by the bushings **70**.

The external gap electrode assembly of the present embodiment is slightly modified from the first-disclosed embodiment to provide the gap **68** with the component portions of the side wall mounted bushing **60**. That is, the conducting adapter member **71** terminates in a stud-like portion **72** acting as a companion gap electrode member with the electrode **63** of the bushing to provide the external gap **68**. The stud need not be externally threaded as with the first-described embodiment. The gasket **39** and the external conducting cap member **42** act to provide a moisture seal and water shed, respectively.

It will be apparent that the present invention has provided the novel combination of mounting a valve-type lightning arrester having an external gap directly to the tank wall of an electrical instrumentality, such as a transformer, for over-voltage protection of that instrumentality. The external gap of the valve-type arrester is provided in addition to a current clearing internal gap for completely isolating the arrester from line both physically and electrically, and wherein both the external gap and the internal gap assembly are positioned at opposite ends of the arrester valve material to provide comparatively low impulse sparkover voltages without affecting the total IR drop across the arrester.

I claim as my invention:

1. In a valve type lightning arrester arranged for protection of an electric line having a terminal gap electrode, said arrester having an insulating housing including a substantially coextensive chamber closed at both ends thereof and containing therein a predetermined amount of negative resistant valve material, and a conductive mounting bracket means having a portion disposed intermediate the ends of said housing and arranged for electrical connection with ground for sationarily supporting said housing; the combination with an external gap electrode having a portion protruding from said housing and terminating at its opposite end within said chamber, said protruding portion arranged for operative association with said line terminal gap electrode whereby a predetermined external sparkover gap dimension is provided therebetween, an internal sparkover gap assembly contained within said chamber and comprising a plurality of gap electrodes spaced apart and electrically insulated from one another, one end of said assembly being electrically connected to a terminal member electrically engaging said bracket means, said valve material being positioned intermediate said opposite end of said external gap electrode and said internal gap electrode assembly, and said portion of said bracket means being disposed in proximity to the end of said internal gap electrode assembly opposite from said one end engaging said terminal member.

2. In a valve type lightning arrester arranged for protection of an electric line having a terminal gap electrode, said arrester having an insulating housing including a substantially coextensive chamber closed at both ends thereof and containing therein a predetermined amount of negative resistant valve material; the combination with an external gap electrode having a portion protruding from said housing and terminating at its opposite end within said chamber, said protruding portion arranged for operative association with said line terminal gap electrode whereby a predetermined external sparkover gap dimension is provided therebetween, an internal sparkover gap assembly contained within said chamber and comprising a plurality of gap electrodes spaced apart and electrically insulated from one another, one end of said assembly being electrically connected to a grounding terminal member, said valve material being positioned intermediate said opposite end of said external gap electrode and said internal gap electrode assembly, and a conductive mounting bracket arranged for electrical connection with ground and having two major portions for supporting said arrester, the first of said portions embracingly engaging said housing intermediate its ends and in the proximity of the end of said internal gap electrode assembly opposite from the grounding terminal connection, and the second portion electrically engaging said grounding terminal.

3. In combination, an enclosed electrical device including a tank arranged for electrical ground connection, an insulating bushing mounted on said device, a terminal member on said bushing including connector means for electrically engaging an electrical line lead, said terminal member including a portion providing a first gap electrode, a valve-type lightning arrester comprising an insulating housing having a substantially coextensive chamber closed at both ends thereof and containing therein a predetermined amount of negative resistant valve material, the closure for one end of said chamber, including a second gap electrode protruding therefrom and jointly providing an external sparkover gap with said first gap electrode and terminating within the chamber of said housing, an internal sparkover gap assembly contained within said chamber and comprising a plurality of gap electrodes spaced apart and electrically insulated from

one another, one extremity of said assembly providing a closure for the opposite end of said chamber and being electrically connected to a grounding terminal member, said valve material being positioned intermediate said second gap electrode and the other extremity of said internal gap electrode assembly, and a conductive mounting bracket fastened to and electrically engaging the wall of said tank, said bracket comprising two major portions for supporting said arrester, the first of said portions embracingly engaging said arrester intermediate the ends of said housing in the proximity of said other extremity of said internal gap electrode assembly, and the second portion electrically engaging said grounding terminal member.

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