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RESISTANCE-SHUNTED LIGHTNING ARRESTER

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Fig. 1.

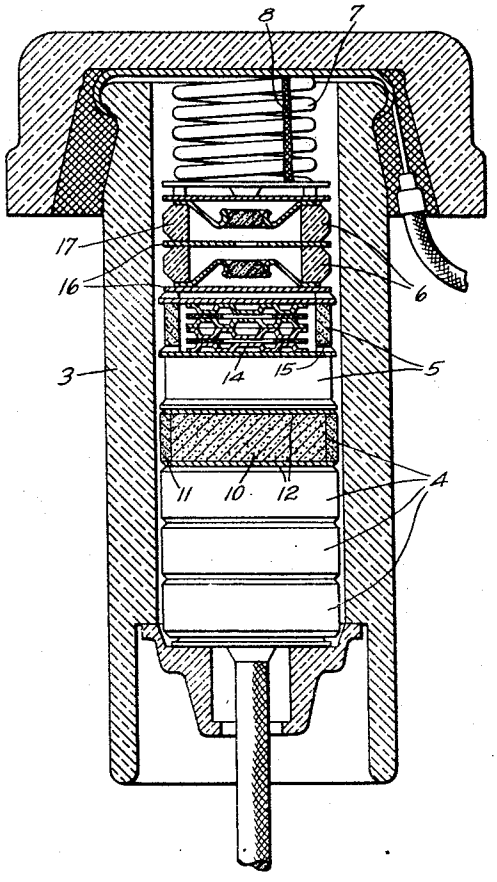
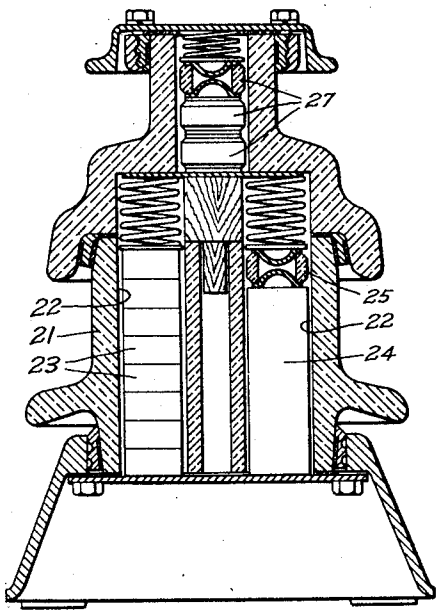


Fig. 2.



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RESISTANCE-SHUNTED LIGHTNING ARRESTER

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3 Claims. (Cl. 175—30)

Our invention relates to excess-voltage protective devices, and particularly, but not necessarily, to those which are utilized for the protection of long transmission lines, or other lines or apparatus which are subject to excess-voltage surges of long duration.

It is our belief that many failures of lightning arresters such as have been previously utilized have been directly the result of the fact that they have been called upon to discharge surges of long duration, or excess-voltage wave-forms which take a very abnormally long time to decrease from their maximum or crest value to the normal voltage of the arrester. Such surges occur when a long transmission line is charged to an excessive voltage, and when that charge is discharged through a single arrester, without any substantial part of the surge-energy being drained off by other apparatus. Such long discharges may also result from a lightning-stroke which itself is of relatively long duration.

To dissipate excess-voltage surges, a common type of protective device has utilized a variable-resistance, valve-type element which is capable of passing heavy discharge-current when impressed with voltages in excess of the rated voltage of the protective device, and which is capable of substantially interrupting said discharge upon the return of rated voltage-conditions, said substantial interruption meaning a reduction of the discharge-current either to a negligibly small amount, or to a somewhat larger value which is still considerably smaller than the maximum surge-current discharge-rate, and which is sufficiently small so that the series gap-device, which is normally connected in series with the valve-type element is capable of finally interrupting the discharge. A valve-type element of this nature has the property of changing from a relatively high resistance, which it has at the normal rated voltage of the device, to a relatively low resistance which it has under excess-voltage conditions when it is discharging heavy currents; and when the applied voltage reduces again, and approaches toward the normal rated voltage of the device, the resistance of the element again returns substantially to its initial high value.

When such a variable-resistance, valve-type element is utilized to dissipate a long-tail surge, or a surge requiring a long time to fall back to normal voltage-conditions after passing its crest-value, the valve-type element begins to return to its high-resistance condition long before the surge is completely dissipated, and this increase in the resistance of the discharge-element aggravates the long-tail condition by materially slowing up the rate at which the tail-end of the surge can be dissipated by the protective element. All of this means that the protective element is discharging for a very long time, being subjected to heating and other deleterious effects during this time, resulting in a very serious reduction in the life of the arrester, or its ability to handle repeated discharges, or even one discharge.

In accordance with our present invention, we provide a relatively constant or non-variable resistance which is connected in parallel to a variable-resistance, valve-type element of the class just described, said relatively non-variable resistance being of a sufficiently low value to materially aid in dissipating the tail-end of an excess-voltage surge. To be sure, this resistance results in a materially increased final current-flow, when normal line-conditions are restored after a surge, but it is relatively easy to design the series gap-device so as to be able to interrupt the larger currents thus obtained. Tests have shown that the addition of a suitable shunting resistor results in a marked increase in the number and severity of surges which can be withstood by a valve-type lightning arrester, particularly when subjected to surges of abnormal length or duration.

Tests have further shown that the addition of our shunting resistor results in a material reduction in the voltage at which the arrester, with its series gap, breaks down, on fast-rising, or steep-wave-front, surges. On such surges, the series gap of a 73 kilovolt arrester may have a capacitance of, say, 10 micro-microfarads, passing a current of 10 amperes on a surge rising at 1000 kilovolts per microsecond. This occurs before the gap breaks down or arcs over. Under these conditions, an unshunted lightning-arrester block may have a resistance of something like 120 ohms per kilovolt, or approximately 9000 ohms for a 73 kilovolt arrester, giving a voltage-drop of 90 kv. at 10 amperes, which has to be added to the gap-breakdown voltage of about 110 kv. on such a wave-front, giving a total break-down voltage of 200 kv. With our shunting resistor of about 120 ohms per kilovolt, this resistance-drop is reduced to 45 kv., giving a total break-down voltage of 155 kv.

With the foregoing and other objects in view, our invention consists in the apparatus, structure, parts, combinations, systems and methods hereinafter described and claimed, and illustrated in the accompanying drawing, wherein:

Figure 1 is a vertical longitudinal view through an arrester embodying our invention in a preferred form of embodiment, and

Fig. 2 is a similar view of a modification.

In Figure 1, our invention is embodied in an arrester comprising a cylindrical porcelain housing 3 which houses the various elements of the arrester. Starting at the bottom, it will be noted that the illustrated arrester comprises four arrester-blocks 4, surmounted by two so-called quench-gaps 5 which are in turn surmounted by two switching-gap structures 6, the whole being held down, in firm contact with each other, by a spring 7 which is shunted by a flexible shunt 8.

Each one of the arrester-blocks 4 comprises a central body-portion 10 which constitutes the variable-resistance, valve-type element, and which may be composed of silicon-carbide granules or crystals and a binder. Surrounding this valve-type core or element 10, in the embodiment of our invention illustrated in Fig. 1, is a tubular resistance-member 11 which, as compared to the valve-type element 10, is of a relatively fixed resistance, being made of any of the well-known composition-materials which are utilized for resistors, such as a finely subdivided resistance-material and a binder. Each of the blocks 4 is coated, at each of its ends, with a terminal conductive coating 12 of sprayed copper or other good conducting material, preferably metallic, so as to make a good electric contact with the next element of the stack of elements of which the arrester is composed.

In accordance with our invention, the resistor 11 has a resistance which is less than 120 ohms per kilovolt of the rated voltage of the valve-type element across which it is shunted, or said resistor should have a value which is of approximately the same order of magnitude as, or less than, that of the associated valve-type element in the final stages of the discharge, near the cut-off point of the valve-type element. We have successfully utilized resistors having a value lying in the range between 25 and 100 ohms per kilovolt of the rated voltage of the protective device, although we contemplate that even lower resistances can be utilized if the series gap-devices are designed to interrupt the larger currents which would be drawn by any smaller resistance.

The particular type of arrester-block 4, as illustrated in Fig. 1, except for the specific range of resistance-values, is described and claimed in an earlier application, Serial No. 280,677, filed June 23, 1939 (case No. 20,444).

The series gap-device, which is connected in series with the resistance-shunted valve-elements 4 in Fig. 1, is illustrated in a form in which it is divided into two parts, a so-called quench-gap part 5 and a so-called insulating or switching-gap-part 6, as is fully described and claimed in a patent of L. R. Ludwig, W. G. Roman and ourselves, No. 2,135,085, granted November 1, 1938. The quench-gap device consists of a plurality of quench-gap elements 14 preferably shunted by a resistor 15, so that this part of the gap-structure has the ability to reduce the final discharge-current to a value which can be handled by the switch-gap elements, which consists of a plurality of metallic electrodes 16 separated by insulators 17.

In operation, our arrester operates as any other valve-type arrester, except for our addition of the resistor-elements 11. When an excessive voltage occurs, the series-gap elements 5 and 6 first draw a certain charging-current, due to their capacitance, and this charging-current produces a certain resistance-drop in the blocks 4. Because of our shunting resistors 11, this resistance-drop in the blocks is materially reduced, so that the arrester, as a whole, has a lower flashover or breakdown voltage on surges, particularly on steep-wave-front surges. As the surge-voltage continues to rise, the series-gap elements 5 and 6 finally flash over, applying substantially the full voltage of the excess-voltage surge to the resistance-shunted valve-elements 10.

These valve elements thereupon change from their normal high-resistance condition to a low-resistance condition which permits them to discharge heavy surge-currents, until the surge-voltage begins to return again so as to approach the normal rated voltage of the protective device, at which time the discharge-current of the valve-element falls sharply off to a small value which varies only relatively slightly as the voltage still further decreases down towards the rated line-voltage of the device. Meanwhile, our shunt-connected resistor 11 is drawing a relatively constant current, which may have a value of the order of between 10 and 40 amperes, this value being perhaps something of the order of 1 or 2 times the final discharge-current which is passed by the valve-element part 10 when normal line-voltage is applied thereto. This final resistor-current of 10 to 40 amperes, plus whatever smaller current is being passed by the valve-type element 10 at the time, is finally interrupted by the series gap-devices 5 and 6, which thus insulate the arrester-blocks 4 from the line.

There are various ways in which a relatively fixed resistance may be shunt-connected, in effect, to a variable, valve-type resistance which constitutes the real lighting-arrester proper. The relatively fixed resistance can be molded in or with the arrester-block in various ways, or the resistor may be entirely separate. Furthermore, any suitable or convenient valve-type excess-voltage or lightning-arrester element may be utilized, not necessarily a block.

In Fig. 2, we illustrate our invention in the form of a heavy-duty lightning-arrester which may comprise a main insulator-body 21 which has a plurality of vertically or longitudinally extending holes 22 therein. In one form of embodiment of the invention, the insulator-body may be round in cross-section, and may have four holes 22 therein. In all but one of the holes 22, suitable valve-type lightning-arrester elements 23 are placed, while the last hole contains an ordinary, relatively non-variable resistor-element 24, and it may also, but not necessarily, contain, at one end of the resistor-element, an auxiliary gap-device 25 which is thus connected in series with the resistor-element, while the resistor and the auxiliary gap are together connected in shunt to all of the lightning-arrester elements 23, which are in shunt with each other. The resistor 24 may conveniently be a composition-block of molded resistance-material comprising a mixture of a finely divided resistance-material and a binder. The various elements which are disposed in the respective holes 22 are all connected in shunt with each other, and in series with the main series gap-device 27.

In operation, when an excessive voltage is applied to the device shown in Fig. 2, the main gap 27 first breaks down, as previously described, applying voltage to the various valve-type elements 23, causing the latter to discharge relatively heavy currents, and at the same time, the volt-

age-drop across the valve-elements is applied to the resistor **24** with its serially connected auxiliary gap **25**, causing the latter to break down and apply, to the resistor-element **24**, substantially the arrester-voltage, minus the almost negligibly small arc-drop in the auxiliary gap-device. At the close of the discharge, the total residual power-follow current passes through the main gap **27**, but most of this current is the current through the relatively fixed resistor **24**, and the resistor-current also passes through the auxiliary gap **25**. The auxiliary gap **25** serves, therefore, as an auxiliary gap in series with the main gap **27**, so far as the resistor-current is concerned, thus aiding the main gap in interrupting the relatively heavy power-follow current through the resistor-element **24**.

While we have illustrated our invention in two preferred forms of embodiment, we wish it to be understood that we are not limited to these particular forms, as many changes, in the way of substitutions, additions and omissions, may be made by those skilled in the art without departing from the essential spirit of our invention. We desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language and the prior art.

We claim as our invention:

1. An excess-voltage protective device comprising a variable-resistance valve-type element capable of passing heavy discharge-currents when impressed with voltages in excess of the rated voltage of the protective device, and of substantially interrupting said discharge upon the return of rated voltage-conditions, a resistor of relatively fixed resistance, means for connecting said resistor in shunt to said valve-type element, and a series gap-means in series circuit relation to both said valve-type element and said resistor, characterized by said resistor having a resistance less than 120 ohms per kilovolt of the rated voltage of the protective device, and said series gap-means being capable of interrupting the combined currents of both said valve-type element and said resistor at the rated voltage of the protective device.

2. An excess-voltage protective device comprising a variable-resistance valve-type element capable of passing heavy discharge-currents when impressed with voltages in excess of the rated voltage of the protective device, and of substantially interrupting said discharge upon the return of rated voltage-conditions, a resistor of relatively fixed resistance, means for connecting said resistor in shunt to said valve-type element, and a series gap-means in series circuit relation to both said valve-type element and said resistor, characterized by said resistor having a resistance of approximately the same order of magnitude as, or less than, that of the valve-type element in the final stages of the discharge, near the cut-off point of the valve-type element, and said series gap-means being capable of interrupting the combined currents of both said valve-type element and said resistor at the rated voltage of the protective device.

3. An excess-voltage protective device comprising a variable-resistance valve-type element capable of passing heavy discharge-currents when impressed with voltages in excess of the rated voltage of the protective device, and of substantially interrupting said discharge upon the return of rated voltage-conditions, a resistor of relatively fixed resistance, a main series gap-means in series with the valve-type element, an auxiliary series gap-means in series with the resistor, and means for connecting said resistor and said auxiliary gap-means in shunt to said valve-type element and in series with said main gap-means.

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