May 22, 1951 S. TESZNER 2,554,278

LIGHTNING ARRESTER

Filed March 23, 1948

Fig.1

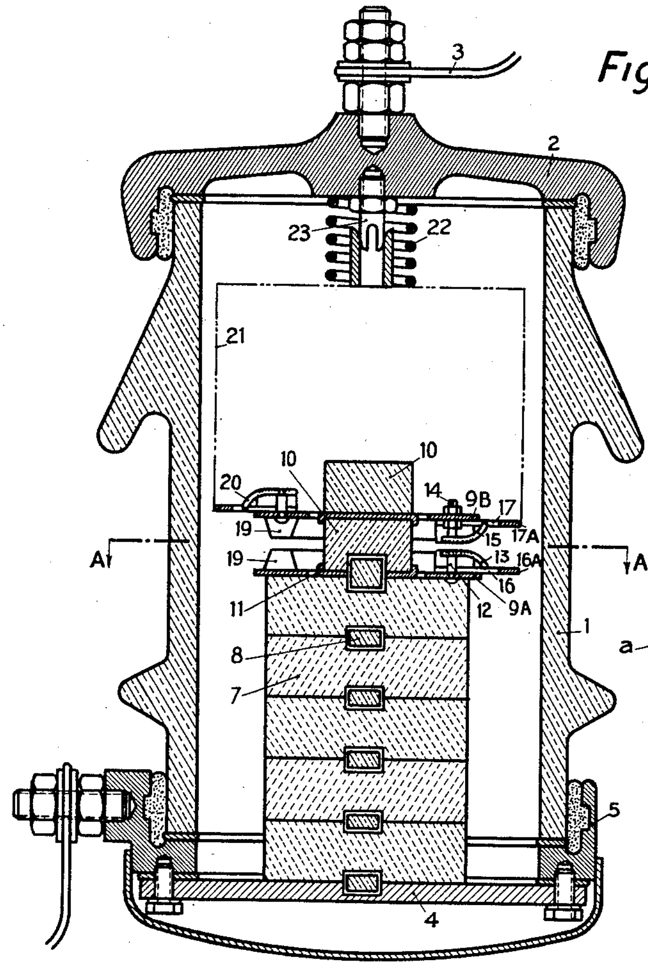


Fig.3

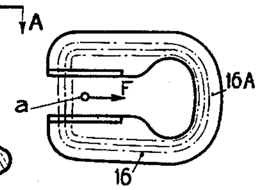


Fig.2

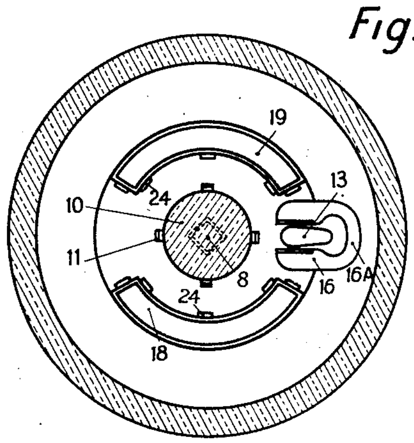
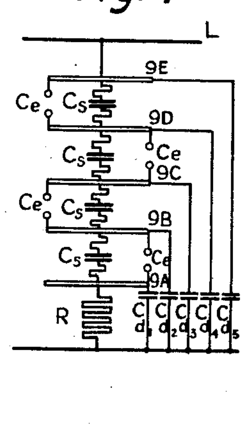


Fig.4



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LIGHTNING ARRESTER

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The present invention relates to lightning arresters comprising essentially an assembly of arc or spark gaps in series with resistances. Special resistances made of valve-type material, which vary in inverse ratio to the voltage, have enabled very considerable progress to be made in the arrester characteristics and performance; on the other hand, the advance in spark gap design has hitherto been less marked.

These spark gaps have to fulfil in particular the following conditions:

(1) To present an adequate breaking power for the interruption of the residual current traversing the resistances and to ensure the stoppage of this current within a short time, of the order of a half-period at the most.

(2) To withstand without considerable erosion the residual current as well as the surge currents, up to the nominal discharge power of the arrestor.

(3) To possess, especially with respect to high frequency or surge waves, a relatively low striking voltage, and, despite this, to present a relatively high breaking voltage at industrial frequencies, without allowing any leakage current.

(4) To be of simple, cheap and compact construction.

Lightning arresters known at the present day do not fulfil all these conditions in a sufficient degree, and the present invention has for its main object to solve the problem thus set. Likewise and in a more general way, it has for another object the provision of improved lightning arresters suitable for medium and high voltages.

A specific object of the invention is the provision of an improved lightning arrester comprising a series of adjustable spark gaps, provided with simple means for magnetic blow-out in a field excited by the current, as well as means for ensuring the optimum distribution of potential over the said spark gaps by the intermediary of suitable capacitances associated with high resistances and constituting a chain in which, at low frequencies, the distribution is essentially determined by the said capacitances, with no current flowing through the resistances, while during the transitory phenomena at high surge frequencies, it is essentially determined by the said resistances and by the capacitances with respect to ground. Due to this, there is obtained, particularly at industrial frequencies, uniform voltage distribution facilitating the obtaining of a relatively high breaking voltage, while for steep-fronted waves, there is obtained a non-uniform distribution which lowers substantially the striking voltage in relation to that which corresponds to industrial frequencies.

Other objects and advantages of the invention will appear from the following description given

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with reference to the accompanying drawings of an embodiment of a lightning arrester designed for a moderate voltage of the order of 7 kv. for example.

Upon the drawings, Figs. 1 and 2 represent this lightning arrester respectively in vertical section and in horizontal section on the line A—A of Fig. 1. Fig. 3 is an explanatory diagram representing the magnetic blow-out field, and Fig. 4 is a diagram of the capacitances and resistances which operate in controlling the voltage distribution.

In Figs. 1 and 2, there is illustrated a container 1 made of insulating material, closed tightly by a metallic cover 2 carrying the terminal 3, connected to the voltage line. The bottom of the container is closed tightly by suitable elements 4 and 5 which are connected to ground by the conductor 6 and which may serve at the same time as supporting means.

The closure plate 4 supports a stack of special resistances 7 made of valve-type material the ohmic value of which decreases according to a suitable law when the applied voltage increases; the centering of these special resistance may be effected in any suitable manner, for example, by insulating blocks 8.

This stack is surmounted by a certain number of metallic disks 9A, 9B, etc., of which only two are shown, separated by insulating spacers 10 and centered in any suitable manner, for example as represented, by cut-out and bent tongues 11. The disk 9A carries upon a metallic pillar 12 a fixed electrode 13 of the first spark gap, while the disk 9B carries by the intermediary of a bolt 14 the other electrode 15 of the same first spark gap, which electrode co-operates with the electrode 13, the parts 13 and 15 having the shape of horns. The electrode 15 is made adjustable for varying the length of the spark gap, adjustability being provided by any suitable and well-known expedient.

To the disks 9A and 9B there are attached in any suitable manner pairs of pole-pieces 16 and 17 made of magnetic metal, the shape of which is seen in plan in Fig. 2 and in detail in Fig. 3. It is seen that the pair of pole-pieces 16 comprises a common yoke 16A, curved in shape and arranged near to the respective electrode and at right angles to the path of the arc burning between the two electrodes 13 and 15. The pair of pole-pieces 17 similarly comprises a common yoke 17A. The disks 9A and 9B likewise carry pairs of armatures having the form of sectors 18 and 19 which are maintained in position in any suitable manner, as by bent tongues 24 (see Fig. 2). These sectors are made of a semi-conductive material having a relatively high resistance, such for example as a synthetic resin comprising a small quantity of conductive material dispersed therein.

The upper face of the disk 9B carries, at a position opposite to that of the adjustable electrode 15, a fixed electrode 20 similar to the electrode 13, and two sectors (not shown) similar to 18 and 19; the upper disks 9C, etc. are arranged in like manner, so that, in the case where the lightning arrester comprises for example five spark gaps in series, there are six disks 9A, 9B, 9C, etc., and corresponding resistance sectors 18 and 19. It is thus seen that the spark gaps are located alternately to right and left of the vertical axis, so that the path of the discharge current forms a series of loops. This assembly presents the overall shape indicated diagrammatically by the chain line 21; it is maintained in place by a spring 22 and a contact 23.

In the operation of the device, an arc which strikes at a in Fig. 3, produces a magnetic field of which the lines of force pass initially along the chain lines shown; it will be understood that this field, which tends to present a minimum reluctance and to shift towards the yoke 16A, exerts upon the arc at a a thrust in the direction of the arrow F. This thrust obviously reinforces the magnetic blow-out action produced by the current loops mentioned above, so that the arc immediately leaves its starting position, effectually deionizing and preserving the striking zone against the action of the arcs, and that the breaking power of the spark gaps is thus appreciably increased.

Since, on the other hand, the working voltage of industrial frequency which each spark gap can stand is relatively high, due to the satisfactory voltage distribution which will be explained hereinafter, the number of spark gaps in series can be reduced to a minimum, which simplifies construction and limits the over-all size. It is thus seen that the above-mentioned conditions 1, 2 and 4, relating to high breaking power, absence of considerable erosion and simplicity of construction, are in fact fulfilled.

As regards the condition 3, relative to striking and breaking voltages, reference will be made to Fig. 4, which represents a simplified electrical diagram of the improved lightning arrester, on the supposition by way of example that it comprises four gaps in series.

The capacitances between the adjacent surfaces of the sectors 18 and 19 of each pair of contiguous disks 9A, 9B, etc. are shown at C_s; the ohmic resistances of these sectors are designated as r. The whole series or chain shown is connected between the high-tension line L and the resistance R, representing the stack of elements 7 shown in Fig. 1, the lower extremity of this resistance R being connected to ground.

The references C_e represent the capacitances between the electrodes of the various spark gaps such as 13—15, but, according to the invention, the capacitances C_s are much greater than the capacitances C_e of which the function is negligible in practice. The by-pass condensers Cd_1 to Cd_5 correspond to the capacitances of the disks 9A, 9B, etc., with all their fittings in relation to ground, these being much smaller than C_s.

It can be seen from this diagram that there is no permanent conductive path between the line L and the ground, so that normally no leakage current exists and the device cannot develop any undesirable or dangerous heating effects.

Supposing, to give a definite example, that the capacitance C_s is of the order of 10 micro-micro-

farads, the capacitative impedance of C_s for the industrial frequency of 50 cycles per second is of the order of 3.10^8 ohms, and if the resistance r is of the order of a few megohms, the distribution of the voltages which appear upon the capacitances C_e of the spark gaps becomes practically uniform, for, at low frequencies, it is essentially determined by the capacitances C_s which then play a dominant part.

On the contrary, at surge frequencies of the order of 10,000 cycles per second, for example, the capacitative impedances of C_s become of the same order as the resistances r, and at surge frequencies of the order of 100,000 cycles per second (corresponding to the wavefronts produced by lightning) they become negligible.

In these conditions, the capacitative current at high frequency (or a steep-fronted surge) which traverses the chain of condensers C_s, neglecting all the by-passes, is limited and determined by the resistances r.

But if, according to a particular feature of the invention, the resistances are then of the same order as, if not higher than the capacitative bypass impedances Cd_1 to Cd_5, the currents which pass through these last have values which become greater and greater in proportion as the frequency increases. It follows that for increasing frequencies, the distribution of the voltages between the spark gaps C_e becomes more and more non-uniform and consequently that the striking voltage of the arrester is lowered more and more.

It is seen, therefore, that due to the described combination of appropriate capacitances and resistances, suitably connected in series, and bypass capacities, there is obtained at industrial frequencies a uniform distribution of the line voltage.

These preferred means may be associated with the magnetic blow-out described above, which improves substantially the deionizing properties of the spark gaps; these last present an increased breaking voltage which allows of operating them under relatively high working voltage, while the uniform distribution of voltage ensures their methodical and rational utilization. These two characteristics allow therefore of reducing to a minimum the number of spark gaps in series.

The effectiveness of the deionization of the arcing or spark gaps presents likewise the advantage of rendering the breaking voltage very close to the striking voltage; the latter can therefore be selected as low as desired per spark gap. Since, moreover, the distribution of voltage over the spark gaps is practically independent of external influences, there is no need at all for providing a wide margin of safety in the adjustment; this margin can be selected as narrow as desired.

Lastly, under steep-fronted surge waves, the striking voltage is substantially lowered (surge factor lower than unity), which is an advantageous characteristic, as well known.

The condition 3 mentioned above is likewise fulfilled, and it is to be noted that this result is attained without onerous complications, nor weakening of service security, as is necessarily involved, for example, by the use of shunting resistances, such as are, in certain known apparatus, permanently traversed by ohmic currents of a value by no means negligible.

It is to be noted that the embodiment described can be modified in various ways without departing from the scope of the present invention. For example, it is possible to increase at will the by-pass capacitances, as well as the capacitances in series; this allows of maintaining the uniform distribution of voltage between spark gaps at industrial frequency, and of obtaining a more unequal distribution at high frequency, that is to say lowering in a still greater proportion the corresponding striking voltage.

For this purpose, it is possible in particular to arrange the disks 9A, 9B, 9C, etc. in the lower part of the apparatus, below the resistances 7, instead of placing them in the upper part, or else to alternate the resistance blocks 7 and the said disks.

It is likewise possible to metallize a suitable part of the external surface of the insulating casing 1 so as to increase the capacitances Cd in relation to earth.

What I claim is:

1. In a lightning arrester of the type having a resistance of valve-type material connected in series with a plurality of spark gaps shunted by voltage-distributing by-pass capacitances, a series-gap structure comprising a stack of superposed and substantially coaxial metal discs adapted to furnish part of said voltage-distributing capacitances, each intermediate disc of said stack carrying an arc electrode upon one face and another arc electrode in a diametrically opposed position on the other face, and each extreme disc of said stack carrying a single arc electrode upon its face adjacent to the next intermediate disc and in closely spaced relation to the electrode upon the adjacent face of said next intermediate disc, all said electrodes having the form of horns, and the combination of all said electrodes providing a plurality of spark gaps located alternately at diametrically opposite positions and interconnected in series by relatively long current loops adapted to produce magnetic blow-out fields for the arcs at said spark gaps, with means for reinforcing the action of said blow-out fields, said reinforcing means comprising magnetic pole-pieces carried by said discs in the vicinity of the respective electrodes and provided with yokes extending radially outside of said stack and at right angles to the arc paths between said electrodes, the magnetic fields induced between said pole-pieces by the arcs between said electrodes operating to force said arcs away from the axis of said stack.

2. In a lightning arrester of the type having a valve-type resistance in series with a plurality of magnetically blown spark gaps shunted by voltage-distributing by-pass capacitances, a series-gap structure comprising a stack of superposed insulated metal discs adapted to furnish part of said voltage-distributing capacitances, each intermediate disc of said stack carrying a horn-like arc electrode upon one face and a horn-like arc electrode in a diametrically opposed position on the other face, and each extreme disc of the stack carrying upon its face adjacent to the next intermediate disc a single horn-like arc electrode in closely spaced relation to the electrode upon the adjacent face of said next intermediate disc, the combination of all said electrodes providing a plurality of spark gaps located alternately at opposite sides of said stack and connected in series by relatively long current loops whereby at each spark gap a magnetic blow-out field for the arc at said spark gap is produced, said series-gap structure being combined with means for increasing the action of said blow-out fields, comprising upon each electrode a pair of magnetic pole-pieces attached to said discs, each pair of said pole-pieces being provided with a common yoke arranged near to the respective electrode and at right angles to the arc path at said electrode, and each yoke being located externally of said stack in order to shift the discharge arc in the same direction as the magnetic blow-out action due to said current loops, whereby a double blow-out effect is obtained.

3. In a lightning arrester according to claim 2, means for selectively controlling the voltage distribution across the spark gaps as a function of the surge frequencies but without producing leakage currents, comprising additional capacitor armatures made of resistive semi-conductive material and forming spaced projections upon adjacent metal discs, whereby capacitive surge currents flowing between said armatures are controlled by the resistance of said semi-conductive material, and the spacing apart of said armatures prevents the establishment of a permanent conductive path between the line and the ground.

4. In a lightning arrester according to claim 2, means for selectively controlling the voltage distribution across the spark gaps according to the surge frequencies but without producing leakage currents, comprising additional resistive capacitors formed by co-operating armatures of a highly resistive semi-conductive material forming opposed projections carried in spaced relation by adjacent metal discs, capacitive surge currents flowing between said armatures being controlled by the resistance of said semi-conductive material, the spacing apart of said armatures preventing the establishment of a permanent conductive path between the line and the ground, and the values of all capacities and resistances of the said series-gap structure having such a relationship that at low frequencies the voltage distribution is substantially regular, while at high surge frequencies it is non-uniform, whereby the striking voltage is lowered.

5. In a lightning arrester according to claim 2, means for selectively controlling the voltage distribution across said spark gaps as a function of the surge frequencies but without producing leakage currents, comprising additional resistive capacitors formed by suitably spaced armatures of a resistive semi-conductive material, said armatures being carried by adjacent metal discs and spaced apart at such distances that their capacitative impedances at high surge frequencies are of the same order as their resistances, whereby large capacitative currents are essentially controlled by the resistance of said resistive material, and the spacing apart of said armatures prevents the establishment of a permanent leakage path between the line and the ground.

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