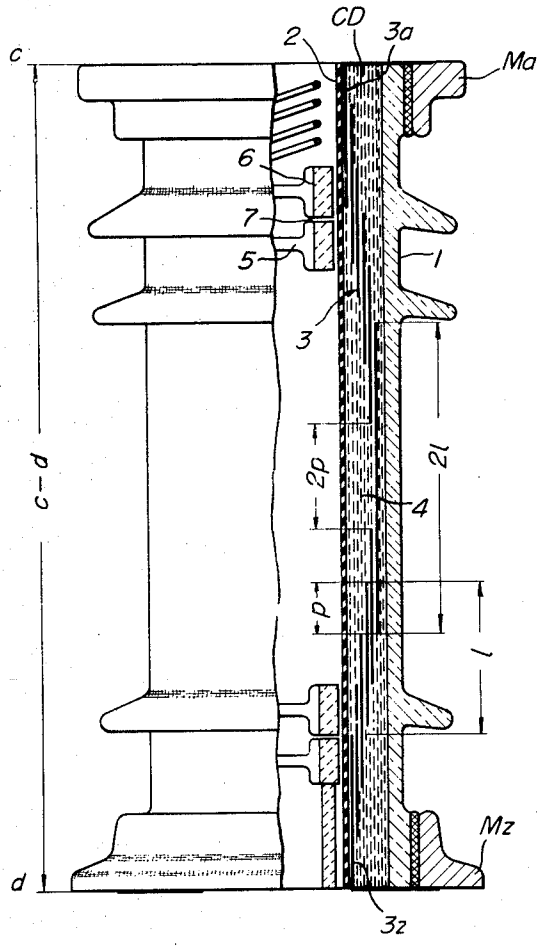
April 26, 1966 J. MASUDA 3,248,599

DIRT-PROOF MULTIPLE-GAP DEVICE FOR LIGHTNING ARRESTERS

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Fig. 1



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Fig. 2

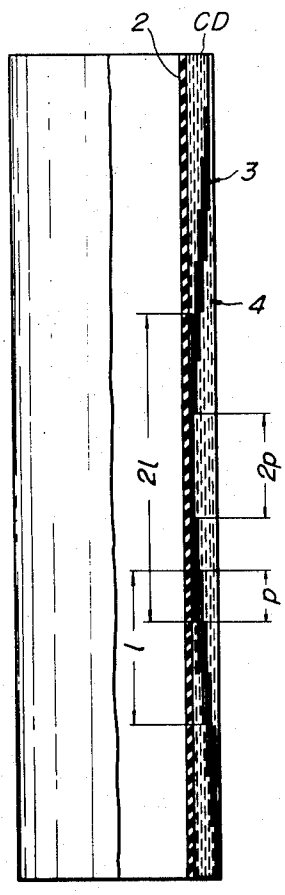
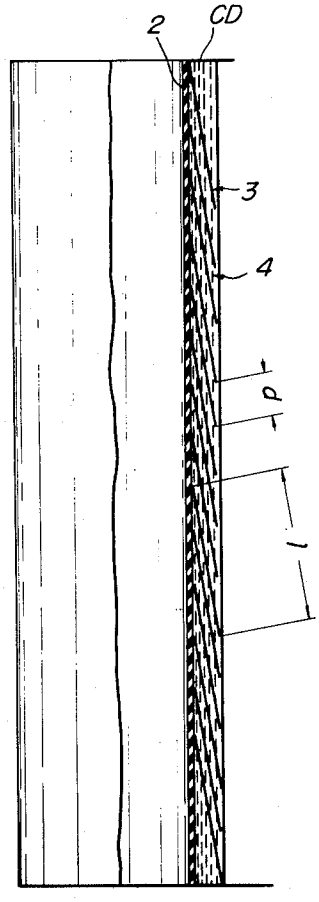


Fig. 3



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Fig. 4

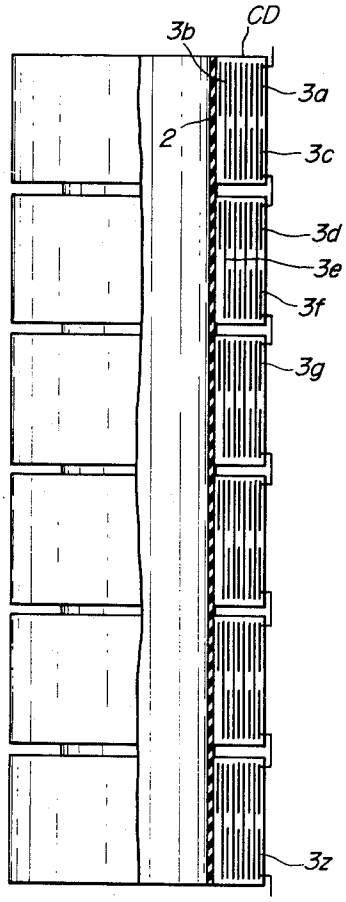
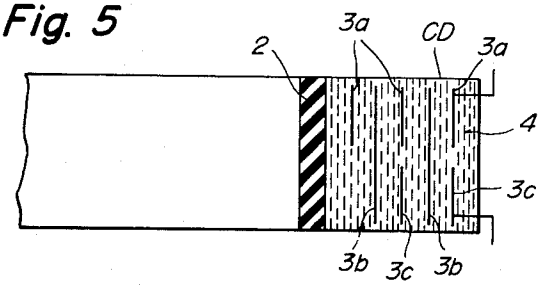


Fig. 5



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DIRT-PROOF MULTIPLE-GAP DEVICE FOR LIGHTNING ARRESTERS

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6 Claims. (Cl. 315—36)

The present invention is designed to solve the problem of the electrical performance of lightning arresters deteriorating due to surface contamination of their porcelain housing and has for its primary object to make uniform the potential gradient along the multiple discharge gaps series-connected with the characteristic elements together to form a single lightning arrester unit. The present invention is also applicable to lightning arresters of the type designed to protect power or distribution lines by means of gaps alone.

Generally speaking, the potential distribution along the surface of the porcelain housing of the lightning arrester in case such surface is not contaminated is substantially rectilinear having a certain gradient from the line to the ground terminal. However, in case the arrester is installed in a filthy area, it has been found that once the housing surface has been contaminated, the leakage resistance of the surface is reduced to allow the occurrence of a considerable magnitude of leakage current rendering the potential distribution along the housing surface markedly non-uniform.

With the increase in the leakage current, which determines the potential distribution along the housing surface, erratic or stray capacities are formed between the respective multiple-gap units in the porcelain housing and the adjacent areas of the housing surface so that the voltage proportions assigned to the respective multiple-gap units are rendered marked non-uniform and thus the voltage at which the arrester starts discharging is lowered.

One of the best measures to be taken for prevention of such deterioration in the arrester characteristics is to intercept the stray capacities formed between the respective multiple-gap units and the adjacent areas of the housing surface thereby to render the potential distribution along the surface free from adverse effects of any surface contamination.

To this end, various proposals have previously been made. One of them is to employ two cylindrical metal shields or shielding rings of different diameters which are inserted in the space between the housing wall and the stacked multiple-gap units of the lightning arrester from the high potential or line side and the low potential or ground side thereof, respectively, in a manner so that the adjacent end portions of the cylindrical metal shields are arranged opposite to each other in spaced overlapping relation.

With this arrangement, though the stray capacities between the respective multpile-gap units and the adjacent areas of the housing surface may be intercepted, the potential distribution obtained over the entire multiple-gap device is necessarily non-uniform as a secondary effect of the use of the inserted metal shields. The reason for this is that the potentials of the multiple-gap units in the upper half of the stack are all raised because of the presence of the high-potential side shielding ring while those of the multiple-gap units in the low half of the stock are all lowered because of the provision of the low-potential side shielding ring. An additional disadvantage of this arrangement is that the porcelain housing of the arrester must have a considerably large diameter to ensure insulation between the adjacent overlapping end portions of the

two shielding rings axially midway of the porcelain housing.

Another measure previously proposed is to form a resistance coating over the inner wall surface of the porcelain housing for conducting the leakage current. With this arrangement, however, not only is heat generated by the leakage current passing through such coating to impair the characteristics of the arrester but also the coating itself is susceptible to damage, making it difficult to maintain the arrester characteristics at a predetermined level.

In view of the present status of the art as described above, the present invention proposes to employ a special tubular capacitor structure between the multiple-gap units and the inner wall of the porcelain housing for the purpose of improving the arrester characteristics.

The foregoing and other objects and advantages will become apparent from the following description when taken in conjunction with the accompanying drawings, in which,

FIG. 1 shows an embodiment of the present invention in half-section,

FIGS. 2, 3 and 4 show other embodiments of the present invention of which the capacitors are modified from that shown in FIG. 1, and

FIG. 5 shows the detailed construction of the capacitor used in the embodiment of FIG. 4.

Referring to the drawings, particularly to FIG. 1, reference numeral **1** indicates a porcelain housing of the arrester; **2**, a tubular insulator inserted into the interior of the porcelain housing; **3**, electrode layers in the form of a lamination of aluminum foils; **4**, insulating sheets; **5**, discharge electrodes forming a multiple-gap unit; **6**, insulating spacers on the respective discharge electrodes, and **7**, a discharge gap in the multiple-gap unit. The capacitor electrodes **3** and the insulating sheets **4** together form a tubular capacitor CD, which is embraced between the tubular insulator **2** and porcelain housing **1**, as illustrated.

Carried by the porcelain housing at the line-side end thereof is a fixture M*a* to which the topmost aluminum foil 3*a* of the tubular capacitor CD is secured. Similarly, a fixture Mz is secured to the ground end of the porcelain housing **1** and to this fixture is electrically connected the lowermost aluminum foil 3*z* of the tubular capacitor CD. All of the intermediate aluminum foils **3** having a width, *l*, except one located at the middle are axially offset by a distance *p* with respect to the adjacent foils to form a stepwise lamination with insulating sheets **4** interleaved so that a series of capacitor units of the same capacity are formed. As indicated in the drawing, the middle foil alone has a width of 2*l* and is not overlapped along the medial portion having an axial length of 2*p*. It is to be understood that the insulating sheets **4** interleaved in the foil lamination are of an identical thickness to give the same electrostatic capacity between the adjacent electrode foils **3**. With this arrangement, it will be understood that if a voltage is applied across the terminals *c, d*, a charging current is formed through the tubular capacitor including a series of capacitor units, the magnitude of the current depending upon the value of the voltage applied.

Accordingly, as will readily be appreciated, the applied voltage is distributed substantially rectilinearly with a definite potential gradient along the axis of the porcelain housing under the control of the tubular capacitor. Under these circumstances, it is evident that the potential distribution along the stack of multiple-gap units is also substantially rectilinear having a definite gradient throughout. Therefore, the potential difference between each of the respective gaps in the stacked electrode assembly and the adjacent capacitor unit is practically negligible throughout the axial length of the arrester.

In other words, with the arrangement including a tubular capacitor CD comprised of a series of elementary capaci-

tors and inserted inside of the porcelain housing 1 according to the present invention, a nearly completely uniform potential distribution is obtainable over the entire multiple-gap assembly. In addition, it has been found that the insertion of such tubular capacitor CD does not impair other arrester characteristics in any manner whatsoever.

It is easy in practice to design the arrangement so that the charging current flowing into the tubular capacitor CD comprised of a series connection of elementary capacitors far exceeds the charging current between the tubular capacitor CD and the surface of the porcelain housing. By doing this, any non-uniform charging current caused by the contamination of the housing surface is made negligible and a uniform potential distribution is ensured in the interior of the tubular capacitor CD under the effect thereof.

As illustrated in the drawing, the tubular capacitor CD is fabricated so as to form a stepwise lamination of electrode layers, the top and bottom electrode layers in said stepwise lamination being arranged innermost thereof with the remaining electrode layers arranged successively outwardly from the opposite ends of said lamination to the middle thereof, providing for adjustment to provide the desired axial potential distribution in use of the finished arrester. It will be readily understood, however, that any other arrangement of the electrode layers substantially differing from that described above may also be suitably employed in conformity with the particular pattern of potential distribution desired. It is evident that the material for the insulating sheets 4 may be selected as desired with due regard to the dielectric constant required of such material.

In the embodiment of FIG. 1, the electrodes 3 of the capacitor CD are so arranged that the electrodes at the ends of the capacitor are placed at the inner-most side of the capacitor and the remaining electrodes are offset stepwise one by one toward the middle of the length of the capacitor, but, it will be understood that a capacitor as shown in FIG. 2 has the same effect with the capacitor of FIG. 1, the capacitor of FIG. 2 having its electrodes 3 so arranged that the electrodes at the top and bottom of the capacitor are located at the outermost side of the capacitor and the remaining inner electrodes are offset stepwise one by one towards the middle portion of the length of the capacitor. In the embodiment of FIG. 3, the electrodes 3 are each conically inclined with respect to the axis of the capacitor and constitute a stepwise lamination, and, with this construction, many more electrodes may be incorporated in a capacitor having a certain thickness, i.e., no increasing of the thickness of a capacitor is necessary when many more electrodes become necessary to be accommodated in a capacitor of the same thickness thus preventing the increase in the volume of the capacitor.

In FIG. 4, there is shown another embodiment of the present invention, in which a series capacitor is formed of stacked block-formed small capacitors to facilitate the manufacture of a capacitor. Each of the blocks comprises, as shown in FIG. 5, an insulating cylinder 2 and layers of taller electrodes 3*b* and shorter electrodes 3*c* alternately wound around the cylinder 2 with insulating sheets inserted therebetween. These blocks are stacked as shown in FIG. 4 and a low-potential electrode of one block and a high-potential electrode of another block adjacent to the one block is electrically connected successively to thus be of a same potential so that a series capacitor formed of capacitors of same capacity is obtained wherein the potential distribution along the whole multiple-gap structure may be made sufficiently uniform as theoretically desired. In this instance, if the connected electrodes, such as 3*c* and 3*d* and 3*f* and 3*g*, are respectively made integral, the whole capacitor will constitute a single cylindrical capacitor.

In an actual use, a desired type of these capacitors may be choosen for the inventive lightning arrester as the cases may require, considering advantages and disadvantages of the respective types.

Having described and shown embodiments of the invention, it is not to be limited to the details set forth but various changes and modifications may be made without departing from the scope of the invention as claimed.

What is claimed is:

1. A dirt-proof multiple-gap device for a lightning arrester of the type including a porcelain housing and a stacked multiple-gap assembly enclosed in said housing with an annular space defined therebetween, comprising an annular capacitor inserted in said space and substantially filling said space and including a series connection of elementary capacitors between the high and low potential sides of the arrester, said annular capacitor being effective to intercept the stray capacities between the surface of the porcelain housing and the stacked multiple-gap assembly.

2. A dirt-proof multiple-gap device as defined in claim 1 in which said annular capacitor comprises a tubular insulation, a plurality of electrode layers and a plurality of insulating sheets, said electrode layers being axially offset relative to the adjacent ones to form a stepwise lamination with said insulating sheets interleaved therebetween, the top and bottom electrode layers in said stepwise lamination being arranged innermost thereof on the high- and low-potential sides of the arrester, respectively with the remaining electrode layers arranged successively outwardly from the opposite ends of said lamination to the middle thereof.

3. A dirt-proof multiple-gap device as defined in claim 1 in which said annular capacitor comprises a tubular insulation, a plurality of electrode layers and a plurality of insulating sheets, said electrode layers being axially offset relative to the adjacent ones to form a stepwise lamination with said insulating sheets interleaved therebetween, the top and bottom electrode layers in said stepwise lamination being arranged outermost thereof on the high- and low-potential sides of the arrester, respectively with remaining electrode layers arranged successively inwardly from the opposite ends of said lamination to the middle thereof.

4. A dirt-proof multiple-gap device as defined in claim 1 in which said annular capacitor comprises a tubular insulation, a plurality of electrode layers and a plurality of insulating sheets, said electrode layers respectively inclining with respect to the axis of the capacitor at an appropriate angle to form a successively stepwise overlapping lamination with the insulating sheets interleaved therebetween.

5. A dirt-proof multiple-gap device as defined in claim 1 in which said annular capacitor being in the form of a block-like capacitor comprises a tubular insulation, a plurality of electrode layers and a plurality of insulating sheets, said electrode layers comprising a first electrode layer wound around the tubular insulation, a second electrode layer wound around the first electrode layer with an insulation sheet layer interleaved therebetween, a third electrode layer wound around the second electrode layer like as above, and like electrode layers.

6. A dirt-proof multiple-gap device as defined in claim 5 in which said annular capacitor comprises a plurality of block-like capacitors stacked one above another, the low-potential side electrode layer of each one of the block-like capacitors being electrically connected with the high-potential side electrode layer of another block-like capacitor adjacent, the next lower block-like capacitor.

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