

Jan. 30, 1968

J. LÄPPLE

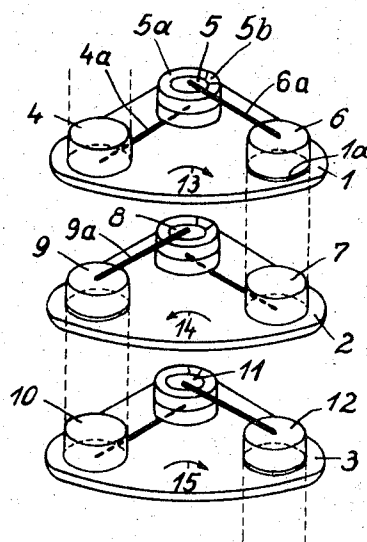
3,366,831

OVERVOLTAGE ARRESTER HAVING STACKED ARRAYS OF ARC
GAP AND GRADING RESISTOR UNITS

Filed April 14, 1965

3 Sheets-Sheet 1

Fig. 1



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Fig. 2

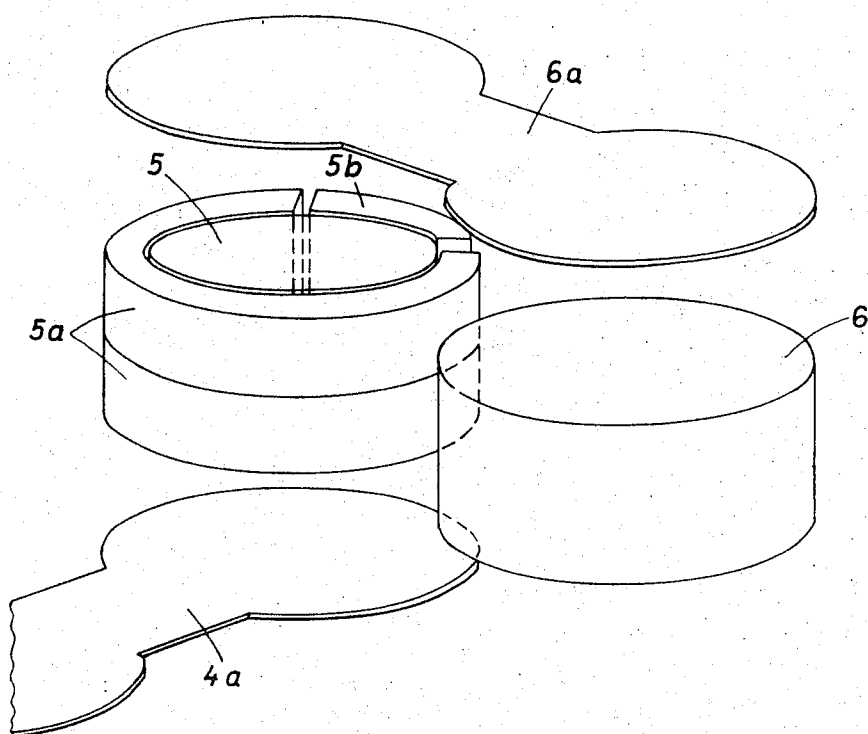
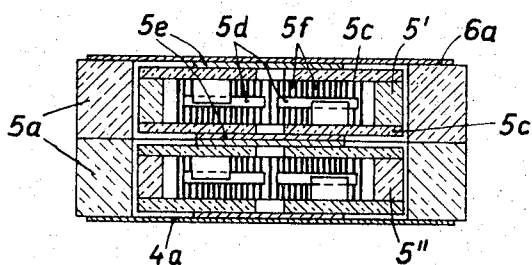


Fig. 3



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Fig. 4

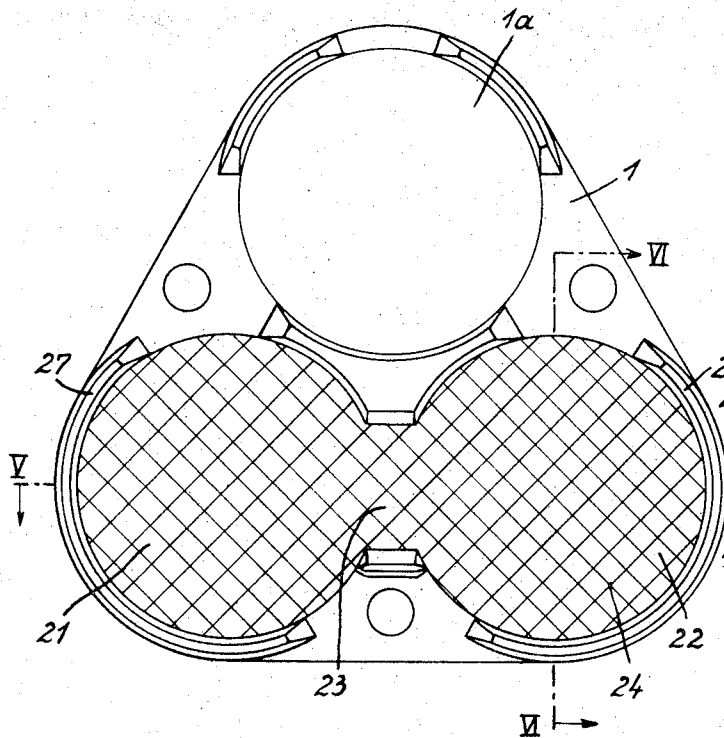


Fig. 6

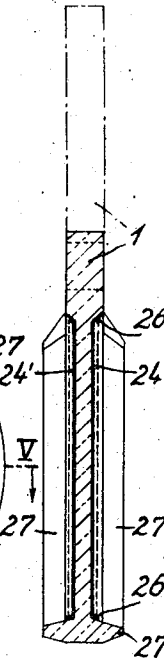
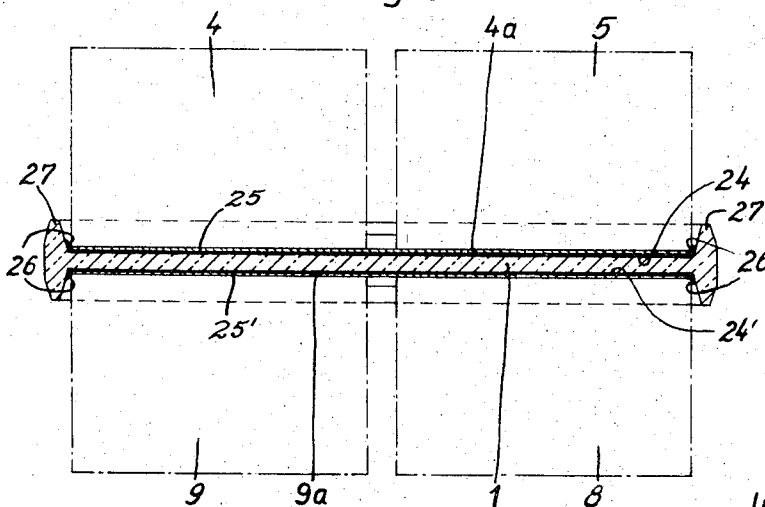


Fig. 5



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OVERVOLTAGE ARRESTER HAVING STACKED ARRAYS OF ARC GAP AND GRADING RESISTOR UNITS

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5 Claims. (Cl. 315—36)

ABSTRACT OF THE DISCLOSURE

An overvoltage arrester comprises a multi-level stack of sections with insulating plates between adjacent ones of the sections. The section of each level has a spark-gap device and a discharge resistor mounted in mutually spaced relation in a common plane. The spark-gap is electrically connected with the resistor. Conductive coatings are provided on the insulating plates in electrical contact with the spark-gap, the resistor and the electrical connector between the spark-gap and the resistor.

My invention relates to overvoltage surge protection devices. More particularly, it relates to novel overvoltage arresters capable of handling very high voltages.

In high voltage systems, such as in polyphase interconnected systems, there is the need for handling external overvoltages caused by lightning and internal overvoltages which are essentially caused by transient switching phenomena. To handle such high overvoltages, heretofore there has been required expensive insulation. To decrease the expense of such insulation, there have been utilized voltage arrester devices which, as protective devices against internal overvoltages, have the task essentially of absorbing the charging energy of the systems' capacitances and of discharging the accompanying long duration currents to ground.

A type of voltage arrester capable of being used where voltages up to 1000 kv. are involved which has been effectively utilized to enable a great saving in insulation is one which comprises a vertical stack of like sections, each of the sections comprising a spark gap device or a group of spark gap devices and a plurality of non-linear discharge resistors, the spark gap device and the discharge resistors for each section being suitably physically disposed in a polygonal arrangement on an insulating plate and electrically connected in series. Each section of the stack lies on the immediately underlying section. The corresponding elements in each section may advantageously be respectively disposed on insulating plates. With such arrangement, the over-all height of the stack may be appreciably reduced. The stack of sections is suitably housed in a hermetically sealed housing such as a nitrogen filled hermetically sealed porcelain housing.

It has been found that high frequency voltage discharges occur in the operation of such arrester and thereby interfere with the proper functioning thereof under operating conditions. A salient cause of the production of such interfering high frequency voltages is the juxtaposed contact of the surface of an insulating plate and the conductive elements of an adjoining section. Since such contacting plate surface and the surfaces of the conducting elements are inherently uneven whereby contact is made only at a few points and the contact surfaces are at a slight distance from each other, voltages which may have a magnitude of 10 kv. may be present in the air gaps between said contact surfaces. Such voltages lead to the production of undesired and deleterious corona discharges.

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Accordingly, it is an object of this invention to provide a stack-type high-voltage surge protection device, whose operation is substantially free of high frequency voltage interference.

To this end, and in accordance with a feature of my invention, I provide the insulating plates in an overvoltage arrester of the above-mentioned stack type with a conductive coating on the surface areas contacted by the adjacent active arrester components and their metallic interconnections.

Preferably, and according to more specific features of the invention, there is provided an overvoltage arrester comprising a stack of like sections, each of the sections comprising an insulating plate, a spark-gap structure and a plurality of discharge resistance members on each plate spaced from each other in a polygonal group means for electrically connecting the spark-gap structure and the resistance in series arrangement, with the spark-gap structure being electrically disposed intermediate the resistances, to provide first and second end resistances in each series arrangement, each of the spark-gap structures and the respective first and second end resistances in the sections being disposed in vertical registration each insulating plate of a section resting on the adjoining next lower section. An opening is provided in each plate of one set of alternately occurring insulating plates to permit the first end resistances to make direct electrical contact with each other and an opening in each plate of the other set of alternately occurring plates to permit the second end resistances to make direct electrical contact with each other. There is further provided an electrically conductive metallic coating in each side of the plate on the areas occupied by the spark-gap structure and the resistances other than the end resistance in direct contact with its registered resistance in the adjoining lower section and in a cross area connecting the occupied areas.

The foregoing and more specific objects and features of my invention will be apparent from, and will be mentioned in the following description of the overvoltage arrester according to the invention shown by way of example in the accompanying drawing, in which:

FIG. 1 is an exploded three dimensional view of an illustrative embodiment of an arrester constructed in accordance with the principles of the invention;

FIG. 2 is an exploded perspective view of some of the components of the same arrester;

FIG. 3 is a sectional view of an assembled arrester according to FIGS. 1 and 2;

FIG. 4 is a plan view of an insulating plate structure in a modification of the embodiment shown in FIG. 1;

FIG. 5 is a view taken along lines V—V in FIG. 4 looking in the direction of the arrows with other associated structures depicted in broken line; and

FIG. 6 is a view taken along lines VI—VI in FIG. 4 looking in the direction of the arrows with structures resting thereon depicted in broken line.

Referring now to FIG. 1 which shows an exploded three dimensional view of a few sections of a vertical stack type voltage arrester, each section comprises a substantially triangular group of a pair of non-linear discharge resistors and a spark gap on an insulating plate. Thus, in the upper section of the three sections shown in FIG. 1, the spark-gap structure is designated by the numeral 5, the non-linear discharge resistors are designated by the numerals 4 and 6, and the insulating plate is designated by the numeral 1. Correspondingly, in the middle section, the spark-gap structure is designated by the numeral 8, the respective non-linear discharge resistors are respectively designated by the numerals 7 and 9 and the insulating plate is designated by the numeral 2. The lower section in FIG. 1 comprises the insulating plate 3 on which there are disposed in substantially triangular

array, spark-gap structure 11 and non-linear discharge resistors 10 and 12.

The spark-gap structures are respectively physically engirdled, as numerically designated at spark-gap structure 5 in FIG. 2, by annular control resistors 5a and control capacitors 5b. The resistors 5a and capacitors 5b are electrically connected in parallel with the spark-gap structure such as spark-gap structure 5. It is, of course, to be realized that the spark-gap structures need not comprise a unitary structure but may include a plurality of superposed spark-gap device units. The insulating plates may suitably have a roughly polygonal outline corresponding to the type of array of circuit elements on each insulating plate. Thus, in the embodiment shown in FIG. 1, insulating plates have a roughly triangular configuration.

In each section, the non-linear discharge resistors such as resistors 4 and 6 on insulating plate 1 may each be chosen, for example, to handle a voltage of 2.5 kilovolts (kv.) and the spark-gap structure, such as spark-gap structure 5, may be rated for a voltage of 5 kv. The corresponding non-leakage resistors and spark-gap structures in the other sections of the vertical stack are correspondingly chosen to handle like corresponding voltages. Accordingly, each section in the stack may be considered, using the above values, as a unit for 5 kv.

The electrical connections between the elements in each section are of the series type. However, the order of series connection is alternately reversed in successive sections. Thus, in FIG. 1, in the upper section, the series connection order is resistor 4, spark-gap structure 5 and resistor 6; in the intermediate section, the series connection order is resistor 7, spark-gap structure 8 and resistor 9; and in the lower section, the series connection order is resistor 10, spark-gap structure 11 and resistor 12. The conductor winding directions in alternately occurring sections are consequently in opposite directions as indicated by arrows 13, 14 and 15 respectively to provide a noninductive winding arrangement analogous to a bifilar noninductive wiring scheme. No loop areas for introducing inductance effects exist therein.

The corresponding elements in each section are disposed in registration, i.e., resistors 4, 9, and 10, spark-gap structures 5, 8, and 11, and resistors 6, 7, and 12 are in respective vertical alignments. The insulating plate of a section lies directly on the spark-gap structure and a resistor of the immediately lower section as determined by the noninductive winding arrangement. Thus, in FIG. 1, insulating plate 1, rests on resistor 9 and spark-gap structure 8. A hole 1a coextensive with the size of the surface of resistors 6 and 7 is provided in plate 1 to enable resistors 6 and 7 to make direct electrical contact. Correspondingly, insulating plate 2 rests on spark-gap structure 11 and resistor 12 and a hole is provided in plate 2 to enable resistor 9 to make direct electrical contact with resistor 10. The electrical connections between the elements in a section, shown in heavy black lines at 4a and 6a (FIG. 1), are suitably sheets of metal which rest on the elements as shown in FIG. 2. The stack of sections is enclosed in a hermetically sealed insulating housing, (not shown), suitably porcelain, in a neutral gas atmosphere such as nitrogen.

Referring to FIG. 2, it will be seen that the spark-gap structure 5 in this embodiment is composed of two individual spark-gap members coaxially adjacent to each other and surrounded by the two control resistors 5a of which each has the shape of a circular segment. The control resistors 5a consist of silicon carbide and bonding medium in the conventional manner. The two control capacitors 5b are likewise shaped as segments of a circle. They consist of a ceramic material having a high dielectric constant and are provided with metal coatings on the top and bottom faces respectively. The resistor 6 also consists of silicon carbide and bonding medium. It has

a relatively high conductivity in comparison with the control resistors 5a.

The set of components 5, 5a and 5b on the one hand, and the discharge resistor 6 on the other hand, are connected with each other on their respective top sides by the above-mentioned conductor 6a consisting of a sheet of electrically conductive metal having approximately a lemniscate shape. The conductive sheet 6a is in electrical contact engagement with the top faces of the respective components. The conductor 4a on the bottom side of the components has the same shape as the conductive sheet 6a and connects the components in the same manner with the bottom side of the discharge resistor 4.

FIG. 3 shows a section through components 4a, 5a, 5b and 6a in assembled condition. Each of the two arc gap structures 5' and 5'' is bordered by two insulating plates 5c respectively. The arc electrodes are denoted by 5d. These electrodes are conductively connected with metal plates 5e arranged on the outer sides of the insulating plates 5c. The device is provided with sheets 5f of magnetizable material extending parallel to each other and forming a quenching gap into which the arc occurring between the electrodes 5b upon response of the device is driven.

The insulating plates 1, 2 and 3 according to FIG. 1 may consist for example of epoxide resin with filler substances such as quartz powder.

In the type of voltage arrester as described, the operation is based on the electromagnetic blow-out principle. A deflecting force, caused by a unilateral magnetic field produced by current acts upon an arc and drives it away from a sparkover point. The arc is thus extended to a multiple of its original length and broken up into a large number of separate smaller arcs which are cooled. Since the root of the arc is rapidly driven away from the initial sparkover point, the spark-gap electrode is not subjected to thermal wear at the latter point. Voltage gradation is effected by the non-linear resistors and capacitors. The characteristic electrical values of the resistors and capacitors are chosen such that the magnitude of the sparkover voltage is substantially independent of external stray capacitances and currents over a wide frequency range extending from normal line voltage frequencies to the steep-fronted travelling waves of lightning overvoltages.

Undesirable increases in voltage handled by the arrester due to inductance effects are substantially eliminated by the non-inductive wiring of said arrester.

However, in the arrester in FIG. 1, assuming, for example, a voltage such as 5 kv. handled by a section, it is to be noted that twice such voltage, namely 10 kv., may build up between two adjacent noncontacting discharge resistors such as resistors 4 and 9, and 7 and 12 respectively. The same situation obtains between adjacent spark-gap structures such as structures 5 and 8, and 8 and 11 respectively. The metal sheets 4a, 6a which series connect the elements in a section abut both sides of an insulating plate, i.e., those that connect resistor 4 and spark-gap structure 5, and resistor 9 and spark-gap structure 8 abut both sides of the insulating plate 1. However, the metal sheets only make contact with insulating plate 1 at a few points. Consequently, spaces result in which discharges can develop to give rise to high-frequency interference voltages.

To substantially reduce and minimize such high-frequency interference voltages, in accordance with the invention, there is provided a conductive coating in the contact areas of adjacent registered or aligned elements in respective adjacent sections. Such coating may suitably be provided by the spraying of a metal such as zinc or copper according to the Schoop process. Alternatively, the surfaces of the insulating plates can be provided with a coating of a conductive paint such as conductive silver, or a metallized adhesive foil may be used to cover the surfaces of the insulating plates. The point to be noted is that the metallic coating adheres areally to the surface of

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the plates at all points where it is provided. The provision of such surface contact of metallic coating on the plates produces a uniform potential which is substantially equal to the potential at the area adjoining a circuit element. The elements need not directly abut the surface of the insulating plate but a sheet of metal can be provided between them and the surface of the plate, such sheet of metal serving to series connect the elements in each section.

Thus, referring to FIGS. 4, 5 and 6 the equilaterally triangularly configured plate 1 is the insulating plate of a section such as plate 1 in FIG. 1. The opening 1a corresponds to an opening such as 1a in FIG. 1 to enable two registered discharge resistors in immediately adjacent sections to make direct contact with each other. Circular areas 21 and 22, connected by a linking area 23, coincide in area with the surface areas of a discharge resistor and a spark-gap structure which rest thereon such as discharge resistor 4 and spark-gap structure 5 shown in FIG. 1. Areas 21 and 22 together with area 23 are coated with a metal coating 24 (shown in hatching), such as zinc, such coating being suitably deposited by the Schoop spray-deposition process. The underside of insulating plate 1 is also so metallically coated on its underside in an area coincident with areas 21, 22 and 23. When assembling a section, an electrically series connecting metallic sheet coinciding in configuration with areas 21, 22 and 23, i.e., coating 24 is first placed on coating 24 and then the elements such as a discharge resistor 4 and a spark-gap structure 5 are mounted on coated areas 22 and 23 respectively.

In the partially sectional views of FIGS. 5 and 6, the metallic coatings on each side of insulating plate 1 are designated by 24 and 24' respectively. The metallic sheets 25 and 25' on coatings 24 and 24' respectively, series connect the discharge resistor 4 with the spark-gap structure 5 in the upper section, and the discharge resistor 9 with spark-gap structure 8 in the next adjoining section. It is thus seen that no high-frequency voltage interference discharges can occur between sheets 25 and 25' and the surfaces 24 and 24' of insulating plate 1 since such surfaces are always at the same potential.

As shown in FIGS. 4, 5 and 6, areas 21 and 22 and 23 on both surfaces of the insulating plate are slightly recessed relative to the surrounding surface and are partly engirdled, bordered or peripherally enclosed by substantially toroidally shaped reinforcing structures 27 integral therewith. In addition, metallic coatings 24 and 24' preferably terminate in extensions at the sides of the recesses, as shown at points 26, since the conditions for forming discharges are particularly favorable at the edges of sheets 25 and 25'.

From the foregoing it is seen that with the providing of metallic coatings on areas 21, 22 and 23 on both sides of the insulating plate, the conditions for forming high-frequency voltage interference discharges are substantially eliminated.

It will be obvious to those skilled in the art upon studying this disclosure that voltage arresters according to my invention permit of a great variety of modifications and hence can be given embodiments other than those particularly described and illustrated herein without departing from the essential features of my invention and within the scope of the claims annexed hereto.

I claim:

1. In an overvoltage arrester comprising a vertical stack

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of like sections, each of said sections comprising an insulating plate, a spark-gap structure and a plurality of discharge resistances on each plate spaced from each other and in polygonal array, means for electrically connecting said spark-gap structure and said resistances in series arrangement, with said spark-gap structure being electrically disposed intermediate said resistances to provide first and second end resistances in each series arrangement, each of said spark-gap structures and said respective first and second end resistances in said sections being disposed in alignment, the insulating plate of each of said sections resting on the adjoining next lower section, the improvement which comprises an opening formed through alternate ones of said insulating plates to permit the first end resistances of alternate adjacent sections to make direct electrical contact with each other, an opening formed through the other alternate ones of said insulating plates to permit the second end resistances of the other alternate adjacent sections to make direct electrical contact with each other, and an electrically conductive metallic coating on each side of each of said insulating plates in the areas occupied by the corresponding spark-gap structure and the corresponding resistance other than the end resistance in direct contact with the end resistance of the adjoining lower section and on a cross area connecting said occupied areas.

2. In an overvoltage arrester as defined in claim 1, wherein said plurality of discharged resistances comprises two discharge resistances and wherein the resistances and the spark-gap structure of each section are disposed in substantially triangular array.

3. In an overvoltage arrester as defined in claim 2, wherein said metallic coating is comprised of zinc.

4. In an overvoltage arrester as defined in claim 2, wherein said means for electrically connecting the spark-gap structure and the resistances in series arrangement in each section comprises metallic sheets respectively having a configuration substantially coincident with the configuration of the areas coated with said metal on said areas on both surfaces of each of said insulating plates, the spark-gap structure and the resistance other than the resistance in direct contact with the resistance of the adjacent section being disposed on each of said metallic sheets, the sheet on the undersurface of each of said insulating plates resting on a spark-gap structure and the resistance in electrical contact with the resistance of the adjoining lower section.

5. In an overvoltage arrester as defined in claim 4, wherein each of said insulating plates comprises flanged portions partially bordering the periphery of the coated area, and wherein said metallic coatings terminate in raised extensions at the junctions of each of said coated areas with said flanged portions.

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