

April 24, 1945.

R. H. EARLE

2,374,527

LIGHTNING ARRESTER AND METHOD OF MANUFACTURE

Filed Oct. 14, 1942

2 Sheets-Sheet 1

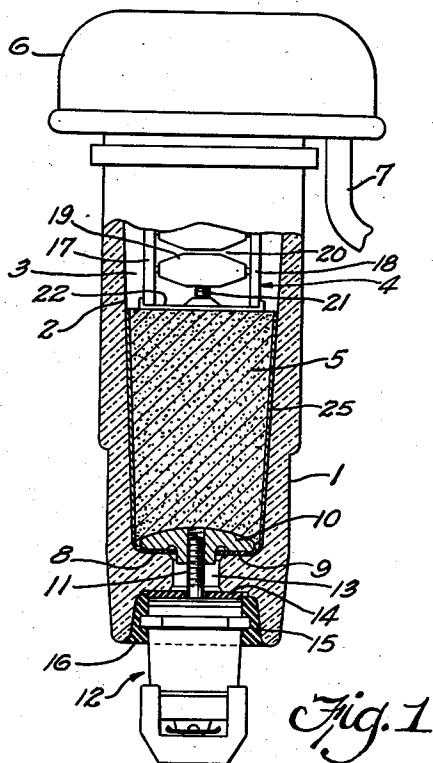


Fig. 1

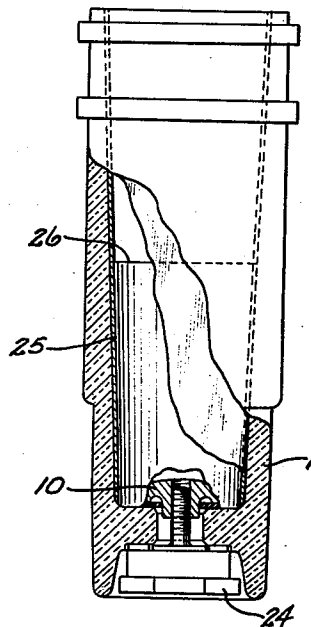


Fig. 2

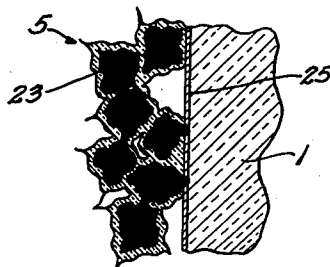


Fig. 3

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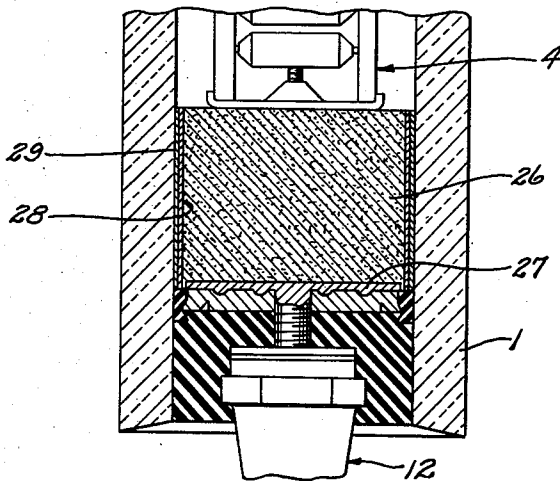


Fig. 4

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UNITED STATES PATENT OFFICE

2,374,527

LIGHTNING ARRESTER AND METHOD OF
MANUFACTURE

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19 Claims. (Cl. 201—76)

This invention relates to lightning arresters and the manufacture thereof, and it has to do more especially with arresters of the type which comprises a spark-gap in series with a resistor constituting a so-called valve element having the property of low impedance to high surge voltages and high impedance to ordinary power line voltages—the purpose being to provide an easy path to ground for high voltage surges while interrupting quickly the power current which tends to follow in the path of the surge.

Working with porcelain housed arresters, my co-worker, Herman O. Stoelting, found that some important improvements and advantages could be realized in lightning arrester manufacture and performance by utilizing the arrester housing as a matrix and compacting therein the resistor-forming material comprising a measured quantity of intermixed granular silicon carbide and sodium silicate (water glass) and thereafter subjecting the compacted mass to dehydration without removing it from the housing.

Functionally, the most important advantage accruing from the Stoelting process is suppression of flashover between the resistor and housing, and that desirable result is attributable to the fact that during the dehydrating operation the mass of resistor material becomes firmly bonded to the bore of the housing—unless steps are taken to prevent the bond forming.

But there are further advantages, principally economic in character, which are inherent in the Stoelting process and wholly in addition to flashover suppression. The fact that the housing constitutes the matrix for molding the resistor, rendering it unnecessary to remove the resistor from its mold or to provide any special means for aligning or supporting the resistor, while dispensing with much costly rehandling of the resistor during the course of manufacture, makes for substantial savings in production costs.

It was found, however, that there were a few losses in manufacture when utilizing the Stoelting process in that in some cases the bond would cause chipping of the housing along the interior thereof adjacent the resistor; and this was particularly objectionable in glass-housed arresters because even when the chipping in no way impaired the arrester functionally, it was visible and consequently gave rise to sales resistance. For that reason the bond had to be eliminated, at least in glass-housed arresters, unless some way could be found, without omitting the bond, to either prevent the chipping altogether or, at any rate,

substantially to reduce the number of occurrences so that the losses would not be excessive.

However, it was desired to retain, if possible, the known economic advantages which were inherent in the Stoelting process; but it was essential that the product be capable of functioning reliably. In other words, there could be no compromise on the score of dependability, which includes the capacity to suppress flashover.

One aspect of the problem confronting me was to prevent the bond from forming, and to do so in a way which would neither greatly impede production nor introduce any new deficiency in the product. Another aspect of the problem was to suppress flashover, after having eliminated the bond.

Insofar as elimination of the bond is concerned, the substance of the present invention consists in the discovery that by applying to the bore of the housing a thin film of adherent, substantially non-conductive material (which I call a "bond-inhibitor"), I am able to prevent formation of a bond between the resistor and housing without giving rise to any new deficiency and without introducing any impairment beyond that which is directly incidental to cancelling the normal effect of the bond; and in so doing I found that the resistor, though not bonded to the housing, fits snugly therein—which fact contributes, in a considerable measure, to flashover suppression, although not to the degree which the presence of a bond would ensure. I tried numerous prospective inhibiting materials which seemed to me to have appropriate characteristics such as suitable adhesiveness and fluidity as well as nonconductivity and all proved to be operative as inhibitors, but were not equally satisfactory from every standpoint. By way of example, I tried lacquers and synthetic resins such as Plascon and Vinylite. These worked satisfactorily, but caused spotty discoloration, which was thought to be objectionable in a commercial product although in no way detrimental functionally. Some inhibitors which were otherwise satisfactory were relatively costly and some were less satisfactory than others because of deterioration on extended exposure. Ultimately, I found that liquid wax gave, in all respects, the best performance. This material is easy to apply, sets rapidly after applying, does not rapidly deteriorate or change its viscosity on exposure in bulk so as to impede production, and it causes no discoloration. Moreover, it is relatively cheap. For those reasons I employ liquid wax exclusively; but I want it to be understood that many other materials can be employed alternatively and that my invention is

not limited as to the particular bond-inhibiting material employed. When porcelain housings are used the previously-mentioned discoloration is of no consequence.

Long prior to the present invention I had discovered in connection with lightning arresters having resistors of unbonded granular silicon carbide that the current flow through the resistor could be diverted, in part, away from the housing and toward the longitudinal axial center of the resistor by making one or both of the resistor terminal electrodes of convex form so that the length of the conductive path along the longitudinal axis of the resistor would be a minimum. So far as I know, this had not previously been tried with a solid resistor such as one composed of granular silicon carbide and dehydrated sodium silicate, but it seemed not unlikely that by using a convex electrode in conjunction with the solid resistor, unbonded to the housing, flash-over might be sufficiently suppressed. This proved to be the case up to a certain point, by which I mean that for arresters designed for use on relatively low voltage lines, in which the resistor elements are dimensionally short, the use of a convex terminal electrode solved the flashover problem. But for arresters intended for use on high voltage lines wherein the resistors are, of necessity, dimensionally long, the problem was not solved. That problem remained to be solved and was solved by my previously mentioned co-worker, Herman O. Stoelting, who found that by embedding in the resistors suitably proportioned metal slugs, as for example a lenticular metal disc, at points intermediate the terminal electrodes, flashover suppression could be extended successfully to glass-housed high voltage arresters.

The hereinbefore mentioned Stoelting process, which involves molding the resistor in the housing and thereafter dehydrating the resistor by placing the housing, with the resistor therein, in a drying oven, constitutes the subject matter of Stoelting Patent No. 2,305,577, issued December 15, 1942. The second-mentioned Stoelting development which involves the use of metal slugs embedded within the resistors at points intermediate the terminal electrodes and designed to prevent flashover in high-voltage arresters constitutes the subject matter of Stoelting Patent No. 2,331,852, issued October 12, 1943.

The present application is a continuation-in-part of my application Serial No. 361,911, filed October 19, 1940.

In the drawings which accompany this specification:

Fig. 1 is an elevational view, partly in longitudinal section, of a lightning arrester;

Fig. 2 is an elevational view, partly in section, of a partially completed arrester;

Fig. 3 is a fragmentary detail view, on a greatly magnified scale, illustrating the mixture of silicon carbide granules and water glass, and showing how a film of wax isolates the water glass from the housing bore and thus prevents formation of a bond; and

Fig. 4 is a fragmentary sectional view illustrating the use of a jacket of water glass and sand or other inert material in a resistor to suppress flashover.

The Fig. 1 illustration is of the lightning arrester manufactured commercially by my assignee and designed for service where the line potentials do not exceed three kilovolts.

It may be assumed that the housing casing

is made of glass or porcelain, that being usually the case where the present invention is employed; but it can, if desired, be made of any other dielectric material which may be suitable for arrester housings generally. The housing casting is formed with a bore 2 which defines a chamber 3 in which is housed a multiple spark-gap 4 and a resistor 5 connected in series. The upper end of the housing casing is closed by a cap 6 which is hermetically sealed thereto to exclude air and moisture, and an incoming conductor 7 extends under the rim of the cap and into the top of the housing where it makes connection with the upper end of the multiple spark-gap. Conductor 7 serves as a medium for connecting the arrester to a line.

At the bottom of chamber 3 and resting on shoulder 8, with a gasket 9 interposed therebetween, is a conductive electrode 10 having a convex upper surface which is protrudent upwardly. Electrode 10 is internally threaded axially to receive a correspondingly threaded stud 11, which forms a part of the lower terminal structure 12 and extends through an aperture 13 formed in the housing casting. This lower terminal structure preferably, but not necessarily, comprises a so-called "isolator" which functions to interrupt the ground circuit in event the arrester should fail to function promptly. The isolator is fully described in my Patent No. 2,315,320, issued March 30, 1943. The isolator is seated against a gasket 14 in a recess 15 formed in the bottom of the housing casing, and said recess is filled with a suitable sealing compound 16. Gaskets 9 and 14, together with the sealing compound 16 function jointly to exclude air and moisture from the interior of the housing. The isolator includes a suitable terminal connector to which a ground lead can be attached.

Multiple spark-gap 4 comprises a pair of spaced, non-conducting stanchions 17, 18 which support between themselves a plurality of roller-like spark electrodes 19 which are spaced vertically to form a series of gaps 20, only one of which is shown. The lowermost electrode 19 is connected by means of a screw 21 with a metal plate 22 which contacts a large part of the area of the upper face of resistor 5, and constitutes the upper terminal electrode of the resistor.

The composition of the resistor is illustrated in Fig. 3 on a greatly magnified scale. The resistor comprises, preferably, an intimate mixture of silicon carbide granules 23 and a binder of sodium silicate, commonly known as water glass. The water glass in liquid form is thoroughly mixed with a quantity of granular silicon carbide to form a plastic mass, of which a measured amount is placed in the housing and thoroughly compacted by tamping. Thus the housing forms the matrix for the resistor. Before putting in the plastic mixture the housing is cleaned to remove all foreign matter and is then coated internally with a thin film of bond inhibitor. As previously stated, this preferably is liquid wax, but not necessarily so.

It should be observed that the film of bond inhibitor defines within the housing bore a volumetric space which is occupied by the resistor material.

In Fig. 2 I have illustrated the housing with the electrode 10 in place and temporarily secured by means of a special screw 24, the head of which does not extend below the bottom of the housing. This facilitates standing the housing on end in the drying oven and during the

operation of tamping the plastic resistor material. The housing is here shown coated internally with wax or other inhibitor 25 and is indicated as being filled to line 26 with a mass of plastic resistor material which has been leveled off and smoothed at the top. The assembly of Fig. 2 is ready to be placed in a drying oven for the purpose of dehydrating the water glass, which is thereby solidified. The inhibitor prevents formation of a bond between the water glass of the resistor and the bore of the housing, and if wax is used as the inhibiting medium it leaves no discoloration due to the oven heat. Generally there is no clearly visible trace of the wax remaining when the dehydrating operation is completed; but that is not usually the case when other inhibitors are employed.

In order to protect the interior of the housing against scratching by silicon carbide granules while the mass of resistor material is being tamped into form, I prefer to coat the entire interior surface of the housing with the wax. This, however, is not an indispensable precaution, but is one which can easily be carried out because the upper part of the housing bore becomes coated with wax almost incidentally to the waxing of the lower part.

When the housing is removed from the drying oven and has cooled sufficiently the temporary screw 24 is withdrawn and replaced by a permanent terminal—preferably the isolator 12—and the arrester is finished by inserting the multiple-gap structure and attaching cap 6 and conductor 7. Preferably, the upper end of the resistor is coated with sprayed copper in order to effect a good contact with plate 22.

In Fig. 1 I have illustrated the inhibitor 25, but so far as wax is concerned this must be regarded as more or less symbolic because the wax is not clearly discernible in the finished product.

Due to the fact that the resistor fits the bore of the housing snugly, the susceptibility to flashover is diminished, by comparison to the condition which would obtain in the absence of a snug fit; but this in itself is not enough. I find it usually necessary to provide some additional means for reducing the flashover tendency in order to obtain a satisfactory product; and the means which I prefer to employ consists in the use of the convex electrode 16 which serves to divert the current flow through the resistor toward the longitudinal axis thereof and away from the housing bore surface. The accepted explanation of this phenomenon is that the shortest path, which is along the axial center, heats up to the greatest extent and the specific conductivity of the resistor increases with increase of temperature—this being a characteristic property of silicon carbide. For that reason the diversion of current toward the center of the resistor is considerably greater than might be deduced purely from the difference in the length of paths.

Resistor 5 is also commonly denominated a "valve element," which terminology is descriptive of its function as a means operative to interrupt the flow of power current following the passage of a surge.

Another way by which the flashover tendency can be diminished or overcome is illustrated in Fig. 4. In that figure the resistor, identified by reference numeral 26, consists, as before, of a rigid block of granular silicon carbide and water glass which is molded in place and dehydrated; and the lower electrode 27 is flat-topped instead of convex. There is no diversion of current

toward the axial center, but flashover is suppressed by coating the peripheral surface of the resistor with an imperforate jacket 28 of water glass and sand or asbestos or mica dust. The bore of the housing is coated, as before, with a thin film of bond inhibitor 29, preferably wax; and to the exposed wax surface there is applied a coating 28 consisting of a plastic mixture of water glass and sand or asbestos or mica dust, but preferably sand. This is allowed to set until firm and thereafter the previously described plastic mixture of water glass and granular silicon carbide is poured in and tamped. The dehydrating operation follows as before. The jacket of insulation thus formed on the outside of the resistor is quite effective and could be employed with the convex terminal electrode if desired.

What is claimed is:

1. In the manufacture of lightning arresters and the like, the process which comprises coating the bore surface of a dielectric housing with a film of substantially non-conductive bond-inhibiting material which is capable of adhering to said surface, placing within said bore and the confines of said film a mass of plastic resistor-forming material including a solidifiable binder which is inherently operative to form a bond between the housing and the hereinafter-mentioned solid resistor block except for the deterrent action of said bond-inhibiting material, compacting said mass while utilizing the housing as a matrix therefor, and thereafter dehydrating said mass while retaining the same within the housing bore to effect conversion of said compacted mass into a solid resistor block.

2. In the manufacture of lightning arresters and the like, the process which comprises coating the bore surface of a dielectric housing with a film of fluid substantially non-conductive bond-inhibiting material which is capable of adhering to said surface, placing within said bore and the confines of said film a plastic mass of resistor-forming material comprising a granular carbide and a liquid solidifiable binder which is inherently operative to form a bond between the housing and the hereinafter-mentioned solid resistor block except for the deterrent action of said bond-inhibiting material, compacting said mass while utilizing the housing as a matrix therefor, and thereafter dehydrating said mass while retaining the same within the housing bore to effect conversion of said compacted mass into a solid resistor block.

3. In the manufacture of lightning arresters and the like, the process which comprises coating the bore surface of a dielectric housing with a film of wax, placing within said bore and the confines of said film a plastic mass of resistor-forming material including a binder which is inherently operative to form a bond between the housing and the hereinafter-mentioned solid resistor except for the bond-inhibiting effectiveness of said film of wax, compacting said mass while utilizing the housing as a matrix therefor, and thereafter dehydrating said compacted mass while retaining the same within the housing bore to effect conversion of said compacted mass into a solid resistor block.

4. In the manufacture of lightning arresters and the like, the process which comprises coating the bore surface of a dielectric housing with a film of wax, placing within said bore and the confines of said film a plastic mass of resistor-forming material comprising a mixture of granular

silicon carbide and a liquid silicate binder which is inherently operative to form a bond between the housing and the hereinafter-mentioned solid resistor block except for the bond-inhibiting effectiveness of said film of wax, compacting said mass while utilizing the housing as a matrix therefor, and thereafter dehydrating said compacted mass while retaining the same within the housing bore to effect conversion of said compacted mass into a solid resistor block.

5. In the manufacture of lightning arresters and the like, the process which comprises coating the bore surface of a dielectric housing with a film of wax, placing within said bore and the confines of said film a plastic mass of resistor-forming material comprising a mixture of granular silicon carbide and liquid sodium silicate, compacting said mass while utilizing the housing as a matrix therefor, and thereafter dehydrating said compacted mass while retaining the same within the housing bore to effect conversion of said compacted mass into a solid resistor block.

6. In the manufacture of glass-housed lightning arresters and the like, the process which comprises coating the bore surface of the glass housing with a film of wax, placing within said bore and the confines of said film a plastic mass of resistor-forming material comprising a mixture of granular silicon carbide and liquid sodium silicate, compacting said mass while utilizing the housing as a matrix therefor, and thereafter dehydrating said compacted mass while retaining the same within the housing bore to effect conversion of said compacted mass into a solid resistor block.

7. In the production of lightning arresters, the process of manufacture which comprises coating an internal bore surface of a dielectric arrester housing with a substantially non-conductive, adherent bond-inhibiting material, said coated surface defining a volumetric space within said bore, filling at least a portion of said volumetric space with a mixture of valve material and solidifiable fluid binder, compacting said mixture within said space to form a partition occupying said space and completely obstructing said bore, and solidifying said binder to convert said compacted mixture into a rigid block snugly fitting said bore but not bonded thereto.

8. In the production of lightning arresters, the process of manufacture which comprises coating an internal bore surface of a dielectric arrester housing with a substantially non-conductive, adherent bond-inhibiting agent, said coated surface defining a volumetric space within said bore, filling at least a portion of said volumetric space with a mixture of granular valve material and liquid binder solidifiable by heat, compacting said mixture within said bore to form a partition occupying said space and completely obstructing said bore, and subjecting said compacted mixture to heat sufficient to solidify said binder and convert said mixture into a rigid block snugly fitting said bore but not bonded thereto.

9. In the production of lightning arresters, the process of manufacture which comprises coating an internal bore surface of a dielectric arrester housing with a bond-inhibiting agent consisting of an adherent wax film, said film defining a volumetric space within said bore, filling at least a portion of said volumetric space with a mixture of valve material and liquid binder solidifiable by heat, compacting said mixture within said bore to form a partition occupying said space

and completely obstructing said bore, and subjecting said compacted mixture to heat sufficient to solidify said binder and convert said mixture into a rigid block snugly fitting said bore, but not bonded thereto.

10. In the production of lightning arresters, the process of manufacture which comprises coating an internal bore surface of a dielectric arrester housing with an adherent film of substantially non-conductive bond-inhibiting material, said film defining a volumetric space within said bore, filling at least a portion of said volumetric space with a mixture of granular silicon carbide and a liquid silicate binder capable of solidification by heat, compacting said mixture within said bore to form a partition occupying said space and completely obstructing said bore, and baking said mixture to solidify said binder and convert said mixture into a rigid block snugly fitting said bore but not bonded thereto.

11. In the production of lightning arresters, the process of manufacture which comprises coating an internal bore surface of a dielectric arrester housing with an adherent film of bond-inhibiting material comprising wax, said film defining a volumetric space within said bore, filling at least a portion of said volumetric space with a mixture of granular silicon carbide and liquid sodium silicate, compacting said mixture within said bore to form a partition occupying said space and completely obstructing said bore, and baking said housing together with said partition to convert said partition into a rigid block snugly fitting said bore, but not bonded thereto.

12. In the manufacture of lightning arresters and the like, the process which comprises coating the bore surface of a dielectric housing with a film of adherent, non-conductive bond-inhibitor, applying to said film an adherent coating of liquid, non-conductive solidifiable binder mixed with granular, inert, non-conductive material, filling the space within said coating with a mass of intermixed granular valve material and solidifiable, liquid, non-conductive binder, compacting said mass within said space, and subjecting the contents of said housing to dehydration to effect solidification of said mass.

13. In the manufacture of lightning arresters and the like, the process which comprises coating the bore surface of a dielectric housing with a film of wax, applying to said film an adherent coating consisting of liquid, non-conductive, solidifiable binder mixed with granular, inert, non-conductive material, filling the space within said coating with a mass of intermixed granular valve material and solidifiable, liquid, non-conductive binder, compacting said mass within said space, and subjecting the contents of said housing to dehydration to effect solidification of said mass.

14. As a new article of manufacture, a lightning arrester comprising in combination a ceramic housing including a spark-gap therein, a thin coating of solid insulating material on and adhering to the inner wall of said housing, and a molded solid resistor block conformed by said inner wall and snugly contacting said coating, said housing characterized as a matrix for molding said block during fabrication of said arrester and said coating characterized as a bond inhibitor between said housing and the material of said resistor block during molding and subsequent solidification of said block in said housing.

15. As a new article of manufacture, a lightning arrester comprising in combination a glass

housing including a spark-gap therein, a thin coating of wax on and adhering to the inner wall of said housing, and a molded solid resistor block of silicon carbide granules and sodium silicate conformed by said inner wall and snugly contacting said coating, said housing characterized as a matrix for molding said block during fabrication of said arrester and said coating characterized as a bond inhibitor between said housing and sodium silicate during molding and subsequent solidification of said block in said housing.

16. As a new article of manufacture, a lightning arrester comprising in combination a transparent glass housing including a spark-gap therein, a coating of wax on and adhering to the inner wall of said housing and sufficiently thin to permit visual inspection of the interior of the housing, and a molded solid resistor block of silicon carbide and sodium silicate conformed by said inner wall and snugly contacting said coating, said housing characterized as a matrix within which said block is molded and solidified during fabrication of said arrester and said wax characterized as a bond inhibitor between said housing and sodium silicate during molding and subsequent solidification of said block in said housing.

17. A lightning arrester comprising a housing

of insulating material having a film of bond inhibiting material on the internal surface thereof, and a solid valve material and a spark gap within said housing, said film adhering to the wall of said housing and preventing said valve material from becoming bonded thereto, said valve material being in snug relation to said film and conformed to a contour demarked by said housing and film.

18. A lightning arrester comprising a transparent dielectric housing, a transparent dielectric inner liner in said housing, and a solid resistor element and a spark gap within said housing, said liner being in adherent relation to said housing and preventing said resistor element from becoming bonded thereto, said resistor element being in snug relation to said liner and conformed to a contour demarked by said housing and liner.

19. A lightning arrester comprising a transparent glass housing, a film of dielectric material covering and adhering to the interior walls of said housing, and a solid valve element and a spark gap within said housing, said film being interposed between the walls of said housing and valve element to prevent adhesions therebetween, said valve element being in snug relation to said film and conformed to a contour demarked by said housing and film.

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