April 13, 1937. A. P. STROM ET AL 2,077,282

ELECTRICAL ARC EXTINGUISHING AND INSULATING MATERIAL

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Fig. 1

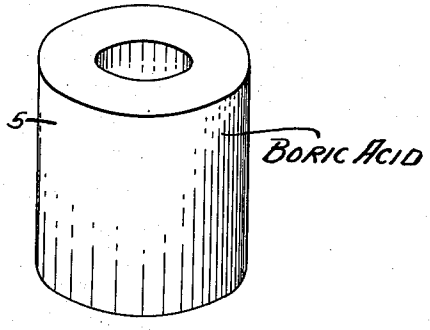


Fig. 2

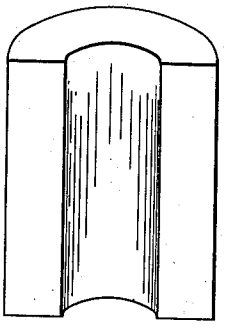


Fig. 3

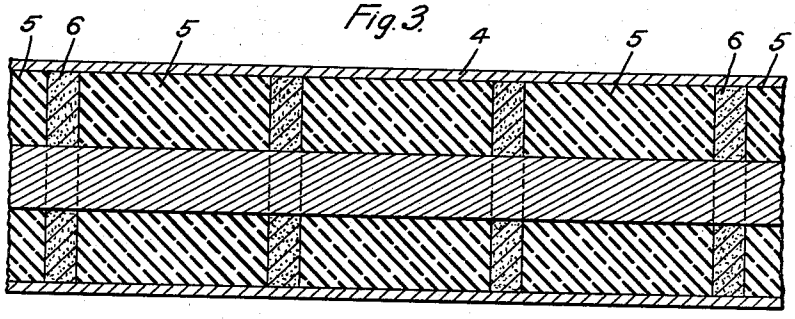


Fig. 4

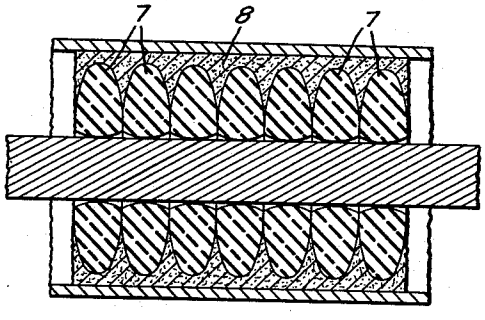
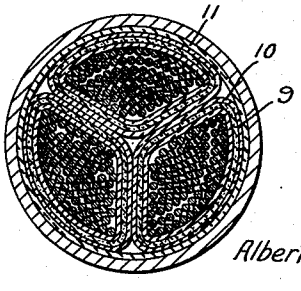


Fig. 5



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ELECTRICAL ARC EXTINGUISHING AND INSULATING MATERIAL

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15 Claims. (Cl. 173—264)

Our invention relates to insulating material, and more particularly to an insulating material that is capable of generating non-inflammable vapors when exposed to the heat developed by electric arcs.

The principal object of our invention is to provide an insulating material that is capable of generating non-inflammable gases at elevated temperatures.

Another object of our invention is to provide an insulating material in the form of compressed blocks, slabs, plates or other shapes which is capable of evolving non-inflammable gases when exposed to the heat of an electric arc.

A further object of our invention is to provide a cable comprising an inner conductor, an outer conducting sheath, and an insulating material interposed between the conductor and sheath, which is capable of evolving non-inflammable gases when the insulation is exposed to the heat developed by an electric arc.

In constructing cables, comprising an inner insulated conductor and an outer sheath, especially those utilized in electric lighting service or in the transmission of power, it has heretofore been the practice to utilize an organic insulating material, such as oil impregnated paper, rubber, etc., as an insulator between the inner conductor and outer sheath. Inorganic material, such as porcelain, glass or earthenware has also been employed for this purpose.

When faults occur in cables of such types either through defective material or construction or when the cable is accidentally punctured by workmen, an arc is often produced between the conductor and the outer sheath, or between the broken or punctured conductor, which, if not promptly extinguished, is liable to cause explosions in the event that the surrounding atmosphere of the duct contains inflammable or combustible gases. When organic insulating material is utilized, the danger from explosion is accentuated because in such cases when an arc occurs, the organic insulating material decomposes and a gas is evolved which is itself explosive. Consequently, the use of organic material for such purpose is particularly dangerous.

In making investigations on the extinction and reignition characteristics of arcs, it has been definitely ascertained that where gases are generated by the decomposition of material by the heat of the arc, the characteristics are remarkably changed. For example, in cables of the type mentioned, in which the insulated material interposed between the inner conductor and the outer sheath is capable of generating gases in the presence of an electric arc, when a fault occurs in the outer sheath or in the inner conductor, the arc occurs "in" the insulation in the same way as the oil circuit breaker arc is "in" the oil. In both cases, the arc is in a gas pocket or bubble. This gas and the arc in it, however, are not in a quiescent state but are being violently stirred by the turbulent mixing of a large volume of fresh, relatively cool, unionized gas into the gas containing the arc which comes from the decomposing insulation. This turbulent inpouring of fresh gas causes the extinction of the arc in circuits of higher voltage than would otherwise be possible. The gases coming from the thermal decomposition of organic insulation in cables are generally regarded as a nuisance, and since they are inflammable, they may even constitute an explosion hazard. Nevertheless, our researches show that, because of the effectiveness of gases in extinguishing arcs, they are extremely useful, if not essential in the proper functioning of cables utilized in low voltage, alternating current networks.

We have made the discovery that, if an insulating material that is capable of generating a non-inflammable gas is utilized between the conductors in which arcs are liable to occur, such as cables, the arc which usually occurs will be promptly extinguished. By utilizing such a material, we are, therefore, not only able to secure the benefit resulting from the generation of gases but since the gases generated are non-inflammable, the danger from explosion is avoided.

Our invention will be better understood by reference to the accompanying drawing, in which

Figure 1 is a perspective view of a compressed cylindrical block composed of our improved insulating material,

Fig. 2 is a similar view in which the insulating material is compressed in a semi-cylindrical form,

Fig. 3 is a cross sectional view of a cable, showing a central conductor, an outer sheath, and insulating material interposed between the two conductor and sheath,

Fig. 4 is a similar view showing another modification, and

Fig. 5 is a sectional view showing a plurality of conductors surrounded by a sheath containing an insulating material.

Referring to Figs. 1 and 2 of the drawing, Fig. 1 shows a block of our improved insulating material which has been consolidated into cylindrical form by means of pressure and Fig. 2 shows a

block which has been compressed into semi-cylindrical shape by similar means.

Figs. 3, 4 and 5 illustrate how the insulating material may be applied to cables such as those utilized in low-voltage, alternating current networks, which are employed for the transmission of electricity for light or power. Such cables usually consist of an inner conductor **3**, which may be either a single conductor or a plurality of strands, as shown in the drawing, and an outer sheath **4** which is preferably made of lead. The inner conductor and the outer sheath are insulated from each other by means of our improved insulation which may be formed entirely of compressed material, as indicated at **5**. In order that the cable may be slightly flexible, however, the insulation is preferably formed of alternate layers of a pulverulent insulation interposed between pieces of the compressed insulation. The compressed pieces may be of the form disclosed at **5** in Fig. 3 or of the form indicated at **7** in Fig. 4. If flexibility is of paramount importance, however, pulverulent material may be utilized alone between the inner conductor and the outer sheath.

In Fig. 4, the compressed pieces are of substantially elliptical shape, as shown at **7**, and the interstices between the outer edges of the elliptical pieces and the additional space between the inner conductor and the outer sheath is filled with pulverulent material, as shown at **8**. It will be understood, however, that the shape of the compressed pieces and the form which the intervening pulverulent material assumes, as shown in the drawing, is merely illustrative as other shapes will be apparent to those skilled in the art without departing from the spirit of the invention. It is highly desirable, however, to utilize, as much as possible, of the compressed material because of its greater mechanical strength, but when some flexibility is essential, a portion of the insulation should be in the pulverulent form, as illustrated in Figs. 3 and 4 of the drawing.

Another method of utilizing our improved material in cables is shown in Fig. 5 of the drawing. In this example, the insulating material is molded to the desired shape or placed in a pulverulent form in a sheath of insulating material **10**, such as asbestos or spun glass and then wrapped around the conductor or strands or the asbestos sheath may be first impregnated with the pulverulent material and a binder, or treated with a material, such as sodium or potassium silicate before being wrapped around the cable. In the latter examples, the sheath may be utilized by itself or may contain the compressed or pulverulent material. Either one or a plurality of conductors **9** may be utilized, depending upon the particular lighting or power system employed. In case a plurality of conductors are utilized, as in the three-phase three-conductor lighting or transmission system, an extra additional waterproof insulating material **11** such as impregnated cloth or mica tape may be employed for the purpose of binding the conductors compactly together and to fill the space between the conductors and the outer sheath. While it is true that in this modification some organic material is utilized, the amount will be relatively small.

The particular insulating material utilized must have a comparatively high insulating value and must be capable of generating a gas in the presence of the arc, which is not inflammable. We have found that boric acid, gypsum, plaster of Paris, borax, magnesium carbonate, basic magnesium carbonate, ammonium carbonate, aluminum ammonium sulphate, or the carbonates or bicarbonates of the alkali or alkaline earth metals, or a mixture of two or more of such compounds, are suitable. As a rule such compounds decompose and give off vapor at temperatures below 500°. The insulating material may be utilized in the pulverulent state, or it may be compressed into the form of blocks, as indicated in the drawing. Asbestos fibers, porcelain, glass or other inert material may be substituted in amounts ranging from one part of asbestos, or other inert material, up to 30 parts of the insulating material, although higher amounts, even up to 80%, of the inert material may be utilized. When asbestos is utilized as a filler, however, the amount should be kept low, say less than 30%, and preferably less than 5%. If desired, the insulating material may be provided, especially for some purposes, with a supporting or backing plate or with suitable heat conducting fins.

We prefer to utilize boric acid or gypsum. These materials will extinguish short circuit arcs between conductors spaced one-fourth inch apart at voltages up to 750 R. M. S. Boric acid is only one-tenth as conducting as talc, and one-thirtieth as conducting as magnesium carbonate. It is not only an excellent insulator, but it also has very favorable arc extinguishing properties, when decomposed in the presence of the arc. Its excellent arc extinguishing properties are undoubtedly caused by the fact that gases are given off in the form of water vapor, when the material is decomposed in the arc. Boric acid may also be readily compressed into cakes, cylinders or other shapes suitable for use in cables. Pressure in amounts up to 25 tons per square inch has been utilized although the cakes may be formed with much less pressure. For example, cakes suitable for insulating purposes have been formed in laboratory experiments by means of simple pressure clamps.

Improved cables, in which our insulating material is utilized in compressed form, have excellent physical properties, and the danger from explosions caused by the decomposition of inflammable gases is completely avoided.

Although we have described our invention in considerable detail, it will be understood that various modifications may be made therein without departing from the spirit of our invention. For example, the insulating material, either with or without fillers, supporting plates or cooling fins, may be utilized for various purposes, such as fuses, or inserts in the arc chamber walls of circuit breakers. The material may also be subject to heat treatment either during or subsequent to the molding operation. The temperature of such heat treatment, however, should not exceed the decomposition temperature of the insulation.

Other modifications of our invention will become apparent to those skilled in the art without departing from the spirit of our invention. It is, therefore, desired that only such limitations shall be imposed thereon as are indicated in the appended claims. Where the claims state that the arc extinguishing and insulating material remains as a solid at ordinary room temperatures, a temperature of approximately 70° Fahrenheit is meant.

We claim as our invention:

1. In electrical apparatus, a member of arc extinguishing material comprising a self-sustaining block which remains solid at ordinary room tem-

peratures and said self-sustaining block when heated by an arc evolving gas substantially all of which is non-inflammable and readily condensable to effect the extinguishment of the arc.

2. In electrical apparatus, an electrical insulating material therefor that is capable of extinguishing arcs when subjected to the heat thereof including at least 70% of boric acid in the free state.

3 In electrical apparatus, a member of conducting material on which an arc may play, and an arc extinguishing material composed of one or more substances, all of which are inert except for a quantity of boric acid in the free state comprising at least 20% of the material.

4. In electrical apparatus, a pair of members of conducting material at different potentials, and an insulating material therebetween comprising substantially entirely a substance selected from a group of materials consisting of boric acid and gypsum in the form of a rigid block-like member.

5. In electrical apparatus, an arc extinguishing material having the form of a rigid block and including only inorganic material, a quantity of which sufficient to effectively extinguish arcs is of boric acid.

6. An electrical insulating material comprising a block of material of good dielectric strength which remains in solid block form at ordinary room temperatures and which emits substantially entirely a non-inflammable, readily condensable vapor when acted upon by an arc to extinguish the arc.

7. In electrical apparatus, a member of conducting material on which an arc may play and a quantity of material effective to extinguish the arc including at least 20% of boric acid positioned along the path of the arc.

8. In electrical apparatus, a member of conducting material on which an arc may play and one or more rigid cakes of a material including a substantial quantity of boric acid in the free state along the path of the arc, said material evolving only non-inflammable gas when acted upon by the arc.

9. In electrical apparatus, a member of conducting material on which an arc may play and an insulating material of high dielectric strength along the path of the arc in the form of a self-sustaining block which remains solid at ordinary room temperatures and said block of insulating material when subjected to an arc evolving gas substantially all of which is non-inflammable and readily condensable to extinguish the arc.

10. In electrical apparatus, a member of conducting material on which an arc may play and a self-sustaining block along the path of the arc which remains solid at ordinary room temperatures and said self-sustaining block when subjected to an arc evolving gas substantially all of which is water vapor to extinguish the arc.

11. An electric insulator comprising a rigid block composed of boric acid.

12. In electrical apparatus, a member of conducting material on which an arc may play, and an arc extinguishing material for the arc comprising a compressed block of boric acid.

13. In electrical apparatus, a member of conducting material on which an arc may play and a quantity of material effective to extinguish the arc positioned along the path of the arc, said material including a major part of boric acid.

14. In electrical apparatus, a member of conducting material on which an arc may play and a quantity of material effective to extinguish the arc including at least 20% of boric acid in powdered form positioned along the path of the arc.

15. In electrical apparatus, a member of conducting material on which an arc may play and a quantity of material effective to extinguish the arc positioned along the path of the arc, said material including boric acid partly in powdered form and partly in solid block form.

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