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Oct. 28, 1969 F. S. SADLER 3,475,546

INSULATING MATERIAL FOR ELECTRICAL APPARATUS

Filed Aug. 22, 1966 2 Sheets-Sheet 1

Fig. 2

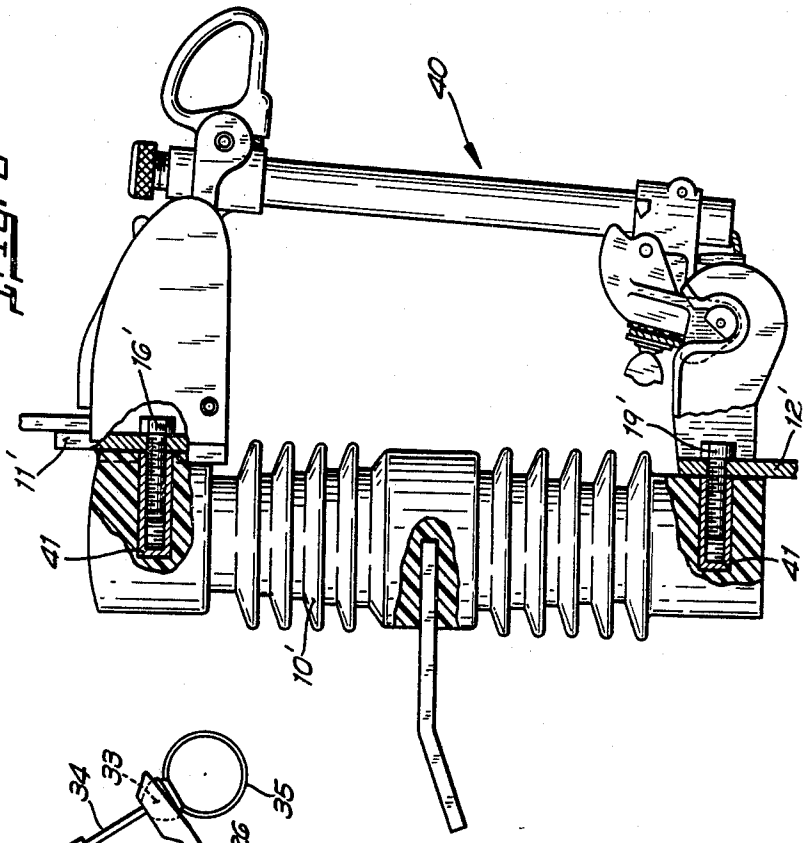
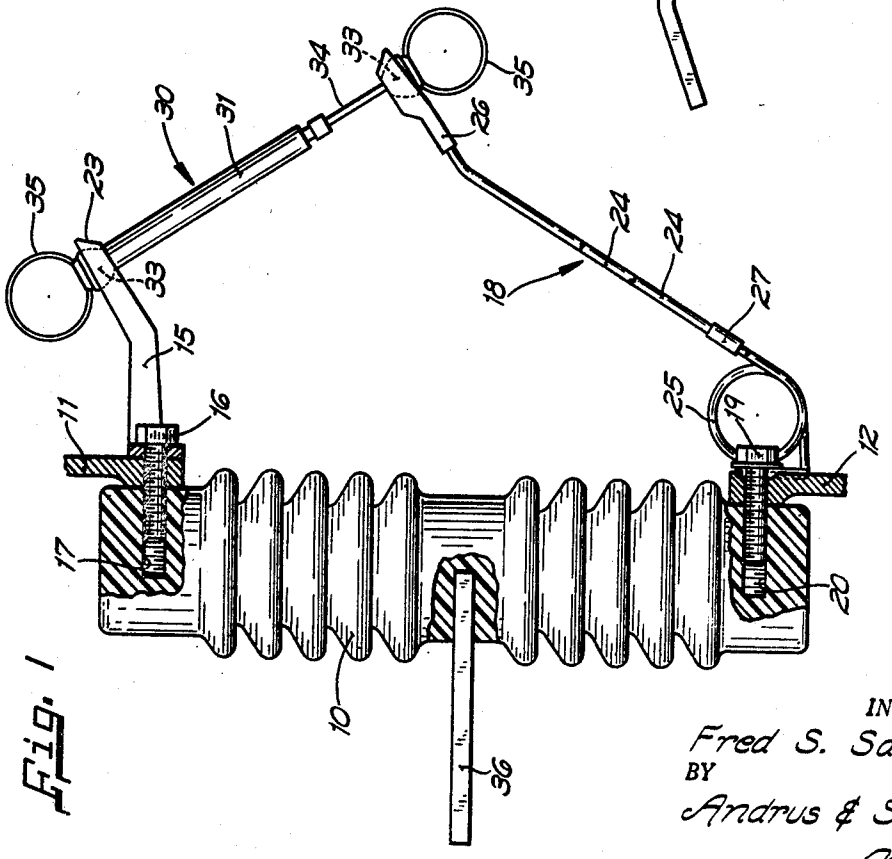


Fig. 1



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INSULATING MATERIAL FOR ELECTRICAL APPARATUS

Filed Aug. 22, 1966 2 Sheets-Sheet 2

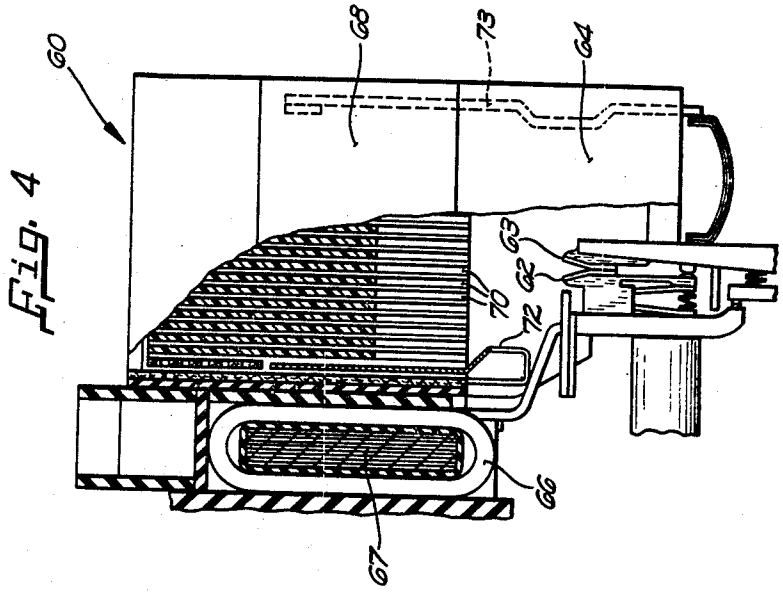


Fig. 4

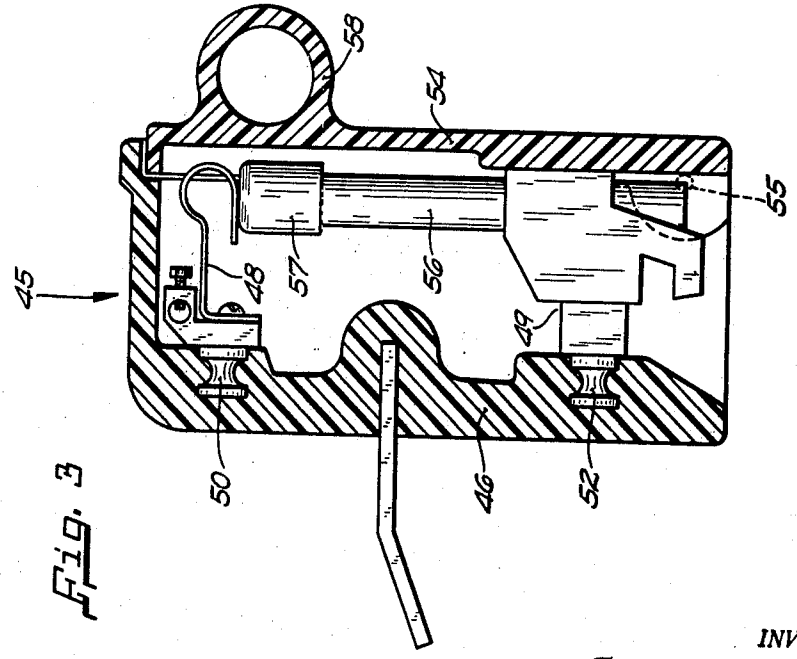


Fig. 3

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3,475,546

INSULATING MATERIAL FOR ELECTRICAL APPARATUS

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Filed Aug. 22, 1966, Ser. No. 574,098
Int. Cl. H01b 17/50
U.S. Cl. 174—137 5 Claims

ABSTRACT OF THE DISCLOSURE

An insulating element for an electrical apparatus which aids in supporting and extinguishing arcs. The insulating material is formed of a synthetic resin or synthetic rubber containing from 5% to 90% by weight of finely divided particles of an inorganic metal fluoride.

This invention relates to insulation for electrical apparatus and in particular to such insulations which are exposed to contaminated atmospheric conditions and aid in suppressing and extinguishing arcs.

Failure of electrical apparatus exposed to contaminating atmospheric conditions such as dust, dirt, salt and moisture due to electrical creepage discharges between spaced conductors at different potentials is well known. Accumulation of dust, dirt, rain or other contaminants on the surface of molded insulation separating two conductors at different potentials may form a high resistance path between the conductors and promote random surface discharges or arcing known as surface creepage. The creepage discharges cause the formation of carbonaceous deposits in the insulation which ultimately result in low resistance paths, or tracks, that cause electrical failure of the apparatus. Tracks due to creepage are random in effect and produce a tree-like path, and creepage type of electrical failure can occur not only due to surface failure but also due to tracking beneath the surface of the insulating material. Organic insulating materials particularly tend to decompose upon exposure to conditions which promote creepage discharges and form carbon tracks and even erode away, thus preventing use of such organic insulating materials even though their low cost and ability to be easily molded in intricate shapes and to close tolerances makes them otherwise ideal for use in electrical apparatus.

Organic insulating compounds are also subject to electrical failure due to carbon tracking caused by power arcing which is distinguished from creepage discharges in that the arc track formed by decomposition of the organic material forms a direct path along the line of the arc between the conductors at different electrical potentials.

The low tracking resistance of organic insulating materials has, in general, prevented their use for insulators in electrical power protective equipment such as lightning arresters and fuse cutouts used to protect electrical power distribution lines, and the insulators of such protective equipment are conventionally constructed of porcelain which has the disadvantages of: (1) it is heavy; (2) it fractures into sharp flying pieces under impact; (3) it is difficult to form to close tolerances, and (4) it has a long manufacturing cycle.

Further, such ceramic insulators require long creepage distances for a given air strike distance, and also flashover may chip the petticoats of the porcelain insulators.

It is an object of the invention to provide improved electrical apparatus having insulation which will overcome the above disadvantages.

It is a further object of the invention to provide improved electrical apparatus having insulation which has high resistance to both arc tracking and creepage tracking.

Another object of the invention is to provide improved electrical apparatus having insulation characterized by high resistance to both arc tracking and creepage tracking and which can be molded to intricate shapes and to close tolerances. A further object is to provide improved electrical apparatus having insulation which does not permit low resistance carbonaceous deposits to form and acts as a catalyst to promote oxidation and removal of the carbon. Still another object of the invention is to provide improved electrical apparatus having insulation which has high resistance to both arc tracking and creepage tracking and can be cast or molded at low temperatures into insulating members having high strength and durability.

Another object of the invention is to provide improved electrical apparatus having insulation which reduces the tendency to form carbonaceous deposits and thus permits reduction in the distance between conductive members having a given potential difference therebetween, thereby allowing a substantial reduction in the overall dimensions of the electrical apparatus.

A still further object of the invention is to provide improved electrical apparatus having insulation which permits a greater creepage distance to be readily operated for a given air strike distance because intricate configurations can easily be formed in the insulating material and which will not chip when subject to flashover.

Still another object of the invention is to provide improved electrical apparatus having insulation which prevents formation of carbonaceous deposits under exposure to contaminating conditions which promote creepage with conventional organic insulation and which also prevent erosion due to discharge between electroconductive members at different electric potentials embedded in the insulation.

It is a further object of the invention to produce an insulating shield or enclosure having improved arc-suppressing properties and which can be molded to intricate shapes without the use of high temperatures.

The electrical insulator or arc-suppressing shield embodying the invention comprises an organic resin binder containing interspersed particles of an organic fluoride. The fluoride co-acts with the organic material under arcing conditions to reduce the formation of carbonaceous material on the surface of the insulator as well as generating arc-quenching gaseous reaction products which aid in suppressing or quenching arcs.

These and other objects and advantages of the invention will be more readily apparent from the following detailed description when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is an elevational view of one form of the invention embodied in an open type fuse cutout;

FIG. 2 is an elevational view of an expulsion type fuse cutout embodying the invention;

FIG. 3 is an exploded elevational view of a closed type of fuse cutout embodying the invention; and

FIG. 4 is a fragmentary elevational view, partly in section, of a magnetic type of circuit interrupter embodying the invention.

Referring now particularly to FIG. 1 of the drawing, the invention is illustrated with reference to an open type fuse cutout which includes an elongated insulator **10** having upper and lower conductive terminals **11** and **12** respectively mounted adjacent opposite ends thereof. A conductor arm **15** is mounted against terminal **11** and both are secured to insulator **10** by a bolt **16** engaged within a threaded hole **17** in the upper end of insulator **10**. Similarly, a lower resilient arm **18** is mounted against

terminal 12 and both are secured to insulator 10 by a bolt 19 engaged within a threaded hole 20 in the lower end of insulator 10. In the preferred embodiment, the threaded holes 17 and 20 for bolts 16 and 19, respectively, are molded within insulator 10.

As those skilled in the art will appreciate, the upper and lower terminals 11 and 12 carry suitable means, not shown, for engaging an electrical distribution power line conductor, not shown, and a contductor from a distribution transformer, not shown.

The conductor arm 15 terminates in an upper hook-like fuse link holding means 23 extending upwardly relative to insulator 10. The resilient arm 18 comprises a pair of elongated resilient wire members 24 having loop portions 25 therein and joined at their ends to a lower hook-like fuse link holding means 26. The wire members 24 are prevented from spreading outwardly relative to each other by a clamp 27, and the ends of wire members 24 are bent upwardly for being secured to the terminal 12 by the bolt 19.

A fuse link 30 including a fusible section, not shown, surrounded by an insulating tubular member 31 may be connected to flexible conductors 32 which terminate in contacts 33 engaged within the upper and lower hook-like fuse link holding means 23 and 26. Contacts 33 may be secured to flexible conductors 34 by solder and may carry tool engaging eyes 35.

A metallic hanger 36 adapted to be secured to a cross arm of a power line pole, not shown, is molded within insulator 10 intermediate the ends thereof.

The upper and lower terminals 11 and 12 are interconnected by fuse link 30, and the fusible section of fuse link 30 will melt if an overcurrent occurs in the transformer and the ends of the fuse link will be separated by resilient arm 18 which will flip the lower flexible conductor 34 out of insulating member 31 to interrupt the circuit.

FIG. 2 shows an insulator 10' according to the instant invention employed with an open type fuse cutout 40. The details of construction and operation of the fuse cutout 40 form no part of the instant invention and accordingly will not be discussed in detail for the sake of brevity. For a detailed description of the fuse cutout 40, reference is made to U.S. Patent 3,002,070, issued Sept. 26, 1961, and assigned to the assignee of the instant invention.

As seen in FIG. 2, the terminals 11' and 12' of cutout 40 are also secured to the upper and lower ends of insulator 10' by bolts 16' and 19', respectively. However, in this embodiment the bolts 16 and 19 are received in threaded metallic inserts 41 which are molded within the insulator 10.

FIG. 3 illustrates yet another application of the invention, i.e., to a housed fuse cutout 45 having a housing 46 of the insulating material according to the instant invention. The cutout 45 also includes an upper contact 48 and a lower contact 49 which are respectively secured by upper and lower mounting studs 50 and 52 which are molded within the housing 46.

The housing 46 is also adapted to receive a door 54 composed of the insulating material according to the invention and pivotally mounted on the housing 46 at 55. The door 54 carries a fuse tube 56 having a terminal 57 at its upper end for engaging the contact 48. An eyelet 58 is formed on the door for receiving a hookstick so that it can be opened and closed in the manner well known in the art.

FIG. 4 illustrates how the invention can be applied to an air magnetic type circuit interrupter 60. The circuit interrupter 60 includes a pair of arcing contacts 62 and 63 disposed within a casing comprising wall portions 64 which may be prepared from sheets or panels of the insulating material according to the invention. A magnetic coil 66, adapted to be energized when contacts 62 and 63 are separated, is associated with a magnetic core 67 and magnetic field pole plates 68 for drawing an arc upwardly into an arc extinguishing structure comprising a plurality of splitter plates 70 also of the insulating material according to the invention. On separation of the contacts 62 and 63, the resulting arc transferred to arcing horns 72 and 73 and under the influence of the magnetic field between the field pole 22, it will be drawn up into the arc extinguishing splitter plate structure where it will be extinguished in the manner well known in the art.

The insulating structure of the invention comprises an organic binder containing finely divided particles of an inorganic fluoride. The composition is characterized by high resistance to both arc tracking and creepage tracking and can be cast or molded at low temperatures into insulating members and arc-suppressing shields of high strength and durability.

As discussed hereinbefore, prior art insulators for fuse cutouts are usually of porcelain which is heavy, tends to fracture into sharp flying pieces upon impact, cannot be held to close tolerances, required that metal mounting products be affixed thereto by special cements or be clamped thereto by special fittings, requires long creepage distance for a given strike distance, chips under flashover, and has a protracted manufacturing cycle due to lengthy pre-firing, firing, and cooling stages. Organic insulating materials have heretofore been unsatisfactory for such insulators because they are subject to the problem of carbonaceous residue formation, an accumulation occasioned by randon electrical discharges which are likely to occur under adverse climatic conditions in outdoor installations.

The organic binder to be used in the insulating material of the invention can be any conventional synthetic resin or synthetic rubber. For example, thermosetting resins such as epoxy resins, polyester resins, phenolic resins, ureaformaldehyde resins, melamine-formaldehyde resins, and the like can be used.

Epoxide resins to be used are those containing more than one epoxide group, such as those obtained by the reaction of bis-phenol with epichlorohydrin or aliphatic diepoxides, such as diglycidyl ether, or epoxides obtained by the reaction of epichlorohydrin with polyhydric alcohols or with polycyclic diepoxide ethers, such as are described, for example, in U.S. Patent Nos. 2,582,985; 2,615,007; 2,615,088; 2,592,560 and 2,581,464. Also epoxides prepared from the reaction of phenol terminated resins which are prepared by the reaction of an excess of dihydric phenol with epichlorohydrin with aliphatic diepoxides, or bisphenolepichlorohydrin resins can be used.

The melamine-formaldehyde and urea-formaldehyde polymers are the reaction product of either melamine or urea with formaldehyde. Urea and melamine share in common the amino group $—NH_2$, and in each case reaction of the amino-bearing material with formaldehyde, under suitably catalyzed conditions forms a reactive monomer. By condensation polymerization, the reactive monomer forms polymeric intermediates which in turn are readily converted to more highly polymerized forms which are infusible.

Phenolic resins are the reaction product of a phenol and an aldehyde. The most common phenolic resin is that based on phenol and formaldehyde. However part of the phenol can be replaced with substituted phenols such as cresols, xylenols, or butyl phenol. For example, p-t-butyl phenol, p-phenyl phenol and resorcinol can be used as a replacement for phenol in the reaction. While formaldehyde is the most widely used aldehyde others such as furfural can be used.

The polyester resin can be formed by the reaction of a polyhydric saturated or unsaturated polybasic acid either with or without a modifying unsaturated monomer such as styrene or the like. Specific examples of the basic material are, for instance, diethylene glycol maleate, dipropylene glycol maleate, diethylene glycol fumarate, and the like. The basic materials are readily polymerized by peroxy catalysts such as benzoyl peroxide, tertiary butyl perbenzoate, and the like.

Thermoplastic resins can also be used as the organic

binder in the insulating material. Examples of common thermoplastic resins which can be used are polyolefins such as polypropylene and polyethylene; vinyl polymers such as polyvinyl chloride, vinylidrine chloride and the like; polyamide (nylon) resins; acrylic resins; and the like.

Polyamide resins are formed by the reaction of straight chain diamines and dibasic acids such as hexamethylenediamine and adipic acid. Specific examples of polyamide resins are polyhexamethylenedipamide and polyhexamethylenesebacamide.

Acrylic resins refer to plastics composed of upwards of about 90% methyl methacrylate, the balance being an ester of methacrylic or acrylic acid, such as ethyl acrylate. Acrylic resins can be modified by co-polymerization with monomers such as acrylonitrile, butadiene styrene, alpha methyl styrene and the like.

In addition synthetic rubbers can be employed as the organic binder. Synthetic rubbers include butyl rubber composed of butenes copolymerized with diolefins, as for example, about 98% isobutene copolymerized with about 2% isoprene or butadiene; ethylene-propylene terpolymer; silicone polymers in which organic side groups such as methyl, phenyl or vinyl are used along the polymer chain, as for example dimethyl polysiloxane; styrene-butadiene polymers, and the like.

The inorganic, arc-suppressing fluoride distributed throughout the organic binder can take the form of aluminum fluoride, AlF_3; hydrated aluminum fluoride (fluellite), $AlF_3.H_2O$; hydrated aluminum fluoride, $AlF_3.3\frac{1}{2}H_2O$; aluminum oxide Al_2O_3 coated with aluminum fluoride; barium fluoride (fluorite), BaF_2; calcium fluosiluate, $CaSiF_6$; hydrated calcium fluosilicate,

$$CaSiF_6.2H_2O$$

lead fluoride, PbF_2; hydrated lead fluosilicate,

$$PbSiF_6.2H_2O$$

and $PbSiF_6.4H_2O$; magnesium fluosilicate, M_gSiF_6; hydrated magnesium silicate, $MgSiF_6.6H_2O$; magnesium fluoride, MgF_2; potassium fluosilicate, K_2SiF_6; silicon fluoride absorbed on silica gel; sodium fluoride, NaF; sodium fluosilicate, Na_2SiF_6; cryolite, Na_3AlF_6; titanium fluoride, TiF_3; lithium fluoride, LiF; hydrated lithium fluosilicate, $Li_2SiF_6.2H_2O$; barium fluosilicate, $BaSiF_6$; and tetra titanium fluoride, TiF_4.

The amount of the inorganic fluoride used in the composition is not critical and may vary widely depending on the particular binder used, the desired structural strength and other factors. Generally, the inorganic fluoride comprises about 5 to 90% by weight of the composition, and preferably 40 to 70%, with the organic binder being the balance.

In some cases finely divided fillers such as asbestos, mica, silica, zircon, fly ash, limestone, barytes, whiting and the like can be incorporated in the composition. If a filler is used, the composition will generally have the following formulation in weight percent:

	Percent
Inorganic fluoride	5 to 90
Filler	Up to 75
Organic binder	Balance

To increase the strength of the insulator 10, fibrous reinforcement can be substituted for a part of the filler and generally can be employed in an amount up to 35% by weight of the composition. Mineral fibers, such as glass, asbestos, or synthetic fibers such as nylon, rayon, Dacron, Orlon and the like can be used as the fibrous reinforcement.

The insulator or arc-suppressing shield can be fabricated by either conventional cold molding or hot molding techniques. In cold molding insulators or arc-suppressing devices, the inorganic fluoride and any fibrous reinforcement or filler, are blended with the organic resin. This premix is then molded under pressure into the desired shape and cured at elevated temperatures. As an alternative method, insulators or arc-suppressing devices can also be formed by a hot moulding process. In this case, a wet mixture of the organic binder, along with the fluoride and any other fillers or reinforcing materials, are molded into an article of the desired form under pressure and/or heat as in conventional compression molding methods. Since fluidity of the hot molded mixture depends on the viscosity of the binder, the organic binder of such mixture should preferably be more than 20% by weight of the molding composition.

As previously mentioned, organic materials tend to decompose upon exposure to conditions which promote creepage discharges and form carbon tracks and even erode away. Thus, organic materials have not been widely used as insulating materials, even though their low cost and ability to be easily molded into intricate shapes and close tolerances makes them otherwise ideal for use as electrical insulators.

The tendency of an organic insulating material to form a carbon track under polluted conditions is believed to be dependent on two opposing processes, carbon forming processes and carbon removal processes. Under a given set of conditions, if carbon is formed faster than it is removed, then tracking will occur. Where an organic material has a tendency to form carbon as a result of pyrolysis, the organic material may still be of use as an insulator if the carbon can be removed as it is formed, and the carbon removal can occur both chemically and mechanically. It is believed that the presence of the fluoride compounds at the arcing or scintillation site acts as a catalyst for the conversion of the carbonaceous materials to gaseous carbon compounds, such as carbon dioxide and carbon monoxide. In addition, the fluoride compounds break down under the arcing conditions and this breakdown results in the mechanical removal of the carbonaceous materials from the surface of the organic binder thereby preventing the formation of low resistant paths or tracks which are apt to destroy further utility of the apparatus. Thus, the fluoride coacts with the organic binding material to aid in reducing the carbonaceous materials on the surface of the organic binder by both the chemical and mechanical action.

As a further advantage, when the fluoride compounds breaks down, fluoride gases are formed which ionize under the conditions of the arc and serve to quench any small arcs or scintillas on the surface of the insulator.

In addition to its use as an electrical insulator, the composition of the invention can also be employed in the molding of switch enclosures, fuse enclosures, and other arc-suppressing shields. In an arc quenching application, the shield does not prevent arcing but tends to quench any arc that forms, thereby reducing the energy represented by the existence of the arc. Under arcing conditions the fluoride breaks down to form arc-extinguishing fluoride gases which serve to quench or suppress the arc. Moreover, the fluorides tend to remove the carboneceous material from the surface of the organic binder, thereby eliminating carbon tracks and preventing re-ignition of the arc on the surface of the shield.

In order that those skilled in the art may better understand how the present invention may be practiced, the following examples are given to illustrate the characteristics of an insulator composed of an organic binder containing finely divided particles of an inorganic fluoride. These examples are given by way of illustration and not by way of limitation.

Sample pieces of material suitable for the invention were evaluated for tracking and using high voltages and low current between the electrodes wherein the "end point" of tracking is defined as the time required to continuously track between the electrodes at a given applied voltage. The Inclined Plane test is well recognized procedure for evaluating insulating materials to be used at high voltages and in contaminating atmospheric condi-

tions. In the Inclined Plane test the sample pieces were mounted at a 45° angle in a test cabinet with electrodes mounted two inches apart on the sample piece and with the upper electrode clamping several layers of filter paper to the surface of the sample piece. An alternating current potential of 6000 volts was applied across the electrodes for the duration of each test. A contaminant solution containing 1% ammonium chloride and 0.02% Triton X–100 wetting agent by weight was fed at a precisely controlled rate into the layers of the filter paper adjacent the top electrode so that the contaminant solution ran down the bottom surface of the sample piece at a flow rate of 0.60 cubic centimeters per minute. The time to failure in which carbon tracking occurred between the electrodes was recorded in minutes.

Example I

Test sample pieces approximately 5" long by 2" wide and approximately ¼" thick were molded with heat and pressure from commercially available polyester resin known as Selectron No. 5140 manufactured by the Pittsburgh Plate Glass Company to which was added 1.5% by weight of benzoyl peroxide, as a catalyst, based upon the weight of the resin, and a mold release agent, zinc stearate, and mixed with varying percentages by weight of aluminum fluoride and ¼" chopped strand glass fiber manufactured by Johns Manville Company. When tested as described above, the results were as follows:

TABLE I

Binder Material	Percent AlF_3	Minutes to failure
Pittsburgh Plate Glass Selection 5140 Polyester Resin	0	21.7
	65.3	(1)

[1] Greater than 200.

TABLE II

Organic Binder	Filler	Percent filler	Minutes to failure
Allied Chemical Company Plaskon 942 Polyester Resin	Al_2O_3	60	15.8
	AlF_3	60	61.7

TABLE III

Organic Binder	filler	Petcent filler	Minutes to failure
Dupont Lucite (polymethyl-methacrylate)	$Al_2O_33H_2O$	40	9.4
	AlF_3	40	(1)

[1] Greater than 300 minutes, No failure.

TABLE IV

Organic Binder	Filler	Percent filler	Minutes to failure
CIBAX 8200/103 Epoxy Resin	None	0	8.2
	Quartz	58.5	12.3
	AlF_3	62.2	(1)

[1] Greater than 300, No failure.

While the invention has been illustrated with respect to a few types of electrical apparatus, those skilled in the art will appreciate that it has application to other types of apparatus as well. In addition, while a number of organic binders and inorganic fluorides have been recited, these are merely intended as examples, it being understood that other suitable materials will be suggested to those skilled in the art once the invention is known. Accordingly, it is not intended to limit the invention by the specifically recited examples, but only by the scope of the appended claims.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. In an electrical apparatus, a pair of electrical conducting members between which an arc may form, an insulating element having a surface extending adjacent the arc-path between said members, said element being formed of a composition comprising a synthetic resin or a synthetic rubber and containing from 5 to 90% by weight of finely divided particles of an arc-suppressing inorganic metal fluoride uniformly interspersed in said composition, said fluoride being selected from the group consisting of calcium fluoride, ammonium fluoride, lithium silico fluoride, sodium silico fluoride, and mixtures thereof.

2. The apparatus of claim 1, in which the element contains up to 75% by weight of a filler selected from the group consisting of asbestos, mica, silica, zircon, fly ash, limestone, barytes, whiting, and mixtures thereof.

3. The apparatus of claim 1, in which the organic material is a thermosetting resin.

4. The apparatus of claim 1, in which the element also contains up to 35% by weight of a reinforcing material.

5. The apparatus of claim 4, in which the reinforcing material is selected from the group consisting of mineral fibers and synthetic organic fibers.

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U.S. Cl. X.R.

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