

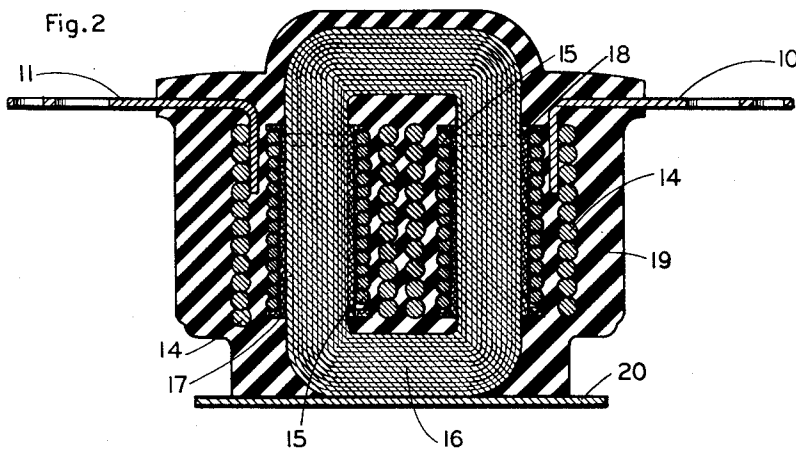
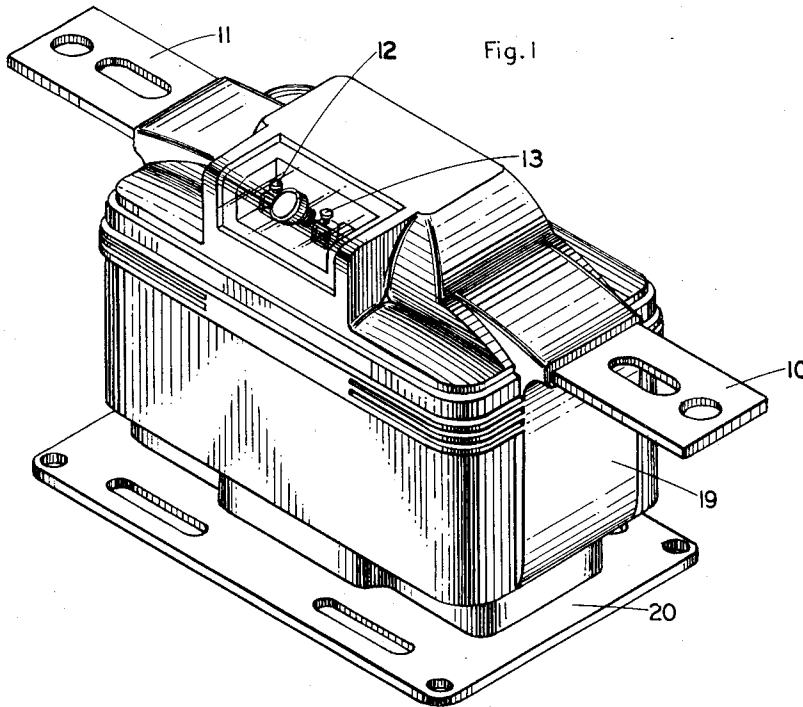
Aug. 22, 1961

A. A. KESSEL ET AL
ELECTRICAL APPARATUS HAVING INSULATION
FOR ELIMINATING CREEPAGE TRACKING

2,997,526

Filed Jan. 9, 1957

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

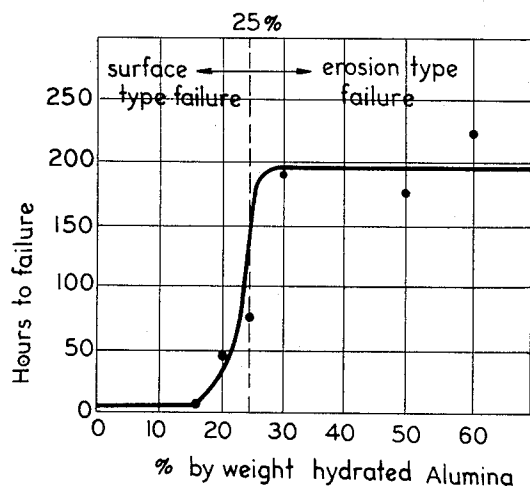


Fig. 3

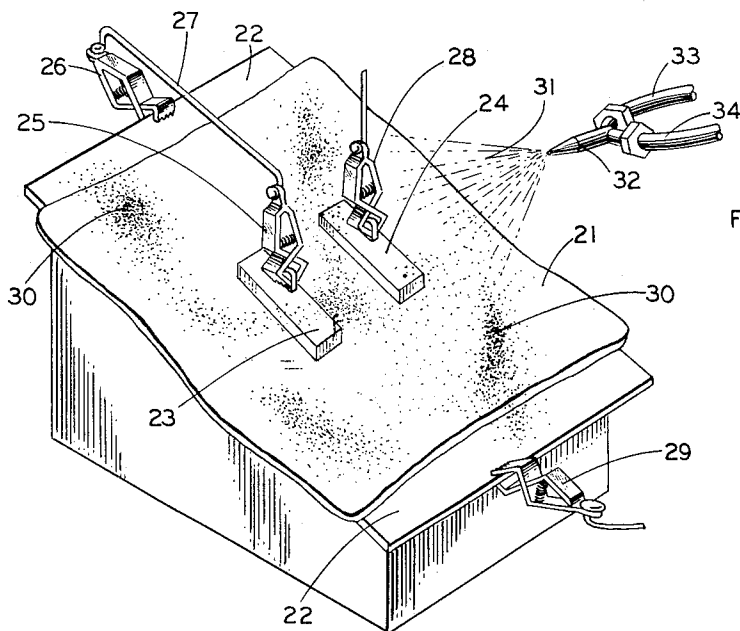


Fig. 4

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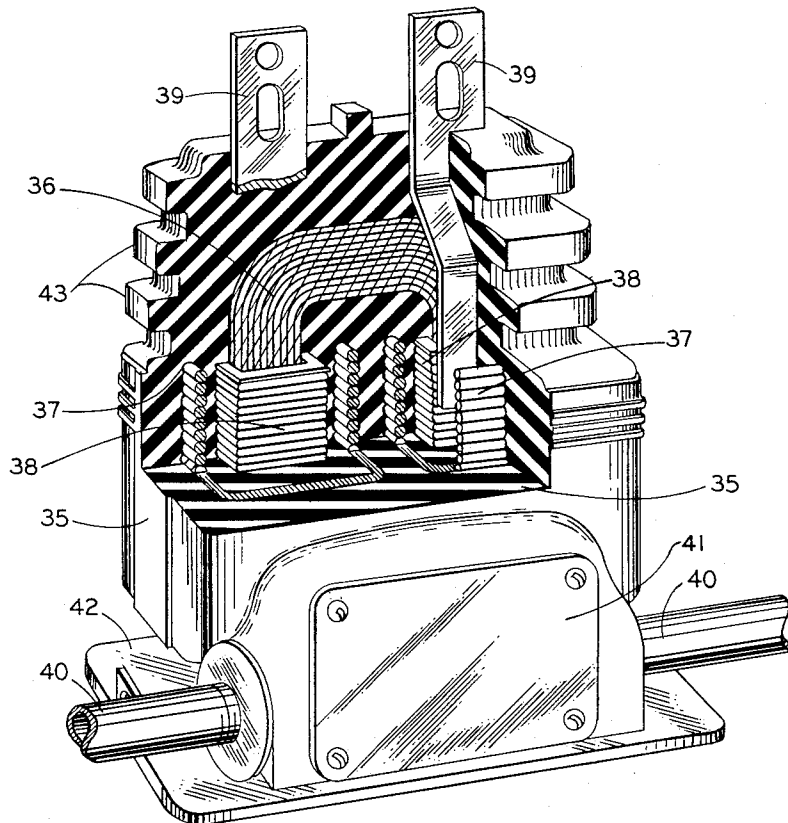


Fig. 5

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1

2,997,526

ELECTRICAL APPARATUS HAVING INSULATION FOR ELIMINATING CREEPAGE TRACKING

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6 Claims. (Cl. 174—137)

The present invention relates to improvements in the insulation of electrical apparatus and, more particularly, to electrical devices and improved insulations therefor which are subject to contaminated conditions which promote creepage electrical discharge conditions. As is well known, certain types of electrical equipment subject to contaminating atmospheric conditions such as moisture, dust, fog and salt frequently fail due to creepage between points of different potentials on the equipment. While the insulating components of electrical equipment desirably include organic materials which are inexpensive and readily molded or otherwise fabricated, it has been a particular disadvantage that the organic constituents of such components tend to form carbonaceous deposits upon exposure to conditions which promote such creepage. These carbonaceous deposits ultimately provide paths of sufficiently low resistance to occasion breakdown of the equipment. This application is a continuation-in-part of our copending application, Serial No. 523,445, filed July 21, 1955, now abandoned.

By way of example in the instrument transformer field, it has heretofore been a distinct limitation to the usefulness of "dry" molded instrument transformers that the molded organic insulation components thereof form low-resistance carbonaceous deposits upon exposure to creepage electrical discharges. High-voltage transformers of this "dry" type may include molded organic insulating compounds not only as the insulation between elements but as the outer protective casing as well, and are thus distinguished from those which are filled with oil or other insulating liquids. In outdoor installations, or others where there may be accumulations of dust, rain and other environmental contaminants, random surface discharges or arcing known as "surface creepage" are promoted between elements. These discharge conditions occasion the formation of carbonaceous deposits in the insulation, ultimately yielding low-resistance paths or tracks which destroy further utility of the apparatus. Discharges of the creepage type are to be distinguished from those caused by the establishment of an arc through or directly between two parts of the apparatus having different potentials. Under arcing conditions, while the organic material adjacent to the arc is carbonized, the arc track so formed is not random in character but forms a direct path along the line of the arc. On the other hand, tracks due to creepage are random in effect and produce a tree-like path. The difference between tracking due to arcing and tracking due to creepage is further pointed out in ASTM test D495-48T in which it is stated specifically that the test directed to determining the resistance of insulating material to arcs does not in general permit conclusions to be drawn as to the resistance of the material to other types of arc such as those promoted by conducting contaminates with which latter the present invention is concerned. It is further pointed out that in the creepage type of electrical failure, failure of the material can occur not only due to surface failure but to subsurface failure. In other words, even if the surface of the organic material is devoid of carbonaceous or conducting material, tracking due to surface creepage may nevertheless occur between two points of different potential beneath the surface of the material itself. It is evident from the above and it has been found that materials which are

2

effective in protecting against the effects of direct arcing are not necessarily effective in protecting against creepage breakdown.

As a result of such disadvantages, organic insulating components have been avoided in the construction of electrical equipment wherein such components would be subjected to the influences of creepage electrical discharges, even though these components would otherwise have been attractive because of different considerations. Organic insulating materials which experience this limitation are Butyl rubber, epoxy resins and polyester resins.

Accordingly, it is one object of this invention to provide improved electrical apparatus having organic insulation which eliminates tracking due to creepage electrical discharge conditions.

It is another object to provide improved electrical apparatus including certain organic compositions which have insulating characteristics and in which formation of carbonaceous deposits upon exposure to creepage type electrical discharges is eliminated.

By way of a summary account of one practice of the teachings of this invention, an improved high-voltage outdoor instrument transformer includes a magnetic core member with linked primary and secondary windings each connected to terminals, and a particular organic composition having hydrated alumina dispersed therein in proportions defined hereinafter. The organic composition with the hydrated alumina is formed about the transformer elements to electrically insulate them and to provide an outer covering which protects these elements against influences of the ambient environment. Uniquely, the creepage discharges occurring across the surface of the transformer even under the most severe contaminating conditions do not occasion tracking and breakdown, inasmuch as low-resistance carbonaceous deposits are not permitted to form. Generally, the organic materials which may be combined with the hydrated alumina in this insulating component with particular advantage include Butyl gum, and epoxy and polyester resins.

Although the features of this invention which are novel are set forth in the appended claims, greater detail of the invention in its preferred embodiments and the further objects and advantages thereof may be readily comprehended through reference to the following description taken in connection with the accompanying drawings, wherein:

FIGURE 1 provides a perspective view of a molded casing type transformer embodying our invention;

FIGURE 2 is a cross-sectional view of the transformer of FIGURE 1;

FIGURE 3 is a graphical presentation of test data obtained with formulations including Butyl rubber;

FIGURE 4 is a pictorial view of electrical test equipment utilized to procure operating life data; and

FIGURE 5 depicts an outdoor high-voltage transformer embodying our invention, portions of the transformer being cut away to reveal constructional details.

Referring to FIGURES 1 and 2 of the drawings, the electrical apparatus there shown is a current transformer having primary terminals 10 and 11 and secondary terminals 12 and 13. The positioning of the primary windings 14 and the secondary windings 15 will be apparent from the view of FIGURE 2. These windings are electromagnetically linked with a core 16 of magnetic material which is provided with a pair of tubular separators 17 and 18 which serve to insulate the core from the windings.

The transformer of FIGURES 1 and 2 includes composition 19 which encapsulates the various components as shown and thereby provides a completed physical enclosure as well as electrical insulation. A support plate 20 facilitates mounting. As has been pointed out above,

organic insulating materials heretofore employed as such components of transformers of this type, and in other applications wherein similar conditions may occur, have been subject to the basic problem of carbonaceous residue formation and accumulation occasioned by random electrical creepage discharges which are likely to occur under adverse climatic conditions in outdoor installations. This difficulty is attributable to the inherent characteristics of organic materials of this type which cause them to break down to form low-resistance carbonaceous deposits when exposed to creepage type electrical discharges. Composition 19 includes an organic material and hydrated alumina dispersed therein in sufficient quantity to prevent accumulation of carbonaceous deposits upon exposure to creepage electrical discharges such as those which may occur between the conducting members 10, 11, 12, 13 and 20.

With apparatus not embodying our teachings, it is believed that the breakdown process with respect to creepage failures occurs as follows. The localized high-temperature discharges produced across the surface of the organic composition breaks down the organic components to form carbon deposits. The process is cumulative, as has been previously desired, and low-resistance tracking failure occurs rapidly.

Electrical apparatus wherein exposure to contaminating conditions is likely to occur and in which our teachings may be embodied to great advantage also includes apparatus other than current transformers which are unprotected from such contaminating conditions. In accordance with one practice of our invention, we provide high-voltage electrical apparatus in which conductors having a large potential difference are found with an insulating organic material having interspersed therein a hydrated alumina in proportions such that material breakdowns ordinarily experienced under creepage electrical discharge conditions do not occur. The concentration of the hydrated alumina employed is critical since it has been found that only a sufficient concentration eliminates carbon accumulation and electrical breakdown. As will be demonstrated, this effect can be achieved by employing a hydrated alumina only in the hereinafter defined critical proportions. A very marked increase in operating life of the apparatus under creepage electrical discharge conditions is observed as the critical levels of concentration are reached.

It has been found that when the hydrated alumina comprises 25 to 65% by weight of the combined Butyl gum-hydrated alumina insulation, failure due to creepage is substantially eliminated. When the hydrated alumina constitutes from about 40 to 65% by weight of the composition failure due to creepage trackage is wholly eliminated. Using epoxy resin, the hydrated alumina effectively prevents creepage failure when present in the amount of 20 to 70% by weight of the insulation and preferably 40 to 70%. When polyesters are used, the hydrated alumina is used in the proportion of from 20 to 70% by weight of the insulation and 30 to 70%. The preferred specific hydrated alumina content of each insulating composition is 60% by weight.

While we do not wish to be bound by any particular theory, it being sufficient that our invention accomplishes the desired end, we believe that the combined water in the hydrated alumina serves to oxidize the carbonaceous particles formed under creepage conditions and that the aluminum oxide component itself acts as a catalytic agent to indirectly promote this oxidation. It has been found that while unhydrated aluminum oxide is useful in delaying tracking under surface creepage conditions, it is not efficacious in oxidizing carbonaceous materials or in preventing the eventual failure of insulation due to creepage tracking. It has also been found that the water must be chemically bound to the aluminum oxide as in the hydrated compound. It will be obvious that in practical commercial applications failure due to sur-

face creepage tracking must be not merely delayed but wholly eliminated as by the practice of our invention.

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 organic insulation components containing organic materials coming within the scope of this invention. These examples are given by way of illustration and not by way of limitation.

EXAMPLE I

Tests were conducted with apparatus mock-ups including various insulating compositions including Butyl rubber and selected concentrations by weight of a hydrated alumina of the chemical composition $Al_2O_3 \cdot 3H_2O$. The test results are graphically presented in FIGURE 3 of the drawings, the actual test point averages for each concentration of hydrated alumina being indicated by the plotted points.

The precise numerical values of the test points graphically presented in FIGURE 3 are shown in Table 1 below, where the percentages are by weight of the table.

Table 1

Percent Hydrated Alumina	Percent Butyl Gum	Hours to Failure	Type Failure
17	40	2	Surface.
20	43	48	Do.
25	46	71	Surface and Erosion.
30	43	190	Erosion.
40	43	187	Do.
50	35	176	Do.
60	28	224	Do.

The remaining material employed in each of the above listed elastomeric organic insulation components was, in each case, a curing system along with diatomaceous earth as a filler. The curing system consisted of the following materials in the percentages by weight of the amount of Butyl gum employed.

Table II

	Percent
Stearic acid	3
Zinc oxide (ZnO)	5
Red lead (Pb_3O_4)	10
Elemental sulfur	2
p,p'-Dibenzoylquinonedioxime	6

The samples of insulation components used in these tests were prepared as molded sheets about .076" thick and about 6" square and were mold cured at 150° C. for about 20 minutes. For testing purposes, these samples, identified by numeral 21 in FIGURE 4, were mounted in a high voltage test cage resting flat against a conducting metal plate 22 tilted at an angle of about 15° from the horizontal.

Two electrodes, 23 and 24, each about 1" by 2" in cross section were placed perpendicularly against the surface of each sample 21 under test, that is, against the upper side of the sample opposite that in contact with the metal plate 22. The electrodes 23 and 24 were positioned about 1" apart with the 2" dimensions of the electrodes extending parallel to each other. One of the two electrodes, identified by numeral 23, was connected to the metal plate 22 by clips 25 and 26 and conductor 27. The two electrodes were electrically connected across the alternating voltage output of an adjustable high-voltage transformer through clips 28 and 29. It will be appreciated that, with the circuit just described, creepage breakdown of the sample may occur between the two electrodes 23 and 24 or between electrode 24 and the metal plate 22 by means of a surface failure, or between electrode 24 and the metal plate 22 through the thickness of the sample by means of an erosion type failure.

After the test samples were placed in the apparatus as just described, they were dusted with a synthetic dust representative of atmospheric dust accumulations, the dust particles being designated by reference character 30. A fine water spray 31 was directed against the samples for the duration of the test, a nozzle 32 being coupled with water and air lines 33 and 34 for this purpose. A 60-cycle voltage of about 1500 volts was applied to the electrodes 23 and 24 to set up surface discharge conditions of the intensity capable of causing decomposition of organic materials. The samples were removed from the apparatus for redusting purposes at the end of each 100 hours of testing, or sooner for inspection purposes if failure occurred.

It will be observed by referring to the dust-spray test data presented in Table I and the graphical presentation thereof as shown in FIGURE 3, that a large increase in operating life of the apparatus under electrical discharge conditions is obtained as the concentration of hydrated alumina is increased beyond a certain level. A more significant consideration is, however, the concentration level at which the type of failure encountered changes from a "surface" type failure to an "erosion" type failure.

The surface failure is one which occurs by reason of formation of a random carbon path along the surface of the material indicating that the life of the material is being limited by carbonization, while an erosion failure is one which occurs because the insulation component 21 is reduced in thickness by an eroding effect not involving carbonization. That is, it is determined by the inherent qualities of the insulation component itself rather than by some external cause such as carbonization.

Hence, at the point where erosion failure begins to occur instead of surface failure, the concentration of hydrated alumina has reached a level where carbonization is no longer the limiting factor with respect to ability of the high-voltage apparatus to withstand creepage electrical discharges. The samples used to obtain the data presented in Table I were inspected upon failure to determine the type of failure involved in each case; that is, whether breakdown occurred across the surface through carbonization or whether it occurred through the thickness thereof by erosion between the ungrounded electrode 24 and the metal plate 22. The types of failures encountered in each case are set forth in Table I.

At a level of about 25% hydrated alumina concentration by weight of the whole insulation component, both types of failures were encountered; that is, certain samples failed by reason of erosion while others failed by reason of surface tracking, some in the latter category showing serious erosion damage. At 30% hydrated alumina concentration, all failures were of the erosion type and average operating life before breakdown of the apparatus was noted to be 190 hours. The critical concentration of hydrated alumina for the particular Butyl rubber formulation employed, and under dust contamination conditions, would therefore appear to extend upward from 25% by weight of the whole, with the expected operating life under the test conditions set forth averaging about 200 hours as compared to a 2-hour average life under the same conditions with apparatus wherein the concentration of hydrated alumina in the organic insulation component was only about 17% by weight, a figure representative of prior art formulations.

Example I was repeated except that insulating compositions containing hydrated alumina on actual transformers such as in FIGURE 5 were exposed to a heavy salt fog containing by weight 10% NaCl and 1.2% $MgCl_2$ in a substantially closed space and subjected to a potential difference of 5 kv. between electrodes or conductive elements with a separation of 13 inches. The results obtained during this test which represents the most severe operating conditions were as follows:

Table III

Percent Hydrated Alumina	Percent Butyl Gum	Hours to Failure	Type Failure
17	40	80	Surface.
37	40	200	Do.
52	35	1,300	No sign of Carbonization.
60	28	1,400	Do.

The severity of the salt fog test described above is illustrated by the fact that the insulating composition tested thereunder containing 37% by weight hydrated alumina failed by surface erosion whereas under the dust-spray test of Table I an insulating composition containing only 30% by weight hydrated alumina resisted surface failure.

At or above the optimum concentration of hydrated alumina, the operating life of the apparatus is largely a function of the thickness of the insulation component, that is, the thickness employed between two conducting members of different potential. Below the optimum point, the operating life is still limited by carbonization, and changes in thickness have a relatively minor, if any, effect on operating life. In general, the quantity of hydrated alumina which can be employed with the organic Butyl insulation components in the practice of this invention ranges from about 25% to about 65% by weight of the whole, although a preferred range effective under the most deleterious creepage conditions extends from about 40% to about 65% by weight of the whole. At concentrations above about 65% by weight of the hydrated alumina, there is a gradual loss of the desirable physical characteristics of the composition.

EXAMPLE II

Tests were conducted on groups of transformers operating in an outdoor area along the west coast of the United States about 100 yards from the ocean at a site where extremely severe conditions of salt spray and salt fog exist almost continuously. The two groups of transformers employed in this test were of the outdoor type illustrated in FIGURE 5 and each included a molded casing 35 corresponding to formulations A and B respectively of Table IV below. These transformers were all rated 5 kv. and an alternating 60-cycle voltage of 5 kv. was applied to the transformers continuously throughout the test.

Table IV

	A	B	C
Butyl Gum	100	100	100
Zinc Oxide (ZnO)	5	5	5
Stearic acid	3	3	3
Diatomaceous earth	40		
Hydrated alumina ($Al_2O_3 \cdot 3H_2O$)	42	210	210
Processing oil	5	15	
Paraffin wax	5	3	
Mineral rubber	20		
MgO	10		
Elemental sulfur	2	2	2
p,p'-Dibenzoylquinonediimine	6	6	6
Red lead (Pb_3O_4)	10	10	10
Total	248	354	336

It will be observed that in formulation A, the amount of hydrated alumina is approximately 16.9% by weight of the whole, while in formulation B the amount of hydrated alumina is about 59.3% by weight of the whole.

The outdoor current transformer shown in FIGURE 5 includes a magnetic core 36 about which are disposed high-voltage primary windings 37 and lower-voltage secondary windings 38. High-voltage conductors or terminals 39 project outwardly from the molded casing and insulating component 35 and serve to couple the pri-

mary windings 37 in series with a high-voltage transmission line. Connections to the secondary windings 38 are completed through conduits 40 and terminals disposed behind the cover plate 41. A metal support plate 42 facilitates mounting of the apparatus. Despite the provision of anti-creepage ridges 43, surface creepage discharges may occur between the terminals and between these terminals and the conducting support plate 42, particularly where surface contamination is experienced.

Of the group of such transformers having insulation components of formulation A of Table IV, all had failed by carbonized tracking after 2400 hours of testing, whereas of the second group of transformers, which included formulation B of Table IV, none showed any damage of any kind at the time of inspection after the test had progressed for over 21,000 hours.

The aforementioned group of transformers including the formulation B were of the solid type. For purposes of a further comparison, like transformers were assembled including an inner insulating component having the formulation A of Table IV and further having an outer jacket insulating component of thickness from $\frac{3}{16}$ to $\frac{1}{4}$ inch. This jacket fully surrounded and was molded to the inner composition, the jacket formulation being formulation C in Table IV. These transformers have also exceeded 21,000 hours of the same testing without failure.

EXAMPLE III

In connection with other types of organic insulation components, dust-spray tests were conducted with an epoxy casting resin or ethoxyline resin) identified as Shell Chemical Company epoxy resin No. 828. The resin was mixed in different batches with the percentages of hydrated alumina ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$) by weight of the whole as indicated below in Table V together with 8.5% by weight of diethylene triamine as a catalyst based on the weight of the resin.

Test sheet samples of approximately .075" in thickness were cast and mold cured at 125° C. for about one hour. The tests were conducted in accordance with the procedure set forth in Example I and in the apparatus of FIGURE 4, and the results tabulated below were obtained.

Table V

Material	Percent $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Hours to Failure	Type of Failure
Shell Chemical epoxy resin No. 828.	0	Less than 1.....	Surface.
	20	18.....	Surface and Erosion.
	30	Greater than 200....	Erosion.
	40	do.....	Do.
	50	do.....	Do.
	66	do.....	Do.

It is noted that with this epoxy resin, the critical concentration of $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$; that is, the concentration level where carbonization is no longer the limiting factor on operating life, is also in excess of 25% by weight of the total insulation.

EXAMPLE IV

Example III was repeated using as the curing agent triethanolamine in the amount of 12.5% by weight of the resin. The results of tests conducted as in Example III on this material are tabulated below:

Table VI

Material	Percent $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Hours to Failure	Type of Failure
Shell Chemical epoxy resin No. 828.	0	Less than 1.....	Surface.
	10	1.....	Do.
	20	10.....	Do.
	30	Greater than 200....	Erosion.
	40	do.....	Do.
	50	do.....	Do.

EXAMPLE V

Example III was repeated using as the epoxy resin Araldite No. 6010 made by Ciba Company and as the curing agent 12.5% by weight of triethanolamine based on the weight of the resin. When tested as in Examples I and III the results were as follows:

Table VII

Material	Percent $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Hours to Failure	Type of Failure
Ciba Company epoxy resin Araldite 6010.	0	2.....	Surface.
	10	$\frac{1}{2}$	Do.
	20	100.....	Surface and Erosion.
	30	Greater than 200....	Erosion.
	40	do.....	Do.
	50	do.....	Do.

EXAMPLE VI

Example III was repeated using phthalic anhydride in the amount of 40% by weight of the resin as the curing agent for Shell Chemical Company epoxy resin No. 828. When these materials were tested as in Examples I and III, the results were as follows:

Table VIII

Material	Percent $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Hours to Failure	Type of Failure
Shell Chemical Co. epoxy resin No. 828.	0	Less than 1.....	Surface.
	10	2.....	Do.
	20	3.....	Do.
	30	35.....	Surface and Erosion.
	40	150.....	Do.
	50	Greater than 200....	Erosion.
35	60	do.....	Do.
	70	do.....	Do.

EXAMPLE VII

Example III was repeated using as the curing agent for Ciba Company epoxy resin 6060, phthalic anhydride in the amount of 30% by weight of the resin. When tested as in Examples I and III, the results were as follows:

Table IX

Material	Percent $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Hours to Failure	Type of Failure
Ciba Company epoxy resin Araldite 6060.	0	Less than 1.....	Surface.
	10	1.....	Do.
	20	2.....	Do.
	30	11.....	Do.
	40	30.....	Surface and Erosion.
	50	Greater than 200....	Erosion.
	60	do.....	Do.
	60	do.....	Do.

It will be noted from the above examples directed to epoxy resins that in general the amine type curing agents produce insulating materials according to this invention which are more resistant at lower hydrated alumina concentrations to creepage failure than epoxy resins cured with acid anhydrides, it being necessary with the latter curing agent to add relatively more hydrated alumina to afford complete protection. It will be also noted that from about 20% to 70% of hydrated alumina based on the total weight of the material provides insulation which prevents creepage under the dust-spray test. In the salt fog test described hereinbefore about 40% by weight or more of the insulation must be hydrated alumina in order to wholly eliminate creep tracking. The upper proportion of hydrated alumina is limited only by the physical characteristics of the insulation.

EXAMPLE VIII

Example I was repeated except that the resin used was a commercially available polyester resin known as Lam-

inac No. 4116 manufactured by American Cyanamid Company to which was added 1% by weight of tertiary Butyl perbenzoate, as a catalyst, based on the weight of the resin. When this material with added hydrated alumina was tested as in Examples I and III, the results were as follows:

Table X

Material	Percent $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Hours to Failure	Type of Failure
American Cyanamid polyester Laminac #4116.	0	Less than 1.....	Surface.
	10	35.....	Surface and Erosion.
	20	170.....	Erosion.
	30	Greater than 200.....	Do.
	40	do.....	Do.
	50	do.....	Do.

EXAMPLE IX

Example I was repeated except that the polyester used was H. H. Robertson Company's Stypol 107E catalyzed with 0.5 part of benzoyl peroxide per each 100 parts by weight of resin. When hydrated alumina was mixed with the resin in varying amounts and the material tested as in Examples I and III, the results were as follows:

Table XI

Material	Percent $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Hours to Failure	Type of Failure
H. H. Robertson Co. Stypol 107E.	0	1.....	Surface.
	10	50.....	Surface and Erosion.
	20	180.....	Erosion.
	30	Greater than 200.....	Do.
	40	do.....	Do.
	50	do.....	Do.

From Examples VIII and IX it will be seen that polyesters mixed with hydrated alumina also exhibit desirable creepage resistance. Under dust-spray condition creep tracking is prevented when from 20 to 70% by weight of the composite insulation is hydrated alumina. Under salt fog conditions a minimum of about 30% hydrated alumina is preferred to eliminate creep tracking. Again, the upper limit is imposed only by the physical requirements of the insulation.

The term "Butyl rubber" or "Butyl gum" as employed herein is intended to mean broadly, a solid, rubbery copolymer or interpolymer comprising the product of polymerization of a mass of copolymerizable materials containing, by weight, a major proportion (e.g., from 60 to 99%) of an olefin (monoolefin), more particularly an isolefin, e.g., isobutylene, 2-ethyl butene-1, etc., and a minor proportion (e.g., from 1 to 40%) of a conjugated diolefin, e.g., butadiene-1,3, isoprene, cyclopentadiene, pentadiene-1,3, hexadiene-2,4, etc. The Butyl gums noted in connection with the examples above were copolymers of about 98 parts isobutylene and 2 parts isoprene.

The term "epoxy resin" or "ethoxyline resin" as used herein is intended to mean a complex epoxide resin comprising a polyether derivative of a polyhydric organic compound, e.g., polyhydric alcohol or phenols containing at least two phenolic hydroxy groups, said derivative containing 1,2 epoxy groups. The ethoxyline resins as just defined are disclosed in various places in the art such as in Castan Patent 2,324,483 as well as Castan Patent 2,444,333, British Patent 518,057 and British Patent 579,698. U.S. Patents 2,494,295; 2,500,600; 2,511,913 and 2,691,007 disclose other examples of ethoxyline resinous compositions falling within the definition. Curing of such compositions is readily accomplished by acidic (e.g., phthalic anhydride, etc.) or strongly alkaline materials (e.g., diethylene triamine, etc.).

The term "polyester resin" refers to a material comprising the reaction product of a polyhydric saturated or unsaturated alcohol and a saturated or unsaturated polybasic acid either with or without a modifying unsaturated

monomer such as styrene, etc. Specific examples of the basic material are, for instance, diethylene glycol maleate, dipropylene glycol maleate, diethylene glycol fumarate and so forth. Such materials are readily polymerized by peroxy catalysts such as benzoyl peroxide, tertiary Butyl perbenzoate, etc.

It will also be apparent that the particular examples set forth above by way of illustration are not limiting in nature and that various forms of electrical apparatus having greatly improved resistance to breakdowns caused by creepage electrical discharges may include insulation components having the organic insulating materials set forth above and a hydrated alumina in concentration defined by the foregoing disclosure, and that such arrangements deriving the advantages of our invention, will fall within the true scope and spirit of our invention as defined in the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. Electrical apparatus comprising at least two spaced electrically conducting members between which electrical potentials may be developed, an organic insulating material disposed and completely filling the space between said members and having an outer surface intermediate said members exposed to ambient contaminating atmospheric conditions, said surface material comprising Butyl gum which tends to form low resistance carbonaceous deposits under the influence of creepage type electrical discharges occurring under contaminating conditions and means for preventing the formation of said carbonaceous deposits due to creepage, said means comprising hydrated alumina interspersed in said surface material in the amount of from 25 to 65 percent based on the weight of said surface material and hydrated alumina.

2. Molded electrical apparatus comprising at least two electrically conducting members between which electric potentials may be developed and an insulating composition disposed between said members and having an outer surface intermediate said members exposed to ambient contaminating atmospheric conditions and fixing said members in spaced relationship such that electrical discharges of the creepage type may occur therebetween and across said surface of said molded insulating composition, said composition including Butyl gum which leaves a low resistance carbonaceous residue under influence of creepage type electrical discharges and further including hydrated alumina interspersed in said position in the amount of from 25 to 65 percent based on the weight of said composition and hydrated alumina, said hydrated alumina preventing accumulation of carbonaceous material upon exposure of said surface of said insulating composition and hydrated alumina to creepage type electrical discharges occurring across said surface under contaminating conditions.

3. An electrical insulator shaped to support and hold in insulating relationship a plurality of conducting members which are adapted to have electrical potentials developed thereacross and between which electrical discharges of the creepage type may occur, said insulator comprising an organic insulating material disposed between said members and having an outer surface intermediate said members exposed to ambient contaminating atmospheric conditions, said surface material comprising Butyl gum which tends to form low resistance carbonaceous deposits under influence of creepage type electrical discharges and hydrated alumina dispersed in said surface material and comprising from about 25 to 65 percent by weight of the combined surface material and hydrated alumina, said hydrated alumina serving to prevent the formation of said carbonaceous deposits under said contaminating conditions.

4. Electrical apparatus comprising at least two spaced electrically conducting members between which electrical potentials may be developed, an organic insulating material disposed and completely filling the space between said members and having an outer surface intermediate

11

said members exposed to ambient contaminating atmospheric conditions, said surface material comprising Butyl gum which tends to form low resistance carbonaceous deposits under the influence of creepage type electrical discharges occurring under contaminating conditions and means for preventing the formation of said carbonaceous deposits due to creepage, said means comprising hydrated alumina interspersed in said surface material in the amount of 60 percent based on the weight of said surface material and hydrated alumina.

5. Electrical apparatus comprising at least two spaced electrically conducting members between which electrical potentials may be developed, an organic insulating material disposed and completely filling the space between said members and having an outer surface intermediate said members exposed to ambient contaminating atmospheric conditions, said surface material comprising Butyl gum which tends to form low resistance carbonaceous deposits under the influence of creepage type electrical discharges occurring under contaminating conditions and means for preventing the formation of said carbonaceous deposits due to creepage, said means comprising hydrated alumina interspersed in said surface material in the amount of from 40 to 65 percent based on the weight of said surface material and hydrated alumina.

12

6. In a molded electrical transformer adapted to be energized by a source of electrical power and having spaced high voltage terminals and low voltage terminals, an insulating material molded about said transformer and fixedly positioning said terminals, said material being disposed and completely filling the space between said terminals and having an outer surface intermediate said high and low voltage terminals exposed to ambient contaminating atmospheric conditions, the improvement which comprises at least the outer surface of said material including butyl gum which leaves a conducting carbonaceous deposit under the influence of creepage electrical discharges and hydrated alumina dispersed in at least said outer surface of said material to comprise from 25 to 65 percent by weight of at least said outer surface of the combined insulating material and said hydrated alumina, said hydrated alumina obviating said carbonaceous deposits.

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**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 2,997,526

August 22, 1961

Alvan A. Kessel et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 46, for "ultimaely" read -- ultimately --; column 3, lines 52 and 53, for "eliminateed" read -- eliminated --; column 4, line 21, for "table" read -- whole --; column 5, line 39, for "elecrical" read -- electrical --; column 7, line 31, before "or" insert an opening parenthesis; column 10, line 46, for "position" read -- composition --.

Signed and sealed this 10th day of April 1962.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents

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