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COMPOUND DIELECTRIC MATERIAL AND
PROCESS FOR MANUFACTURING THE
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The present invention relates to a dielectric material and to a process for manufacturing the same.

It is an object of the invention to produce a dielectric material having a comparatively low power factor whereby the loss in power in an alternating current transmission line encased in the dielectric material is materially reduced. More specifically, it is an object of the invention to provide improvements in dielectric materials which comprise laminated structures, constituent laminae possessing different dielectric properties. An example of such a material is varnished cambric.

Varnished cambric or varnished cloth, in the form of tape, is widely used as an insulating wrapping for high tension alternating current cables and other electrical conductors. Such varnished cloth is defective because its absorption of moisture increases the power factor and means a substantial dissipation of energy in the circuit and a decrease in the amount of electrical load that the circuit can carry. Efforts have been made to diminish these objections by increasing the electrical resistance of the cloth as by purifying it and removing electrically conductive impurities therefrom.

We have discovered that in the alternating current carried by a conductor encased in such an insulating material, the power loss can be materially reduced, not by increasing the electrical resistance of the cloth, but, on the contrary, by reducing that electrical resistance, for example to a value less than 1/20000 of the resistance in ohms of the dry cloth or fabric that has heretofore been used. This is directly contrary to present practice and trends. Thus we make the cloth an adequate conductor of electricity. For this purpose we load the cloth with conducting substances, such as finely divided or colloidal carbon black, graphite, salts, finely divided metal or starch.

The result of our treatment is for all practical purposes to minimize the resistance of the cloth so that the power factor of the compound dielectric, i. e., cloth and varnish, approaches that of the varnish alone. Therefore, moisture absorption by the cloth cannot cause a materially increased dielectric loss or increase in the power factor of the compound dielectric. The power factor of the varnish can be controlled by the ingredients used in making up the varnish.

We have devised an efficient process for incorporating insoluble conducting materials such, for example, as carbon, into the cloth, distribut-

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ing them uniformly and making them fast therein. Our invention provides an improved process of incorporating an electric conducting material into cloth, yarn or other fibrous material. This improved process involves a pre-treatment of the cloth or fibrous material to create therein an affinity for the finely-divided conducting material.

Thus, carbon black, which carries a negative charge when dispersed in water, will normally be repelled by cotton cloth because the cloth carries a similar charge. By treatment of the cloth with a cationic agent of positive charge, however, an affinity for the carbon black may be created.

As an example of the practice of our process, the following may be given.

A light, closely-woven cotton cloth of combed yarn, thoroughly purified by boiling, bleaching and washing, was soaked in a 1% solution of Triton K-60 (a quaternary ammonium compound) for five minutes at 100° F., with constant agitation. Then the cloth was given a squeeze by a standard adjustment of the squeeze rolls (the cloth probably holds 200% of its weight of water) and dried in the oven. The cloth was removed as soon as it felt bone dry. The cloth was then immersed, with agitation, in a 12.5% aqueous dispersion of carbon black (using polymerized organic salts of the alkyl-aryl type, for example Daxad, as a dispersing agent) at 100° F. for five minutes. The cloth was then washed in open width under flowing water at 80° F. until no more carbon black could be seen in the water running off. The cloth was given a heavy squeeze and dried in the dryer. The cloth was then starched by submerging it in open width in 10% potato starch at 100° F. or higher temperature, until completely wet out.

An example of a procedure for making the starch bath is as follows: 100 lbs. of potato starch and 10 lbs. of a wax emulsion was mixed in a 100 gallon tub containing cold water, with agitation. This mixture was heated by an open steam pipe and brought to a boil. The temperature was maintained until the potato starch was thoroughly thickened and then the mix was transferred to a two-bowl mangle.

The cloth treated with carbon black was drawn through the starch in the mangle and dried on a standard tenter frame. Subsequently, the starched cloth was sprinkled lightly with water and then hot friction calendered on both sides, using a pressure of 40 to 70 tons. The calendered

cloth was varnished with a black insulation varnish in the usual tower coating equipment.

The carbon black was found to be well distributed through the cloth and tenaciously fixed therein. The electrical conductivity of the unvarnished cloth was greatly increased.

The negative charge of the carbon black is increased by absorption of the dispersing agent and the black should be so dispersed in this agent as to give it the optimum negative charge, so that it will be strongly attracted by the cationic substance on the cloth. The particle size of the carbon black should be sufficiently small to permit the black to enter the pores of the fibres and be absorbed therein. Furthermore, the electrical conductivity of the black is increased as particle size diminishes. The carbon black or other material should be sufficiently conductive to keep the power factor of the compound dielectric low and approximately equal to that of the varnish, even under conditions of high humidity and high temperature.

It is desirable to wash the cloth in water after the application of the carbon black and before drying in order to remove from the surface all carbon black that has not actually been absorbed onto or into the cloth. It is important that none of the carbon black find its way into the layers of insulating varnish which are later applied.

Cationic materials generally, for example salts of alkyl amines such as tetra alkyl quaternary ammonium halide, are effective in treating fibrous material in accordance with our invention. Aluminum acetate is representative of a class of cationic compounds of chemical structure different from that of salts of alkyl amines, which may be used.

In lieu of impregnating the cloth with carbon black or like conducting material, the cloth may be made electrically conducting by the proper addition of sizing materials such as starch, providing such materials are added in quantities such that the finished cloth partakes of the characteristics of the sizing, instead of the characteristics of the cloth. Sufficient starch must be added so that the starch goes through the cloth from one side to the other, producing a continuous film rather than a stratified layer of starch and cloth.

For maximum effectiveness it is well to use boiled, bleached cotton, washed free of soaps and salts.

It is advantageous to have the cloth as thin as possible, consistent with such desirable physical properties as tensile strength, stretch, tearing strength, etc.

The cloth thus obtained is a very good conductor of electricity as compared with the cloth previously used in varnished insulating tapes. We have obtained excellent results when the resistance of the cloth is made as low as 50 ohms for a 4-mil thick conducting cloth measured with 2 in. diameter electrodes on opposite sides of the cloth. Good results, however, may be obtained where the resistance value of the finished or impregnated cloth may be as much as 50,000 to 100,000 ohms or even 500,000 ohms. 500,000 ohms is about $\frac{1}{20000}$ of the resistance of the dry cloth used in varnished insulating tapes at the present time.

The contribution of the cloth to the percent power factor of the varnished tape of this invention may be expressed approximately by $100 R\omega C$, in which R is the resistance of the finished or impregnated cloth in ohms per unit of area, ω is 2π

times the frequency in cycles per second of the alternating current and C is the capacitance in farads per unit area of the varnish film. This value, $100 R\omega C$, should be as low as practicable, for example not over 5 and preferably 1 or less. The foregoing may be used to determine the allowable resistance of the cloth for a given situation.

We have found that, while the electrical breakdown voltage of the dielectric embodying our invention is decreased in the order of about 20% by the use of the cloth of low resistance, as above described, the power factor is reduced to substantially that of the varnish itself which is roughly of the order of 5%. For this reason there is less heat generated in the dielectric and less loss of energy in the alternating high tension current transmitted by a conductor encased in our dielectric material than has heretofore been obtained with an insulated conductor and the material has a longer life.

While we have described various features and embodiments of our invention in detail, we do not desire to be limited to the exact details set forth, but the invention is susceptible of variation within the scope of the appended claims.

We claim:

1. A dielectric material, adapted to be used as a tape for wrapping cables conducting high tension alternating electric currents, comprising an inside cloth element consisting of cambric, electrically conductive finely divided carbon particles impregnating said cambric and absorbed and tenaciously fixed in the cambric by the electrical affinity of the cambric and the carbon particles and fast to washing, said carbon impregnated cambric having at least 20,000 times less resistance than the dry unimpregnated cambric, and a coating of starch having a hard smooth surface on each side of said carbon impregnated cambric, said cloth element being substantially free from other materials of electrical insulating character, and a layer of insulating varnish on the surface of each starch coating.

2. A dielectric material, adapted to be used as a tape for wrapping cables conducting high tension alternating electric currents, comprising an inside cloth element consisting of cambric, electrically conductive finely divided carbon particles impregnating said cambric and tenaciously fixed therein and a coating of starch having a hard smooth surface on each side of said carbon impregnated cambric, said cloth element being substantially free from other materials of electrical insulating character, and a layer of insulating varnish on the surface of each starch coating.

3. A dielectric material, adapted to be used as a tape for wrapping cables conducting high tension alternating electric currents, comprising an inside cloth element consisting of cambric, electrically conductive finely divided carbon particles impregnating said cambric and in part at least contained within the structure of the fibers of the cambric and tenaciously fixed therein and a coating of starch having a hard smooth surface on each side of said carbon impregnated cambric, said cloth element being substantially free from other materials of electrical insulating character, and a layer of insulating varnish on the surface of each starch coating.

4. The method of making a dielectric material adapted to be used as a tape for wrapping cables conducting high tension alternating electric currents, which comprises impregnating a cambric with a solution of a cationic agent of positive

electrical charge, drying the cambric, impregnating the dried cambric with an aqueous dispersion of electrically conductive finely divided carbon particles whereby said particles are absorbed and tenaciously fixed in the cambric by the electrical affinity of the cambric and the carbon particles, washing said cambric free of loose carbon particles, applying a coating of starch to each side of said impregnated cambric, calendering said starched and carbon impregnated cambric to provide smooth hard surfaces on each side thereof, and applying a layer of insulating varnish to each of said surfaces.

5. A tape, adapted for insulating cables conducting high tension alternating electric current, comprising a textile fabric layer impregnated with electrically conductive finely divided carbon particles fast therein and coated with starch and being substantially free of other insulating substances, and layers of insulating varnish on the surfaces of said starch coating, the resistance in ohms, R , of the fabric being so related to the capacitance in farads, C , of the layers of insulating varnish that the contribution of the textile fabric layer to the percent power factor of the tape, calculated as $100 R\omega C$, (ω being 2π times

the frequency in cycles per second of the alternating current) does not exceed 5.

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