Nov. 25, 1969 R. C. MILDNER 3,480,725

CONDUCTOR WITH INSULATING LAYER OF PAPER FIBERS AND HOLLOW PLASTIC PARTICLES

Filed May 28, 1968 2 Sheets-Sheet 1

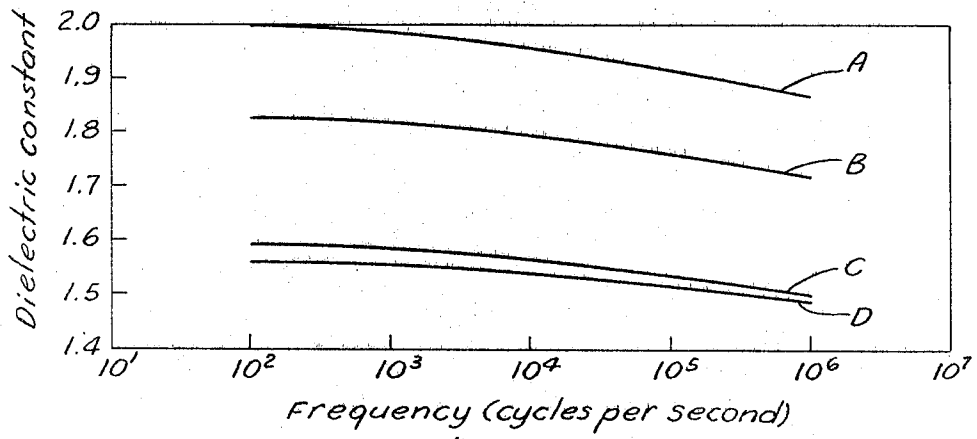


Fig. 1

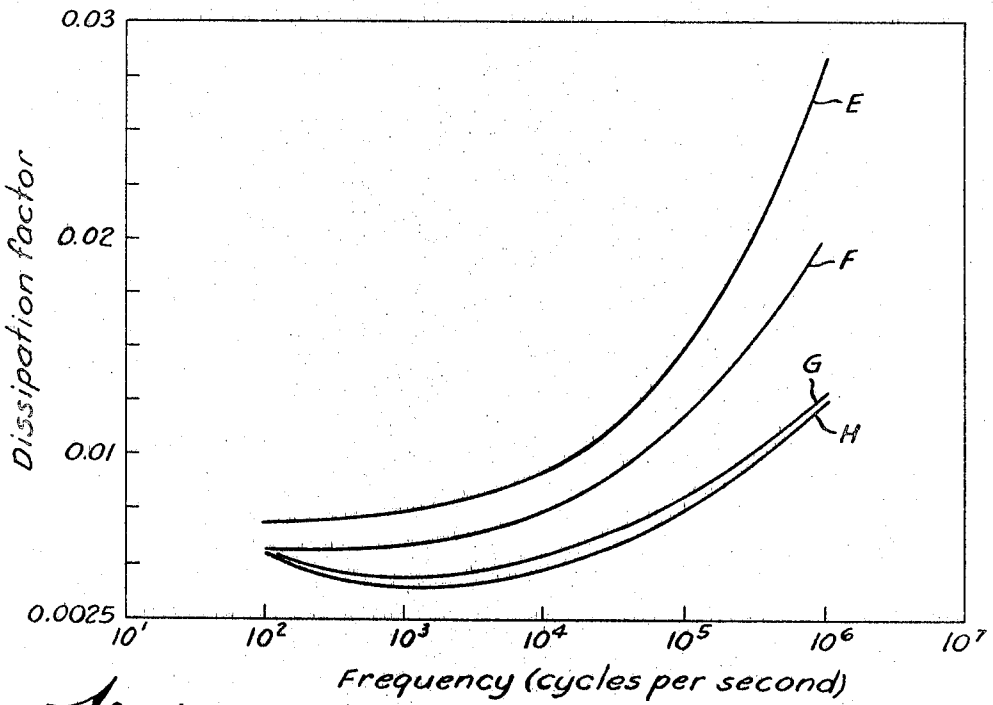


Fig. 2

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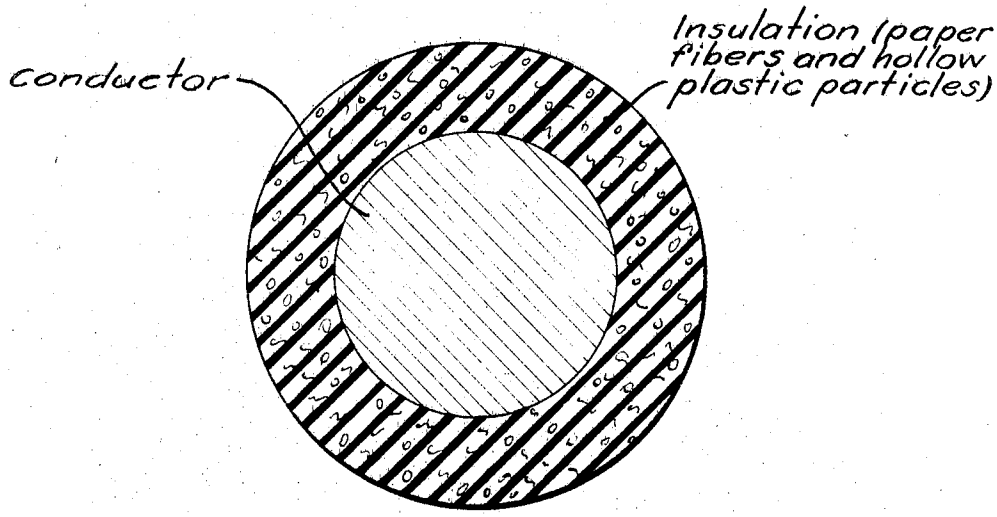


Fig. 3

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CONDUCTOR WITH INSULATING LAYER OF PAPER FIBERS AND HOLLOW PLASTIC PARTICLES

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U.S. Cl. 174—124 4 Claims

ABSTRACT OF THE DISCLOSURE

A conductor for transmitting electrical power or communication signals is provided with an insulating layer comprising paper-making fibers such as a ground wood pulp and a multitude of hollow synthetic particles of a thermoplastic material such as poly(methyl methacrylate). The insulating layer is applied to the conductor by passing the conductor into a separation zone to which the paper-making fibers and hollow particles have been added and exist as a slurry and wherein the paper-making fibers and the hollow particles are formed into a ribbon around the conductor.

This invention relates to insulation for conductors for transmitting electrical signals and to insulation for conductors for transmitting communication signals. In one aspect, this invention relates to methods of providing a conductor with an insulating layer and to the product produced thereby. In another aspect, this invention relates to insulating tapes useful for insulating electrical or communication conductors.

The necessity of isolating conductors from one another by an insulating layer when the conductors are grouped together into a cable has prompted the development of a variety of different materials for fabricating the insulation. Popular types of insulation include a paper ribbon wrapped around the conductor, a paper tube formed around the conductor from a paper pulp slurry, and, more recently, a plastic tube formed around the conductor such as by an extrusion coating technique or the like. In most types of conductor insulations including those enumerated, efforts are continually being made to improve the insulating properties and the electrical characteristics of the materials used for insulation purposes.

While paper is generally regarded as a satisfactory insulating material for a conductor when it is used either in the form of a ribbon wrapped around the conductor or in the form of a tube deposited around the conductor from a paper pulp slurry, the signal transmission characteristics of a conductor having paper as the insulation is not completely satisfactory. For example, when transmitting high frequency electrical or communication signals through a conductor having paper as the insulation material, the efficiency of the transmission is reduced because of the increase in the dissipation factor of the paper insulation at these higher frequencies. This undesirable characteristic of paper imposes a definite limitation on its utility as an insulating material, especially in those situations where it is desirable and/or necessary to transmit electrical or communication signals at high frequencies.

Another property of paper which governs its acceptance as an insulating material for electrical or communication conductors is its dielectric constant. Since the dielectric constant of an insulating material on a conductor also affects the efficiency of a signal transmitted through the conductor, it is always desirable to employ an insulating material having a low dielectric constant.

According to this invention, the electrical power and signal transmission characteristics of an insulated conductor are improved by an insulation comprising a multitude of hollow synthetic thermoplastic particles and paper-making fibers. As will become apparent from the data and results hereinafter reported, the electrical properties of the new insulation are greatly improved in that it has a lower dielectric constant and a substantially lower dissipation factor especially when the signals are transmitted at high frequencies.

Accordingly, it is an object of this invention to improve the electrical characteristics of an insulating paper for conductors.

Another object of this invention is to provide an insulating tape for conductors and the like.

A further object of this invention is to provide a method of applying an improved insulating layer to a conductor.

Still another object of this invention is to improve the dissipation factor and the dielectric constant of an insulating material for a conductor.

These and other objects of the invention will become apparent to one skilled in the art after studying the following detailed description, the appended claims, and the accompanying drawing wherein:

FIGURE 1 is a plot of the dielectric constant versus frequency for a paper insulation and for insulation materials of the invention; and

FIGURE 2 is a plot of the dissipation factor versus frequency for a paper insulation and for insulation materials of the invention.

FIGURE 3 is a cross section of a conductor having an insulating layer of paper-making fibers and hollow synthetic thermoplastic particles illustrative of the invention.

In the practice of this invention, a conductor is provided with an insulating layer which comprises paper-making fibers consolidated together and having incorporated therein and cooperating therewith a multitude of hollow synthetic thermoplastic particles of generally spherical configuration. Any suitable communication or electrical type of conductor can be provided with the insulating material of this invention. For example, the popular 19, 22, 24, and 26 gauge (AWG) telephone wire can be insulated with the material of the invention. Similarly, any suitable paper-making fiber can be used in forming the insulating material such as, for example, long or short fiber pulp, groundwood pulp, rag pulp, kraft pulp, or the like.

The hollow synthetic thermoplastic particles which, together with the paper-making fibers, are incorporated into the new insulation generally have a diameter within the range of between about 0.5 and about 200 microns. The particles can be present in the insulating layer on the conductor in an amount between about 0.25 and about 60 percent by weight based upon the weight of the insulating layer. It is evident that the size and concentration of the particles employed in the insulating layer is largely a matter of choice and particles of a size and concentration outside of the ranges given can be employed without departing from the spirit and scope of the invention.

A conductor having an insulating layer comprising paper-making fibers consolidated together and having incorporated therein a multitude of the hollow synthetic thermoplastic particles is illustrated in FIGURE 3 of the drawings. It is evident that FIGURE 3 is illustrative only and is not necessarily drawn to scale nor is FIGURE 3 necessarily representative of the relative size of the components.

In one embodiment of the invention, a conductor is provided with an insulating layer of paper making fibers and hollow synthetic thermoplastic particles of the type

specified by depositing them continuously on the conductor from a Fourdrinier screen or on the collecting surface of the cylinder in a paper-forming machine. In practicing this method of the invention, suitable paper-making fibers and hollow synthetic thermoplastic particles of generally spherical configuration are introduced into a mixing zone containing water. The paper-making fibers are admitted to the mixing zone in the form of a beaten pulp. The beaten pulp and the hollow synthetic thermoplastic particles are then mixed to form a mass of paper-making fibers which includes a multitude of the particles. The mass is then passed to a separation zone such as a vessel containing a Fourdrinier screen or a screened cylinder mounted to rotate through the separation zone and thereby form continuous webs or ribbons of the paper-making fibers containing the thermoplastic particles. The conductor which is to be provided with the insulating layer is also passed through the separation zone in proximity with the ribbon of paper-making fibers such that the conductor is centered on the web or ribbon. As the conductor and web of paper are taken from the separation zone, the web is shaped or polished by spinning it around the conductor to form a tube of the insulating layer. While the thickness of the insulating layer is largely a matter of personal choice, this thickness of this layer is generally within the range of between about 3 and about 30 mils. Apparatus which can be used for practicing the method of this invention is described in an article appearing at page 1764 in the October 1967 issue of "Wire and Wire Products." As an optional step in the method, the ribbon of paper-making fibers containing said particles around said conductor is passed through a pressing zone to remove water therefrom before the ribbon is polished around the conductor.

Further details of this apparatus can be had by reference to this article, the disclosure of which is specifically incorporated herein by reference.

In another embodiment of the invention, the insulating layer of paper-making fibers and hollow thermoplastic particles is formed into a tape which can be stored in a roll or the like, if desired, until it is wrapped or otherwise positioned around the conductor to serve as insulation. The insulating tape is relatively long as compared to its width. The insulating tape can be obtained by stripping the paper pulp ribbon containing the hollow particles from the Fourdrinier screen or from the collecting surface of the screened cylinder in a paper pulp machine. The stripped ribbon is compressed under heat to consolidate the paper-making fibers by forming chemical bonds between the individual fibers. This step also serves to partially dry the ribbon. The insulating tape can also be cut from a large sheet formed continuously by depositing a slurry of the paper-making fibers and hollow particles on a moving screen. The large sheet can be cut to provide various width tapes. It is evident that the novel insulating tape of the invention can be formed by a variety of different techniques and practices.

The insulating tape comprising the paper-making fibers consolidated together and having incorporated therein a multitude of hollow synthetic thermoplastic particles of generally spherical configuration is formed in any suitable and convenient thickness and width. In general, the insulating tape can be of any desirable width and of a thickness between about 3 and about 30 mils. As stated in connection with that embodiment wherein the insulating layer is a cooperating conglomerate of paper-making fibers and synthetic thermoplastic particles formed around the conductor substantially continuous and without seams, the hollow particles in the insulating tape have a diameter within the range of between about 0.5 and about 200 microns. The particles are present in the insulating tape in an amount between about 0.25 and about 10 percent by weight based upon the weight of the insulating tape.

Thus, a conductor can be provided with an insulating layer in accordance with this invention by (1) depositing the paper-making fibers and hollow particles from a paper pulp slurry, by (2) forming an insulating tape which is longitudinally folded around the conductor, or by (3) forming an insulating tape which is helically positioned or wound around the conductor. It is evident that other modes for applying the insulating tape to a conductor may become apparent to one skilled in the art without departing from the spirit or scope of the invention.

The hollow synthetic thermoplastic particles employed in the practice of this invention can be prepared from any suitable polymer material. As a general proposition, it has been found that the hollow particles can be suitably prepared by the limited coalescence polymerization technique. This polymerization technique involves the use of a polymerizable monomer and a volatile blowing agent which has a limited solubility in the polymer.

An illustrative technique for preparing the hollow particles involves charging a polymerization reactor with about 100 parts by weight de-ionized water and about 15 parts by weight of a 30 weight percent colloidal silica dispersion in water. The reactor is then charged with about 2.5 parts by weight of a 10 weight percent aqueous solution of a separately prepared copolymer of diethanolamine and adipic acid prepared from equimolar proportions by carrying out a condensation polymerization reaction to yield a polymer having a viscosity of about 100 centipoises at 25° C. The reactor is then charged with about 1 part by weight of an aqueous solution containing about 2.5 weight percent potassium dichromate. Hydrochloric acid is then added to the aqueous solution in the reactor until a pH of 4 is reached.

An oil phase mixture is then prepared by mixing about 100 parts by weight methyl methacrylate which contains 20 weight percent neopentane and 0.1 part by weight of benzoyl peroxide as a catalyst. The oil phase mixture is added to the water phase in the reactor with agitation supplied by a blade rotating in the reactor. The mixture is maintained in the reactor at a temperature of about 80° C. for a period of about 24 hours. At the end of this period, the temperature of the reaction mass is lowered and a white, milky liquid is recovered. A portion of the reaction mixture is filtered to recover particles which are air-dried in an oven at a temperature of about 30° C. Microscopic examination of a representative number of the particles indicate that they have a diameter of between about 2 and about 10 microns. The particles are of hollow, spherical configuration and appear to contain a liquid and a small vapor space. A portion of the dried particles are then heated in an air oven to a temperature of about 150° C. for a period of about 3 mintues. The heated particles have diameters which range between about 2 and about 5 times the diameters of the particles before they are heated. The particles have a relatively thin, transparent wall and a gaseous center.

While the foregoing illustration of one technique for producing hollow synthetic thermoplastic particles which can be used in fabricating the insulating layer of this invention, it is evident that other techniques can be employed with monomers other than methyl methacrylate. Similarly, expanding agents other than neopentane can be used if desired. Thus, for example, a copolymer of methyl methacrylate and acrylonitrile can be used in fabricating the hollow particles. The hollow particles can also be prepared by the technique outlined above from a copolymer containing 75 percent by weight combined vinylidene chloride and 25 percent by weight combined acrylonitrile by employing isobutane as the blowing agent. A polymer of styrene containing up to about 40 percent by weight combined acrylonitrile can be used to fabricate the hollow particles, if desired.

Other exemplary materials which can be used to make the hollow particles employed in the practice of this in-

vention include a copolymer of 80 percent by weight methyl methacrylate and 20 percent by weight styrene; a copolymer of between about 10 and about 90 percent by weight methyl methacrylate and between about 10 and about 90 percent by weight ethyl acrylate; a copolymer of between about 10 and about 90 percent by weight methyl methacrylate and between about 10 and about 90 percent by weight ortho-chlorostyrene; poly(ortho-chlorostyrene); poly(vinylbenzyl chloride); a copolymer of between about 10 and about 90 percent by weight acrylonitrile and between about 10 and about 90 percent by weight vinylidene chloride; a copolymer of between about 10 and about 90 percent methyl methacrylate and between about 10 and about 90 percent by weight acrylonitrile; a copolymer of methyl methacrylate and para-tertiary-butylstyrene; a copolymer of methyl methacrylate and vinyl acetate; a copolymer of methyl methacrylate and butyl acrylate; and the like. It is evident that any suitable thermoplastic material in addition to those enumerated above can be used if desired in the practice of the invention.

As an illustration of the improvement which is realized in the transmission characteristics of a conductor insulated with the insulating material of this invention, several specimens of paper-like products having paper-making fibers and hollow synthetic thermoplastic particles incorporated therein were prepared and the electrical properties thereof determined. These specimens were prepared on a Fourdrinier paper machine. The paper pulp employed was 100 percent bleached kraft beaten to a freeness of 400 ml. on the basis of the Canadian Standard Freeness. About 0.5 percent by weight rosin and about 2 percent by weight alum was added and the pH of the slurry including the pulp was adjusted to about 5 by adding sulfuric acid. Expanded hollow particles of poly(methyl methacrylate) having an average diameter of about 30 microns were suspended in water to provide a concentration of about 2.5 percent by weight, the water containing the particles was then pumped into the pulp slurry at a rate to provide the concentration of hollow particles desired. A ribbon of pulp containing the hollow microspheres was recovered and dried. The amount of hollow particles added was varied to provide ribbons of pulp having 1.4; 4.4; and 5.7 weight percent hollow particles.

Several discs about 2 inches in diameter were cut from each ribbon and stacked to provide specimens having thicknesses of between about 80 and about 120 mils. The flat ends of each stack were coated with silver paint prior to testing to provide contact surfaces for the test electrodes. The dielectric constant and the dissipation factor for specimens from each group of specimens were determined by placing the specimen between the electrodes of a bridge. The test procedures outlined in ASTM D–150 was then followed with each specimen to determine the dielectric constant and the dissipation factor at several different frequencies.

Table I below reflects the dielectric constant of the several specimens at various frequencies. These values of dielectric constant are also reflected in FIGURE 1 of the drawing. Curve A corresponds to control specimens having no hollow synthetic thermoplastic particles. Curves B, C and D correspond to specimens having 1.4, 4.4, and 5.7 weight percent hollow particles, respectively, as shown in Table I.

TABLE I

	Specimen			
	A	B	C	D
Hollow particles (percent)	0	1.4	4.4	5.7
Frequency (Hz):				
10^2	2.0	1.83	1.59	1.56
10^3	1.98	1.81	1.58	1.53
10^4	1.96	1.80	1.55	1.53
10^5	1.90	1.81	1.54	1.54
10^6	1.87	1.72	1.50	1.49

Table II below reflects the dissipation factor for the several specimens at the various indicated frequencies. Curve E corresponds to control specimens having no hollow hynthetic thermoplastic particles. Curves F, G, and H of FIGURE 2 correspond to the dissipation factor for specimens with 1.4 weight percent hollow particles, 4.4 weight percent hollow particles, and 5.7 weight percent hollow particles, respectively.

TABLE II

	Specimen			
	E	F	G	H
Hollow particles (percent)	0	1.4	4.4	5.7
Frequency (Hz):				
10^2	0.0067	0.0056	0.0054	0.0053
10^3	0.0074	0.0062	0.0051	0.0036
10^4	0.0089	0.0070	0.0053	0.0048
10^5	0.0149	0.0116	0.0079	0.0076
10^6	0.0276	0.0197	0.0127	0.0124

It is evident from the results reported in Tables I and II and in FIGURES 1 and 2 of the drawings that the electrical characteristics of the insulating materials of this invention are substantially better than the electrical characteristics of paper insulations. In this regard, the dielectric constant of the insulating material of the invention is consistently lower than the dielectric constant of a paper insulating material not having any hollow synthetic thermoplastic particles. The improvement in dissipation factor for the insulating material of this invention is even more pronounced in that a very large reduction in this value is realized at high frequencies.

Although the invention has been described and illustrated in connection with particular type of paper-making fibers and particular type of synthetic thermoplastic polymer, it is evident that materials other than those enumerated can be used without departing from the spirit and scope of the invention. Similarly, while the insulating layer is described as a tape in certain embodiments, it is evident that the insulation material can be in any suitable form either before or after it is placed around a conductor.

Although the invention has been described in considerable detail, it must be understood that such detail is for the purpose of illustration only and is not intended to be limiting of the invention.

That which is claimed is:

1. A conductor having an insulating layer comprising paper-making fibers consolidated together and having incorporated therein a multitude of hollow synthetic thermoplastic particles of generally spherical configuration and having a diameter within the range of between about 0.5 and about 200 microns, said particles being present in said insulating layer in an amount between about 0.25 and about 60 percent by weight based upon the weight of said insulating layer.

2. A conductor according to claim **1** wherein said insulating layer is in the form of a tape longitudinally folded around said conductor.

3. A conductor according a claim **1** wherein said insulating layer is in the form of a tape helically positioned around said conductor.

4. A conductor according to claim **1** wherein said insulating layer is formed around said conductor substantially continuous and without seams.

References Cited

UNITED STATES PATENTS

2,295,290 8/1942 Piercy ..... 174—121
3,293,114 12/1966 Kenaga.

E. A. GOLDBERG, Primary Examiner

U.S. Cl. X.R.

161—168; 174—110