

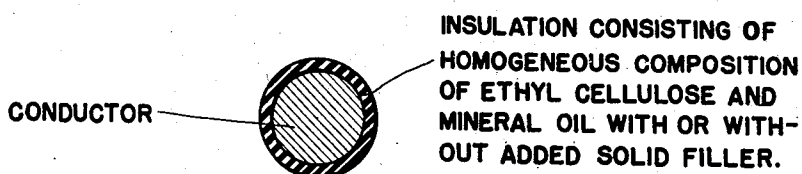
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INSULATED ELECTRICAL CONDUCTOR

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INSULATED ELECTRICAL CONDUCTOR

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This invention relates to a method of insulating wire conductors and the product obtained thereby.

For many years an electrical wire conductor with flexible, substantially heavy insulation which would not embrittle with age or become brittle at low temperatures or cold flow at the usual temperatures of use has been sought. The numerous resinous and oleo-resinous compositions which have been used for insulating purposes have not been sufficiently flexible to be applied in heavy coatings and furthermore they embrittle in the cold. Rubber coats embrittle with age, especially under the usual warm conditions of use. Cellulose derivative compositions have been proposed, but when cellulose derivatives are plasticized so that they have the requisite flexibility, they suffer from the defect of slow flow at moderate temperatures under stress. Thus, when wires coated with cellulose derivative compositions are wound into coils or pressed against any object around which they are bent, the pressure developed causes the wire slowly to cut through the insulation. This defect is accentuated at the moderately warm temperatures at which most electrical conductors are used.

It is an object of this invention to provide a simple and expedient method for insulating wire so as to obtain a flexible insulated conductor free of these defects.

It is a further object to provide a wire conductor insulated with a composition which does not cold flow and which will not cut through in ordinary use but which is at the same time highly flexible, and which will maintain its flexibility upon aging.

It is a still further object to provide a wire conductor insulated with a composition which will not cut through under the temperatures of ordinary use and which will at the same time maintain its flexibility at extremely low temperatures.

Now in accordance with this invention, electrical conductors are insulated by covering or extruding thereover a fused composition consisting of ethyl cellulose with a certain range of substitution and a mineral oil. The insulated wire is then cooled. In this manner there is obtained an insulated electrical conductor, the insulation of which is highly flexible even at extremely low temperatures such as -40°C . and at the same time the insulation does not cut through at the temperatures of ordinary use.

The accompanying drawing is a cross-sectional

view of an insulated electrical conductor in accordance with this invention.

The ethyl cellulose which I utilize in the method of this invention has a substitution in the range of from about 45% ethoxyl to about 51% ethoxyl, preferably in the range from about 46% to about 49%. It may have a viscosity characteristic varying over a wide range, for example, from about 2 seconds to about 10,000 seconds, the highest viscosity material practicably prepared being utilizable in this invention. This viscosity characteristic is the number of seconds required for the fall of a $\frac{1}{8}$ inch steel ball through 10 inches of solution contained in a glass tube 25 mm. in diameter at 25°C ., the solution consisting of 20% by weight of ethyl cellulose dissolved in a solvent consisting of 80% by weight of toluene and 20% by weight of ethyl alcohol. Toughness of the insulation increases with the viscosity of the ethyl cellulose utilized. However, preparation of the insulation composition is more rapid and flow in extrusion is more easily obtained with moderate viscosity material than with very high viscosity material. Preferably, ethyl cellulose having a viscosity characteristic of above 50 seconds is utilized, say from 50 seconds to 500 seconds, higher viscosity material being utilized when maximum toughness is desired.

The mineral oil which is utilized in the method of this invention is a mineral oil which is liquid and non-volatile at the usual room temperatures. It is such oil as, for example, ordinary motor lubricating oil such as SAE 20, SAE 30, SAE 40 oil, or steam cylinder and general lubricating mineral oils such as those sold under the designations of Teresso No. 52 and Teresso No. 65, or ordinary transformer oil, or white refined mineral oil such as White Oil, Nujol, and Fractol. The highly refined colorless and odorless oils such as Nujol and Fractol are preferred. Preferably also, the solidification point of the oil is as low as possible, say below 0°C . The mineral oil may be derived from any of the common crudes by fractionation, solvent extraction, etc., and it may be a hydrogenated fraction, if desired. The mineral oil preferably has a zero acidity.

The ethyl cellulose and mineral oil utilized in this invention are not mutually soluble materials in the ordinary sense. Mineral oil seems to dissolve some ethyl cellulose at a temperature of about 180°C ., but upon cooling the ethyl cellulose separates out. However, in the practice of this invention, these two ingredients are stably combined by fusing together and inter-dispersing

a limited quantity of mineral oil with ethyl cellulose of the hereinabove mentioned limited ethoxyl range. A suitable procedure is to mix the two materials, the mineral oil in quantity from about 5 to about 25% and the ethyl cellulose in quantity from about 95% to about 75% of the combined ethyl cellulose and mineral oil, preferably in the range from about 15% to about 24% of mineral oil and from about 85% to about 76% of ethyl cellulose. The inhomogeneous mixture is then charged, for example, into a Banbury mixer, heated to about 150° C. The floating plug of the Banbury mill is inserted and pressure applied thereto while the mill is operated. After about 10 to 15 minutes the hot plastic mass formed is discharged and immediately sheeted by means of a hot two roll mill for convenient reduction to strips or molding powder. Alternatively the inhomogeneous mass of ethyl cellulose and the mineral oil may be worked into a plastic dispersion of uniform appearance by means of a two roll mill heated to about 150° C.

By this procedure no volatile solvent is necessary and thus the problem of eliminating residual solvent does not arise. When solvents are used, a certain amount of solvent always remains in the plastic where it serves as a slowly volatile solvent plasticizer. In wire insulation, residual solvent is particularly disadvantageous since in volatilizing, it slowly changes the dimensions and electrical properties of the insulation. Furthermore, because of its plasticizing action, it tends to cause early failure of the insulation due to cutting through of the wire.

According to this invention the electrical conductor is insulated by extruding around it the hereinabove mentioned composition. The usual extrusion equipment of the plastics art may be used if it is provided with suitable dies and heating means. For example, the wire is fed centrally through a die to which the insulating composition is fed under pressure by means of a screw. The wire is preferably preheated. Preferably the plastics prepared as hereinabove mentioned and reduced to strips or to molding powder, are preheated to about 130° C. and fed to the screw of the extruding press. The screw feeds the material through a heated cylinder, heated, for example by hot oil or electrical heating elements, in which the plastic is heated to a temperature above its fusion point. The fused material then flows into the die and is extruded around the wire, the clearance between the wire and the die, the fluidity of the plastic, and the pressure on the plastic regulating the thickness of the insulation. Preferably the die is heated. Preferably the screw of the extruding press feeds an excess of fused insulating composition to the die, the excess material leaving by an overflow fitting for return to the press entrance.

It is essential, in obtaining the product of this invention, that the temperature of the insulating composition be above a certain minimum as it flows around the wire. This minimum temperature varies considerably with the ethoxyl content of the ethyl cellulose and it varies slightly with the percentage of mineral oil present. However, the effect of too low a temperature is readily apparent and readily corrected. If the insulated wire covered with about a 0.005-0.010 inch thickness of insulation, is cooled to room temperature and it is then found that the insulation breaks on sharply bending the wire, the extrusion temperature was too low. Because of the variables affecting the minimum extrusion temperature,

the term "fused" as used herein and in the appended claims is best defined in its effect upon the composition and it means that the composition has been applied at a sufficiently high temperature to insure flexibility of the insulation at room temperature. For example, if a composition consisting of 20-23% mineral oil and 80-77% ethyl cellulose of an ethoxyl content of 47.5% is being extruded, the insulation will be brittle if extruded at about 160°-170° C. but will be flexible if extruded at a temperature of above 180° C., say from about 180° C. to about 220° C. around a preheated wire. Using less mineral oil calls for only slight increase in temperature. Increase of the ethoxyl content toward 51% or decrease toward 45% calls for a very considerable increase in the temperature of extrusion to a temperature which may be as high as 250-270° C.

The wire to be insulated is preferably preheated before it is insulated. It may be heated to a temperature in the range from about 80° C. to about 300° C., preferably in the range from 180° C. to 240° C. when 46-49% ethoxyl ethyl cellulose is utilized or in the range from 230-280° C. when about 45 or about 51% ethoxyl ethyl cellulose is used, intermediate temperatures being preferred for intermediate ethoxyl material. Where the wire is very fine, preheating may be unnecessary but for ordinary wire, say No. 30 to No. 12, B. & S. gauge, it expedites the formation of flexible insulation. Cold wire can cause the formation of brittle insulation by chilling the composition in the die. In general, the cooler the wire the higher must be the temperature of extrusion.

The insulating composition may be heated and extruded in non-oxidizing atmosphere, for example, carbon dioxide, nitrogen, flue gas, etc., if desired. An inert atmosphere offers only slight advantage with the ethyl cellulose in the hereinbefore mentioned preferred ethoxyl range but its use becomes increasingly desirable as ethoxyl is increased or decreased, as at the higher temperatures of extrusion required, yellowing and degradation tend to take place.

The insulation applied according to the method of the present invention is a homogeneous clear composition with fairly good adhesion to the wire. It may be of a thickness from 0.001 to 0.020 inch or even thicker and yet, in the absence of pigment or filler, it will be of sparkling clarity even at any thickness. This result is unexpected in view of the insolubility of ethyl cellulose in mineral oil.

Modifying agents such as stable dyes or stable fillers and pigments may be incorporated in the insulation, provided that the materials used do not have unfavorable electrical properties. Suitable dyes which do not affect the clarity of the insulation are such oil soluble dyestuffs as Sudan Red R, Oil Red GRO, Du Pont Oil Red, Du Pont Oil Yellow, etc. Suitable solid inert fillers, including pigments within the term "filler" as used herein, are silica, lithopone, talc, precipitated chalk, fine clay, asbestine, titanium dioxide, barium sulphate, calcium sulphate, chromium oxide, zinc oxide, antimony oxide, zinc sulphide, etc., ground to a suitable fineness. Fillers cheapen the insulation and may be used to modify its appearance and to harden it. A quantity up to about 25% of the total insulating composition may be used, this quantity depending on the density of the filler, but to avoid embrittling, preferably less than 15% will be incorporated. The filler is incorporated by adding it to the ingredients charged to the Banbury or roll mill

used in compounding the insulation. The filler is thereby readily dispersed in the compositions hereinabove defined.

The insulated conductor does not change in properties with time as the insulation is free of volatile matter and does not embrittle or otherwise deteriorate with age. The insulated wire obtained according to this invention is flexible at temperatures as low as -40°C ., that is, insulation about 0.010 inch thick on No. 22 wire will not crack when the wire is bent back sharply and the bend then continued to form a tight kink in the wire, the test being conducted at -40°C . Furthermore, the insulated conductor is distinguished by a resistance to cut through which is unique for conductors having flexible non-aging insulation. Resistance to cut through is measured in the art to which this invention pertains by the following standardized test. The test consists of suspending a one kilogram weight from a loop of No. 30 wire which is hung over the insulated wire, the latter being held in a horizontal position. The whole arrangement is kept at 75°C . Insulated wire is considered to possess satisfactory resistance to cut through if the No. 30 wire has not cut through the insulation in 8 hours. The insulated conductor in accordance with this invention has a cut through resistance in excess of two days; in fact, as hereinafter shown, in excess of 72 hours.

The following table gives examples of insulating compositions which may be compounded and applied by the method in accordance with this invention:

	Composition, parts by weight					
	I	II	III	IV	V	VI
Ethyl cellulose—47.8% ethoxyl, 1100 sec. viscosity	77					
Ethyl cellulose—47.9% ethoxyl, 66.7 sec. viscosity		65.5	77	69.3	77	77
Mineral oil (SAE 20 lubricating oil)						23
Mineral oil (transformer oil)					23	
Mineral oil (Nujol)	23					
Mineral oil (Fracol A)		19.5	23	20.7		
Sudan Red R Dye (General Dyestuff Co.)	0.125					
Oil Red GBO Dye (National Aniline Co.)	0.125					
Du Pont Oil Yellow Dye			0.06			
Titanium dioxide		1.0				
Precipitated chalk		14.0				
Talc				10		

The accompanying drawing illustrates a specific example of an insulated conductor in accordance with this invention. The insulation shown in the drawing may have a composition such as any of the compositions given in the examples.

The resistance to cut through of the insulated conductors according to this invention is illustrated by the fact that when compositions I, II, and III were extruded around No. 22 B. & S. gauge bare copper wire according to the method of this invention, in thicknesses of 0.009, 0.011, and 0.011 inch respectively, the conductor obtained had not yet failed in the cut through test hereinbefore mentioned after 72 hours after which the test was discontinued. These insulated conductors were flexible and could be kinked tightly without cracking the insulation at -40°C .

It will be understood that the details and examples hereinbefore set forth are illustrative only, and that the invention as broadly described and claimed is in no way limited thereby.

What I claim and desire to protect by Letters Patent is:

1. An insulated electrical conductor comprising an electrical conductor and as insulation therefor a fused, homogeneous composition consisting of from about 75% to about 95% of ethyl cellulose having an ethoxyl content in the range from about 45% to about 51% and from about 25% to about 5% of mineral oil, the said insulated conductor being characterized by resistance to cutting through of the insulation by pressure at temperatures of the order of 75°C . and also being characterized by flexibility at low temperatures.

2. An insulated electrical conductor comprising an electrical conductor and as insulation therefor a fused, homogeneous composition consisting of from about 75% to about 95% of ethyl cellulose having an ethoxyl content in the range from about 45% to about 51% and from about 25% to about 5% of mineral oil, the said composition having dispersed therein an inert solid filler, and the said insulated conductor being characterized by resistance to cutting through of the insulation by pressure at temperatures of the order of 75°C . and also being characterized by flexibility at low temperatures.

3. An insulated electrical conductor comprising an electrical conductor and as insulation therefor a fused, homogeneous composition consisting of from about 75% to about 95% of ethyl cellulose having an ethoxyl content in the range from about 46% to about 49% and from about 25% to about 5% of mineral oil, the said insulated conductor being characterized by resistance to cutting through of the insulation by pressure at temperatures of the order of 75°C . and also being characterized by flexibility at low temperatures.

4. An insulated electrical conductor comprising an electrical conductor and as insulation therefor a fused, homogeneous composition consisting of from about 75% to about 95% of ethyl cellulose having an ethoxyl content in the range from about 46% to about 49% and from about 25% to about 5% of mineral oil, the said composition having dispersed therein an inert solid filler, and the said insulated conductor being characterized by resistance to cutting through of the insulation by pressure at temperatures of the order of 75°C . and also being characterized by flexibility at low temperatures.

5. An insulated electrical conductor comprising an electrical conductor and an insulating covering therefor of a homogeneous composition consisting of about 77% of ethyl cellulose having an ethoxyl content in the range from about 45% to about 51% and about 23% of mineral oil.

6. An insulated electrical conductor comprising an electrical conductor and an insulating covering therefor of a homogeneous composition consisting of about 77% of ethyl cellulose having an ethoxyl content in the range from about 45% to about 51% and about 23% of mineral oil, said composition having dispersed therein an inert solid filler.

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