

June 29, 1943.

V. T. WALLDER

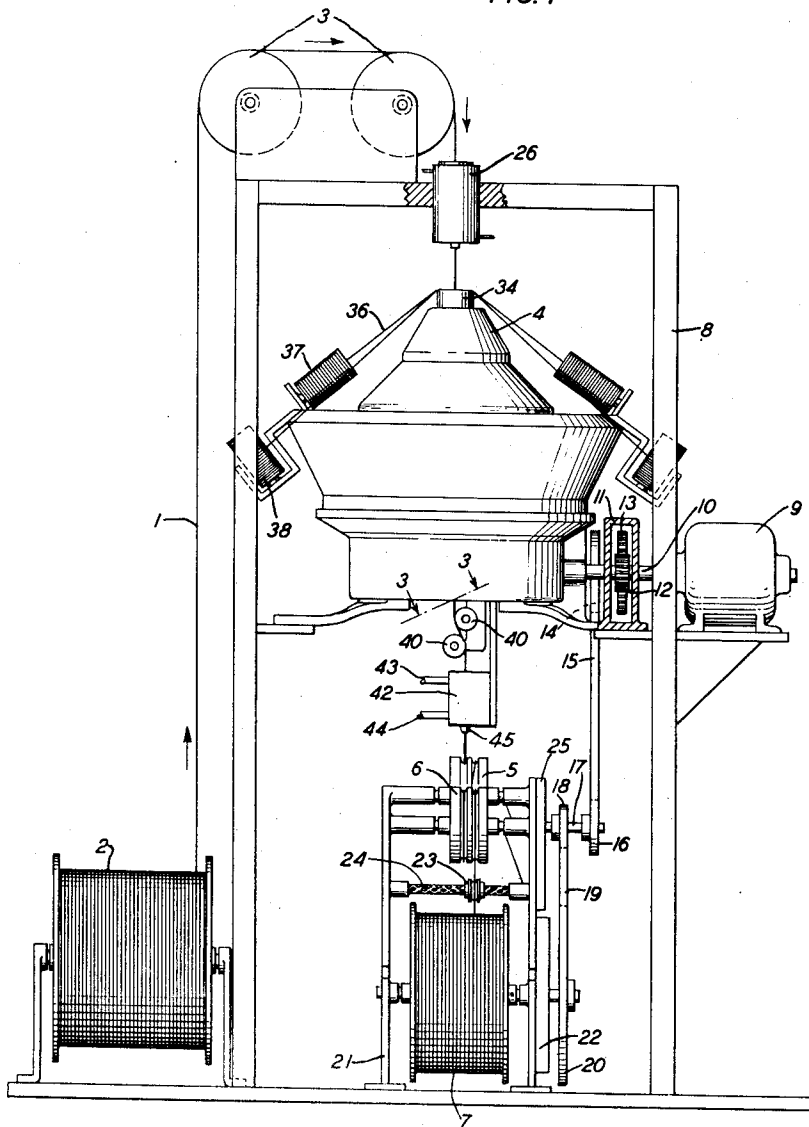
2,322,756

METHOD OF IMPREGNATION

Filed July 11, 1941

2 Sheets-Sheet 1

FIG. 1



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2 Sheets-Sheet 2

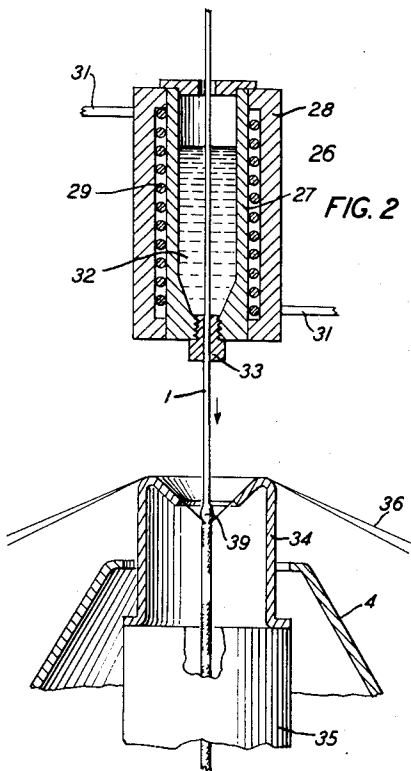


FIG. 2

FIG. 3

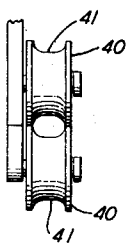


FIG. 5

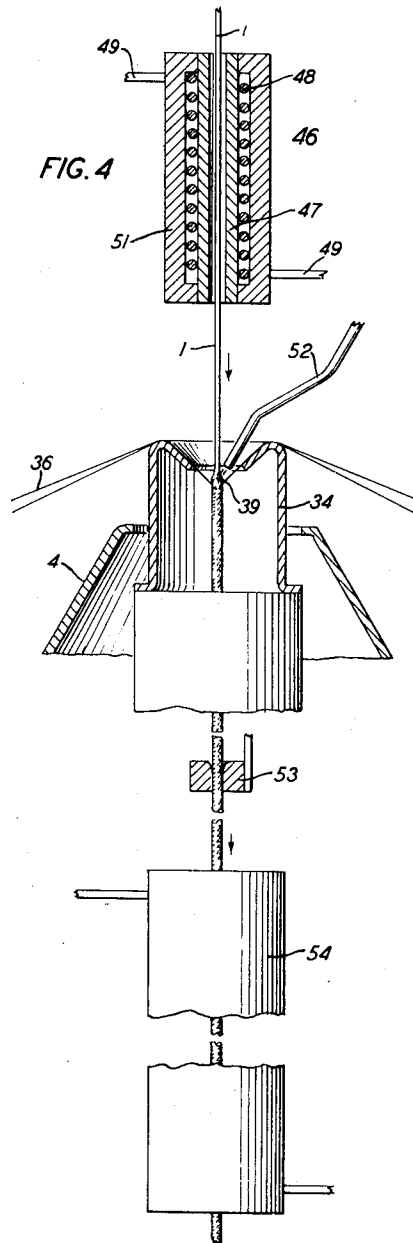
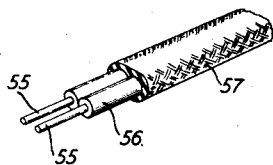


FIG. 4

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METHOD OF IMPREGNATION

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Application July 11, 1941, Serial No. 402,003

16 Claims. (Cl. 87-1)

This invention relates to methods for forming a layer of impregnated fibrous material on a strand, and more particularly to the formation of an insulating covering layer of impregnated fibrous material about an electrical conductor, such as a wire.

It is common practice to produce and employ electrical conductors having a covering layer of fibrous material such as cotton, impregnated with a suitable substance such as asphalt, or a pitch mixture. The primary purposes of the impregnant are to insulate the conductor, to protect the fibrous material and metal conductor from moisture and weather conditions, and to increase the strength and resistance to abrasion of the covering layer. For such use the impregnant should be such that, when impregnated into a layer of suitable fibrous material such as cotton, it has good electrical insulating characteristics, is tough, flexible and strong, is adherent to the fibrous material, is resistant to moisture and weather conditions, is resistant to embrittlement due to weathering, and is abrasion resistant. Usually the covering layer of fibrous material is first formed on the conductor by braiding or knitting and is thereafter impregnated with the desired impregnant. In order to obtain even reasonably satisfactory impregnation under such conditions it is necessary that the impregnant be in the form of a liquid of low viscosity so that it can penetrate the interstices in and between the fibers of the fibrous material. The impregnating material may be dissolved in a volatile solvent to form an impregnating solution of the desired viscosity, but in most cases it is desired to avoid the use of solvents because of the extra cost and industrial hazards involved. Therefore the impregnating material is usually heated to put it in a liquid state and to reduce its viscosity.

Most, if not all, of the materials employed for impregnation of a fibrous covering layer in place on a conductor and having the necessary low viscosities in the molten state do not possess characteristics such as abrasion and weather resistance, strength and toughness as good as is desirable. On the other hand materials which, if employed as impregnants, would provide good characteristics in these and other respects desirable for impregnants cannot be readily employed, if at all, for impregnation according to a procedure in which the impregnant in the molten state is applied to a fibrous covering previously formed on a conductor. Such materials in general are liquids of such high viscosity under the conditions during which impregnation can be carried out that they cannot readily penetrate the fibers or interstices therebetween of the fibrous material if they are applied to a layer of fibrous material already on the conductor.

Under such conditions such an impregnating material will merely form an external poorly adherent layer over the fibrous material, which layer can be readily damaged or chipped off with consequent exposure of the fibrous material beneath. Yet the viscosity of such a molten impregnating material cannot be lowered sufficiently by elevating its temperature to make satisfactory impregnation possible according to the procedure indicated above. Temperatures sufficiently elevated to reduce the viscosity of such an impregnating material to an extent permitting thorough impregnation according to such a method are so high that they result in damage to the impregnating material, or to the textile material usually employed as the fibrous covering and the rubber insulating layer usually disposed between the conductor and the covering layer. For these reasons it has heretofore been very difficult, if not impossible, to impregnate fibrous layers on the electrical conductors with materials, such as highly blown asphalt, which have very high viscosities at the temperatures which it is safe to employ in impregnation, even though such materials if thoroughly impregnated would be far superior to the low viscosity impregnants ordinarily employed.

The present invention overcomes such difficulties and makes it possible easily and thoroughly to impregnate into fibrous materials on an electrical conductor impregnating materials which at the permissible impregnating temperatures are are very viscous liquids, that is, liquids having viscosities between about 500 and about 500,000 centipoises or more. According to the invention this is accomplished by first forming on the conductor a thick coating of the impregnating material in the form of a thick liquid, then forming on the conductor before the impregnating material solidifies a layer of interlaced fibrous material, as by braiding or knitting, under conditions such that the fibrous material is pressed into the coating of impregnating material to force it into the interstices of the layer of fibrous material, and thereafter solidifying the impregnating material. The thickness of the initial coating of the impregnating material is such that sufficient impregnating material is provided to permeate thoroughly and penetrate completely the layer of fibrous material until the impregnating material exudes from the outer surface of said layer, after which such exuded material while soft can be smoothed to form a smooth surface on the conductor. The initial coating of impregnating material preferably is at least about as thick as the thickness of the layer of fibrous material formed on the conductor for the most advantageous results in providing thorough impregnation and an ample supply of exuded impregnating material for smoothing purposes.

Impregnating material in the molten state which may be impregnated in this manner according to the invention should not be at a temperature high enough to damage the fibrous material, rubber, or other insulating material employed in conjunction with the impregnating material. The lower limit of its temperature is determined by the temperature necessary to maintain it in the molten state during formation of the layer of fibrous material. Usually the temperature should be at least about 60° C., particularly if the impregnating material is one which is fusible after impregnation, so that its melting point will be above the operating temperatures of the conductor.

Thus, the invention makes it possible readily to produce electrical conductors having fibrous covering layers thoroughly impregnated with materials, heretofore impregnable only with great difficulty if at all, which are superior in toughness, flexibility, strength, abrasion resistance, weather and moisture resistance, resistance to harmful embrittlement, etc. An insulated electrical conductor having an impregnated fibrous covering layer of improved qualities and long life is therefore made possible by the present invention.

The features of the invention will be described hereinafter in connection with the accompanying drawings in which:

Fig. 1 shows one form of apparatus for forming an impregnated braided fibrous covering layer on an electrical conductor in accordance with the invention;

Fig. 2 illustrates to an enlarged scale a portion of the apparatus of Fig. 1, parts being shown in section to illustrate the formation of the impregnated braided covering layer of fibrous material;

Fig. 3 is an enlarged detail elevation from line 3—3 of Fig. 1;

Fig. 4 illustrates to the same scale as Fig. 2 a corresponding portion of another form of apparatus operating according to the invention to form an impregnated braided covering layer of fibrous material on an electrical conductor; and

Fig. 5 is a perspective elevation to an enlarged scale showing a portion of a conductor produced according to the present invention.

Suitable high molecular weight linear polymers, i. e., those having essentially long chain linear molecules, provide advantageous results when thoroughly impregnated into fibrous coverings on electrical insulators. More particularly, linear polyesters of suitable high molecular weights provide advantageous results when so employed. The melting points of such polyesters in general are low enough so that molten polyesters may be contacted with other materials on the conductor, such as textile and rubber, without damage thereto and may be high enough so that in the case of fusible polyesters the melting points are above the temperature normally encountered in use; i. e., advantageously at least about 60° C. However, within the range of temperatures which may be employed without damage to such other insulating materials, such linear polyesters in general are extremely viscous liquids, and hence as a practical matter cannot be readily satisfactorily impregnated into fibrous material previously placed on a conductor. Such polyesters may, however, be readily employed in the formation of impregnated fibrous covering layers on electrical conductors according to the invention. For illustrative purposes several embodiments of the invention will be described hereinafter in con-

nection with the use of such polyesters as impregnants.

In the apparatus of Figs. 1 and 2 of the accompanying drawings the wire 1, which may be rubber covered if desired, is withdrawn from the supply spool 2 upwardly to and over the guide pulleys 3 and thence downwardly through the braiding head 4 by the power driven draw rolls 5 and 6 around which the wire is looped to prevent slippage and which feed the wire to the collecting spool 7. The braiding head 4 diagrammatically shown in the illustrated apparatus is of the "Wardwell" type, although any other suitable type of braiding head may be employed.

The braiding head 4 in the illustrated apparatus is supported by a suitable frame 8 and is driven from motor 9 through shaft 10. In the housing of speed reduction unit 11, through which shaft 10 passes is disposed a pinion 12 rigidly fixed to said shaft 10 and meshing with a larger gear 13. Said gear 13 is rigidly fixed to a shaft (not shown) on which is rigidly mounted sprocket 14 carrying the endless driving member 15 which drives the sprocket 16. Said sprocket 16 is rigidly fixed to shaft 17 which rotates the draw rolls 5 and 6 and has rigidly mounted thereon a small sprocket 18 over which passes endless driving member 19 arranged to rotate the large sprocket 20 which is adapted to rotate the collecting spool 7. Said spool is demountably mounted in said supporting frame 21 for replacement purposes. The speed of the motor 9 is thus reduced to the considerably lower take-up speed of the collecting spool 7 through the agency of the speed reducer 11 and the difference in sizes of the small sprocket 18 and the large sprocket 20. Since the take-up speed of the spool 7 tends to increase as the diameter of the wire package being collected on the spool increases, suitable means, such as a slip clutch, is provided in the housing 22 of the supporting frame 21 to permit the spool 7 to rotate at a progressively slower speed as the diameter of the wire package collected on the spool increases, so that the peripheral speed of said package and the linear speed at which the wire is supplied thereto from the draw rolls 5 and 6 are identical. The reciprocating wire guide 23 which serves to lay the wire in the desired pattern in the package on the spool is reciprocated by rotation of the suitably helically grooved shaft 24, which in the apparatus of Fig. 1 is rotated from shaft 17 by suitable means in housing 25.

In the embodiment of Figs. 1 and 2 the member 26 serves as a means for applying molten polyesters to the wire. As shown in Fig. 2 it comprises the container 27 which is formed of a suitable metal and is provided with a layer 28 of heat insulating material and, within said layer, electrical heating means such as element 29 having current supply leads 31. A suitable molten mass 32 of the impregnating material, which in this embodiment is a polyester of the type described later is disposed in said container 27 which is suitably heated to maintain the polyester in the molten condition at the desired temperature. Molten or solid polyester may be added from time to time to the container 27 to replenish that removed by the wire 1 passing through the container. As it passes through the container the wire acquires a coating of the polyester, the thickness of the coating being regulated by the die 33 through which the wire leaves the container at the bottom thereof. The wire containing a thick coating of liquid poly-

The reactants should be of such character and particularly should be of such chain lengths that long chain linear molecules, rather than ring molecules, are formed. For advantages in hardness and strength, the reactants preferably are such that the resulting polyesters are crystalline upon solidification, although the non-crystalline polyesters may also be employed according to the invention.

The polyesters impregnated according to the present invention are of high molecular weights, i. e., of molecular weights in the thousands, in order that they possess the necessary strength and toughness. Because of their molecular weights the polyesters in the molten state are liquids of high viscosity. The magnitude of the molecular weight of the polyester is indicated by its absolute viscosity or by its intrinsic viscosity. Those having particularly desirable properties when employed as impregnants according to the invention when molten and at temperatures of about 120° C. have absolute viscosities ranging from about 500 to about 500,000 centipoises or more, and are particularly advantageous when their absolute viscosities are above about 5,000 centipoises. Their viscosities at the somewhat lower impregnating temperatures employed are even greater.

The intrinsic viscosity V_i , which is useful in viscosity and molecular weight determinations when the material being measured has an absolute viscosity so high as to render unfeasible ordinary methods of determining viscosity, is determined by the formula

$$V_i = \frac{\log_e V}{C}$$

where V is the viscosity of a fairly dilute solution of the polyester divided by the viscosity of the solvent such as chloroform in the same units and at the same temperature and C is the concentration in grams of the polymer per 100 cubic centimeters of the solution. Polyesters having an intrinsic viscosity of about 1 as determined in this manner have an absolute viscosity of about 200,000 centipoises or more.

Saturated straight chain polyesters having viscosities in the molten state of the magnitudes indicated above may be readily impregnated according to the invention and in general after such impregnation possess the desirable properties indicated above. Such a polyester may be formed by a reaction of a suitable straight chain aliphatic dicarboxylic acid and a suitable straight chain aliphatic glycol or derivatives of such reactants, or by self esterification of a hydroxy acid of the formula $\text{OH}-(\text{CH}_2)_n-\text{COOH}$, where n is a suitable integer, or a derivative of such acid. Examples of such dicarboxylic acids which may be employed are glutaric acid, adipic acid, pimelic acid, azelaic acid, sebacic acid, decamethylene dicarboxylic acid, dodecamethylene dicarboxylic acid and octadecane-dioic acid. Examples of suitable glycols are ethylene glycol, propylene glycol, hexamethylene glycol and decamethylene glycol.

In order to obtain flexibility, toughness and resistance to embrittlement even greater than those obtainable with such linear polyester impregnants and, if desired, insolubility or infusibility, it is advantageous to employ as impregnants according to the invention essentially linear polyesters in which in the linear molecules of the impregnated polyester are gelled or mildly cross-linked. In such a case, crystallization is

inhibited although not prevented so that the solidified impregnated polyamide contains amorphous regions which increase such properties.

One type of such polyester useful for impregnation according to the invention is obtained by addition to the reactants capable of forming a linear polyester of a small amount of polyfunctional compound containing more than two ester forming groups, such as glycerol, as described in the copending application of C. J. Frosch, Serial No. 401,958, filed July 11, 1941. The amount of such compound having more than two functional groups should not be so great to cause sufficient cross-linking to gel the polyester during polymerization and prevent linear polymerization to the desired molecular weight. A polyester of this type which is not excessively cross-linked may be melted. The molten polyester tends to be more viscous than similar non-cross-linked polyesters, but may be readily impregnated according to the invention.

Another type of cross-linked linear polyester which may be employed to advantage in impregnation according to the invention is obtained by preparing the linear polyesters from reactants such that the resulting polyester contains a small amount of linear, or non-benzenoid, carbon-to-carbon unsaturation. Properly prepared polyesters of this type, which are described in the copending applications of C. J. Frosch, Serial No. 401,951, filed July 11, 1941, and Serial No. 401,959, filed July 11, 1941, and in the copending application of C. S. Fuller, Serial No. 401,952, filed July 11, 1941, after formation may be rendered molten for impregnating purposes but after impregnation may be cross-linked to form tough, flexible, infusible substances by heating or otherwise curing them in the presence of oxygen which may be supplied by the air or by a suitable oxygen liberating substance. Such an unsaturated polyester may be prepared by including among the reactants which will form a linear polyester a substance which will provide the desired small amount of carbon-to-carbon unsaturation. Thus, when a dicarboxylic acid and a glycol are reacted to form a polyester, all or a portion of the saturated dicarboxylic acid may be replaced by a suitable amount of unsaturated dicarboxylic acid or all or a portion of the glycol may be replaced by a suitable amount of glycol containing unsaturated carbon-to-carbon bonds, or both the saturated acid and saturated glycol may be all or in part replaced by an unsaturated acid and glycol. Examples of unsaturated dicarboxylic acids which may be employed are maleic acid, fumaric acid, itaconic acid, citraconic acid and dihydromuconic acid, while any one of various glycols having the general formula $\text{OH}-\text{R}-\text{OH}$, where R is a suitable organic radical containing carbon-to-carbon unsaturation may be employed. As mentioned in said copending applications, however, the amount and kind of such unsaturation in each linear molecule should not be such that sufficient polymerization at the multiple bonds occurs during the esterification reaction to prevent the linear polymerization necessary to obtain linear molecules of the lengths and molecular weights desirable. For example, when the unsaturated carbon-to-carbon bonds are conjugated with either another unsaturated carbon-to-carbon bond or with a carbon-to-carbon double bond the reactivity of the conjugated unsaturated bonds is sufficiently great to make it advantageous to keep the number of such conjugated unsaturated car-

ester passes downwardly through the braiding head 4. An annular guide 34 rigidly mounted on the stationary columnar central member 35 of the braiding head 4 surrounds the wire 1 and aids in changing without entanglement the direction of the braiding threads 36 passing to the wire 1 from the bobbins 37 and 38. Since the braiding head 4 operates in the usual manner no detailed explanation of the operation of forming a braid on the wire 1 is deemed necessary.

A braid is applied to the wire 1 coated with the liquid polyester as the wire passes downwardly. The tension in the threads 36 during and immediately after the braiding operation is sufficiently great to cause the braided layer of threads to sink into the coating of liquid polyester and force the polyester into the braided layer, thus thoroughly impregnating it. The coating of the polyester on the wire is quite thick, being sufficiently thick to permit the liquid polyester thoroughly to impregnate the braided layer, penetrate entirely through said layer, and exude from the interior of said layer. For best results the thickness of the coating of the liquid polyester applied to the wire should be such that a globule 39 of the liquid polyester forms on the wire immediately above the point at which the braid is formed. Said globule acts as a reservoir to provide at all times an ample supply of liquid polyester to the point of braid formation.

In the illustrated embodiment the impregnated braid covered wire passes through the grooved rolls 40 (Figs. 1 and 3) after it leaves the braiding head. The polyester is still warm and soft when the wire reaches this point and these rolls smooth the surface of the wire by spreading the polyester which has exuded through the braided layer of thread into a smooth layer over the exterior surface of the wire, and by ironing out irregularities in the braided threads; they aid in impregnation through the pressure of the rolls on the still soft polyester to force such polyester into any remaining crevices in the impregnated braided layers; they aid in shaping the cross section of the wire 1 by means of the shapes of the grooves 41 in the rolls 40, as shown in Fig. 3; and they serve as guiding means for accurately locating the wire as it passes through the braiding head 4. The rolls 40 thus aid in producing a smooth, thoroughly and uniformly impregnated fiber covered wire of accurate cross-sectional size and shape. The rolls 40 are shown as freely rotatable but if desired they may be power driven to rotate either in or against the direction of travel of the wire 1 to intensify their smoothing action. The rolls may or may not be heated for these purposes, being in the illustrated embodiment unheated. Other smoothing means than rollers of the type illustrated may be employed. For example, heated or unheated smoothing dies may be employed.

In the embodiment of Figs. 1 and 2 cooling means is provided to cool and solidify the still soft impregnated polyester of the wire leaving the rolls 40. The illustrated cooling means comprises a vessel 42 containing water or other suitable liquid, pipes 43 and 44 being provided to circulate the liquid therethrough. The impregnated braided wire passes through the water in said vessel and passes out of the vessel at the bottom through a rubber or other suitable gasket 45 which presses firmly against the wire and prevents the escape of water from the vessel 42. Thereafter the completed wire 1 passes twice around the draw rolls 5 and 6 which thus provide

a good grip on the wire and is collected by spool 7.

In the apparatus shown in Fig. 4, which is similar to that of Figs. 1 and 2, the polyester is not applied to the wire 1 on the apparatus but is applied to the wire in the form of a solidified coating before the wire is supplied to the apparatus. The solidified polyester on the wire is reduced to the state of a liquid of a suitable temperature and viscosity by the heating means 46 which in the apparatus of Fig. 4 comprises a metallic sleeve 47 through which the wire passes and which is electrically heated by a heating element 48 to which current is supplied by leads 49. The heating element 48 and sleeve 47 are enclosed in a jacket 51 of suitable heat insulating material.

In the apparatus of Fig. 4 is also provided means for applying a setting or vulcanizing agent to the polyester on the wire. This comprises the tube 52 through which a liquid agent is applied to the wire 1 immediately above the point at which the braid is formed, or at about the point on the wire at which the globule 39 is disposed. The liquid is supplied to tube 52 from a suitable source, not shown.

A smoothing die 53 is shown as disposed in the apparatus of Fig. 4 at a point such that the braided impregnated wire can be drawn there-through while the impregnant is still soft. This die, which may be heated or unheated, is in the illustrated apparatus adapted to perform the smoothing, impregnating, guiding and shaping functions described in connection with the rolls 40 of the apparatus of Figs. 1 and 3.

The apparatus of Fig. 4 moreover includes means 54 for heating or curing the impregnated braided wire after it has passed through the die 53 and before it is collected. This is shown as being a suitable electric heating means similar to the heating means 46 although larger because of the greater amount of heat required. The reasons for the desirability of employing means 52 for applying a curing or vulcanizing agent to the impregnating material and the means 54 for curing the impregnated braided wire will be brought out more fully in the following discussion of the linear polyesters which may be applied according to the invention.

The linear polyesters, which, when impregnated into a layer of fibrous material on an electric conductor according to the invention, are advantageous in providing, besides good insulating qualities, superior strength, toughness, abrasion resistance, moisture and weather resistance, and other desirable qualities, contain essentially linear long chain molecules consisting of divalent organic radicals connected together by groups which are substantially, if not entirely, ester groups. Such polyesters usually are prepared by reaction of suitable dicarboxylic acids and suitable glycols, or derivatives of such reactants, or by self-esterification of suitable monohydroxy-monocarboxylic acids, or derivatives thereof, for prolonged periods at suitable elevated temperatures and under conditions such as to remove or render innocuous the water or other reaction by-products. Such by-products, for example, are most readily removed by bubbling an inert gas such as dry oxygen-free hydrogen, nitrogen or carbon dioxide through the molten reaction mixture with or without the application of a reduced pressure, or by the use of a molecular still as described in United States Patent 2,071,250, or by continuously stirring the reaction mixture under reduced pressure, or by other means.

bon-to-carbon bonds less than about 5 per four hundred atoms in the linear chain of the average polyester molecule, assuming no cross-linking to have occurred. In a polyester prepared from ethylene glycol, succinic acid, and maleic acid this corresponds to about 10 per cent or less of maleic acid by weight of total acid.

Carbon-to-carbon unsaturation which will result in cross-linking upon curing may also be reduced in other manners, as by incorporating with the polyester forming reactants resin producing substances such as vinyl compounds which may be reacted to form cross-linkages between the molecules.

Cross-linking of the unsaturated molecules is achieved by curing of the polyester, which may be effected in various ways. If the cross-linking obtained by curing is sufficient, the polyester will be rendered infusible and insoluble, which is usually desirable and usually occurs. Heating of polyesters to temperatures over about 100° C. in the presence of air for a suitable period will in some cases cause cross-linking. The polyester may be heated in the presence of one or more suitable compounds which promote cross-linking. Among the cross-linking agents, which may be of various kinds, may be mentioned the organic peroxides such as benzoyl peroxide, hydrogen peroxide, acetone peroxide, methylcellulose peroxide, dioxane peroxide, ethylene peroxide, the drying oil peroxides, etc. Moreover, mere exposure of the unsaturated polyesters at ordinary temperatures for prolonged periods to ultra violet light and oxygen, as occurs in weathering, will cause cross-linking.

Saturated polyesters may also be cross-linked, although not so readily, by exposing them to heat in the presence of a powerful cross-linking agent, such as benzoyl peroxide.

Various impregnation procedures embodying the invention and employing various types of molten polyesters may be followed. The temperature at which a polyester is applied to the conductor should not be so high that the fibrous braiding material or auxiliary rubber covering or the like is damaged, or so that the polyester cross-links harmfully before the braid is applied, but should, of course, be above the melting point of the polyester. Thus, a thick coating of a liquid saturated polyester, such as an aliphatic straight chain saturated polyester, may be applied to a wire either by passage of the wire through a molten bath of the polyester as occurs in the apparatus of Figs. 1 and 2 or by heating a previously applied coating of the polyester as is the case in the apparatus of Fig. 4. After braiding of the threads in place in the liquid polyester and solidification of the polyester, no further treatment need be applied to the impregnant in such case.

If it is desired to cross-link such saturated polyester after impregnation, a suitable cross-linking agent such as benzoyl peroxide may be applied to the polyester and the polyester thereafter heated. Application of such a catalytic substance may be accomplished in various manners. For example, it may be mixed with the molten polyester before it is applied to the wire, as for example, by being mixed with the molten polyester in the container 27 of Fig. 2; or it may be impregnated into or coated on the threads being braided; or such substance may be applied to the polyester at the point of braiding as is shown in Fig. 4. In the apparatus of said figure the cross-linking agent is applied as a

liquid, as for example, a solution of benzoyl peroxide in benzene, alcohol, or the like. Cross-linking may be accomplished by heating the impregnated polyester either before or after it has solidified. Thus, the heating may be accomplished by removing the impregnated braided wire from the braiding apparatus and heating it in an oven, or by passing the wire concurrently with the braiding and impregnation thereof through a heating means on or associated with the braiding apparatus as is shown in Fig. 4. In general, only a few minutes heating time at a temperature between about 125° C. and about 150° C. is necessary.

Cross-linking of unsaturated polyesters impregnated according to the invention may be accomplished in manners similar to those described, above as well as in other manners. If a cross-linking agent such as benzoyl peroxide is employed, it may be supplied by the braiding thread into which it is impregnated or on which it is coated, or it may be applied to the coated wire preferably in a solution applied at the point of application to the braid, or it may be mixed in the molten polyester applied to the wire, or it may be supplied in other suitable manners. Not all polyesters may have the cross-linking agent mixed therewith for application to the wire, since cross-linking and gelation may occur before the polyester is applied to the wire if the temperature necessary to maintain the polyester in the molten state approaches the curing temperature required. A polyester having a low melting point, such as polyethylene adipate, may satisfactorily have a cross-linking agent such as benzoyl peroxide mixed therewith for application to the wire.

Curing to cause the cross-linking to occur in the unsaturated polyester impregnant may be accomplished in various ways, as by heating the wire after its removal from the braiding apparatus and after solidification of the polyester in a suitable oven, or by heating of the wire concurrently with its braiding and impregnation as shown in Fig. 4.

It is not necessary that such unsaturated polyesters be heated to cause the desired cross-linking since after solidification of the impregnated unsaturated polyester, which may or may not contain a substance to promote cross-linking, the wire may be put into use. Exposure of the wire to ultra violet rays of the sunshine and the oxygen of the air usually will in time cause cross-linking to occur even at ordinary temperatures. In such case the characteristics of the impregnating material improve with aging of the wire.

Fig. 5 shows to an enlarged scale a portion of a wire which has been braided and impregnated according to the invention. As shown in said figure, two conductors 55, each covered with a layer 56 of rubber or the like, have a common covering layer 57 consisting of braided cotton threads having thoroughly impregnated therein a high molecular weight essentially linear polyester which at the time of impregnation was an extremely thick viscous liquid. The impregnated layer has a smooth, pore-free surface, good electrical characteristics and is moisture-proof, strong, tough, flexible and weather resistant.

Several manners in which the present invention may be carried out will be illustrated by the following examples:

Example 1

The linear polyester, polyethylene sebacate,

was prepared by placing substantially equal molecular weights of ethylene glycol and sebacic acid into a suitable aluminum container which was heated to about 200° C. During the entire heating operation a stream of dry hydrogen gas was bubbled through the mixture, the heating being carried on for more than 10 hours until the polyethylene sebacate had an intrinsic viscosity in chloroform of about 1.13.

The resulting polyethylene sebacate was placed in a container corresponding to the container 27 of the apparatus of Figs. 1 and 2, in which it was kept at a temperature of about 100° C. Copper wire, No. 18 AWG, covered with a layer of rubber about 0.028 inch thick, was drawn downwardly through the molten polyester in the container and through a die to the bottom of the container, a thick coating being thus applied thereto. At a distance of a few inches below the bottom of the container, where the temperature of the molten polyester was still between 85° C. and 90° C., a 10/1/3 cotton braid was applied to the wire by a suitable braiding head as the wire traveled downwardly, an annular guide corresponding to guide 34 in the illustrated apparatus being provided to change the directions of the braiding threads. The braiding speed was approximately 2 feet per minute. While the impregnant was still soft, the impregnated braided wire was passed between two smoothing and shaping rolls similar to the rolls 40 shown in Figs. 1 and 3 of the drawings.

After complete solidification of the impregnant the wire had a covering layer consisting of a thoroughly impregnated cotton braid having a smooth, pore-free surface. The covering layer had good electrical insulation properties, was strong, tough and flexible, and was extremely resistant to moisture, weather conditions, and abrasion. Laboratory abrasion tests indicated that its abrasion resistance was more than 13 times as great as that of standard asphalt-stearin-pitch impregnated wire.

Example 2

Polyethylene sebacate prepared according to the procedure indicated in Example 1 and of comparable molecular weight was applied to a wire similar to that of Example 1 under the conditions of said example. A 10/2/2 braid of cotton thread impregnated with a urea formaldehyde resin was formed in the thick layer of molten polyester. After being passed through smoothing and shaping rolls and after solidification of the polyester, the resulting wire had a covering layer having characteristics as excellent as those of the covering layer on the wire of Example 1.

Example 3

Ethylene glycol, sebacic acid, and maleic acid in the molecular ratio of approximately 1.05:0.95:0.05 were reacted in the same manner as indicated in Example 1 until the molten polyethylene sebacate maleate had an absolute viscosity of about 7,500 centipoises at about 120° C.

A thick coating of the molten polyester was formed on wire of the kind described in Example 1 and a 10/1/3 cotton braid was formed in the molten polyester under the conditions indicated in Example 1. After the wire had passed through the shaping and smoothing rolls and the impregnant had solidified, the covering layer on the completed wire had the excellent charac-

teristics of that described in Example 1 and furthermore was somewhat more flexible.

Example 4

A polyethylene sebacate maleate having the same proportions as that of Example 3 was formed under the same conditions as that of said example, the reaction, however, being carried out until the resulting linear polyester had an intrinsic viscosity in chloroform of approximately 1.06.

A wire of the kind described in Example 1 was passed through the molten polyester maintained at a temperature of about 100° C. on apparatus of the character shown in Figs. 1 and 2 of the drawings. At a distance a few inches below the die which formed the coating on the desired thickness on the wire, at which point the temperature of the polyester was between about 85° C. and 90° C., a 10/2/2 cotton braid was formed in the liquid layer on the wire under the conditions described in Example 1. The finished wire after being passed through smoothing and shaping rolls and after solidification had an impregnated braided covering layer which was smooth surfaced, homogeneous, strong, tough, flexible and of good abrasion and moisture resistance. The toughness, strength, flexibility, and abrasion resistance of the covering layer increased after the wire was put in use under conditions where it was exposed to sunlight, due to cross-linking which occurred in the impregnant.

Example 5

Ethylene glycol, succinic acid, and maleic acid in the approximate molecular proportions of 1.05:0.95:0.05 were placed in a suitable aluminum container and heated to about 200° C. while a stream of dry hydrogen gas was constantly bubbled through the reaction mixture. The heating was continued until the polyethylene succinic maleate had an absolute viscosity of about approximately 20,000 centipoises at about 120° C. Approximately 0.1 per cent of hydroquinone was added to retard subsequent oxidation of the reaction mixture upon exposure to the air.

The polyethylene succinic maleate so prepared, maintained in the molten condition at about 100° C., was applied to rubber covered copper wire and a 10/1/3 cotton braid formed in the molten layer in accordance with the procedure described in Example 1. In this case, however, the cotton braid had previously been impregnated with a 2 per cent solution of benzoyl peroxide in benzene. Immediately after the braiding operation the wire was passed between shaping and smoothing rolls and then through a curing oven maintained at about 150° C. similar to that shown in Fig. 4. A tough, hard, flexible abrasion resistant covering was obtained which had excellent insulation and weathering properties.

Example 6

Polyethylene succinate maleate of the kind described in Example 5 was applied to a rubber covered copper wire in a manner similar to the procedure of said example, and a 10/1/3 cotton braid formed in place in the thick layer of molten polyester. However, in this case the cotton threads contained no benzoyl peroxide, but a 10 per cent solution of benzoyl peroxide in benzene was applied to the wire at the point at which the braid was formed by means of apparatus similar to that shown in Fig. 4. The braided im-

pregnated wire was passed through smoothing and shaping rolls and thence through a curing oven maintained at a temperature of about 150° C. A wire having an impregnated coating of characteristics similar to that of the wire of Example 5 was obtained.

Example 7

Ethylene glycol, adipic acid and maleic acid in molecular proportions of 1.05, 0.95 and 0.05 were reacted together in a suitable aluminum container, being heated to a temperature of about 200° C. while a stream of dry hydrogen gas was bubbled through the reaction mixture. The reaction was carried on for about 29 hours until the polyethylene adipate maleate had an absolute viscosity at about 120° C. of about 13,000 centipoises. About 0.1 per cent by weight of benzoyl peroxide was added to the molten polyester while it was at about 60° C. This material, heated to 60° C., in which state it was molten, was applied to a rubber covered wire and a 10/13 cotton braid formed about the wire in the layer of molten polyester by apparatus similar to that of Figs. 1 and 2. The wire was passed through smoothing and shaping rolls and solidified. Thereafter it was cured at about 150° C. and allowed to cool. The finished wire had an impregnated braided covering which had extremely good abrasion resistance, resistance to embrittlement, moisture and weather resistance, electrical insulation properties, flexibility, toughness and strength.

Example 8

In this example polyethylene adipate maleate of the kind described in Example 7 was prepared and coated on a rubber covered wire at about 60° C., and a 10/13 cotton braid formed about the wire in the layer of molten polyester by apparatus similar to that of Figs. 1 and 2. In this case, however, no benzoyl peroxide was incorporated in the molten polyester applied to the wire. After the braiding operation the wire with the still soft impregnated was passed through smoothing and shaping rolls and cooled. At this stage the wire had an impregnated covering layer which had a smooth impervious surface and which was tough, strong, flexible, resistant to moisture and weathering, abrasion resistant and of excellent electrical insulation characteristics. After the wire was put into use and exposed to weather conditions including sunlight for a period of several months the strength, toughness, flexibility, and abrasion resistance of the impregnated layer was increased due to the cross-linking which occurred in the impregnant.

Example 9

Ethylene glycol, succinic acid, adipic acid and maleic acid in respective molecular proportions of 1.05:0.85:0.1:0.05 were heated in an aluminum reaction vessel at about 200° C. while dry oxygen free hydrogen gas was bubbled through the reaction mixture. The reaction was continued for about 33 hours until the molten polyester had an absolute viscosity at about 120° C. of about 17,000 centipoises. By means of apparatus similar to that of Figs. 1 and 2 a thick coating of the polyester at about 100° C. was applied to a rubber covered wire and a 10/13 cotton braid formed in the coating while it was at a temperature between about 85° C. and about 90° C. The impregnated wire, while the polyester was still soft, was passed through smoothing and shaping rolls similar to those shown in Figs. 1 and 3 and cooled. At this stage the wire had an impreg-

nated covering which had a smooth impervious surface and which was resistant to moisture, weathering and abrasion and which was strong, tough, flexible and of good electrical insulating characteristics. The toughness, flexibility, abrasion resistance and strength of the impregnated covering increased after the wire was put into use where it was exposed to weather conditions including sunlight.

Example 10

Polyethylene succinate maleate prepared in the manner described in Example 5 but in which the maleic acid constituted about 7 per cent by weight of the total acid used and which had a viscosity of about 20,000 centipoises at about 120° C. was intimately mixed while hot with 20 per cent by weight of the polyester of styrene and about 3 per cent by weight of the polyester of lamp black. This material was applied in the molten condition at about 100° C. to a rubber covered wire in accordance with the procedure described in connection with the apparatus of Figs. 1 and 2. At a point a few inches away from the means for applying the polyester coating a 10/13 cotton braid was formed about the wire in the thick coating of molten polyester. The threads forming the braid had on their surfaces a deposit of benzoyl peroxide in an amount sufficiently great to promote the cross-linking reaction. After the impregnated braided wire was passed through smoothing and shaping rolls, it was cured at a temperature of about 130° C. for about 10 minutes. A braided covering layer having a smooth, pore-free surface, good moisture and weather resistance, abrasion resistance, strength, flexibility, toughness and electrical insulation characteristics was obtained.

In each of the above examples the thickness of the coating of the molten polyester applied to the wire prior to the braiding operation was sufficiently thick to cause a globule of molten polyester to form at the point of braiding. Hence, the coating was thicker than the thickness of the braided layer of threads applied to the wire and therefore was thick enough to permit the polyester thoroughly to impregnate the subsequently applied braided covering and to exude through the interstices therein in sufficient amount so that upon subsequent smoothing and shaping of the impregnated braided layer a smooth surface was obtained.

Various modifications may be made in the processes and apparatus described above without departing from the spirit of the invention. Thus, an additional coating of impregnating material or the like may, if desired, be applied over the fibrous material which has been impregnated according to the invention and, if desired, such added coating may be smoothed by a suitable die or rolls. If it is desired to maintain under an inert oxygen-free atmosphere a mass of liquid impregnating material which is to be applied to the wire or other strand material, the reservoir containing such material, such as the container 27 of the apparatus of Figs. 1 and 2, may be provided with means for supplying therein an inert gas, such as nitrogen or carbon dioxide. While in the apparatus of Figs. 1 and 2 means for cooling the impregnated wire is shown, such means may be omitted in cases where the impregnant is sufficiently solidified to permit the impregnated wire to be collected without harm thereto. Whereas in each of the illustrated

forms of apparatus the impregnated wire is passed between smoothing rolls or through a die before it solidifies, it is apparent that such smoothing may be done subsequently, as by passing the wire containing solidified impregnant between heated rolls or through a heated die to soften and smooth the impregnant in cases where the nature of the impregnant is such as to permit it. The downward travel of the wire through the means for forming a fibrous covering on the wire shown in the two illustrated forms of apparatus, is advantageous since any movement of the liquid in the coating along the wire is in the downward direction into the layer of fibrous material being formed on the wire, but other directions of travel of the wire may be employed.

While the invention has been particularly described in connection with the braiding of thread into a liquid coating it is also applicable to other systems of formation of a layer of fibrous material, as knitting. When the layer of fibrous material is formed in place by an operation such as braiding or knitting which provides an interlaced or interlocking arrangement of threads, such thread arrangement resists spreading of the threads by the viscous impregnating material, which spreading would result in non-uniform impregnation.

Speeds of formation of the fibrous covering other than and higher than those indicated in the examples may be employed. In general, the speed of formation of the impregnated fibrous layer is not limited by the application or impregnation of the impregnating material, but is solely limited by the speed at which the fibrous covering can be formed. Braiding speeds of 25 feet per minute or more are possible with suitable braiding machines, and knitting speeds considerably higher are possible.

While the process of the invention has been discussed primarily with the impregnation of molten polyesters of high viscosity which are particularly advantageous, other impregnating materials of high viscosity under the impregnating conditions may be similarly employed. For example, high viscosity asphalts such as blown asphalts, pitches, synthetic resins or other polymers, or mixtures of these and other substances, having viscosities of the order of from 500 to 500,000 centipoises or more at the impregnating temperatures may be impregnated according to the invention, and, if necessary, cured on strands. Suitable polyamides, such as linear polyamides, which have melting points sufficiently low so that they may be employed as impregnants without harmful deterioration of the fibrous material being formed into a covering, or rubber or other insulating materials employed on the wire may also be impregnated according to the invention. Moreover, while the invention has particular advantages in the impregnation of highly viscous molten impregnants, it may also be employed to an advantage in the impregnation of highly viscous impregnants which are liquified by means of suitable solvents.

While in the above examples the fibrous material was described as being cotton, other types of fibrous materials may be employed such as silk, rayon, polyamide of the nylon type, and other materials.

Other modifications may be made in the processes and apparatus described above without departing from the spirit of the invention.

It is intended that the patent shall cover by suitable expressions in the appended claims whatever features of novelty reside in the invention.

What is claimed is:

1. The method of covering a strand with an impregnated layer of fibrous material comprising interlacing in place about a longitudinally downwardly moving strand, which is coated with a previously formed thick coating of an impregnating material in the form of a solidifiable, highly viscous liquid, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the exterior surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the interlacing of said stranded fibrous material begins, and thereafter solidifying said impregnating material.

2. The method of covering a strand with an impregnated layer of fibrous material comprising moving the strand longitudinally downwardly, applying to said moving strand in the form of a thick coating an impregnating material which is in the form of a solidifiable, highly viscous liquid, interlacing in place about said moving strand coated with said liquid impregnating material, at a point below the point of application to said strand of said liquid impregnating material, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the exterior surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the interlacing of said stranded fibrous material begins, and thereafter solidifying said impregnating material.

3. The method of covering a strand with an impregnated layer of fibrous material comprising interlacing in place about a longitudinally downwardly moving strand coated with a previously formed thick coating of an impregnating material in the form of a solidifiable, highly viscous liquid of a viscosity of at least about 500 centipoises, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the exterior surface thereof and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which interlacing of said fibrous material begins, and thereafter solidifying said impregnating material.

4. The method of covering a strand with an impregnated layer of fibrous material comprising braiding in place about a longitudinally down-

wardly moving strand which is coated with a previously formed thick coating of an impregnating material in the form of a solidifiable, highly viscous liquid, stranded fibrous material to form a braided layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said braided layer, exude from the exterior surface thereof, and impregnate thoroughly said braided layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the braiding of said stranded fibrous material begins, and thereafter solidifying said impregnating material.

5. The method of covering a strand with an impregnated layer of fibrous material comprising braiding in place about a longitudinally downwardly moving strand which is coated with a previously formed thick coating of an impregnating material which is in the form of a solidifiable, highly viscous liquid of a viscosity of at least about 500 centipoises, stranded fibrous material to form a braided layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said braided layer, exude from the exterior surface thereof, and impregnate thoroughly said braided layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the braiding of said stranded fibrous material begins, and thereafter solidifying said impregnating material.

6. The method of covering a strand with an impregnated layer of fibrous material comprising interlacing in place about a longitudinally downwardly moving strand, which is coated with a previously formed thick coating of an impregnating material in the form of a solidifiable, highly viscous liquid, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the exterior surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the interlacing of said stranded fibrous material begins, pressing the surface of said impregnated layer of fibrous material while said impregnating material is soft to form a smooth surface, and thereafter solidifying said impregnating material.

7. The method of covering a strand with an impregnated layer of fibrous material comprising interlacing in place about a longitudinally downwardly moving strand which is coated with a previously formed thick coating of an impregnating material in the form of a solidifiable, highly viscous liquid, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is at least about as thick as

said interlaced layer of stranded material, whereby said liquid impregnating material of said coating is forced through said interlaced layer, exudes from the surface thereof and forms and maintains a globule of said liquid impregnating material on said moving strand at the point at which the interlacing of said stranded fibrous material begins, and thereafter solidifying said impregnating material in said layer of fibrous material.

8. The method of covering a strand with an impregnated layer of fibrous material comprising interlacing in place about a longitudinally downwardly moving strand, which is coated with a previously formed thick coating of an impregnating material in the form of a solidifiable, highly viscous liquid of a viscosity of at least about 500 centipoises, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is at least about as thick as said interlaced layer of stranded material, whereby said liquid impregnating material of said coating is forced through said interlaced layer, exudes from the surface thereof and forms and maintains a globule of said liquid impregnating material on said moving strand at the point at which the interlacing of said stranded fibrous material begins, and thereafter solidifying said impregnating material in said layer of fibrous material.

9. The method of covering a strand with an impregnated layer of fibrous material comprising forming on a strand a thick coating of an impregnating material which is solidifiable when cooled but which is at an elevated temperature which causes it to be a molten viscous liquid, moving said strand longitudinally downwardly, interlacing in place about said moving strand coated with said impregnating material at a point along said strand where said impregnating material is still molten but removed from the point where said coating of molten impregnating material is formed, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the exterior surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the interlacing of said stranded fibrous material begins, and thereafter cooling said impregnating material to solidify it.

10. The method of covering a strand with an impregnated layer of fibrous material comprising forming on the strand a thick coating of an impregnating material which is capable of being melted to a viscous liquid which is solidifiable, and which is capable of being cured to cross-link the molecules thereof to form a tough flexible solid, the impregnating material in said coating being at a temperature sufficiently elevated to cause it to be a viscous liquid but insufficient to cause substantial cross-linking to occur, moving said strand longitudinally downwardly, interlacing in place about said moving strand coated with said impregnating material at a point along said strand where said impregnating material is still

molten but removed from the point where said coating of molten impregnating material is formed, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the exterior surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the interlacing begins, pressing the surface of said impregnated layer of fibrous material while said impregnating material is soft to form a smooth surface, and thereafter curing said impregnating material.

11. The method of covering a strand with an impregnated layer of fibrous material comprising interlacing in place about a longitudinally downwardly moving strand, which is coated with a previously formed thick coating of an impregnating material which is in the form of a thick, highly viscous liquid which is solidifiable and which is capable of being cured to cross-link the molecules thereof to form a tough, flexible solid, stranded fibrous material in the presence of an agent which promotes cross-linking of said impregnating material to form an interlaced layer about said strand under such tension that said stranded fibrous material is forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the interlacing of said stranded fibrous material begins, and thereafter solidifying said impregnating material.

12. The process of claim 11 in which said agent which promotes cross-linking of said impregnating material is a liquid which is applied in the form of a stream to said strand in the vicinity of said globule.

13. The method of covering a strand with an impregnated layer of fibrous material comprising forming on the strand a thick coating of an impregnating material which is capable of being melted to a viscous liquid, which is solidifiable and which is capable of being cured to cross-link the molecules thereof to form a tough flexible solid, the impregnating material in said coating being at a temperature sufficiently elevated to cause it to be a viscous liquid but insufficient to cause substantial cross-linking to occur, moving said strand longitudinally downwardly, interlacing in place about said moving strand coated with said impregnating material at a point along said strand where said impregnating material is still molten but removed from the point where said coating of molten impregnating material is formed, stranded fibrous material to form an interlaced layer about said strand under such tension that said stranded fibrous material is

forced into said liquid impregnating material of said coating, which is of sufficient thickness to permit said liquid impregnating material to be forced through said interlaced layer, exude from the exterior surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid impregnating material on said moving strand at the point at which the interlacing begins, applying to said molten impregnating material in the vicinity of said globule a stream of a liquid agent which promotes cross-linking of said impregnating material, pressing the surface of said impregnated layer of fibrous material while said impregnating material is soft to form a smooth surface, and thereafter curing said impregnating material.

14. The method of covering an electrical conductor with an impregnated layer of fibrous material comprising interlacing in place about a longitudinally downwardly moving conductor which is coated with a previously formed thick coating of a high molecular weight essentially linear condensation polymer which is in the form of a viscous liquid but which is solidifiable, stranded fibrous material to form an interlaced layer about said conductor under such tension that said stranded fibrous material is forced into said liquid polymer of said coating, which is of sufficient thickness to permit said liquid polymer to be forced through said interlaced layer, exude from the surface thereof, and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid polyester on said moving conductor at the point at which interlacing of said stranded fibrous material begins, and thereafter solidifying said polymer impregnated in said fibrous material.

15. The process of claim 14 in which said interlacing operation is a braiding operation.

16. The method of covering an electrical conductor with an impregnated layer of fibrous material comprising forming over a conductor a thick coating of a high molecular weight essentially linear polyester which is solidifiable but which is in the form of a viscous liquid, moving the conductor longitudinally downwardly, interlacing in place about said moving conductor coated with said liquid polyester at a point along said strand where said polyester is still liquid but removed from the point where said coating of liquid polyester is formed, stranded fibrous material to form an interlaced layer about said conductor under such tension that said stranded fibrous material is forced into said liquid polyester of said coating, which is of sufficient thickness to permit said liquid polyester to be forced through said interlaced layer, exude from the exterior surface thereof and impregnate thoroughly said interlaced layer, and which is of sufficient thickness to cause the formation and maintenance of a globule of said liquid polyester on said moving conductor at the point at which the interlacing of said stranded fibrous material begins, and thereafter solidifying said polyester impregnated in said fibrous material.

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