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HIGH STRENGTH BANDING TAPE

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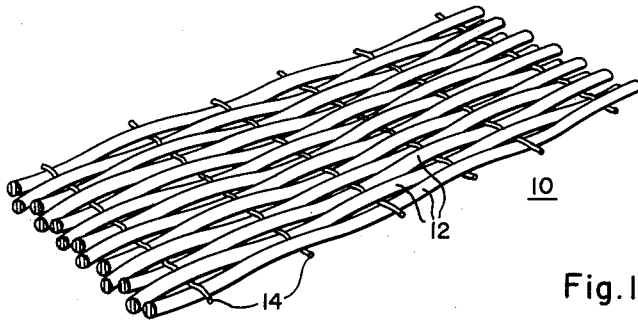


Fig. 1.

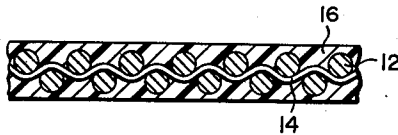


Fig. 2.

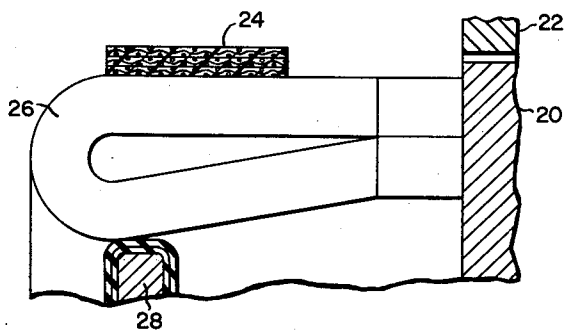


Fig. 3

WITNESSES

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HIGH STRENGTH BANDING TAPE

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This invention relates to tapes and particularly to flexible, tack-free tapes having high tensile strength.

This invention is directed to banding tapes of high tensile strength, which tapes comprise a fabric composed of a plurality of glass warp yarns which extend longitudinally of the tape and soft, non-abrasive fill yarns and a potentially thermosettable resinous composition impregnating and coating the fabric. The banding tapes of this invention have particular application for the banding of armatures and like members. The tapes can also be employed for other applications requiring high strength band members.

For a full and complete understanding of the nature of this invention, reference is made to the following detailed description and drawing, in which:

FIG. 1 is a fragmentary perspective view of fabric suitable for use in this invention;

FIG. 2 is a cross-sectional view showing the fabric of FIG. 1 having applied thereto a potentially thermosettable resinous composition; and,

FIG. 3 is a fragmentary longitudinal sectional view of a portion of a direct current dynamo-electric machine showing a band member applied on one end of the armature.

In accordance with this invention there is prepared a high strength tape having a tensile strength within the range of at least 800 to 1500 pounds per inch, which tape is highly suitable for the banding of armatures and like members. The tape of this invention comprises a fabric composed of a plurality of closely packed continuous filament glass warp yarns which extend longitudinally of the tape and spaced fill yarns of a relatively soft, non-abrasive yarn disposed at angles substantially perpendicular with respect to the glass warp yarns, and a potentially thermosettable resinous composition impregnating and/or coating the fabric to provide a resin ratio of from about 1.10 to 1.50. The preferred resin ratio being within the relatively narrow range of from 1.15 to 1.30.

Resin ratio is defined as the ratio of the weight of the untreated sheet of fabric plus the weight of the resin that is applied to the sheet to the weight of the untreated sheet.

The glass warp yarns that extend longitudinally of the tape are prepared from continuous filament glass yarns for ultimate tensile strength properties. The glass yarns are closely packed and the number of warp yarns per inch is preferably with the range of from about 60 to 100.

The fill yarns are preferably widely spaced and can be employed in the amount of from about 1 to 20 yarns per inch, with from about 10 to 18 fill yarns per inch being preferred.

For the purposes of this invention the fill yarn is of a soft, non-abrasive type organic fibrous material such as natural and synthetic organic fibers. Examples of suitable natural organic fibers are cotton and silk. Examples of suitable synthetic organic fibers are those prepared from polymers of acrylonitrile, such as those available commercially under the proprietary names Orlon and Acrilan; copolymers of vinyl chloride and acrylonitrile, available commercially under the proprietary name Dynel; polyethylene terephthalate, available commercially under the proprietary name Dacron; high molecular weight linear polyamides, available commercially under

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the name nylon; copolymers of vinyl chloride and vinylidene chloride available commercially under the proprietary name Saran; and copolymers of vinyl chloride and vinyl acetate, available commercially under the proprietary name Vinyon. Fill yarns comprising various combinations of the above fibers can be employed.

The tapes of this invention may be prepared from sheet material of a substantial width, for example, from about 36 inches to 40 inches or they may be prepared from fabric already cut into the desired tape width, for example 3/4 inch to 2 inches. If sheet material of substantial width is employed, it is, after resin treatment, slit into tapes of desired width.

The characteristics of a highly suitable glass fabric, in sheet or tape form, that can be employed in this invention are set forth in Table I below.

TABLE I

Weave	Unidirectional.
Weight, ounce per square yard	9.7.
Glass warp yarn (continuous filament)	150-2/2.
Warp yarn per inch	80
Fill yarn, Dacron (continuous filament)	70 denier.
Fill yarns per inch	14.

150-2/2 means that two ends of 150 untwisted yarns are brought together, and then two of these 150-2 end yarns are piled together; the expression 150 means 15,000 yarns to the pound.

Referring to FIG. 1 of the drawing, there is shown fabric 10 which is a unidirectional weave made by interleaving yarns 12 of continuous glass filament fibers with fill yarns 14 of smaller diameter. The yarns 14 are more widely spaced than the warp yarns 12, which are closely packed.

A single continuous filament of about 70 denier and prepared from one of the synthetic organic materials hereinbefore described has proved highly satisfactory in preparing the unidirectional fabric for use in this invention. The fill yarns are of substantially smaller diameter, usually of the order of from about 60 to 120 denier, than the warp yarns and are spaced apart relatively widely. A fabric constructed in this manner and as shown in FIG. 1 has little tensile strength in a direction generally transverse to the direction of the warp yarns 12, and extremely high tensile strength in the direction of the glass warp yarns 12. The relatively small diameter of the fill yarns 14 and the relatively wide spacing thereof prevents sharp bends in the glass fiber yarns 12 so that the glass fiber yarns 12 are arranged in a relatively straight line. In this relation the warp yarns are in the best position to bear high tensile stresses.

The unidirectional fabric is impregnated and/or coated with the desired resinous composition, preferably by dipping a sheet or tape of the fabric in a bath containing the resinous composition dissolved in a suitable solvent. After this impregnation and/or coating of the fabric, the treated fabric is dried to remove the solvents therefrom and to provide a treated sheet material that is flexible and tack-free. It may be then stored for future use or used immediately. Sheets of fabric are subsequently slit into tapes of desired width.

It is important that the resin or resin composition employed in treating the fabric of this invention be such that a tack-free resin coating is provided on the surface of the treated fabric. It is apparent that a tack-free treated tape is highly desirable for ease of application and furthermore, a tack-free condition prevents dirt and other deleterious material from adhering to the tape during application thereof.

FIG. 2 of the drawing is a cross section of the glass fabric 10 impregnated and coated with a potentially thermosettable resinous composition 16.

There are many heat-hardenable resins and resin compositions that may be employed in treating the fabric to produce the banding tape of this invention. Thermoplastic resinous compositions are not desirable because they will soften at relatively low temperatures. The banding tapes of this invention will ordinarily be employed in apparatus that will be subjected to high temperatures in service. Thus it is preferred to employ thermosettable resinous compositions.

Numerous thermosettable resinous compositions are available. Phenolic resins, polyepoxides, melamine-aldehyde resins, and silicone resins, for example, may be employed.

Exceptionally good results have been secured with completely reactive polyester-type resinous compositions that thermoset. These completely reactive compositions may comprise one or more compounds containing two or more unsaturated aliphatic groups. Examples of such compounds are diallyl phthalate, diallyl sebacate, and divinyl benzene. The liquid resinous compositions to be used may employ two or more compounds having reactive unsaturated $>C=C<$ groups capable of vinyl-type addition polymerization. Particularly good results have been secured by employing a solution comprising a liquid monomeric compound having the group $H_2C=C<$, in which is dissolved an unsaturated polyester having the group $>C=C<$. Particularly good results have been secured by employing as a polyester resin the reaction product of an ethylenic dicarboxylic acid or anhydride thereof such, for example, as maleic acid, fumaric acid, maleic anhydride, monochloromaleic acid, itaconic acid, itaconic anhydride, citraconic acid and citraconic anhydride. The unsaturated dicarboxylic acid or anhydride or mixtures thereof are reacted with a substantially molar equivalent of one or more polyhydric alcohols such as ethylene glycol, glycerol, propylene glycol, diethylene glycol, pentaerythritol or mixtures of two or more. Castor oil has been employed successfully in an esterification reaction with maleic anhydride. The resultant ester, such as castor oil maleate ester, is admixed with a polymerizable unsaturated monomer, for example, monostyrene, in the proportions of from about 10 to 95 parts by weight of the monostyrene and from 90 to 5 parts by weight of the ester.

In the preparation of the unsaturated alkyd esters, an ethylenically unsaturated alpha-beta dicarboxylic acid or anhydride thereof may be replaced with up to 95% of the weight thereof by a saturated aliphatic dicarboxylic acid or aryl dicarboxylic acid or anhydride, such for example as succinic acid, adipic acid, sebacic acid, phthalic acid, phthalic anhydride or the like. In some instances, epoxides have been employed in lieu of glycols, particularly in reaction with dicarboxylic acid instead of their anhydrides.

The unsaturated alkyd esters are dissolved in a liquid unsaturated monomer having the group $H_2C=C<$. Suitable liquid unsaturated polymerizable monomers are: monostyrene, alpha-methylstyrene, 2,4-dichlorostyrene, paramethyl styrene, vinyl acetate, methyl methacrylate, ethyl acrylate, diallyl phthalate, diallyl succinate, diallyl maleate, allyl alcohol, methallyl alcohol, acrylonitrile, methyl vinyl ketone, diallyl ether, vinylidene chloride, butyl methacrylate, allyl acrylate, allyl crotonate, 1,3-chloroprene, and divinyl benzene, as well as mixtures of two or more of any of these monomers.

An excellent completely reactive composition is one composed of a solution of from 90 to 50 parts of aryl-alkene polymerizable monomer of from 10 to 50 parts by weight of the alkyd reaction product of (A) an unsaturated acidic compound from the group consisting of maleic acid, maleic anhydride, fumaric acid, citraconic acid, and citraconic anhydride in admixture with one or more saturated straight chain dicarboxylic acids having the carboxyl groups disposed at the end of the straight chain, the chain having from 2 to 10 non-carboxyl car-

bon atoms and no other reactive groups, and (B) a molar equivalent within $\pm 10\%$ of an aliphatic saturated glycol having no other reactive groups than the hydroxyl groups. The proportion of the unsaturated acidic compound in the mixture of acids should be between 5% and 50% of the weight of the mixture. Suitable saturated dicarboxylic acids are adipic acid, sebacic acid, azelaic acid, suberic acid, succinic acid, decamethylene dicarboxylic acid and diglycolic acid and mixtures thereof. With the longer chain saturated dicarboxylic acids as, for example sebacic acid, the proportion of maleic anhydride, for example, may be higher than if the saturated acid were all succinic acid, if cured products of similar degrees of hardness are desired. Suitable glycols for reaction with the mixture of saturated and unsaturated acids are ethylene glycol, propylene glycol, diethylene glycol, 1,5-pentanediol and triethylene glycol. Mixtures of the glycols are suitable for producing the reaction product. The reaction of the (A) acidic compounds and (B) the glycols can be carried out by heating in a reaction vessel at temperatures of from 100°C . to 250°C . for from 24 hours to 2 hours to a low acid number of below 60.

The following are specific examples of the preparation of the unsaturated alkyd reaction products to be dissolved in a vinyl aryl monomer:

Example I

A mixture of 44 mole percent of adipic acid and 6 mole percent of fumaric acid are combined with 50 mole percent of propylene glycol and reacted with CO_2 sparging for about 4 hours at 140°C . in a closed reaction vessel after which the temperature is raised to about 220°C . over a 4 hour period and the reaction is continued at 220°C . for 8 hours. A syrupy polyester resin is produced.

Example II

Another composition comprises the reaction product of 10 mole percent of maleic anhydride, 40 mole percent of adipic acid, and 50 mole percent of diethylene glycol.

Example III

A reaction product is prepared by reacting 30 mole percent of sebacic acid, 20 mole percent of maleic anhydride, and 50 mole percent of diethylene glycol under the same conditions as in Example I with a syrupy resin of low acid number resulting.

The unsaturated esters of alkyd resins of these examples are dissolved in a monomeric compound having the group $H_2C=C<$, such as monostyrene, or a simple substitution derivative of monostyrene, or a mixture of two or more monomers, as above described, to produce low viscosity completely reactive solutions having present from 15% to 80% by weight of the unsaturated ester. Particularly good results are obtained by dissolving the unsaturated esters in monostyrene to produce solutions containing from 20% to 85% by weight of monostyrene and the balance, 80% to 15% by weight, composed of the unsaturated esters.

The above solutions are solvent reactive compositions which will polymerize completely when admixed with one or more vinyl-type polymerization catalysts, such as benzoyl peroxide, lauroyl peroxide, methyl ethyl ketone peroxide, t-butyl hydroperoxide, ascaridole, t-butyl perbenzoate, di-t-butyl diperphthalate, ozonides, and similar catalysts, in an amount of from 0.5% to 5% and more, by weight. A proportion of the catalyst obviously may be present in amounts differing from these percentages.

Example IV

The resin composition of Example III is dissolved in monostyrene to produce a solution composed of 35% by weight of monostyrene and 65% by weight of the polyester reaction product. Each 100 parts of the resulting solution by weight is admixed with 3 parts by weight of t-butyl hydroperoxide. The resinous composition thus produced is dissolved in toluene to provide a resinous

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varnish impregnating composition composed of about 50% resin solids.

Other suitable solvents that may be employed for dissolving the resin polyester compositions described above are benzene, xylene, ethanol, isopropanol, and methyl ethyl ketone.

The resinous varnish composition of Example IV is employed to impregnate and coat a sheet of fabric having the construction as set forth in Table I to a resin ratio of about 1.20. The impregnated sheet is passed into an oven to remove the solvent, to advance the cure of the resin composition to the B-stage, and to provide a tack-free, flexible sheet of fabric composed of the glass fabric of Table I and the polyester resin composition of Example III.

The treated sheet is slit to one inch widths to provide tack-free, flexible banding tapes. One of the banding tapes is wrapped around a 6 inch diameter mandrel to provide thereon a convolutely wound band or hoop having a wall thickness of about 1 inch. The wrapped mandrel is placed in an oven for 30 minutes at a temperature of about 160° C., removed from the oven and cooled to room temperature. The band thus produced is removed from the mandrel and tested for tensile strength and the resulting test indicated that the hoops would withstand a load of 29,900 pounds and had an ultimate tensile strength of 96,800 pounds per square inch. The tensile tests were performed on a Baldwin Southwark universal testing machine.

Referring now to FIG. 3 of the drawing, there is illustrated the application of the banding tape of this invention to an armature or rotor member 20 of a direct dynamo-electric machine which also has a field-member or stator member 22. As shown, an armature band or band member 24 has been applied about the periphery of coil ends or end turns 26 of the armature winding to retain the winding against centrifugal force. A desired number of layers of the flexible, tack-free tape of this invention is wound tightly around coil ends 26. Heat is applied to cure the resin composition comprising the tape to an infusible, insoluble state to produce armature band 24.

It is well known in the art that it is necessary to provide a band about the winding end turns of a rotor, armature and like rotating members of electro-dynamic machines to prevent the end turns from moving radially outwardly under the action of centrifugal force.

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In the particular case illustrated, the armature band 24 is used to hold end turns 26 against coil support 28.

It is intended that the above description and drawing are merely descriptive of the invention and not in limitation thereof.

I claim as my invention:

1. A flexible banding tape comprising a fabric comprised of from 60 to 100 closely packed continuous filament glass warp yarns per inch which warp yarns extend longitudinally of the tape and from 1 to 20 spaced continuous organic filament fill yarns per inch, and a potentially thermosettable resin composition selected from at least one of the group consisting of polyepoxide resins, polyester resins, phenolic resins and silicone resins impregnating and coating the fabric to provide a resin ratio of from about 1.10 to 1.50, said tape being tack-free and having a tensile strength within the range of from at least 800 to 1500 pounds per inch.

2. A flexible banding tape comprising a fabric comprised of from 60 to 100 closely packed continuous filament glass warp yarns per inch which warp yarns extend longitudinally of the tape and from 8 to 18 spaced continuous organic filament non-abrasive fill yarns per inch, and a potentially thermosettable resin composition selected from at least one of the group consisting of polyepoxide resins, polyester resins, phenolic resins, and silicone resins impregnating and coating the fabric to provide a resin ratio of from about 1.15 to 1.30, said tape being tack-free and having a tensile strength within the range of from at least 800 to 1500 pounds per inch.

3. A flexible tack-free banding tape comprising a fabric comprised of from 60 to 100 closely packed continuous filament glass warp yarns per inch which warp yarns extend longitudinally of the tape and from 8 to 18 spaced continuous organic filament non-abrasive fill yarns per inch, and a potentially thermosettable polyester resin composition impregnating and coating the fabric to provide a resin ratio of from about 1.15 to 1.30, said tape having a tensile strength within the range of from at least 800 to 1500 pounds per inch.

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Dedication

3,073,004.—*Clarence L. Zeise, Jr.*, Plum Boro, Pa. **HIGH STRENGTH
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Hereby dedicates the remaining term of the patent to the Public.
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