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R. S. OWENS
KNOTTABLE GLASS FIBER STRAND

2,903,779

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FIG. 1.

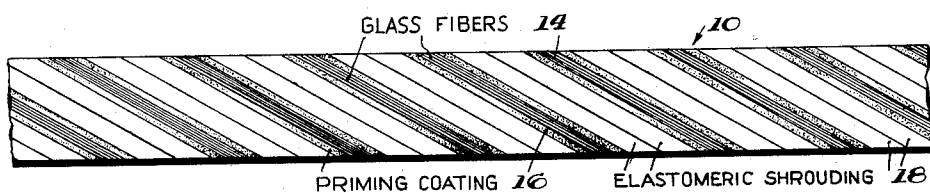


FIG. 2.

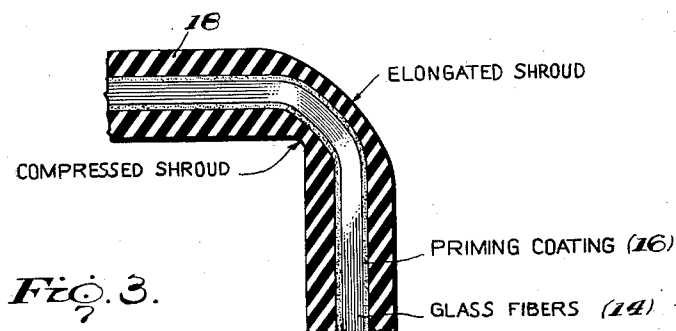
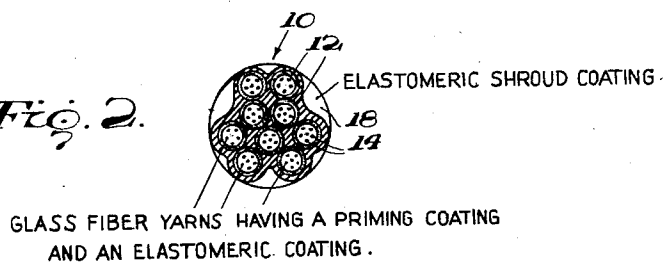


FIG. 3.

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2,903,779

KNOTTABLE GLASS FIBER STRAND

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3 Claims. (Cl. 28—80)

This invention relates to fiber glass yarn or cord, and more particularly to fiber glass yarn or cord of increased flexibility and knot strength.

The present application is a continuation-in-part of my copending application for patent, Serial No. 429,103 for a Knottable Glass Fiber Strand, filed May 11, 1954 and now abandoned.

Because of its relatively great tensile strength, fiber glass yarn or cord has advantages over other yarn or cord where that quality is desired, but it has the serious disadvantage of being relatively non-flexible or brittle. This characteristic limits the angle or radius of curvature through which the fiber glass yarn or cord may be bent, twisted, or flexed before the individual filaments or fibers in the yarn or cord break. This non-flexibility seriously reduces the strength of untreated fiber glass yarn or cord when it is knotted, for example, as compared to its straight-line strength.

In the past, attempts to increase the flexibility of fiber glass yarn or cord have included the application of sizing or lubricants to the individual fibers or filaments in the strands or plies making up this yarn or cord, or the application of a shroud coating of a flexible or resilient material to the individual yarns, or a finish coating to the completed article made from the fiber glass yarn. The sizing acts as a lubricant to reduce abrasion between the individual filaments or glass fibers in the strands which are plied together to form a length of yarn or cord and thus reduces breakage due to internal abrasion, while a shroud or finish coat upon the strands reduces breakage due to external abrasion. However, the application of sizing or a resilient shroud coating to fiber glass yarn or cord, as practiced in the past, has not appreciably reduced breakage which results from flexing of these fiber glass yarns or cords when the critical angle of flex is approached.

Although it has been found that reduction of the diameter of the individual filaments or fibers in fiber glass yarn or cord increases the flexibility thereof, there is a practical limit to which the diameter can be reduced. Moreover, yarn or cord made from the smallest commercially available glass fibers or filaments still lacks the desired flexibility and knot strength. However, I have discovered that the flexibility and knot strength of fiber glass yarn or cord may be greatly increased by coating the same with an elastomeric material, provided the quantity of the material applied and the method of application are such that it is made to penetrate not only the interstices between the separate plies or strands of fiber glass which are plied together to form the yarn or cord in question but also the interstices between the individual filaments or fibers in the separate plies or strands, and by insuring that this coating material is bonded to the individual filaments or fibers.

Since the individual filaments in a length of fiber glass yarn or cord so fabricated will be isolated from each other by the elastomeric coating, abrasion between these individual fibers or filaments in the yarn or cord will be prevented. Likewise, abrasion between the separate strands or plies in the yarn or cord will be prevented when it is knotted or wound. This will also be true

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of this yarn or cord when it is used, for example, in making a fabric, should the latter be creased or folded. In addition, and more importantly, flexing of yarn or cord of this type beyond its critical angle of flex is prevented apparently due to the fact that the coating forms an elastic cushion at the point of flexure of a flexed length of yarn or cord which cushion inhibits the flexing of the fibers or filaments beyond their critical angle of flex.

10 Accordingly, an object of my invention is to provide a new or improved yarn or cord of increased tensile and knot strength.

Another object of my invention is the provision of a new and improved fiber glass yarn or cord of increased knot strength as compared to conventional fiber glass cord or yarn of corresponding size.

15 A further object of the invention is to provide a new and improved fiber glass yarn or cord provided with a coating which inhibits flexing of the yarn or cord beyond the critical angle of flex thereof.

A more general object of the invention is the provision of a new and improved fiber glass yarn or cord which may be woven into fabrics that may be folded or creased without damage to the fabrics.

20 These and other objects, advantages, and capabilities of the invention will become apparent from the following description wherein reference is made to the accompanying drawings, and in which:

Fig. 1 is a schematic longitudinal view of an improved 9-ply cord or yarn embodying the present invention showing the relationship of the coated plies in the cord to each other and the manner in which the coating on the individual plies cushions the plies from each other;

Fig. 2 is a diagrammatic diametrical sectional view of the strand shown in Fig. 1; and

Fig. 3 is an axial or longitudinal sectional view of a single length of elastomeric coated yarn or cord embodying the present invention bent at substantially a right angle to show the effect of this bending on the fiber glass core and the outer or shroud portion of the coating.

As indicated more or less diagrammatically in Fig. 2 the improved yarn or cord of the present invention indicated as an entirety by the number 10 comprises a plurality of plies or strands 12 of fiber glass which are plied together as explained hereinafter. Each of these plies or strands, in turn comprises a large number of individual glass filaments or fibers, a few of which are indicated at 14 in Figs. 1 and 2. These individual filaments or fibers may be of the continuous type, or of the staple length type, and they are formed into strands or plies in much the same way as textile fibers. In order to avoid confusion, it will be assumed that the individual fibers are of the continuous length type in the description which follows, and the plies or strands 12 will be considered the basic ply or strand because this strand or ply is available commercially either as a single strand or as a number of single strands plied together to form different multi-ply yarn or strands depending upon the needs of a particular user.

20 In the fabrication of a length of yarn or cord 10, and assuming the basic strands or plies 12 are free of sizing, these basic strands or plies are each first given a primer coat indicated at 16. Suitable apparatus may be used for this purpose, such as the apparatus shown in my prior Patent No. 2,800,761. In the process of applying this primer coat to the basic strands by the apparatus shown in this patent, the strands 12 pass through a bath of this primer in a liquid form. Any suitable primer may be used which will serve to bond to fiber glass the elastomer with which it is desired to coat the glass fibers or filaments in the basic strands 12. Examples of suitable primers will be mentioned hereinafter. To achieve

the best results, the primer bath should be sufficiently fluent to infiltrate, penetrate, or enter into the voids or interstices between the individual filaments or fibers 14 in the strands 12 so that a film of binder completely covers the exterior surface of each separate filament or fiber 14.

After the primer coat 16 has dried to the desired extent, a suitable elastomeric coating 18 is applied to the basic strands or plies 12, and they are then twisted together under tension, while the elastomeric coating 18 is still in a liquid state or only slightly dried, hardened or set as disclosed in my aforesaid patent. This coat may vary in amount, but should be sufficiently heavy so that the pressure generated between the basic plies or strands 12 as a result of the fact that they are under tension during twisting thereof, forces the elastomeric coating material to penetrate or infiltrate the voids or interstices between the individual filaments or fibers 14 and the voids or interstices between the several twisted together basic strands or plies 12. Since each fiber or filament 14 is covered by a film 16 of primary or binding material as before described, the elastomeric coating material entering the interstices between the fibers or filaments will be bonded to the same throughout the entire surface area thereof. A unitary structure is thus provided as indicated in Figs. 1 and 2 in which the individual glass filaments 14 in each of the basic strands 12 are each protected against abrasion by the other filaments in the strand and each ply or strand 12 is protected against abrasion by other plies or the strands with which it is plied.

ments designated E and F which are .00028" and .00033" in diameter, respectively.

The whole number 450 following the letters ECD in the example here used indicates approximately $\frac{1}{100}$ of the yardage in one pound of the individual fiber or filament.

Finally, the two numbers separated by a diagonal line following the number 450 in the example used herein indicate the number of plies in a particular yarn or cord, the number before the diagonal line indicating the number of basic plies or strands plied together to make an intermediate multi-ply strand, and the number following the diagonal line indicating the number of these multi-ply strands which are plied together in the particular composite yarn or cord in question. Thus, in the example used above, the 1/0 designates a single basic strand or ply.

Because the tensile strength desired in yarn or cord will depend on the use to which it is to be put, the various yarns or cords available on the market may consist of a number of the basic strands or plies above-mentioned plied into a unitary strand of yarn. For example, three of these basic strands may be plied together to form a triple-ply intermediate strand, and three of these triple-ply strands may then be plied together to form a unitary yarn or cord consisting of nine basic plies or strands as indicated in Fig. 2. This would be indicated by the use of the symbol 3/3 in place of 1/0 in the example above given.

In the following table, the results obtained with various commercially available Owens-Corning Fiberglas Corporation yarns are shown.

Sample No.	1	2	3	4	5
Type yarn and structure.....	ECD 450-3/3.	ECD 450-3/3.	ECD 450-3/3.	ECD 450-3/3.	ECD 450-3/3
Twists per inch.....	3.	3.	3.	3.	3.
Weight percent glass.....	100.	48.2	33.93	13.7	46.0.
Weight and elastomer (incl. primer coating) percent.....	0.	51.8(N)	66.07(N)	86.9(N)	54.0(R).
Average breaking strength (lbs.).....	11.35	14.2	11.7	12.9	11.6.
Knot strength (lbs.).....	2.1	3.6	4.6	7.2	3.5.
Ratio knot strength breaking strength, percent.....	18.5	25.4	39.3	66.0	30.1.

(N)=neoprene, (R)=natural rubber, in the above table.

It is to be understood that the ratio of the weight of the elastomeric coating to the weight of the glass in the improved yarn or cord of the present invention may be varied, depending on the purpose for which the yarn or cord is to be used and upon the type of elastomeric coating which is used. For the purpose of more clearly disclosing the invention, a few examples will be set forth below using as the basic ply or strand first a yarn or cord supplied to the commercial market by Owens-Corning Fiberglas Corporation, and identified by the manufacturer by the designation ECD 450-1/0. A single ply or strand of this yarn has a straight pull breaking strength of approximately 1.1 pounds.

From the letters and figures by which this particular yarn is identified, information with respect to the physical characteristics thereof may be obtained by reference to the tables compiled by the manufacturer. Using ECD 450-1/0 as an example, the letter E indicates that the glass in the fibers or filaments composing the yarn has good electrical properties, C indicates that the filaments or fibers are of the continuous length type as distinguished from the staple length type, and the third letter D indicates the diameter of the individual filaments or fibers, the letter D being used to designate a filament .00023" in diameter. In general, the smaller the diameter of an individual filament or fiber, the greater its flexibility and the flexibility of yarn made from the same, but a diameter of .00023" is about the smallest that can be obtained from a commercial production standpoint. Where less flexibility and greater tensile strength are desired, a yarn having a larger diameter filament may be used, but it preferably should not exceed approximately .00038". This diameter is designated by the letter G. Owens-Corning Fiberglas Corporation also makes fila-

The primer coating used will be determined by the elastomeric coating which it is intended to use. For example, if the elastomer to be applied is neoprene, the primer may be Neoprene Cement (du Pont Company) which is neoprene dissolved in toluene and thinned with ethyl acetate. If the elastomer is to be natural rubber, Goodrich Acid Seal Paint No. 1040 (B. F. Goodrich Co.) may be the primer. This paint comprises a mixture of a thermoprene and pigments. It thus differs from ordinary paint which may comprise a mixture of pigments with suitable oils and turpentine. Thermoprenes are rubber isomers prepared by the treatment of rubber with isomerizing agents such as sulphonic acids. Particular advantages of Acid Seal Paint are its great adhesive power, elasticity, and resistance to chemical and moisture penetration, and to temperature change. In the event a vinyl coating (vinyl chloride-acetate copolymer for example) is to be the elastomer, the glass fibers may have a primer coating which provides a silicone oil treatment. The vinyl coating with a suitable plasticizer, e.g., dioctyl phthalate, is then applied directly to the fibers so finished.

The neoprene latex used for the coatings on Samples 2 to 4 of the above table had the following composition on a wet basis:

	Parts
59.6% Neoprene Latex 601A (Vanderbilt)	168
10% Aquarex D solution.....	10
50% Zinc oxide dispersion.....	10
70 73% Sulfur dispersion.....	1.37
50% Age-Rite White dispersion.....	4
50% McNamee clay slurry.....	20
12.5% Acrysol GS.....	1
Setsit-5	2
75 Plastogen emulsion	8.3

Aquarex D solution is a product of the E. I. du Pont Company and it is listed in Report No. 50-2 of that organization dated August 1950. It comprises the sodium salts of sulfate mono-esters of a mixture of higher fatty alcohols consisting chiefly of lauryl and myristyl derivatives, and it serves as a surface wetting agent.

Acrysol GS is manufactured and sold by the Resinous Products and Chemical Company, Philadelphia, Pennsylvania. It is described in Circular No. PL-3 of that organization dated December 1936. Acrysol GS comprises a water solution of the sodium salts of polymerized esters of acrylic acid, the solids comprising 25% of the solution. It is used as a thickening agent for natural and synthetic latex.

The rest of the ingredients of the neoprene based coating are available from R. T. Vanderbilt Co., 230 Park Avenue, New York city, New York, including the zinc oxide dispersion which comprises approximately 50% zinc oxide, 48% water, and 2% Darvin No. 1, the latter being a dispersing agent for dry materials. Darvin comprises the sodium salt of polymerized alkylaryl sulphonic acid, and it acts as an activator for the accelerator used in the coating, which, in this case, is the Setsit-5 described below. Its purpose is to retard setting.

The sulphur dispersion comprises approximately 73% sulphur, 25% water and 2% of a suitable dispersing agent. It is included in applicant's coating to impart high modulus, to increase freeze resistance, and to reduce stiffening.

The Age-Rite White dispersion is a di-beta-naphthyl-paraphenylenediamine, and it acts as an antioxidant. It increases the resistance of the coating material to sunlight and to aging, and it also increases the tensile strength thereof both before and after aging.

The McNamee clay slurry is a dispersion comprising approximately 50% clay, 49% water, and 1% Darvin. It acts as a filling agent thereby reducing the cost of the coating, and it also improves the drapiness or hand of fabric or textile materials.

The Setsit used in the coating is a dithiocarbamate and may be diluted with water in the proportion of 1 to 2 parts of water. It acts as an accelerator, and it improves tensile strength and enhances retention of other desirable properties as the coating ages, particularly, its elasticity.

The Plastogen emulsion used in compounding the coating comprises 87.5% Plastogen, 9% oleic acid, and 3.5% triethanolamine, the Plastogen per se in this emulsion comprising a mixture of an oil soluble sulphonic acid of high molecular weight with a paraffin oil. Plastogen emulsion is a plasticizing and softening agent and also improves dispersion of the ingredients compounded together in the coating.

In the examples included in the first table set forth above, the commercial yarn used consisted of a total of nine basic strands plied together as indicated by the designation 3/3. In fabricating coated strands 2 to 5 in this table, three of the basic strands were first coated and plied together in accordance with the method and by the use of apparatus disclosed in my aforesaid Patent No. 2,800,761. Three of the intermediate plies or strands thus formed were coated and plied together in the same manner. Additional coating was then applied to the nine ply strand or cord thus formed to bring the percentage of the elastomer in the cords up to that shown in Examples 2 to 5 of the table. For example, a second coat of elastomer was applied to the cord formed in Examples 2 and 5 above-mentioned to bring the percentage of elastomer in the finished cord to approximately 50% by weight. In Example 4, a total of three coats was used to bring the percentage of elastomer in the finished cord up to approximately 86%.

For the purpose of comparing the strength of the improved yarn or cord of the present invention with standard commercial yarn, it should be noted that standard fiber glass cordage of $\frac{1}{64}$ " diameter (cord No. EC-5-1),

which appears to be the smallest size cord manufactured by Owens-Corning Fiberglass Corporation, shows a straight line breaking strength of 15 pounds and a knot strength of 2 pounds for the untreated cord. This gives a ratio of knot strength to breaking strength of 13.3%. The smallest rubber treated fiber glass cordage shown in literature on which the breaking strength is also shown is EC-10-1. The straight-line breaking strength is shown as 15 pounds and the knot strength as 2.8 pounds. This gives a ratio of knot strength to breaking strength of 18.7%.

By reference to the last line of the first table above set forth, it will be clearly seen that the yarn or cord of the present invention is superior, particularly in flex life as determined by the knot strength to cord or yarn in which the individual filaments or fibers are not coated sufficiently to inhibit bending of these filaments or fibers to a degree approaching or exceeding the critical angle of flex. It will further be noted that the most appreciable increase in knot strength occurs when the percentage of elastomer is above 50% and up to approximately 87%.

The action of the elastomeric coating 18 in effecting this result will best be understood by reference to Fig. 3. In this view, it will be noted that the coating on the outer surface of the bend has been thinned out by stretching as compared with the thickness of this coating along the straight portions of the yarn or cord 10. This stretching is greatest on the outer surface of the bend and is zero at the surface where the elastomeric coating makes contact with the primer coat 16 because the glass filaments 14 do not elongate or stretch. It will be noted that the elastomeric coating 18 is less thick on the inner surface of the bend than along the unbent portion of the yarn 10. This is due to the compression of the elastomeric coating 18 at this area of the bend. Thus, the resistance of the elastomeric coating 18 to distortion at an area of bend in the yarn, either by stretching or compression, and its thickness will determine the abruptness or angle of the bend. With the elastomeric coating materials of the type suggested in this specification and applied in the quantities herein suggested, the critical angle of flex may be approached but not reached prior to the time the ratio of the knot strength to straight pull strength is at least 25%.

As a result of various tests performed on fiber glass cord or yarn embodying the present invention, it was concluded that the greater the percentage of the elastomer by weight in the cord up to approximately 87%, the higher the knot strength and the greater the resistance of the elastomeric coating to compression and the less likelihood that the critical angle or flex will be reached.

While a preferred embodiment of the invention has been shown and described, it will be apparent that variations and modifications thereof may be made without departing from the underlying principles of the invention. It is desired, therefore, by the following claims, to include within the scope of the invention, all such variations and modifications by which substantially the results of the invention may be obtained through the use of substantially the same or equivalent means.

What I claim is:

1. A knottable fiber glass yarn comprising glass fibers of an average diameter ranging from .00023 to .00038 inches and including a plurality of plies each of which is impregnated and coated with first a priming coating, and second, a shroud coating of a compressible chemically-resistant elastomer bonded to the plies by the primer coating; the yarn having several twists per inch; the weight percentage of the glass fiber being between approximately 13 and 50 but below 50; the weight percentage of the elastomer, including the primer coating, being above 50 and up to about 87; the average breaking strength ranging between 11.7 and 14.2 pounds; the knot strength ranging between 3.6 and 7.2 pounds; and the ratio of the knot strength to the breaking strength being

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above 25 percent and ranging up to 56 percent or more.

2. A knottable fiber glass yarn comprising glass fibers of an average diameter ranging from .00023 to .00038 inches, said yarn including a plurality of plies each of which comprises a plurality of individual fibers and each of which is impregnated and coated with first a priming coating, and second, a coating of a compressible chemically-resistant elastomer bonded to the plies and the individual fibers in said plies by the priming coating; the yarn having several twists per inch; the weight percentage of the glass fiber being between approximately 13 and 50 but below 50; the weight percentage of the elastomer, including the primer coating, being above approximately 50 and up to about 87; and the ratio of the knot strength to the breaking strength being above 25 percent.

3. A knottable fiber glass yarn or cord comprising a plurality of plies, each of which comprises a plurality of glass fibers of an average diameter ranging between

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approximately .00023 inch to .00038 inch, said yarn being impregnated and coated with a compressible, chemically-resistant elastomer bonded to the plies and to the individual fibers in said plies so as to fill the interstices between the fibers in the individual plies and between the several plies and forming a shroud coating on said yarn, said plies being intertwisted by several twists per inch, the weight percentage of glass fiber being above 13, and the weight percentage of the elastomer including the primer coat being above 50, and the ratio of the knot strength to the breaking strength being above 25 percent.

References Cited in the file of this patent

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