

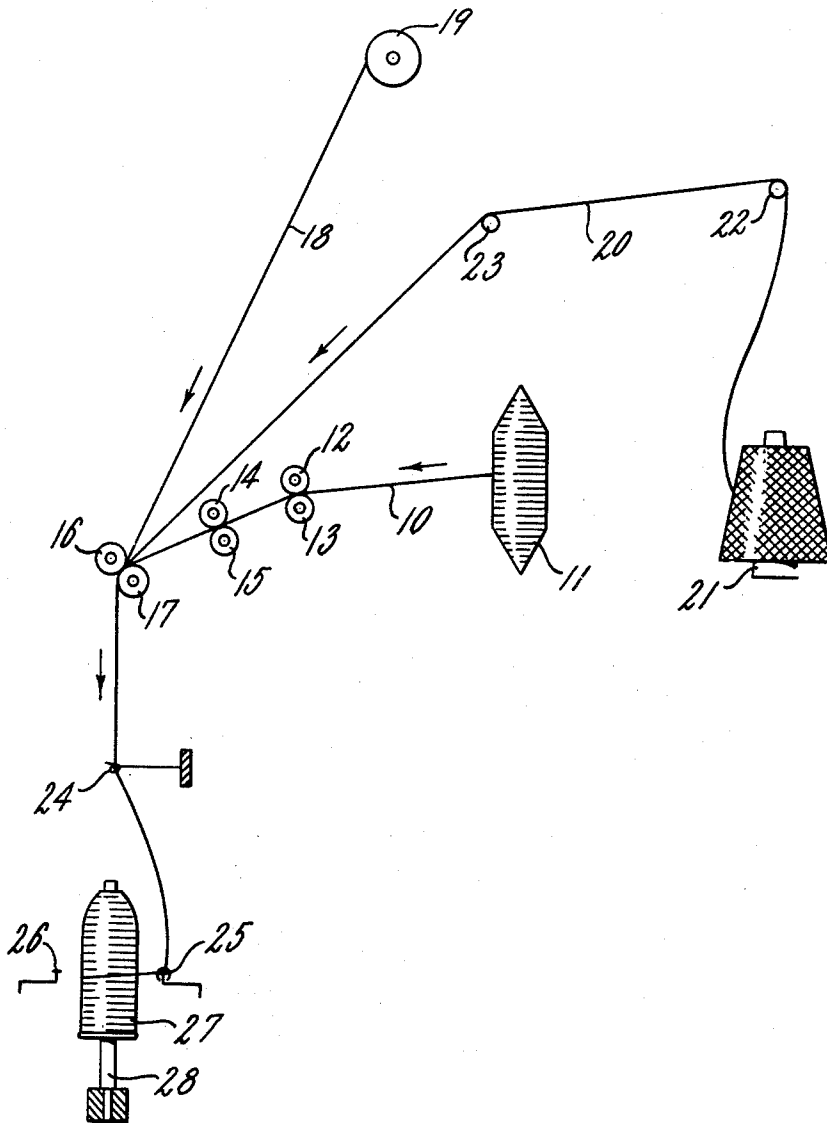
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ELASTIC CORE YARN

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3,127,731

PLASTIC CORE YARN

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20 Claims. (Cl. 57—152)

This invention relates to a novel elastic yarn of the type disclosed in the copending application for United States Letters Patent Serial No. 739,780, filed June 4, 1958 by K. J. Rupprecht now Patent 3,011,302. Said application is incorporated herein in its entirety by this reference.

The yarn of this invention, like the yarn there disclosed, comprises a low twist, multi-fiber, e.g. multi-filament, textile strand and an elastic thread twisted together. The elastic thread is capable of being stretched and of contracting from the stretched condition. The multi-fiber strand and the elastic thread are so arranged and proportioned in the composite yarn that at an elongated condition, e.g., the fully stretched condition, of the elastic thread the fibers of the multi-fiber strand are pressed relatively closely against the elastic thread along the length of the two strands in the sense that the plies of a normal ply yarn are pressed relatively closely against each other along their length, and that at a contracted condition, e.g., when contracted to one-half its fully stretched length, of the elastic thread, but at a generally linear condition of the composite yarn, the fibers of the multi-fiber strand are wrapped about the elastic thread in somewhat loose wraps.

As in that invention, the preferred embodiments of this invention are elastic yarns in the sense that the term elastic is understood in the textile art to refer to the elasticity possessed by a rubber core, or similar elastic core, having a single textile cover as is disclosed, for example, in U.S. Letters Patent 2,024,155 and 2,024,156 to Foster, or having a double textile cover as disclosed, for example, in U.S. Letters Patent 1,822,847 to Adamson.

The improvement of the present invention comprises the use of a low-twist multi-fiber strand formed of a multiplicity of staple length fibers, i.e., fibers from about one and one-half inches to eight inches long, as the multi-fiber strand and the addition to the combination of a high strength (as compared to the multi-fiber strand of staple length fibers) continuous strand, for example, a spun yarn or a mono-filament yarn, or a multi-filament yarn, which last may be twisted or which may be untwisted as in the aforesaid copending application.

As in the earlier invention, in the composite yarn of this invention at a contracted condition of the elastic thread, but at a generally linear condition of the composite yarn, the multi-fiber strand is wrapped about the elastic thread loosely, generally in somewhat random size wraps that are larger than the diameter of the elastic thread within the wraps, and the individual fibers of the multi-fiber strand are only loosely associated with each other in the sense that the fibers in a roving are not pressed tightly against each other at a contracted condition of a rubber thread with which the roving was coiled while the thread was stretched near its maximum as hereinafter disclosed embodiments of this invention teach.

The yarns of this invention give a pleasing texture to fabric. Additionally the yarns of this invention give the fabric a much higher loft than could heretofore be achieved. The yarns of this invention have an additional advantage in that the multi-fiber strand employing staple length fibers according to this invention is better able to protect the elastic thread from chafing and breakage in the fabric manufacturing machine.

In some embodiments of the present invention the high strength strand, which helps hold the staple length fibers

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of the multi-fiber strand associated with the elastic thread so they are not readily removed from the composite yarn, may serve the additional function of itself forming a low twist multi-fiber strand as disclosed in the aforesaid copending application. In these embodiments this yarn element is itself a low twist, multi-filament, continuous filament textile yarn which "blossoms," and itself contributes a substantial part to the texture of the composite yarn and the fabric made therefrom.

The yarn according to this invention will be made by techniques generally similar to those disclosed in the aforesaid copending application, and it will be used in the same general way.

For a better understanding of the nature of this invention, reference should be had to the following detailed description of specific embodiments thereof, when read in conjunction with the accompanying drawing forming a part hereof, wherein the single figure is a schematic view of twisting apparatus illustrating the manufacture of yarn in accordance with this invention.

There is shown in this figure apparatus similar to parts of a conventional twisting frame used to cover rubber thread with a roving to produce a product disclosed in the aforesaid Foster patents, but the frame shown in the figure has been modified slightly to produce yarn according to this invention.

Multi-fiber strand 10 from a bobbin 11 is led through the nip of rear draft rolls 12, 13 thence through the nip of intermediate draft rolls 14, 15, and thence through the nip of front draft rolls 16, 17. As is well known the rear, intermediate and front draft rolls rotate at progressively greater rates of speed so that the strand 10 is drafted as it passes between the three sets of rolls.

An elastic thread 18 is fed from a supply spool 19 at a controlled rate to the nip of the front draft rolls 16, 17.

A high strength strand 20 is led from a cone 21 over guides 22, 23 and to the nip of the front draft roll 16, 17 to pass therethrough with the elastic thread 18 and the multi-fiber strand 10.

As the multi-fiber strand 10, elastic thread 18 and high strength strand 20 leave these draft rolls they are twisted together by forces which are well known, and are advanced downwardly through a pigtail guide 24 thence through a traveler 25 on a ring 26 to be wound as the composite yarn of this invention on a bobbin 27 carried by a rotating spindle 28.

Like the yarn of the aforesaid copending application, the multi-fiber strand 10, high strength strand 20 and elastic thread 18 will be twisted together in an arrangement resembling a ply yarn formation, although it will be appreciated the arrangement will have a somewhat different appearance due to the discontinuity of the fibers forming the strand of staple length fibers. Like the yarns of the aforesaid copending application, what might be termed the "ply helix" of any of the three strands in the composite yarn is relatively long, i.e., the number of turns of ply twist in the yarn per unit of length of any such strand in the new yarn, if compared to the single cover elastic yarns of the type which preceded the aforesaid copending application, is relatively low. However like the yarns of the aforesaid copending application, there must be a minimum number of coils per unit length of the multi-fiber strand to achieve the desired texture. There must be at least 5 turns of ply twist per inch of the multi-fiber strand 10 with the elastic thread 18 to achieve this texture, and preferably there are at least 10 turns of such ply twist per inch of multi-fiber strand 10 so that the fibers in that strand 10 generally lie along a somewhat helical path about the elastic thread 18 at a contracted condition of the composite yarn. Since the fibers in the multi-fiber strand 10 are only loosely associated with each other and since this strand

will not, if unsupported, maintain its continuity when subjected to substantial stress, it is difficult to measure the number of turns of such ply twist. However in the preferred embodiments made on apparatus similar to that shown in the drawing, this can readily be calculated by counting the number of turns of ply twist between the high strength strand 20 and the elastic thread 18; for each turn of ply twist between strands 20 and 18 there is one turn of ply twist between strands 10 and 18. If the product is made by a different technique, this ply twist could be calculated readily by the simple expedient of running a continuous yarn in place of, and under the same conditions of feed to the plying point, as the strand 10, and then counting the number of turns of ply twist between that yarn and the elastic thread.

At a contracted condition of the composite yarn, yet one in which the composite yarn is still elongated to a large fraction of its total length, the staple fibers of the multi-fiber strand 10 are associated loosely about the thread 18, similar to the construction of said copending application, but the association will not be so regular because the individual staple length fibers from point to point along the length of the composite yarn are free to adjust more individually and more independently of the fibers in the multi-fiber strand at a different point along the length of the composite yarn. In general however the staple length fibers from strand 10 will be wrapped about thread 18 in a bulky or fluffy fashion with the individual wraps being generally substantially larger in diameter than the thread 18.

This excess may be expressed in terms of the ratio of the average length (X) of multi-fiber strand 10 per ply coil, to the theoretical length (Y) of a coil of helix having a diameter equal to the average diameter of the elastic thread 18. The formula for Y is the following:

$$(I) \quad Y = \sqrt{(2\pi R)^2 + h^2}$$

wherein R is the size (i.e., the nominal radius) of the relaxed elastic thread (expressed in inches) and h is the reciprocal of the length of relaxed elastic thread (expressed in inches) per unit length of composite yarn divided by the number of turns of ply twist of the elastic thread with the multi-fiber strand 10 in that unit length.

X is calculated by dividing the length (in inches) of strand 10 in a unit length of composite yarn by the number of turns of ply twist of strand 10 with elastic thread 18 in that unit length. The length of strand 10 in a unit length of composite yarn is difficult to measure for reasons noted above, but again in preferred embodiments of this invention where the high strength strand 20 and the multi-fiber strand 10 both are fed through the common delivery rolls 16, 17 this length can be readily calculated because for each inch of strand 20 in the composite yarn there will be one inch of strand 10 inasmuch as the common delivery rolls will feed virtually equal lengths of each. It is well to remark that the length of strand 10 as employed throughout this specification and the appended claims, is the length of this strand in the composite yarn; consequently this length is that length of this strand which is delivered by the roll 16, 17 and is not the shorter, undrafted length that is fed to the rolls 12, 13, for example. Again if a different apparatus were used than that shown in the drawing, the length of strand 10 could be calculated by running a yarn through the delivery rolls under the same conditions as suggested hereinabove. This length might also be thought of as the length of spun yarn which would be produced on a spinning frame running as shown in the drawing but only spinning yarn from the strand 10.

To produce any given yarn in accordance with this invention, the multi-fiber strand 10 and the elastic thread 18 should be combined in such a way that when Y is calculated as in Equation I relative to the relaxed elastic thread 18, the ratio X/Y is at least 1.4 and preferably is less than 3.0. This ratio will be slightly greater in

the yarns of this invention than in the embodiments disclosed in the aforesaid copending application; it is believed this is due to the staple length fibers permitting the attainment of practical yarns using a wider helix.

The value of Y will vary as noted in the aforesaid copending application as the composite yarn is stretched or permitted to contract. Its value Y_1 at any given condition of elongation is

$$(II) \quad Y_1 = \sqrt{A(2\pi R)^2 + \frac{h^2}{A^2}}$$

wherein A equals a unit length L_0 of relaxed elastic thread 18 divided by L_1 which is the new length of the unit length L_0 of thread at the given stretched condition of the yarn, and h and R are as noted above.

By differentiating the material within the radical in Equation II and equating to 0 the maximum ratio of X/Y for any given construction can be found. The maximum ratio of X/Y occurs at that condition of stretch, i.e. at that value of A, where Y_1 (Equation II) is a minimum, and is attained when

$$(III) \quad A = 3\sqrt{\frac{2h^2}{(2\pi R)^2}}$$

By substituting the value of A from Equation III in Equation II, the minimum value of Y_1 may be obtained for any given construction.

The specific embodiments of this invention disclosed in the following Table I have maximum ratios in the range of 2.04-2.45 and in one type of yarn in accordance with this invention this maximum ratio of X/Y will be at least 1.7 and preferably less than 3.0. The high strength yarn 20 may be a spun yarn, a continuous mono-filament or a continuous filament multi-filament yarn. If it is the last mentioned, it can be a twisted yarn or a low twist yarn. The yarn 20 must have the necessary strength and continuity to bind the staple length fibers from the strand 10 in the composite yarn. The high strength strand may be a continuous filament, multi-filament low twist yarn, i.e., a yarn containing 7 or more filaments, less than 5 turns per inch twist and be of from 20 to 210 deniers in size as disclosed in the aforesaid copending application. In that event the strand 20 contributes to the texture of the composite yarn as disclosed in that application, and serves this additional function in it.

The multi-fiber strand 10 may be formed from any fiber such as cotton, nylon, Dacron, Orlon etc., although those listed are now preferred. Such fibers of staple length, i.e., from 1½ inches to 8 inches long, loosely arranged in the form of a strand containing a multiplicity of staple length fibers sufficient to achieve a strand equivalent in size to from 70's to 20's single cotton count form multi-fiber strands suited for use in this invention. Preferably this strand is in the form of roving. This strand should be a low twist strand; preferably it may be completely untwisted. Or it might be given a slight amount of twist, not to exceed 5 turns per inch, if desired. Of course the multi-fiber strand should be free of material which prevents the desired separation of the fibers.

The elastic thread 18 is an elastomer thread capable of being stretched to several times its relaxed length and of contracting forcibly upon release of stress. Natural or synthetic rubber thread is used; a polyurethane elastomer thread is an especially desirable synthetic rubber thread for some embodiments because of its good abrasion resistance. Conventional rubber threads suitable for use as the thread 18 are of course well known to the elastic yarn art; the sometimes preferred polyurethane elastomer threads to date are less well known to the elastic yarn but suitable polyurethane elastomer threads are known. One example of a suitable polyurethane elastomer thread is disclosed in copending United States application of Kohn et al., Serial No. 756,420, filed August 21, 1958, now Patent No. 2,953,839.

Elastomer threads are manufactured capable of stretching to at least 5 times their original length and up to 600% to 700%, i.e., to 7 to 9 times their original length, under tension without breaking. Heretofore they have generally been manufactured as mono-filament threads 5 having average diameters of from .016 to .005 inch.

at by measuring the length and twist of the continuous yarn as explained hereinabove. Nevertheless, the data are accurate within the tolerances recognized in the elastic yarn trade, and it is such averaged data which is used in this specification and the appended claims to identify this invention.

Table I

Examples	A	B	C	D
1. Elastomer thread:				
(a) Material (single filament).....	Natural Rubber.....	Natural Rubber.....	Natural Rubber.....	Natural Rubber.....
(b) Size (diameter relaxed) (2R).....	.0135" (75's).....	.0111" (90's).....	.010" (100's).....	.0091" (110's).....
(c) Pre-twist (turns per inch of relaxed thread).....	None.....	None.....	None.....	None.....
(d)* Inches relaxed thread per yard composite yarn.....	7.0.....	7.2.....	7.3.....	6.9.....
(e) Inches relaxed thread per yard composite yarn when ratio X/Y is a maximum.....	11.1.....	10.0.....	9.3.....	8.9.....
2. Additional strands:				
(a) Material—				
1. High strength strand.....	One end 50's single cotton yarn.....	One end 100 denier viscose rayon (also serves as continuous filament, multi-filament low twist yarn).....	One end 100 denier viscose rayon (also serves as continuous filament, multi-filament low twist yarn).....	One end 100 denier viscose rayon (also serves as continuous filament, multi-filament low twist yarn).....
2. Multi-fiber strand.....	One end cotton roving drafted to equivalent of size 53.6 cotton count yarn (when on elastomer thread).....	One end cotton roving drafted to equivalent of size 53.6 cotton count yarn (when on elastomer thread).....	One end cotton roving drafted to equivalent of size 53.6 cotton count yarn (when on elastomer thread).....	One end cotton roving drafted to equivalent of size 53.6 cotton count yarn (when on elastomer thread).....
(b) Twist (turns per inch before twisting with elastomer thread)—				
1. High strength strand.....	23.0 "S".....	3 "S".....	3 "S".....	3 "S".....
2. Multi-fiber strand.....	none.....	none.....	none.....	none.....
(c)* Inches of high strength strand per yard of composite yarn.....	39.4.....	38.5.....	39.9.....	37.7.....
(d)* Inches of staple fiber strand per yard of composite yarn.....	39.4.....	38.5.....	39.9.....	37.7.....
3. Composite yarn:				
(a)* Yards per pound.....	11,120.....	13,450.....	13,530.....	15,049.....
(d) Percent elastomer thread (by weight).....	42.6.....	34.9.....	29.3.....	25.2.....
(c) Percent high strength strand (by weight).....	30.2.....	36.0.....	36.7.....	38.6.....
(d) Percent multi-fiber strand (by weight).....	27.2.....	29.1.....	34.0.....	36.2.....
(e)* Twists of elastomer thread with multi-fiber strand per yard of composite yarn.....	524.....	558.....	583.....	552.....
(f) Average length of multi-fiber strand coil in inches (X) [item 2(d) divided by item 3(e)].....	.0842.....	.0806.....	.0842.....	.0738.....
(g) Length in inches of one coil of a helix with diameter of 2R, and pitch equal to item 1(d) divided by item 3(e) [Y, based on elastomer thread completely relaxed].....	.0450.....	.0380.....	.0350.....	.0314.....
(h) Ratio X/Y (based on elastomer thread completely relaxed) [item 3(f) divided by item 3(g)].....	1.87.....	2.12.....	2.41.....	2.35.....
(i) Length in inches of one coil of helix having same diameter as the elastomer thread when composite yarn is relaxed to condition 1(e); and having a pitch equal to 1(f) divided by item 3(e) [Y minimum].....	.0412.....	.0362.....	.0340.....	.0302.....
(j) Ratio X/Y, maximum [item 3(f) divided by item 3(i)].....	2.04.....	2.22.....	2.47.....	2.45.....

*Measurements based on fully elongated condition of composite yarn.

Although if desired for some applications, the elastic thread 18 could be pre-twisted in a way similar to that in which the rubber core is pre-twisted in making a single cover elastic yarn disclosed in the aforementioned Foster patents, it is preferred that the elastic thread not be pre-twisted; the use of untwisted elastic threads affords great economies in manufacturing the preferred embodiments of this invention.

It is preferred that the high strength strand 20 and the elastic thread 18 be so proportioned in a given length of composite yarn that the composite yarn nearly has what is called an "even break," i.e., both thread 18 and strand 20 reach their breaking point at nearly the same elongation of the composite yarn. For some applications, it may be desirable to vary the proportions and strand 20 and elastic thread 18 somewhat, so that near the breaking point the strand 20 will take a slightly larger part of the breaking load.

The following specific examples of yarn further illustrate this invention. In considering the data in the following table, it is to be noted that the data were compiled from measurements on yard lengths or less, or on a fraction of a pound of the composite yarn, and consequently any slight error in measurement thereof may have been multiplied in the figures given in the table. Also the figures given represent, where appropriate, [e.g., items 1(d), 2(c), 3(a), 3(d)] averages of at least three readings. Further where appropriate [e.g., items 2(c), 3(d)] the length and twist of the multi-fiber strand was arrived

Each of the elastomer threads of the foregoing examples is capable of stretching from 600 to 800%.

This application is a continuation of my copending application, Serial No. 861,394, filed December 22, 1959, now abandoned.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. Elastic yarn comprising a low-twist multi-fiber strand formed of a multiplicity of staple length fibers having the individual fibers loosely arranged therein, an elastomeric thread, and a continuous high strength strand, said multi-fiber strand, said high-strength strand and said elastomeric thread being so arranged and proportioned in the composite yarn that at a contracted condition of the elastomeric thread the fibers in the multi-fiber strand and said high-strength strand may be only loosely associated with said elastomeric thread and the individual staple fibers in the multi-fiber strand are loosely associated with each other, said high strength strand, said elastomeric thread and said multi-fiber strand being so arranged and proportioned in the composite yarn that at an elongated condition of the elastomeric thread the fibers in the multi-fiber strand may be pressed relatively closely against the elastomeric thread throughout the length of the multi-fiber strand.

2. Elastic yarn comprising a low twist roving, a rubber thread, and a continuous high strength strand, said roving, said rubber thread and said high strength strand being so arranged that a sinuous path about the other is

followed by one of said rubber thread on the one hand and the group including said high strength strand and said roving on the other, said roving and said rubber thread being so arranged and proportioned that the ratio of X/Y is at least 1.4, wherein X equals the length in inches of roving per unit length of yarn divided by the number of turns of twist of the roving with the rubber thread in said unit length, and

$$Y = (\sqrt{2\pi R})^2 + h^2$$

in which R equals the radius in inches of the rubber thread relaxed, h equals the length in inches of relaxed rubber thread in said unit length of yarn divided by the number of turns of twist of the roving with the rubber thread in said unit length of yarn, said yarn at a contracted condition of the rubber thread having the roving wrapped about the rubber thread and the individual fibers of the roving loosely associated with each other, said high strength strand preventing the ready disassociation of the staple length fibers in said roving from said thread.

3. Yarn in accordance with claim 2 wherein said rubber thread is capable of expanding to at least five times its relaxed length and of contracting from this expanded length.

4. Yarn in accordance with claim 3 wherein said ratio of X/Y is less than 3.0.

5. Yarn in accordance with claim 4 wherein said rubber thread is a polyurethane rubber thread.

6. Yarn in accordance with claim 4 wherein said high strength strand is a multi-filament continuous filament strand formed of at least 7 filaments, and wherein said multi-filament strand is from 20 to 210 denier in size and has less than 5 turns of twist per inch.

7. Yarn in accordance with claim 4 in which there are at least 10 turns of twist of the roving with the rubber thread per inch of roving.

8. Yarn in accordance with claim 7 wherein the rubber thread has a diameter between .016" and .005", and the roving has less than five turns of twist per inch and is of a size between the equivalents of 20's and 70's singles cotton count.

9. Yarn in accordance with claim 8 wherein said rubber thread is a polyurethane rubber thread.

10. Yarn in accordance with claim 8 wherein said high strength strand is a multi-filament continuous filament strand formed of at least 7 filaments, and wherein said multi-filament strand is from 20 to 210 denier in size and has less than 5 turns of twist per inch.

11. Elastic yarn comprising a low twist roving, a rubber thread, and a continuous high strength strand, said roving, said rubber thread and said high strength strand being so arranged that a sinuous path about the other is followed by one of said rubber thread on the one hand and the group including said high strength strand and said roving on the other, said roving and said rubber thread being so arranged and proportioned that the ratio of X/Y is at least 1.7, wherein X equals the length in inches of roving per unit length of yarn divided by the number of turns of twist of the roving with the rubber thread in said unit length, and

$$Y_1 = \sqrt{A(2\pi R)^2 + \frac{h^2}{A^2}}$$

in which R equals the radius in inches of the rubber thread relaxed, h equals the length in inches of relaxed rubber thread in said unit length of yarn divided by the number of turns of twist of the roving with the rubber thread in said unit length of yarn, and A is the ratio of

the relaxed length in inches of the segment of rubber thread in said unit length to the segment's new length in inches at the stretch condition of the yarn at which Y_1 is a minimum, and wherein the ratio X/Y is at least 1.4 when,

$$Y = \sqrt{(2\pi R)^2 + h^2}$$

said yarn at a contracted condition of the rubber thread having the roving wrapped about the rubber thread and the individual fibers of the roving loosely associated with each other, said high strength strand preventing the ready disassociation of the staple length fibers in said roving from said thread.

12. Yarn in accordance with claim 11 wherein said rubber thread is capable of expanding to at least five times its relaxed length and of contracting from this expanded length.

13. Yarn in accordance with claim 12 wherein the ratio of X/Y_1 is less than 3.0 and the ratio X/Y is less than 3.0.

14. Yarn in accordance with claim 13 wherein said rubber thread is a polyurethane rubber thread.

15. Yarn in accordance with claim 13 wherein said high strength strand is a multi-filament continuous filament strand formed of at least 7 filaments, and wherein said multi-filament strand is from 20 to 210 denier in size and has less than five turns of twist per inch.

16. Yarn in accordance with claim 13 in which there are at least 10 turns of twist of the roving with the rubber thread per inch of roving.

17. Yarn in accordance with claim 16 wherein said rubber thread has a diameter between .016" and .005", and the roving has less than five turns of twist per inch and is of a size between the equivalents of 20's and 70's singles cotton count.

18. Yarn in accordance with claim 17 wherein said rubber thread is a polyurethane rubber thread.

19. Yarn in accordance with claim 17 wherein said high strength strand is a multi-filament continuous filament strand formed of at least 7 filaments, and wherein said multi-filament strand is from 20 to 210 denier in size and has less than five turns of twist per inch.

20. Elastic yarn comprising a low twist roving strand, a rubber strand, and means in the yarn preventing the ready disassociation of the staple length fibers in said roving from said rubber strand, each of the strands in said yarn being so arranged that a sinuous path is followed by one of said rubber strand on the one hand and the remainder of said strands on the other, each strand in said yarn except said rubber strand being so arranged and proportioned with said rubber strand that the ratio of X/Y is at least 1.4, wherein X equals the length in inches of strand per unit length of yarn divided by the number of turns of twist of the strand with the rubber strand in said unit length, and $Y = \sqrt{(2\pi R)^2 + h^2}$ in which R equals the radius in inches of the rubber strand relaxed, h equals the length in inches of relaxed rubber strand in said unit length of yarn divided by the number of turns of twist of the strand with the rubber strand in said unit length of yarn, said yarn at a contracted condition of the rubber strand having the roving wrapped about the rubber strand and the individual fibers of the roving loosely associated with each other.

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