Dec. 5, 1961 K. J. RUPPRECHT 3,011,302

ELASTIC YARN AND METHOD OF MAKING SAME

Filed June 4, 1958

Fig. 1

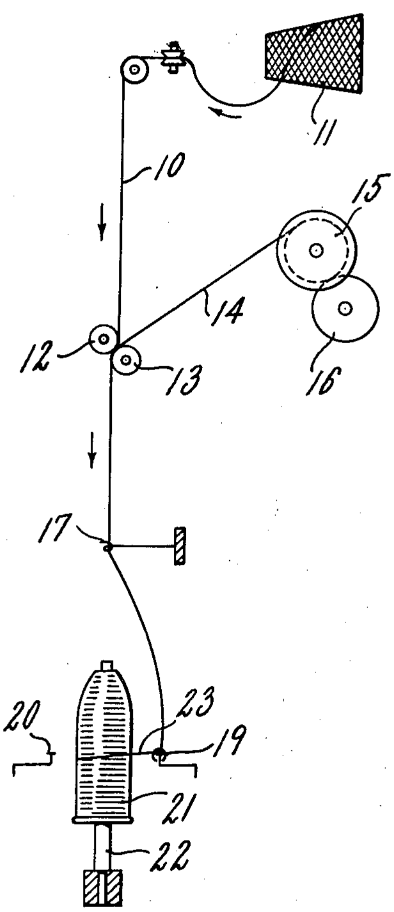


Fig. 2

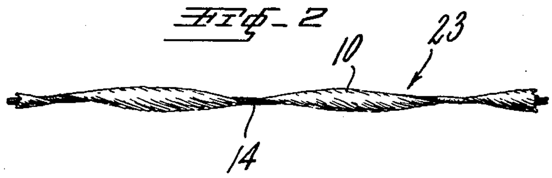


Fig. 3

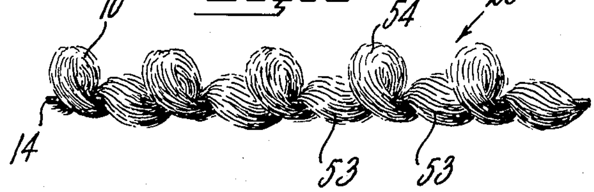
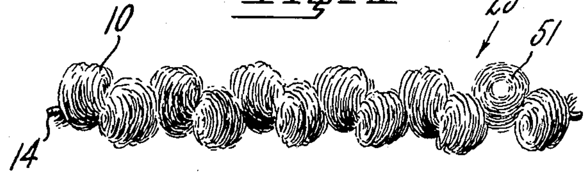


Fig. 4



INVENTOR.
KENNETH J. RUPPRECHT
BY David B. Miller
ATTORNEY

United States Patent Office

3,011,302

Patented Dec. 5, 1961

1

3,011,302

ELASTIC YARN AND METHOD OF MAKING SAME

Kenneth J. Rupprecht, Charlotte, N.C., assignor to United States Rubber Company, New York, N.Y., a corporation of New Jersey

Filed June 4, 1958, Ser. No. 739,780

26 Claims. (Cl. 57—152)

This invention relates to a novel yarn and to a method of making this yarn.

The yarn in accordance with this invention comprises a low twist, multi-filament, continuous filament, textile thread and an elastic thread twisted together. The multi-filament thread is relatively unstretchable, and the elastic thread is capable of being stretched and of contracting from the stretched condition.

The multi-filament thread and the elastic thread are so arranged and proportioned in the composite yarn that at an elongated condition of the elastic thread, preferably a ply yarn formation is assumed by the multi-filament thread and the elastic thread; and that at a contracted condition of the elastic thread, but at a generally linear condition of the composite yarn, the continuous filament thread is wrapped about the elastic thread in somewhat loose wraps.

The yarn in accordance with this invention can be used to produce novel textile fabrics by weaving, knitting, or otherwise interlacing such yarns exclusively, or in conjunction with more conventional yarns, to form the fabrics. For example, a fabric may be knitted exclusively with the yarns of this invention; or a fabric may be woven using the yarns of this invention as weft; etc.

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 other elastic core, having a single textile cover, as is disclosed in U.S. Letters Patent 2,024,155 and 2,024,156 to Foster, for example, or having a double textile cover as disclosed in U.S. Letters Patent 1,822,847 to Adamson, for example. Consequently the preferred embodiments of this invention can be used in applications similar to those in which such elastic yarns are used, but their use in such applications will achieve, generally, novel texture and/or more economical fabrics permitted by the instant yarn; the yarns of this invention can also be used in additional applications to utilize their novel texture properties.

At a contracted condition of the elastic thread, but at a generally linear condition of the composite yarn, the continuous filament thread is wrapped about the elastic thread in somewhat random size wraps that are larger than the diameter of the elastic thread within the wraps, and the individual filaments of the multi-filament thread blossom out from their normal close parallel arrangement. The yarn gives a pleasing texture to fabric. The type of texture depends upon the association of the elastic thread and the multi-filament thread in the composite yarn. In preferred embodiments having high texture, the wraps of multi-filament thread are substantially larger than the elastic thread within the wraps at some contracted conditions, and in some such embodiments, the multi-filament thread may curl upon itself occasionally and randomly to form crunodal loops through which the elastic thread does not pass. The composite yarn, in preferred embodiments, when relieved of all forces tending to hold it linear is very kinky and lively and curls and kinks on itself unless it has been treated to overcome this condition.

In using the preferred embodiments of this invention, a technique modified somewhat from that customarily used in processing elastic yarns of the prior art is em-

2

ployed. The yarns in accordance with this invention are elongated during the interlacing operation, as by tensioning them; in the finished fabric, the elastic threads contract, but generally to an unkinked condition of the composite yarn. Thus the fabric producer should work from a stretched condition of the novel yarn in designing his fabric, which is contrary to practice used heretofore with conventional elastic yarns.

Fabrics produced from preferred embodiments of the yarn in accordance with this invention have soft hands; the effect produced in fabrics by the use of such yarns is similar to the effect produced by the use in fabrics of the so-called "textured" or "bulked" yarns, such as, for example, those yarns which are produced by twisting a continuous filament thermoplastic yarn, heat setting the twisted yarn and detwisting the yarn, or by crimping a continuous filament thermoplastic yarn, or by heat setting a crimped continuous filament thermoplastic yarn. Further, the fabrics have moduli of elasticity and stretch characteristics comparable to fabrics in which the rubber threads and covered rubber threads of the prior art have been employed.

The yarn may be produced on conventional twisting apparatus by a method in which an untwisted continuous filament multi-filament thread is fed to the twisting point with an elastic thread, preferably untwisted, and at such rates, as will become apparent hereinafter, as to produce the herein disclosed yarn.

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:

FIG. 1 is a schematic view of twisting apparatus that can be used to make the yarn in accordance with this invention;

FIG. 2 is a somewhat schematic view of a length of yarn of one embodiment in its fully, or nearly fully, elongated condition;

FIG. 3 is a somewhat schematic view of the yarn of FIG. 2 in a contracted condition but in which the yarn is held elongated enough to prevent it from curling upon itself, and

FIG. 4 is a somewhat schematic view of a length of the yarn of FIG. 2 contracted further than in FIG. 3.

Referring first to FIG. 1 of the drawing, apparatus similar to parts of a conventional twisting frame used to cover rubber thread is shown. A multi-filament relatively unstretchable thread **10** is led from a package **11** to the nip of rotating rolls **12**, **13**. Elastic thread **14** is led from a supply spool **15**, which is driven by a rotating drum **16** running against the elastic thread on the spool **15**, to the nip of rolls **12**, **13**. Between spool **15** and rolls **12**, **13**, elastic thread **14** is elongated.

From the nip of rolls **12**, **13**, threads **14** and **10** pass to a pigtail guide **17** thence through a traveller **19** on ring **20** to a bobbin **21** on rotating spindle **22**. Between the nip of rolls **12**, **13** and bobbin **21**, the threads **14** and **10** are twisted together to form composite yarn **23**.

Referring next to FIG. 2, the condition of composite yarn **23** (fully, or nearly fully elongated) as it is wound on bobbin **21** is illustrated, somewhat schematically. Threads **14** and **10** are twisted together in a ply yarn formation, i.e., neither thread is wrapped as a cover about the other as a core but rather both follow generally similar paths about each other. The pitch of what might be termed the "ply helix" of thread **10**, or of thread **14** (since they follow generally similar paths) is relatively long, i.e. the number of turns of ply twist per unit length of threads **10** and **14** in the new yarn, if compared to the single cover elastic yarns of the prior art, is relatively low. However there must be a minimum number of coils per unit length of the multi-filament thread to achieve the desired texture. There must be at least 5 turns of ply twist per inch of the multi-filament thread **10** to achieve this texture, and preferably there are at least 10 turns of ply twist per inch of multi-filament thread **10** so the multi-filament thread **10** generally lies along a somewhat helical path about the elastomeric thread **14** at a contracted condition of yarn **23**.

In FIG. 3 one embodiment of composite yarn **23** is illustrated, somewhat schematically, at a contracted condition, yet one at which yarn **23** is still elongated a large fraction of its total elongation. FIG. 3 might be considered to represent one embodiment of this invention which has been allowed to contract to about one-half of the length at which the measurements given in Table I appearing hereinafter were made. The multi-filament thread **10** in this condition of yarn **23** when thread **14** is contracted, is wrapped loosely about thread **14** with a large number of the individual wraps or coils being substantially larger in diameter than the part of thread **14** within these wraps. The size of the individual wraps is not uniform throughout the length of the yarn; for example in FIG. 3 which was prepared from a specimen of yarn, alternate wraps, as at **53**, lie relatively closely adjacent thread **14** while intermediate wraps **54** are very much larger than thread **14**. In general the thread **10** is wrapped about thread **14** in a bulky or fluffy, somewhat helix-like, fashion with the individual wraps or coils averaging substantially larger in diameter than thread **14**.

This excess of the multi-filament thread **10** may be expressed in terms of the ratio of the average length (X) of multi-filament thread **10** per coil, to the theoretical length (Y) of a coil of a helix having a diameter equal to the average diameter of the elastomeric thread **14**. Y is calculated using the well-known formula for the length of a helix coil

$$C=\sqrt{(2\pi M)^2+N^2} \tag{I}$$

wherein M is the radius of the helix and N is the pitch of the helix. The formula for Y based on Formula I is

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

This theoretical coil length may be calculated for any given condition of the composite yarn if at one condition the number of wraps, the length of multi-filament thread, and the length of relaxed elastomeric thread, per unit length of composite yarn, and the average diameter of the relaxed elastomeric thread are known. The value "h" is the length of relaxed elastomeric thread (expressed in inches) per unit length of yarn divided by the number of turns of ply twist of the elastomeric thread with the multi-filament thread in that unit length. The value "R" is the size (i.e. the nominal radius) of the relaxed elastomeric thread (expressed in inches).

To produce any given yarn in accordance with this invention, the multi-filament thread **10** and the elastomeric thread **14** should be combined in such a way that when Y is calculated, as in Equation II, relative to the relaxed elastomeric thread **14**, the ratio X/Y is at least 1.4 and preferably is less than 2.5 (when X is expressed in inches).

The value of Y in any given construction obviously will vary somewhat as the composite yarn is stretched or permitted to contract. The value of X however will remain constant for any given construction regardless of its condition of stretch. If a unit length L_0 of relaxed elastomeric thread **14** occupies at a stretched condition of the yarn a length L_1, and if

$$A=\frac{L_0}{L_1} \tag{III}$$

then the radius R_1 of the elastomeric thread at L_1 equals

$$R_1=R\sqrt{A} \tag{IV}$$

and

$$h_1=\frac{h}{A} \tag{V}$$

Then Y_1 at this condition is

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

Thus the value Y, for any given construction, varies with the ratio A (percent stretch), and the ratio X/Y similarly varies. By differentiating the material within the radical in Equation VI and equating to zero 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, when Y_1 (Equation VI) is a minimum, and is attained when

$$A=\sqrt[3]{\frac{2h^2}{(2\pi R)^2}} \tag{VII}$$

By substituting the value of A from Equation VII in Equation VI, 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 1.73 to 2.18, 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.

When composite yarn **23** contracts, the individual filaments of the multi-filament thread **10** in the individual convolutions and bends along the length of thread **10** separate from their normally close parallel arrangement, i.e., multi-filament thread **10** "blossoms" as can be seen at wraps **53** and **54**.

In FIG. 4, the composite yarn **23** is shown relaxed still more than in FIG. 3. As will be seen, more of the wraps have buckled farther away from thread **14**, and an occasional and random crunodal loop, as at **51**, has formed in thread **10** through which thread **14** does not pass.

The thread **10** is a continuous filament, multi-filament low twist yarn. Silk, and most of the man-made fibers, such as nylon (polyamide fiber); acetate; viscose (rayon); Dacron (an oriented super polyester); etc. are available in continuous filament form. The thread **10** is also a multi-filament yarn, and by this is meant it has a sufficient number of filaments, generally 7 or more, to blossom out and give texture to the composite yarn at the individual convolutions of thread **10** upon contraction of the elastic thread **14**. The man-made fibers such as those mentioned above are generally produced in multi-filament form, e.g., the nylon yarns which have been used in the rubber cored elastic yarns of the prior art are available with from 7 to 68 filaments per thread. The multi-filament threads which are useful as covers for the rubber cored elastic yarns of the prior art, i.e. those having from 7 to about 70 filaments, and from 20 to 210 denier are those suited for use in this invention.

The thread **10** is also a low twist thread, and by low twist is meant that it does not have any twist that would prevent the desired separation of the filaments, or blossoming, of the thread as described hereinabove upon contraction of thread **14**; of course, a multi-filament thread which is completely devoid of twist would be satisfactory. But generally, the yarns of the man-made fibers are sold today having a so-called producer's twist of from 0.5 to 2.5 turns per inch, and it has been found this twist does not interfere with the desired blossoming; therefore it is now preferred that these yarns be used. Undoubtedly a slightly greater twist, up to about 5 turns per inch, would not interfere unduly with the blossoming of the strand, and would be a low twist strand suitable for use in accordance with this invention. Generally above 5 turns per inch twist does interfere with the desired blossoming, and threads having this much twist are not suitable in general for this invention. In considering the twist in the multi-filament thread, the twist imparted by twisting the thread **10** and thread **14** together is disregarded, for relative to the axis of the thread **10** as it lies in its helix-like formation about thread **14**, thread **10** is not twisted, although if thread **10** were pulled into a straight line by a force exerted on its ends it would be found to have the number of twist imparted by twisting together threads **10** and **14**.

Of course the continuous filament thread **10** should be free of material which prevents the desired blossoming upon contraction of the elastic thread **14** as by adhering the individual filaments to each other.

The elastic thread **14** 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 and its other properties as will be explained more fully hereinafter. Conventional rubber threads suitable for use as the thread **14** 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 art but suitable polyurethane elastomer threads are known. One example of a suitable polyurethane elastomer thread is disclosed in copending United States application of Kohrn et al., Serial No. 622,370, filed November 15, 1956, now abandoned, refiled as Serial No. 756,420, on August 21, 1958, now United States Patent 2,953,839.

Elastomer threads are manufactured capable of stretching to at least five times their original length and up to 600% to 800%, i.e. to 7 to 9 times their original lengths, under tension without breaking. Heretofore they have generally been manufactured as monofilament threads having average diameters of from .016 to .005 inch.

It has been discovered that when polyurethane elastomer threads are used for the elastic thread **14**, the composite yarn can be heated to alter its properties. For example, if a composite yarn including a polyurethane thread as the elastic member is heated at 300° F. for a period of time up to 10 minutes while the thread is held in the elongated condition shown in FIG. 3, it loses much of its tendency to curl and kink on itself which tendency may be undesirable. Further, after such treatment, the composite yarn will not thereafter readily

contract to a length less than the length of the composite yarn at the time of treatment. It will be obvious that this heat treatment can be effected either before or after the yarn is interlaced into fabric.

Although if desired for some applications, the elastic thread **14** 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 known heretofore, 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 multi-filament thread **10** and the contractible thread **14** be so proportioned in a given length of composite yarn **23** that the composite yarn has what is called an "even break," i.e. both threads **10** and **14** reach their breaking point at nearly the same elongation of yarn **23**. For some applications, it may be desirable to vary the proportions of multi-filament thread **10** and elastic thread **14** somewhat, for example it may be found desirable to increase slightly the length of elastic thread **14**, so that near the breaking point the multi-filament thread **10** will take a slightly larger part of the breaking load.

The novel yarn of this invention uniquely combines several properties desired in the textile art. It partakes of the texture characteristics of the so-called textured yarns such as the bulked yarns, and it partakes of the modulus characteristics of the single or double covered elastomer threads. It resembles the single cover elastomer threads known heretofore in that an elastomer thread is associated with a non-stretchable thread. It differs from the single cover elastic thread in its texture, its use of a low twist continuous filament thread, the unbalance of the preferred embodiments in the yarn's untreated condition, and the loose and somewhat irregular association of the multi-filament thread with the elastomer thread which contributes to the novel texture of the yarn of this invention.

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 tables, and the figures given represent, where appropriate [e.g. items 1(*d*), 1(*e*), 2(*c*), 3(*a*), 3(*d*)], averages of at least three readings. 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	E	F	G	H	I
1. Elastomer thread:									
(a) Material (single filament)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(2)	(1)
(b) Size (diameter relaxed) (2R), inch	[3] .01	[3] .01	[3] .01	[3] .01	[3] .01	[3] .01	[4] .0133	[5] .0067	[3] .01
(c) Pre-twist (turns per inch of relaxed thread)	None	None	None	None	None	None	None	None	[6] 1,662
(d) Inches relaxed thread per yard composite yarn [10]	6.1	6.2	6.8	6.9	7.5	8.2	7.4	7.1	11.2
(e) Twist per yard of stretched elastomer thread [10]	559	707	569	729	967	1,394	507	1,168	−529
(f) Inches relaxed thread per yard composite yarn when ratio X/Y is a maximum	10.2	11.8	10.7	12.6	15.3	20.2	12.7	13.9	19.2
2. Multi-filament thread:									
(a) Material	(7)	(7)	(7)	(7)	(7)	(7)	(8)	(9)	(7)
(b) Twist (turns per inch before twisting with elastomer thread)	.5Z	.5Z	.5Z	.5Z	.5Z	.5Z	.5Z	.5Z	.5Z
(c) Inches multi-filament thread per yard of composite yarn [10]	38.2	39.4	38.0	39.5	42.0	45.0	40.8	41.6	47.2
3. Composite yarn:									
(a) Yards per pound [10]	20,743	20,712	19,800	20,330	19,302	16,840	9,566	53,229	15,120
(b) Percent elastomer thread (by weight)	30	31	30	30	31	33	28	46	46
(c) Percent multi-filament thread (by weight)	70	69	70	70	69	67	72	54	54
(d) Twist of elastomer thread with multi-filament thread per yard of composite yarn [10]	596	729	607	763	980	1,423	566	1,300	1,133
(e) Average length of multi-filament thread coil in inches (X) [Item 3(d) divided by Item 2(c)]	.0648	.0541	.0626	.0518	.0429	.0316	.0721	.0320	.0417
(f) Length in inches of 1 coil of a helix with diameter of 2R, and pitch equal to Item 1(d) divided by Item 3(d) (Y, based on elastomer thread completely relaxed)	.0330	.0326	.0333	.0327	.0323	.0319	.0438	.0218	.0329
(g) Ratio X/Y (based on elastomer thread completely relaxed) [Item 3(e) divided by Item 3(f)]	1.96	1.66	1.88	1.58	1.33	.990	1.65	1.47	1.27

See footnotes at end of table.

Table I—Continued

Examples	A	B	C	D	E	F	G	H	I
(h) Length in inches of 1 coil of helix having same diameter as the elastomer thread when composite yarn is relaxed to condition 1(f); and having a pitch equal to Item 1(f) divided by Item 3(d) [Y minimum]	.0297	.0279	.0306	.0285	.0270	.0245	.0390	.0185	.0294
(i) Ratio X/Y, maximum [Item 3(e) divided by Item 3(h)]	2.18	1.93	2.04	1.82	1.59	1.29	1.85	1.73	1.42

[1] Natural rubber. [2] Polyurethane rubber.
[3] 100's. [4] 75's. [5] 150's, nominal.
[6] Calculated.
[7] 1 end 140 denier, 68 filament nylon.
[8] 2 ends 140 denier, 68 filament nylon.
[9] 1 end 40 denier, 13 filament nylon.
[10] Measurements based on fully elongated conditions of composite yarn

In the foregoing table, Examples A, B, C, D, G and H are yarns in accordance with this invention. Yarn I is a single cover elastic yarn produced in accordance with the teachings of the prior art, for example the co-pending application of Wang, Serial No. 645,721, filed March 13, 1957 but having a somewhat uneven cover, which is included herein for purposes of comparison to help illustrate the nature of the yarns of this invention. Yarns E and F are experimental yarns not in accordance with this invention which were made and are included for purposes of comparison to illustrate the nature of this invention.

Each of the elastomer threads of the foregoing examples is capable of stretching from 600 to 800%. It should be noted that although the elastomer thread in Examples A–F, G and H was not twisted prior to the production of the elastic yarn, the twists of elastomer thread per yard of composite yarn differ from the twists of the elastomer thread with the multi-filament thread per yard of composite yarn. Theoretically these twists should be the same; the difference is accounted for by the fact that the measurements were made by disassembling and de-twisting the elements of the composite yarn. When the elastomer thread seemed to be completely untwisted, in fact it retained some small percentage of the twist because of the "set" of the elastomer thread.

Example A is one now preferred high texture embodiment of the invention. Example B differs from Example A in that although it has approximately the same length of elastomer thread, it differs in that it has a somewhat greater amount of twist between the elastomer thread and the multi-filament thread. The addition of ply twist reduces somewhat the texture effect; in the tables this is reflected somewhat in items 3(*e*), 3(*g*) and 3(*i*).

Example C differs from A in that although they both have approximately the same amount of ply twist, Example C has a somewhat longer elastomer thread than does Example A. Yarn C has a somewhat decreased texture from Example A; in the tables this is reflected somewhat in items 3(*e*), 3(*g*) and 3(*i*). What may not be apparent from the tables is that the ratio of the length of multi-filament thread [item 2(*c*)] to the length of the elastomer thread [item 1(*d*)] is slightly greater in Example C than in Example A. This produces a sometimes desired result in that the yarn of Example C, as it nears the breaking elongation, will tend to take a larger portion of the breaking load on the multi-filament strand than would Example A.

A comparison of Examples C and D shows that although they both have approximately the same length of elastomer thread, Example D has substantially greater ply twist than does Example C. In Examples E and F the ply twist has been increased substantially and progressively over construction D. Examples C, D, E and F were all made with approximately the same component feeds to the plying point but the twist was increased progressively for the several examples; Examples E and F illustrate the result of passing the bounds of this invention; they do not possess the advantages of this invention.

Example G is a heavier yarn than Examples A–D and H. Example H is a fine, i.e. small, yarn as will be apparent from item 3(*a*). Items 3(*g*) and 3(*i*) show Example H falls near the lower limits within the range of this invention. The texture of yarn H is not as pronounced as, for example, yarn A. Yarn H, however, is economical to produce, and, when woven into cloth, produces a cloth of excellent quality.

Examples A, B, C, D, G and H, although differing from each other all exhibit satisfactory texture. Examples E and F exhibit no texture. A comparison of items 3(*g*) and 3(*i*) for the several examples shows that when the ratio of X/Y based on the elastomer thread completely relaxed falls below approximately 1.4 the yarn of this invention is not achieved. When the ratio of X/Y based on the elastomer thread completely relaxed is above approximately 2.50 the association of the elastomer thread and the multi-filament thread is such that the yarn of this invention is not achieved. In producing the yarn by the method illustrated in FIG. 1 of the drawing, care should therefore be taken that the multi-filament thread **10** and the elastomer thread **14** are so combined that, based on the elastomer thread completely relaxed, the ratio of X/Y is in the range of from approximately 1.40 to approximately 2.50.

By comparing item 3(*i*) for the several examples, it will be noted that when the ratio of X/Y, maximum, is beneath approximately 1.7 the textured yarn in accordance with this invention is not achieved. When this ratio is above approximately 3.0 the association of the elastomer thread and the multi-filament thread is such that the textured yarn of this invention is not achieved. Accordingly, when combining the elastomer thread and the multi-filament thread to achieve this invention, care should be taken that the maximum ratio of X/Y does not fall beneath approximately 1.7 nor above approximately 3.0.

A comparison of Examples A, B, C, D, G and H with Example I will show that in the yarns in accordance with this invention there is an excess of multi-filament strand per coil [item 3(*e*)] over that needed to produce a well covered single cover elastic yarn of the prior art. The yarns of this invention are characterized by this excess of multi-filament thread in which the multi-filament thread in a contracted condition of the elastomeric thread is disposed in somewhat loose coils about the elastomeric thread. There must be enough of these coils to distribute the multi-filament thread about the elastomeric thread relatively evenly along its length; there must be at least five coils per inch of length of multi-filament thread and generally there will be at least ten coils per inch of multi-filament thread.

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

1. Yarn comprising a low-twist multi-filament, continuous filament thread and an elastic thread twisted together, said elastic thread being capable of elongating and of contracting from this elongating condition, said multi-filament thread and said elastic thread being so arranged and proportioned that at a contracted condition of the elastic thread the multi-filament thread is wrapped about the elastic thread in loose wraps with the average diameter of the wraps being substantially larger than the diameter of the portion of the elastic thread within the wraps, said multi-filament thread being held about said elastic thread solely by the intertwist of the

elastic thread and thread in said arrangement and proportion therewith.

2. Elastic yarn, comprising a low-twist multi-filament, continuous filament thread and an elastic thread twisted together, said elastic thread being capable of elongating at least 100% and of contracting from this elongated condition, said multi-filament thread and said elastic thread being so arranged and proportioned that at an elongated condition of the elastic thread the elastic thread and the multi-filament thread are arranged in a tight ply formation, and that at a contracted condition of the elastic thread the multi-filament thread is wrapped about the elastic thread in loose wraps with the average diameter of wraps being substantially larger than the diameter of the portion of the elastic thread within the wraps, said multi-filament thread being held about said elastic thread solely by the intertwist of an elastic thread and thread in said arrangement and proportion therewith, and the individual filaments of the multi-filament thread being blossomed out from their normal close parallel arrangement at said contracted condition.

3. Yarn comprising a low-twist, multi-filament, continuous filament thread and an elastic thread twisted together, said elastic thread being capable of elongating at least 100% and of contracting from this elongated condition, said multi-filament thread and said elastic thread being so arranged and proportioned that the ratio of X/Y is at least 1.7, wherein X equals the length of inches of, multi-filament thread per unit length of yarn divided by the number of turns of ply twist of the multi-filament thread with the elastic thread in said unit length of yarn, and

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

in which R equals the radius in inches of the elastic thread relaxed, h equals the length in inches of relaxed elastic thread in said unit length of yarn divided by the number of ply twists of the multi-filament thread with the elastic thread in said unit length of yarn, and A is the ratio of the relaxed length in inches of the segment of elastic thread in said unit length to the segment's new length in inches at the stretched condition of the yarn at which Y is a minimum, said multi-filament thread being held about said elastic thread solely by the intertwist of the elastic thread and thread in said arrangement and proportion therewith, and the individual filaments of the multi-filament thread being blossomed out from their normal close parallel arrangement at a contracted condition of the elastic thread.

4. Yarn in accordance with claim 3 wherein said elastic thread is an elastomeric thread, and wherein there are at least 10 turns of ply twist of the multi-filament thread with the elastomeric thread per inch of multi-filament thread.

5. Yarn in accordance with claim 4 wherein the ratio of X/Y is not above approximately 3.0.

6. Yarn in accordance with claim 5 wherein the diameter of said elastomeric thread is from about .016" to about .005", said multi-filament thread has from approximately 7 to 70 filaments twisted together with not more than about 2.5 turns per inch and wherein the multi-filament thread is from approximately 20 to 210 denier.

7. Yarn in accordance with claim 5 wherein the multi-filament thread is nylon.

8. Yarn in accordance with claim 5 wherein said elastomeric thread is a polyurethane elastomer.

9. Yarn having at least 100% stretch comprising a low-twist, multi-filament, continuous filament thread and a rubber thread twisted together, said rubber thread being capable of elongating and of contracting from this elongated condition, said multi-filament thread 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 multi-filament thread per unit length of yarn divided by the number of turns of ply twist of the multi-filament thread 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 ply twist of the multi-filament thread with the rubber thread in said unit length of yarn, said yarn at a contracted condition of the rubber thread having the multi-filament thread wrapped about the rubber thread and the individual filaments of the multi-filament thread blossomed out from their normal close parallel arrangement, and said multi-filament thread being held about said rubber thread solely by the intertwist of the rubber thread and thread in said arrangement and proportion therewith.

10. Yarn in accordance with claim 9 wherein the rubber thread and the multi-filament thread are twisted together with an average of at least 10 turns per inch length of multi-filament thread.

11. Yarn in accordance with claim 10 wherein the ratio X/Y is not above approximately 2.50.

12. Yarn in accordance with claim 11 wherein the rubber thread is from approximately .016" to .005" in diameter, and said multi-filament thread has from about 7 to 70 filaments and wherein said multi-filament thread has not more than about 2.5 turns per inch.

13. Yarn in accordance with claim 11 wherein said multi-filament thread is nylon.

14. Yarn in accordance with claim 11 wherein said rubber thread is a polyurethane rubber.

15. Yarn composed of a low-twist, multi-filament, continuous filament thread and a rubber thread twisted together, said rubber thread being capable of elongating and of contracting from this elongated condition, said multi-filament thread and said elastic thread being so arranged and proportioned that the ratio of X/Y_1 is at least 1.7 when X equals the length in inches of the multi-filament thread per unit length of yarn divided by the number of turns of ply twist of the multi-filament thread with the rubber thread in said unit length and when

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

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 divided by the number of turns of ply twist of the multi-filament thread with the rubber thread in said unit length 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 stretched 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 multi-filament thread wrapped about the rubber thread and the individual filaments of the multi-filament thread blossomed out from their normal close parallel arrangement.

16. Yarn in accordance with claim 15 wherein the multi-filament thread and the rubber thread are twisted together with at least ten turns per inch of multi-filament thread.

17. Yarn in accordance with claim 16 wherein the ratio X/Y_1 is not above about 3.0 and wherein the ratio X/Y is not above about 2.5.

18. Yarn in accordance with claim 17 wherein the diameter of the relaxed rubber thread is between .016" to .005", said multi-filament thread has been about 7 and 70 filaments and said multi-filament thread is twisted

together with not more than about 2.5 turns per inch.

19. Yarn in accordance with claim 18 wherein said multi-filament thread is nylon.

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

21. A method of producing yarn which comprises advancing a continuous filament, multi-filament thread having less than five turns twist per inch and advancing a stretched elastomeric thread toward a twisting point, twisting said elastomeric thread together with each other thread in the yarn in such proportions that the ratio of X/Y of the yarn produced is at least 1.4 wherein X equals the length in inches the other thread per unit length of yarn produced divided by a number of turns of ply twist of the other thread with the elastomeric thread in said unit length and

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

in which R equals the radius in inches of the relaxed elastomeric thread and h equals the length in inches of the relaxed elastomeric thread in said unit length divided by the number of turns of ply twist of the other thread with the elastomeric thread in said unit length.

22. A method in accordance with claim 21 wherein said elastomeric thread and said multi-filament thread are twisted together with at least ten turns per inch length of multi-filament thread.

23. A method in accordance with claim 22 wherein said elastomeric thread and said multi-filament thread are plied together with a slightly greater breaking length of multi-filament thread than of the elastomeric thread.

24. Yarn comprising a low-twist strand formed of a multiplicity of fibers so arranged that the individual fibers therein are free to separate or blossom, and a rubber thread, said low-twist strand and said rubber thread being so associated that at least one thereof follows a sinuous path about the other, said rubber thread being capable of elongating and of contracting from this elongated condition, each strand in said yarn except said rubber thread being so arranged and proportioned with said rubber thread that the tratio of X/Y is at least 1.4, wherein X equals the length in inches of the strand per unit length of yarn divided by the number of turns of twist of the strand 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 strand with the rubber thread in said unit length of yarn, said yarn at a contracted condition of the rubber thread having each strand in said yarn except said rubber thread wrapped about the rubber thread and the individual fibers of the low-twist strand blossomed out, and means preventing the ready disassociation of said fibers from the rubber thread.

25. A method which includes tensioning and holding substantially straight a yarn comprising a low-twist, multi-filament, continuous filament thread and a polyurethane rubber thread twisted together with at least ten turns per inch of multi-filament thread, said rubber thread being capable of elongating and of contracting from this elongated condition, said multi-filament thread and said rubber thread being so arranged and proportioned that the ratio of X/Y_1 is at least 1.7 and not above about 3.0 when X equals the length in inches of the multi-filament thread per unit length of yarn divided by the number of turns of ply twist of the multi-filament thread with the rubber thread in said unit length and when

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

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 divided by the number of turns of ply twist of the multi-filament thread with the rubber thread in said unit length 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 stretched condition of the yarn at which Y_1 is a minimum, and wherein the ratio X/Y is at least 1.4 and not above about 2.5 when

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

said yarn at a contracted condition of the rubber thread having the multi-filament thread wrapped about the rubber thread and the individual filaments of the multi-filament thread blossomed out from their normal close parallel arrangement, and while tensioning and holding the yarn substantially straight heating the yarn until it no longer evidences a tendency to contract substantially from the length at which it is heated upon release of the yarn.

26. A method of producing fabric which includes providing a yarn comprising a low-twist, multi-filament, continuous filament thread and a rubber thread twisted together with at least ten turns per inch of multi-filament thread, said rubber thread being capable of elongating and of contracting from this elongated condition, said multi-filament thread and said rubber thread being so arranged and proportioned that the ratio of X/Y_1 is at least 1.7 and not above about 3.0 when X equals the length in inches of the multi-filament thread per unit length of yarn divided by the number of turns of ply twist of the multi-filament thread with the rubber thread in said unit length and when

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

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 divided by the number of turns of ply twist of the multi-filament thread with the rubber thread in said unit length 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 stretched condition of the yarn at which Y_1 is a minimum, and wherein the ratio X/Y is at least 1.4 and not above about 2.5 when

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

said yarn at a contracted condition of the rubber thread having the multi-filament thread wrapped about the rubber thread and the individual filaments of the multi-filament thread blossomed out from their normal close parallel arrangement, stretching said yarn to a length in which the unit length of the yarn is stretched to a length that is less than the maximum stretched length of said unit length by a factor not greater than h, and while the yarn is so stretched interlacing it in a fabric.

References Cited in the file of this patent

UNITED STATES PATENTS

2,024,156	Foster	Dec. 17, 1935
2,324,989	Aldenfer	July 20, 1943
2,588,361	Cooper	Mar. 11, 1952