Oct. 27, 1964 P. F. MARSHALL 3,154,111

TEXTILE FABRIC

Filed July 27, 1962

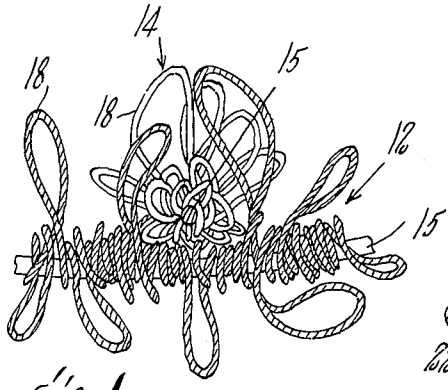

Fig. 1.

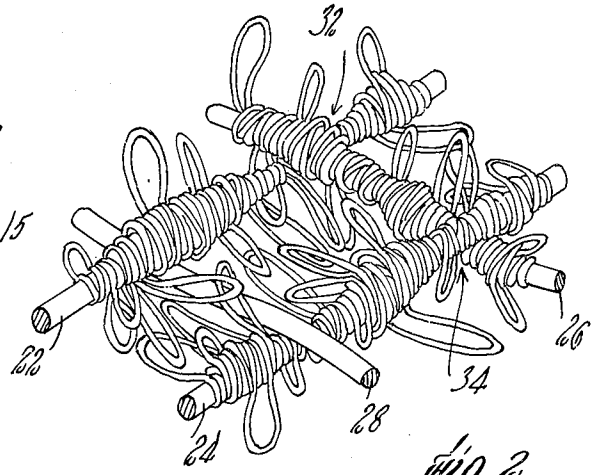

Fig. 2.

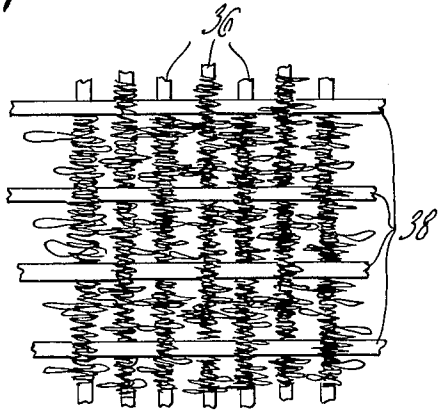

Fig. 3.

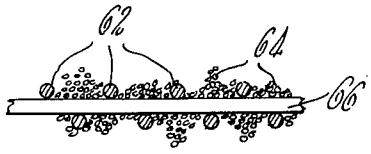

Fig. 8.

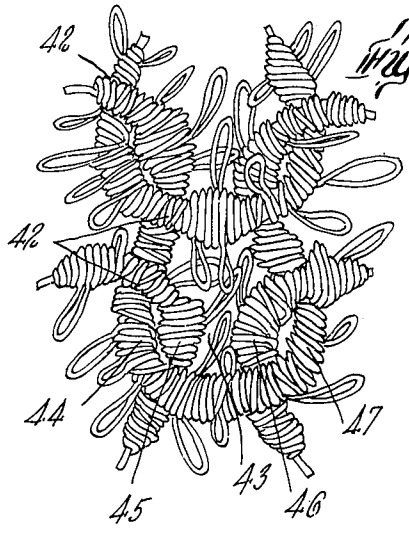

Fig. 4.

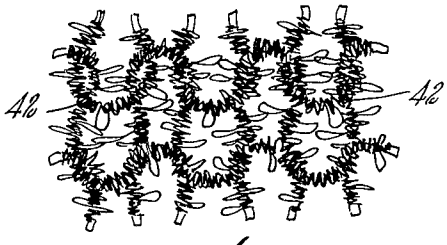

Fig. 5.

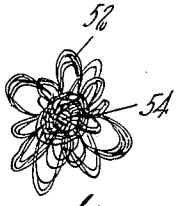

Fig. 7.

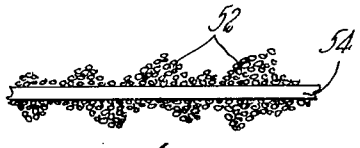

Fig. 6.

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3,154,111

TEXTILE FABRIC

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9 Claims. (Cl. 139—420)

This invention relates to textile fabrics comprising wrapped yarns. More particularly, it relates to fabrics woven or knitted from yarns comprising a core strand wrapped in such a manner as to impart to fabrics composed of such yarns, an unusual fray resistance to lateral, transverse, and bias stress, together with resistance to curling or other planar instability.

In my copending applications Serial Nos. 858,694; 125,814, now U.S. Patent 3,078,654, and 160,090, now U.S. Patent 3,076,307, of which this application is a continuation-in-part, I described wrapped yarns in which a wrapping strand is doubled into loops, which are then wrapped in doubled configuration around a core strand for a multiplicity of turns in the form of closely spaced and partially overlapping helices characterized by an equal number of right-hand and left-hand twists around said core strand. I have now found that the use of such yarns will impart to fabrics woven or knitted therefrom a degree of stability that cannot be attained by the use of any conventional wrapped yarns with which I am familiar, stability, in this application, being a combination of factors including resistance to yarn slippage when a fabric is subjected to longitudinal, transverse, or bias stress, and minimal tendency of the fabric to curl at the edges or to buckle, corrugate or deform locally due to yarn torque—so-called planar stability, which is particularly difficult to realize in fabrics made from single-wrapped elastic-cored yarns. Additionally, the fabrics of this invention are characterized by an unexpectedly high covering power. These characteristics may be enhanced by the dampening and pressing operations conventional in textile finishing.

By reason of this unique fabric stability, more stable fabrics may be made with a far fewer number of yarn interlacings, that is yarn crossing points which are largely responsible for fabric stability. In more detail, this effect may be explained as follows:

In order to make a fabric, yarns must be interlaced as in weaving or knitting. Interlacings are expensive. In weaving, the package of filling yarn is passed through the shed. In knitting, a separate needle is required for each stitch in a course. Interlacings are made individually and successively. The expense of knitting and weaving is closely related to the number of interlacings. Yet, as mentioned above, the number of interlacings is a source of integrity and stability in a fabric and is what makes fabrics out of yarns.

I have found that the yarns described and claimed in my copending applications are remarkably effective to produce fabrics which are stable but have relatively few interlacings. This is partly because two or more yarns are combined by wrapping one in doubled configuration around another. This "consumes" a lot of yarn. When these composite yarns are woven or knitted together or with other yarns, a stable fabric may be produced with a surprisingly small number of interlacings. Apparently this results from the peculiar interactions of my novel yarns at yarn crossing points and otherwise adjacent to one another in the fabric. These novel yarns are thick and contain irregularities and rugosities. The wrapping is soft and slack and is not tensed by pulling on the composite yarn so that crossing yarns tend to imbed in one another. The protruding loops of the wound yarn fill up space and contribute to opacity and "cover." Therefore, the yarns are greatly resistant to slipping over one another

with the result that a remarkable stability can be obtained in a fabric made from a given size of warn and constructed with a smaller than expected number of interlacings. Moreover since the composite yarns have effectively zero twist, there is no tendency for the fabric to curl, twist, corrugate or crepe.

It is therefore an object of this invention to provide textile fabrics comprising wrapped yarns, said fabrics displaying an enhanced resistance to applied stress due to a novel type of inter-yarn engagement, as will appear more fully hereinbelow.

It is a further object of this invention to provide textile fabrics of enhanced planar stability comprising a core strand wrapped with a single wrapping strand, the combined core and wrapping strand being balanced by having an equal number of turns of S-twist and Z-twist in the single wrap, whereby the fabric is substantially free from the localized torque which is inherent in fabrics comprising conventional singly-wrapped yarns. This torque is particularly apparent in fabrics made from yarns in which an elastic core is covered with but a single wrapping strand.

Still further features and objects of the invention will be apparent from the following description of preferred embodiments thereof, together with the accompanying drawings, wherein:

FIG. 1 is a diagrammatic view of a portion of a textile fabric according to the present invention;

FIGS. 2 and 3 are diagrammatic views of woven fabrics according to the present invention;

FIGS. 4 and 5 are diagrammatic views of knitted fabrics according to the present invention;

FIGS. 6 and 7 are diagrammatic views, respectively, side and cross sectional, of a wrapped yarn useful in certain embodiments of the present invention; and

FIG. 8 is a diagrammatic view of a woven fabric according to the present invention utilizing the strand of FIGS. 6 and 7.

In my copending applications, I have described, as stated above, the preparation of a wrapped yarn in which a wrapping strand is wound, in doubled configuration, around an unconvoluted substantially straight core strand, said wrapping strand being doubled into turns and loops wound around the core strand a multiplicity of times, there being an equal number of S-turns and Z-turns of wrapping strand around the core strand. Due to the circumferential nature of the wrapping process, and the fact that two ends of the wrapping strand, forming the two elements of a loop, are involved in each increment of wrap, the wrapping strand is described as being in the general configuration of a multi-layered and partially overlapping helix around the core strand.

The fabrics of this invention may employ conventional weaving or knitting techniques, using my wrapped yarns as the set of yarns in either the warp or filling of a woven fabric, or in both warp and filling. The fray-resistant nature of my woven fabrics is most pronounced when my wrapped yarns are used in one direction, conveniently in the filling, combined with any conventional warp of spun or filament yarns. In the knitted fabrics of this invention, my wrapped yarns may be used throughout, or the structure may contain the wrapped yarns interlaced with conventional yarns. The yarn core may be elastic or inelastic.

The construction of the textile fabric of the present invention, whether woven, knitted, braided, or the like, is characterized by yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern. In FIG. 1 is shown a typical such crossing of yarns **12**, **14**, each having a core **15** and a single wrapping strand **18**, the wrapping strand of yarn **12** being distinguished in FIG. 1 by hatching, while that of yarn **14** is plain. As therein shown,

the cores of yarns 12, 14 are closely adjacent one another at their crossing point, and the space intervening between this pair of yarns is to a considerable degree filled with looped turns of wrapping strand evolving from the surface of both yarns. Since the wrapping strands of both yarns penetrate this intervening space, the wrapping strand of one yarn infiltrates into the wrapping strand of the adjacent yarn, whereby the two yarns are frictionally interengaged and intertangled with each other to resist relative movement of the crossing yarns and to stabilize the fabric at the numerous crossing points.

Woven fabrics according to the invention are shown in FIGS. 2 and 3, that of FIG. 2 being an enlarged diagrammatic showing having filling yarns 22, 24, and warp yarns 26, 28. Yarn crossings typical of that of FIG. 1 are shown at 32, 34, the wrapping strand about the core of warp yarn 28 being omitted for clarity of illustration. In addition to interaction of adjacent yarns at crossings 32, 34, the interaction of the parallel adjacent filling yarns 22, 24 is particularly important in woven fabrics according to the present invention, since the associated loops and turns of the adjacent parallel filling yarns 22, 24 are frictionally interengaged and intertangled with one another and are effective to resist relative movement of such adjacent filling yarns throughout their length. The same effect will occur between adjacent warp yarns. The stability provided by the frictional interengagement of adjacent parallel yarns, whether warp or filling, is sufficient so that it is not essential that both sets of yarns be of the wrapped type. This latter type of fabric is shown in FIG. 3, wherein but a single set of yarns, filling yarns 36 are wrapped, with the warp yarns 38 being unwrapped.

Typical knitted fabrics according to the invention are shown in FIGS. 4 and 5, again providing interaction of the yarns at crossing points 42 (FIG. 4), but with a lesser degree of interaction between adjacent, non-crossing yarns. FIG. 4 is a less open knit fabric than that of FIG. 5, the latter in particular showing the high covering power characteristic of open knit fabrics of the invention.

In addition to the effect of yarn interaction at crossing points, fabrics knitted from yarns of this type show a degree of loop stability and resistance to stretching that is exceptional in open-knit fabrics. The circumferential disposition of the wrapping strand, plus the associated protruding loop arrangement extending radially from the core, apparently increases the effective bulk of the yarn, so that the inner loop space 43 of a wale (FIG. 4) is effectively filled with a lighter weight of yarn than would be the case if the wrapping strand were conventionally disposed around the core strand. As is well known in the knitting art, the extent to which a knitted fabric may be stretched is related to four times the diameter of the knitting yarn, since when the diameters of the four yarns 44, 45, 46, and 47 (FIG. 4) are packed together, no further distortion is possible. By increasing the effective diameter of a yarn by a wrapping process as described above, I find that I can produce open-knit structures which have exceptional stability as well as high covering power.

With either the woven or knitted fabrics described above, particularly unique fabrics may be produced utilizing a single wrapped strand doubled into loops and wound in doubled-back configuration with an equal number of S and Z turns about an elastic core strand. Conventionally, in order to construct a fabric having a wrapped elastic core yarn component, it is essential that a double wrapping be employed in order to provide a yarn having suitably low residual torque, and a fabric which will lie flat without curling. But with such a double wrapping, only heavy yarns can be produced, which in turn provide heavy fabrics. The fabric of the present invention can be constructed with an elastic core having but a single wrap, essentially free from residual torque, so that an eleastic core yarn fabric according to the invention can be constructed in a much lighter, yet highly stable form, as is particularly desirable in knitted fabrics. The material of the elastic core may comprise one or more untwisted strands of natural or synthetic rubber, or spandex, such as Lycra, a polyurethane filament manufactured by Du Pont. The wrapping strand may be of any suitable filament or staple yarn, either natural or synthetic, as may the core strand with non-elastic core fabrics of the present invention.

Furthermore, I have found that if the wrapping strand is chosen so as to satisfy certain requirements set forth more fully hereinbelow, the wrapping strand becomes generally filamentary in nature, and imparts to fabrics made thereof an even greater degree of stability. By a wrap of filamentary nature I mean that a multi-filament wrapping strand of the proper nature can be so disposed around the core strand that a cross section of a wrapped yarn of this type resembles the yarn of FIGS. 6 and 7, wherein the individual filaments 52, which constitute the wrapping strand around core strand 54, are not grouped into a more or less cylindrical bundle characteristic of spun yarns or of continuous filament yarns of true textile twist, but are arranged in a scattered configuration forming an irregularly dispersed layer or bed of individual filaments. This type of filamentary dispersion of a doubled wrapping strand around a core strand imparts to fabrics made therefrom characteristics which affect the fabric stability in a significant and unexpected manner. A more detailed discussion of this stability will be found in the examples set forth hereinbelow.

In general I have found that a noticeable degree of enhanced stability is realized when the core strands of my wrapped yarn elements are wrapped with at least about 50 double-ended loop wrappings per inch, equivalent to 100 single-end wrappings, or as in the case of the 20-filament wrapping strand of Examples 1 and 2, equivalent to 2,000 individual filamentary loop-like turns circumferentially disposed around the core.

In selecting the wrapping strand for the fabrics of this invention, I prefer, in order to provide an irregularly dispersed layer or bed of individual filaments, to use multifilament strands with a twist multiple of less than about 1.0. The term twist multiple is conventionally applied to spun yarns, and is defined as the number of turns of twist per inch divided by the square root of the yarn count, in the cotton system. By twist multiple in the present invention, I mean the number of filamentary turns per inch divided by the square root of the yarn count. In the case of synthetic yarns, the fineness or coarseness of the yarn is customarily expressed in denier, which can be converted to yarn count (cotton system) by dividing the denier into 5320.

As an example, a 75-denier viscose yarn will correspond to 5320/75 or approximately a 71's spun cotton yarn. In using such a viscose yarn as a wrapping strand, therefore, I prefer to have fewer than about 8.5 turns per inch, this figure being obtained from the above expression for twist multiple.

By using wrapping strands of low twist multiple I find that, as set forth above, the wrapping strand becomes filamentary in nature. Two structural factors are prominent in a consideration of these yarns. First, most of the individual filamentary loops pass around the circumference of the core strand, in a plane generally perpendicular thereto, unlike the filamentary loops of many bulk or blown yarns which lie along and are in planar parallelism with the axis of the strand from which they are formed, a typical example of the latter being the yarn shown in FIGURE 4 of U. S. Patent 2,783,609.

Second, since the multifilament wrapping strand is always disposed around the core strand in looped wrapping, the two ends of the strand in the loop must make an equal number of turns per inch around the core. Therefore, if a composite wrapped yarn in a fabric of the present invention is cut transversely in cross section, as in FIG-

URE 7, for every filament which is regarded as wrapping clockwise around the core strand, there must, from the geometry of the process, be an equalizing filament which is wrapped around the core counterclockwise. Since the wrapping strand is disposed around the core strand for a multiplicity of turns per inch, the combination of clockwise and counterclockwise filamentary turns in the yarns of my fabrics is on a very fine grained scale, effecting a stability that is quite unusual in a yarn wrapped with a single strand.

As a further consequence of the circumferential filamentary wrapping, fabrics made from yarns of the above-described type tend to resist the slippage of yarn along yarn, in a set of yarns passing in the same direction. In the manufacturing and finishing operations, utilizing heat and moisture the yarns become to an even greater degree interlocked one with another, with the filamentary loops of one yarn becoming intermeshed and interengaged with the filamentary loops of the adjacent yarns. In this manner, the inter-yarn space appears filled with filamentary material, providing a high degree of opacity and covering power for the fabric. Since the filamentary wrapping is disposed around the cores of adjacent yarns, and is in general inclined at an angle of nearly 90° to the long axis of the core strands, the mutual embedment of the wrappings of a pair of adjacent yarns interlocks the yarns in an interengagement which resists the tendency of one yarn to slide past another, or to be separated from another.

Not only do the wrapped yarns of the fabrics of this embodiment of my invention resist slippage past each other, but additionally they display an effective locking action when used in one set of yarns of a woven fabric in which conventional yarns constitute the other set. The voluminous filamentary bed of the wrapping strand of my wrapped yarn is penetrated by normal yarns, due to the tensions and the shedding action during weaving. The result is a typical fabric of conventional textile warp with my wrapped yarns in the filling is shown in FIGURE 8, which is a cross-section taken across the warp of such a fabric. The warp yarns **62** are shown embedded in a bed of filaments **64** which constitute the low-twist wrapping strand disposed circumferentially around the core **66**. Since both the warp yarns and the wrapping filaments are disposed substantially at right angles to the filling direction of the core, any attempt to move a warp yarn to the right or left in the drawing is met with a countering wedging action on the part of the filamentary wrap, which tends to tighten around the warp yarn and prevent further movement. It is, therefore, difficult to ravel a warp yarn from a fabric of this invention comprising a warp of conventional yarns and a filling of filamentary wrapped yarns of the type described above. Similar effects are noted with warps of wrapped yarns and a filling of conventional yarns, either instance leading to fabrics of enhanced stability against yarn-past-yarn slippage.

Still a further consequence of the use in fabrics of the previously described wrapped yarns lies in the resistance to curling, resistance to ravelling, and resistance to distortion under stress which particularly characterizes knitted fabrics such as Example 2, below. It may be postulated that when a loop is formed from a filament or yarn in a knitting process, the elements of the outside of the loop are in extension and the elements of the inside are under compression, which makes the loop an unstable configuration and accelerates the propagation of runs from broken stitches. In forming a loop from my wrapped yarns, however, I have found that the individual filamentary wraps, since they are circumferentially disposed, apparently can slide past each other without taking on any particular stress. In this readjustment they maintain their wrapped contact with the core strand, and the knitted loop is stabilized to a considerable degree. When my wrapped yarns are bent, the bent configuration becomes the preferred configuration, due to the sliding rearrangement of the ring-like filamentary loops. This is what I mean by a "dead-fold" character, which is unusual in textile fabrics. Together with the unique yarn-to-yarn frictional engagement explained above, it imparts to knitted fabrics a high resistance to curling, ravelling, or loop-extension on the application of stress.

The invention will be more clearly understood from the following examples:

Example I

A bathing suit fabric was woven employing a warp of 5,000 ends of 70 denier 34 filament Dacron strand (a polyester yarn made by Du Pont) reeded out to 86 inches wide, in a leno weave. The filling yarn was an elastic-cored yarn produced in accordance with the process described in my co-pending application Serial No. 125,814, wherein a 20-filament 75 denier acetate strand, 2 **Z** turns per inch, was wrapped in doubled configuration for a multiplicity of turns around the circumference of a 420 denier zero twist spandex core strand. The total denier of the wrapped filling yarn was approximately 1800 in the relaxed state, which is in excess of 100 acetate strand loops or 2000 filamentary loops wrapped around each inch of core strand.

The fabric was woven under such filling tension as to finish down to about 38 inches in the retracted, off-loom state. In this condition, the fabric weighed about 10.4 oz. per square yard, and had excellent opacity and coverage. It could be readily stretched by hand 135% of its finished width, and showed exceptional resistance to warp and filling slippage for a fabric of this weight.

Example II

A knitted dress-goods fabric weighing 8 oz. per square yard was constructed entirely of a wrapped yarn made in accordance with the process described in my co-pending application Serial No. 160,090. In the preparation of this yarn, the core was 260 denier 17 filament nylon with 1 **Z** turn per inch, and the wrapping strand was a 75 denier 20 filament acetate, 2 **Z** turns per inch, solution dyed. The acetate strand was wrapped in the form of double-back loops wound with false twist for a sufficient number of turns around the nylon core to bring the total denier of the composite yarn to 1020.

The fabric was knitted in a plain jersey stitch construction on a circular knitting machine using 8 needles per inch. Despite the openness of the knit, the fabric had a cover and opacity characteristic of fabrics with many more courses per inch. The fabric was also characterized by a dimensional stability and resistance to distortion which is exceptional in open-knit fabrics, since when fashioned into a skirt it could be machine-washed and machine-dried and re-worn immediately with no evidence of sagging or stretching. The resistance to sagging or local distortion was also apparent during the wearing of the skirt, which retained its form-fitting nature despite the absence of resin-treatments or special construction usually resorted to for the realization of stability in open-knit fabrics.

In conclusion, then, it will be apparent that the invention provides a wide variety of fabrics unique in many respects. Still further modifications of the invention, not herein specifically disclosed yet within the spirit thereof and the scope of the appended claims, will occur to those skilled in the art.

I claim:

1. A fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, a substantial proportion of said yarns consisting of an unconvoluted, substantially straight core strand and a wrapping strand about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times, there being an equal number of **S**-turns and **Z**-turns of wrapping strand about said core strand, the turns and loops of adjacent strands being frictionally

intertangled and interlocked to resist relative movement of said adjacent strands.

2. A fabric comprising yarns disposed in over-and under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, a substantial proportion of said yarns consisting of an unconvoluted, substantially straight core strand and a wrapping strand about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times to effect a wrapping density of at least 50 loop-turns, equivalent to 100 wrapping strand turns, per inch of core strand, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the turns and loops of adjacent strands being frictionally intertangled and interlocked effective to resist relative movement of adjacent strands.

3. A fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, a substantial proportion of said yarns consisting of an unconvoluted, substantially straight core strand and a continuous multifilament wrapping strand of twist multiple less than 1.0 about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times to effect a wrapping density of at least 50 loop-turns, equivalent to 100 wrapping strand turns, per inch of core strand, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the individual filaments of said wrapping strand being dispersed into a substantially continuous bed of filaments surrounding said core strand, the turns and loops of adjacent strands being frictionally intertangled and interlocked to resist relative movement of said adjacent strands.

4. A fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, a substantial proportion of said yarns consisting of an unconvoluted, substantially straight elastic core strand and a single wrapping strand about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the turns and loops of adjacent strands being frictionally intertangled and interlocked effective to resist relative movement of adjacent strands.

5. A knitted fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, a substantial proportion of said yarns consisting of an unconvoluted, substantially straight core strand and at least one wrapping strand about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times to effect a wrapping density of at least 50 loop-turns, equivalent to 100 wrapping strand turns, per inch of core strand, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the turns and loops of adjacent strands being frictionally intertangled and interlocked effective to resist relative movement of said adjacent strands.

6. A woven fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, said yarns being arranged into at least one warp set and at least one filling set, at least one of the warp and filling sets of said yarns consisting of an unconvoluted, substantially straight core strand and at least one wrapping strand about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times to effect a wrapping density of at least 50 loop-turns, equivalent to 100 wrapping strand turns, per inch of core strand, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the turns and loops of adjacent strands of one of said sets being frictionally intertangled and interlocked with those of the other effective to resist relative movement of adjacent strands of said one set.

7. A woven fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, said yarns being arranged into a warp set and a filling set, the filling set of said yarns consisting of an unconvoluted, substantially straight elastic core strand and a single continuous multifilament wrapping strand, of twist multiple less than 1.0, about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times to effect a wrapping density of at least 50 loop-turns, equivalent to 100 wrapping strand turns, per inch of core strand, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the individual filaments of said wrapping strand being dispersed into a substantially continuous bed of filaments surrounding said core strand, said wrapping strand comprising at least 25% of the weight of said textile fabric, the turns and loops of parallel adjacent filling strands being frictionally intertangled and interlocked effective to resist relative movement of adjacent strands of said one set.

8. A woven fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, said yarns being arranged into a warp set and a filling set, the warp set of said yarns consisting of unwrapped yarn and the filling set of said yarns consisting of a substantial proportion of an unconvoluted, substantially straight core strand and a wrapping strand about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the turns and loops of adjacent filling strands being fractionally intertangled and interlocked effective to resist relative movement of adjacent strands.

9. A woven fabric comprising yarns disposed in over-and-under intercrossing relationship providing a multiplicity of yarn crossings in a predetermined pattern, said yarns being arranged into a warp set and a filling set, the warp set of said yarns consisting of unwrapped yarn and the filling set of said yarns consisting of a substantial proportion of an unconvoluted, substantially straight elastic core strand and a single wrapping strand about said core strand, said wrapping strand being doubled into turns and loops wound around said core strand a multiplicity of times, there being an equal number of S-turns and Z-turns of wrapping strand about said core strand, the turns and loops of adjacent filling strands being frictionally intertangled and interlocked effective to resist relative movement of adjacent strands.

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