WARP KNIT TWILL, SHARKSKIN AND PIQUE FABRICS

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ABSTRACT
Warp knit twill, sharkskin or pique fabrics having a ground fabric structure formed by one or more yarns knit in every course and every wale to provide a ground structure, and yarns alternately laid-into the ground structure in a pattern which advances course-wise as it alternates wale wise resulting in an effect which appears diagonally or obliquely to the course and wale directions throughout one or more surfaces of the fabric. Each of the laid-in yarns is substantially within a wale, and periodically makes an excursion toward or into an adjacent wale, laying in around the bases of two lap portions of yarn which terminate in that adjacent wale, the laid in yarn pulling the bases of those laps toward the wale in which the laid in yarn primarily lies, thereby periodically disrupting the uniformity of the technical back side of the warp knit fabric, and simultaneously tightening the loop which joins the two aforementioned laps thereby distorting the technical face of the warp knit fabric, to provide a pattern effect.

34 Claims, 21 Drawing Figures
WARP KNIT TWILL, SHARKSKIN AND PIQUE FABRICS

This invention relates in general to simulated twill, sharkskin, and pique fabrics, and more specifically to warp knit twill, sharkskin, and pique fabrics, including warp knit elastic fabrics having the surface effects of twill, sharkskin, and pique fabrics.

Known twill, sharkskin, and pique fabrics, have typically been produced by weaving yarn to produce a pattern which extends obliquely to the warp and weft directions which characterize woven fabrics. More specifically, woven twills have the appearance of diagonal lines or ribs produced by passing the weft threads over one and under two or more warp threads, instead of merely passing under the next one warp thread. Woven piqués have the appearance of raised diamond or hexagonal shaped patterns extending diagonally or obliquely to the warp and weft directions on the surface of the fabric. Woven sharkskins are like very fine piqués having the appearance of an animal skin pattern, for example, a diamond-like pattern extending diagonally or obliquely to the warp and weft directions.

In contrast to woven fabrics, the structure of warp knit fabrics is more complicated. It is therefore not so easy to produce diagonal or oblique patterns in warp knit fabrics as it is in woven fabrics. However, warp knit fabrics have distinct advantages over woven fabrics, including the fact that warp knit fabrics are more extensible and therefore more readily accommodate the movements of a wearer of garments manufactured from warp knit fabrics. In addition, warp knit fabrics are today typically made of materials which are less prone to creasing and wrinkling, and the warp knit fabric structure itself provides improved resistance to creasing and wrinkling, thereby providing a fabric which is easier to care for than woven fabrics. Still further, warp knit fabrics have in the last few years been manufactured in quite elastic spandex yarns, for example, to provide light weight elastic fabrics, which when manufactured into garments readily conform to body curvatures and may even provide some support. Such fabrics have become particularly popular in applications such as swimsuits. However, such elastic fabrics are typically made having uniform, flat surfaces, with visual effects usually being provided by use of yarns of different color, or by fabric printing techniques.

Furthermore, while bare elastic yarns provide desirable high elastic elongations and stretch recovery, such yarns also have certain undesirable characteristics which typically must be dealt with in producing commercially acceptable elastic fabrics. One of these problems is that bare rubber and bare spandex yarns have an undesirably clammy feeling when brought into contact with human skin. Another undesirable characteristic is that bare rubber and bare spandex yarns are difficult to dye with dyes suitable for use in coloring commonly used textile yarns. Therefore if fabrics incorporating both the common yarns and the bare rubber or spandex yarns are to be dyed after being knit, it is desirable to cover the rubber or spandex yarns with the relatively inelastic yarns. Similarly, it is desirable to cover bare rubber or spandex yarns with the relatively inelastic yarns in order to avoid direct contact between the undesirably clammy rubber or spandex yarns and human skin when garments made from such fabrics are worn next to the skin. There is a continuing need for warp knit elastic fabric structures wherein the desirable elasticity characteristics of bare rubber and spandex yarns may be used, while minimizing yarn consumption of both elastic and inelastic yarns per unit fabric area. There is also an apparent absence of elastic fabrics having twill, sharkskin and pique surface effect.

BRIEF SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide warp knit fabrics which overcome the above-noted disadvantages of prior art fabrics. It is more specifically an object of this invention to provide warp knit twill, sharkskin, and pique fabrics, and particularly warp knit elastic fabrics having twill, sharkskin, and pique surface effects.

The foregoing objects and others are accomplished in accordance with this invention by providing a ground structure formed by one or more hard or texturized, relatively inelastic yarns knit in every course and every wale to provide a rather opaque ground structure, and alternately laying yarns into that ground structure in a pattern which advances coursewise as it alternates wale wise to result in an effect which appears diagonally or obliquely to the course and wale directions throughout one or more surfaces of the resultant fabric. Each of the laid-in yarns is laid substantially within a wale, and periodically makes an excursion toward or into an adjacent wale, laying-in around the bases of two lap portions of yarn which terminate in that adjacent wale, the laid in yarn pulling those laps toward the wale in which the laid-in yarn primarily lies, thereby periodically disrupting the uniformity of the technical back side of the warp knit fabric, and simultaneously tightening the loop which joins the two aforementioned laps thereby distorting the technical face of the warp knit fabric, to thereby provide a pattern effect. The laid-in yarns may be of any desired type, including hard yarns, textured yarns, or even relatively highly elastic yarns.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed disclosures of preferred embodiments of the invention taken in conjunction with the accompanying drawings thereof, wherein:

FIG. 1 is an about 10× photomicrograph of the technical face of a warp knit twill fabric of the present invention, and FIG. 1B is a photomicrograph of the technical back of the same fabric.

FIG. 2 is an about 10× photomicrograph of the technical face of a warp knit sharkskin fabric of the present invention, and FIG. 2B is a photomicrograph of the technical back of the same fabric.

FIG. 3 is an about 10× photomicrograph of the technical face of a warp knit sharkskin fabric of the present invention, and FIG. 3B is a photomicrograph of the technical back of the same fabric.

FIG. 4 is an about 10× photomicrograph of the technical face of a pique fabric of the present invention, and FIG. 4B is a photomicrograph of the technical back of the same fabric.

FIG. 5 is an about 5× photomicrograph of the technical face of a warp knit pique fabric of the present invention, and FIG. 5B is a photomicrograph of the technical back of the same fabric.

FIG. 6 is an about 5× photomicrograph of the technical face of a warp knit pique fabric of the present in-
vention, and FIG. 6B is a photomicrograph of the technical back of the same fabric.

FIG. 7 is a point diagram schematically illustrating the patterns by which each of four yarn sets or warps are knit into a fabric of the present invention. FIG. 8 is a point diagram schematically illustrating the patterns by which each of four yarn sets or warps are knit into another fabric of the present invention. FIG. 9 is a point diagram schematically illustrating in superimposed form, the stitch pattern by which the four yarn sets of FIG. 8 are knit together to form a fabric according to the present invention.

FIG. 10 is an about 18x scanning electron photomicrograph of the technical back of a fabric made according to the pattern illustrated in FIG. 9, said fabric being extended in both the course and wale directions.

FIG. 11 is an about 18x scanning electron photomicrograph of the technical face of a fabric knit according to the pattern illustrated in FIG. 9, said fabric being extended in both the course and wale directions.

FIG. 12 is a point diagram schematically illustrating in superimposed form, the stitch patterns by which the four yarn sets of FIG. 7 are knit together to form a fabric according to the present invention.

FIG. 13 is a point diagram schematically illustrating in superimposed form, another stitch pattern by which the four yarn sets of FIG. 7 are knit together to form another fabric according to the present invention.

FIG. 14 is a point diagram schematically illustrating in superimposed form, another stitch pattern by which the four yarn sets of FIG. 8 are knit together to form another fabric according to the present invention.

FIG. 15 is a point diagram schematically illustrating in superimposed form still another stitch pattern by which the four yarn sets of FIG. 8 are knit together to form still another fabric according to the present invention.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The warp knit twill, sharkskin, and pique fabrics of the present invention are made by knitting one or more yarns into a rather opaque ground structure, and alternately laying threads into that ground structure in patterns which sequentially or periodically distort the technical back and/or technical face of the fabric to provide an effect which appears diagonally or obliquely to the course and wale directions throughout one or both faces of the fabric. The ground structure is typically knit in every course and every wale, and is typically formed of one or more hard or textured, relatively inelastic yarns. The yarns which are laid into the ground structure are typically laid-in in a pattern which alternates walewise and which advances course-wise so that the surface effects which result from the laid-in yarn appear diagonally or obliquely to the course and wale directions.

One preferred way of making the warp knit twill and sharkskin fabrics of the present invention is to knit one or more types of yarns together using the stitch pattern:

- Bar 1: 2-0, 2-4
- Bar 2: 2-4, 2-0
- Bar 3: 4-4, 2-2, 4-4, 0-0
- Bar 4: 4-4, 0-0, 4-4, 2-2

said stitch pattern being given in Raschel designations. Those skilled in the art will appreciate that such a stitch pattern, or combination of bar movement patterns, conventionally define the coordinated movements by which the guide bars feed yarns to the knitting needles during knitting, and such a stitch pattern also defines the way in which the yarns lie in relationship to each other in the resultant fabric. Typically, two sets of yarns, usually of the same type, are knit according to the Bar 1 and Bar 2 patterns, to form a substantially uniform ground fabric structure, which absent the sets of yarns laid-in by Bars 3 and 4, would not itself illustrate any extraordinary surface effect. Other yarns, which may be the same type as the yarns used in the ground structure, or different, are laid-into the ground structure according to the Bar 3 and Bar 4 patterns. The foregoing patterns for Bars 1, 2, 3, and 4, are schematically illustrated in point diagram notation in FIG. 7.

In the present invention, the ground structure is typically formed of one or more yarn sets or warps which knit stitch loops in every course and every wale. In the stitch pattern illustrated in FIG. 7, the ground fabric is formed from two warps or sets of yarns, one yarn of each of the two warps knitting in every course and every wale. In actual practice this would be done by fully threading Bar 1 and Bar 2 across the appropriate desired fabric width on a warp knitting machine, for example a tricot or a Raschel machine, and knitting those fully threaded bars, using the stitch pattern, or bar movement patterns, disclosed above and shown in FIG. 7. Such warp knitting machines are typically provided with appropriate pattern chains or cams to operate the guide bars in accordance with a desired stitch pattern. While the ground structure is thus formed with two full warps of yarns, the yarns which are laid-in according to the Bar 3 and Bar 4 patterns illustrated in FIG. 7, are laid-in using two complementary warps, each threaded one-in, one-out, one of which is placed in the fabric by the Bar 3 pattern, and the other of which is placed in the fabric by the Bar 4 pattern. The total number of ends of laid-in yarns may therefore be approximately equal to the total number of ends in one of the two full warps which are knit together by the patterns of Bar 1 and Bar 2 to form the ground fabric structure.

The most common way to alternate the respective yarns of two complementary warps, as typically used for placing the inlaid Bar 3 and Bar 4 yarns in a fabric, is to prepare one warp for Bar 3, single ends of which are threaded one-in, one-out through alternate guides of a third bar of a warp knitting machine across the desired fabric width, and prepare another complementary warp from which single ends are threaded one-in, one-out, through alternate guides of a fourth guide bar of the warp knitting machine. However, there are other ways of alternating the yarns of the two complementary warps to still place a full complement of inlaid yarns in the fabric while still achieving the desired surface effects of the present invention. For example, the yarns of each of Bar 3 and Bar 4 could be placed in the fabric by threading those bars on the machine two-in, two-out, respectively, or three-in, three-out, respectively. Furthermore, the Bar 3 and Bar 4 warps may be differently threaded, but still complementary. For example, the warp fed to Bar 3 of the knitting machine may be threaded two-in, one-out, through the guides of the third guide bar across the desired fabric width, and the complementary fourth guide bar warp threaded two-out, one-in, through the guides of the fourth guide bar. While such variations in how the alternating laid-in threads are placed in the fabric will make some variation in the resultant surface effects, for example they
may vary the angle at which the dominant lines of the pattern intersect the wale and course lines of the warp knit fabric, the principles by which the surface effects are created in such warp knit fabrics are basically the same. In further variations of the present invention, the total number of laid-in yarns need not comprise a full warp. In this way, ground fabrics having stripes of twill, sharkskin or pique surface effects throughout their length, may be produced.

Two of the aforementioned ways of alternating the laid-in yarns in fabrics using the stitch patterns illustrated in FIG. 7, are shown in FIGS. 12 and 13. In FIG. 12, the Bar 3 and Bar 4 yarns are alternated one-in, one-out, and in the FIG. 13 combination, the Bar 3 and Bar 4 yarns are alternated two-in, two-out. The results of making changes such as those illustrated by the combinations of FIGS. 12 and 13, may be visually appreciated by comparing FIGS. 1 and 2, which show fabrics which are made using the combination in FIG. 12, with the fabric of FIG. 3, which shows a fabric manufactured using the combination of FIG. 13. FIG. 1 shows a warp knit twill fabric of the present invention, and FIG. 2 shows a warp knit fabric of the present invention which is more akin to a sharkskin fabric, produced using the same yarns and stitch pattern used in making the fabric shown in FIG. 1; however, the length of yarn fed from one of the warps which forms the ground fabric was reduced, thereby altering the appearance of the surface effect. This illustrates another way in which the principles of the present invention may be used to create a somewhat different surface effect. FIG. 3 shows a fabric which exhibits an even more accentuated sharkskin effect produced by the stitch pattern illustrated in FIG. 13.

A preferred way of making the warp knit pique fabrics of the present invention is to knit one or more types of yarns together using the stitch pattern Bar 1: 2-0, 2-4
Bar 2: 2-4, 2-0
Bar 3: 4-4, 2-2, 4-4, 2-2, 4-4, 2-2, 4-4, 0-0
Bar 4: 4-4, 2-2, 4-4, 2-2, 4-4, 2-4, 4-4, 2-2
said stitch pattern being given in Raschel designations. As is previously described in the present invention, one or more yarns may be knit, usually in every course and every wale to form a ground fabric structure and in the fabric defined by this stitch pattern, or combination of bar movement patterns, two warps or sets of yarns are knit together, one by the pattern of Bar 1, and another by the pattern of Bar 2, to form a substantially uniform ground fabric structure. Again, two complementary partial warps of yarn are laid into the fabric by the patterns of Bar 3 and Bar 4, and it is the laid-in yarns which create surface effects in the resultant fabric. FIG. 8 schematically illustrates the foregoing pattern of Bars 1, 2, 3, and 4 in point diagram notation. The points diagrams of FIG. 8 are also helpful in illustrating the present invention, in that it can be seen that the yarns which are laid into the structure by the patterns of Bar 3 and Bar 4 are generally laid into a single wale, for example the wales labelled A in FIG. 8, and those laid-in yarns only periodically make an excursion toward or into an adjacent wale labelled B in FIG. 8. Now that this principle has been pointed out in FIG. 8, it is also clear that yarns laid into fabrics in accordance with the patterns of Bar 3 and Bar 4 of FIG. 7, also lie primarily in one wale, labelled A' in FIG. 7, and periodically make an excursion toward or into the adjacent wale labelled B' in FIG. 7. As previously mentioned, the alternating laid-in yarns appear to advance course-wise as they advance wale-wise to provide the surface effects of the present invention. The wale-wise alternation has previously been explained. The course-wise advance of the pattern of the alternate laid in yarns, may best be explained by following in successive wales the course-wise advance of those portions of the laid-in yarns which make an excursion out of the wale in which a particular yarn is primarily laid-in, toward or into the adjacent wale. This is illustrated, for example, in FIG. 7 where it is seen that the Bar 4 yarn first makes an excursion into wale B' on course II', and then the Bar 3 yarn makes an excursion into its adjacent wale B' in course IV'. Returning then to Bar 4 yarn, it next makes an excursion into its adjacent wale B' in course VI', and then the Bar 3 yarn makes an excursion into its adjacent wale B' in course VIII'. It will be appreciated that when the yarns are laid-in according to the patterns of FIG. 8, that the Bar 4 yarn first makes an excursion into adjacent wale B on course IV, while the Bar 3 yarn first makes an excursion into its adjacent wale B in course VIII.

A simple combination of the patterns of FIG. 8, is shown in FIG. 9 where two full warps of yarns are schematically illustrated as being knitted according to each of the Bar 1 and Bar 2 patterns, respectively, and two complementary half warps, alternately threaded one-in, one-out, are schematically illustrated laid-into the aforementioned described structure according to the Bar 3 and Bar 4 patterns. The patterns schematically illustrated in FIG. 9 illustrated even more fully the course-wise progression of the periodic excursions in the laid in yarns, and why those combinations of laid-in yarns produce diagonal or oblique surface effects in the fabrics of the present invention. For example, observe the excursions of the laid-in yarns as one moves from the yarns laid-into wale C to the yarn laid-into wale D to the yarn laid-into wale E, and eventually to the yarn laid-into wale F. Accompanying that wale wise progression, it is seen that the excursion in the laid-in yarns occurs in courses IV, VIII, XII, and XVI, respectively, and that those excursions of the laid-in yarns lie on a line X, which is oblique to both the wale and course directions of the fabric.

The way in which the surface effects caused by the excursions of the laid-in yarns, is photomicrographically shown in FIGS. 10 and 11, which are respectively about 18X scanning electron photomicrographs of the technical back and technical face of a fabric made according to the pattern shown schematically in FIG. 9 the fabric having been photomicrographed when extended in both the course and wale directions.

Since the course-wise progression of the excursions of the laid-in yarns is advanced the same number of courses between excursions in each of the two laid-in yarns, it does not matter at which side edge of the fabric one starts in locating such an oblique line on a diagram such as FIG 9. For example, one can just as easily locate such an oblique line by considering the excursions of the yarns which are primarily laid-in wales G, F, E, and D, respectively, which lie on a substantially straight line Y, which is likewise oblique to both the wale and course directions in the fabric of FIG. 9. However, so long as the number of courses between excursions in the two laid-in sets of yarns is the same, and as long as the excursions occur on different courses in the yarns of the two different laid-in warps, it does not mat-
ter how many courses the individual excursions of the laid-in yarns of one warp are offset from the excursions of the yarns of the other laid-in warp, since any such offsetting will produce the desired oblique surface effects in the fabrics of the present invention.

One way in which the excursions of the laid in yarns manifest themselves in the fabric of the present invention is that in making an excursion toward or into the wale adjacent to the wale in which a laid-in yarn primarily lies, the laid-in yarn loops or passes about the base of two lap portions of one of the ground fabric yarns, and tends to pull the bases of those lap portions, which otherwise extend in directions away from the excursion of their associated laid-in yarn, toward the wale in which that laid-in yarn primarily lies, giving the appearance that those two laps actually extend across approximately two wales. This is shown, for example, in FIG. 10 where the path of laid in yarns K, L, M, and N have been superimposed upon the photomicrograph, and at each of the excursions of these yarns, which tend to pull the base of laps which terminate in the adjacent wale back toward the wale in which the laid-in yarn primarily lies, those distended laps have been labelled 20. It is readily seen that those laps apparently terminate somewhere between the wale in which the laid-in yarn which is pulling those laps primarily lies, and the adjacent wales toward which the excursion of the laid in yarn took place. Using as a point of reference the point at which the bases of the distended laps seem to disappear between the wales, it can be seen that the effect caused by the excursions of the laid in yarns progresses wale-wise throughout the fabric along oblique lines represented by lines X' and Y'. Since point diagrams are usually drawn as if looking down upon the technical back of the fabric, the apparent paths of the laid-in yarns shown in FIG. 9 and FIG. 10 are similar.

FIG. 11 then shows the paths of the laid-in yarns superimposed upon a photomicrograph of the technical face of a fabric of the present invention, the same fabric whose technical back was shown in FIG. 10, and whose stitch pattern is shown in FIG. 9. The paths of the laid-in yarns have been labelled K', L' and M', substantially corresponding to the designations used in FIG. 10. Of course in this face view of the fabric, the excursions of the laid-in yarns take place toward the opposite edge of the fabric. In the face view of FIG. 11 the lap portions of one of the ground yarns, which are distended toward each of the wales in which the laid-in yarns primarily lie, are visible, but that portion of those laps which extends behind a wale and away from the excursion of their associated laid-in yarn, have been superimposed on the photomicrograph of FIG. 11, and labelled with the numeral 20'. FIG. 11 also shows that the stitch loops 21, which connect the laps 20' which are distended on the technical back of the fabrics of the present invention, are distended on the technical face of the fabric so that each of the stitch loops 21 connecting correspondingly distended laps 20', is canted more obliquely to the wale line than the other loops in that wale line. These extraordinarily canted loops form a wale-wise progression on the face of the fabric, those canted loops lying on a line which is also oblique to both the wale and course directions of the fabrics of the present invention, as indicated by lines X'' and Y''. As thus shown on the face of the fabric in FIG. 11, and as shown on the technical back of the fabric in FIG. 10, it is clear that the advantageous twill, sharkskin, or pique patterns in the warp knit fabrics of the present invention may occur on either the technical face or the technical back of the fabrics, and either side may be used as the desired effect surface, depending upon the application by the user.

Just as FIGS. 12 and 13 illustrated two combinations in which the pattern of FIG. 7 may be used in fabrics of the present invention, FIGS. 14 and 15, in addition to FIG. 9 illustrate various combinations in which the pattern of FIG. 8 may be used to produce fabrics according to the present invention. In FIG. 14, the yarns laid into the fabric according to the Bar 3 and Bar 4 patterns of FIG. 8, occur in a two-in, two-out alternation. The FIG. 15 pattern schematically illustrates a fabric wherein the laid-in yarns are placed in the fabric in alternation in three-in, three-out, sequences, respectively.

All of the foregoing makes it clear that the two sets of laid-in yarns of the present invention have stitch patterns wherein each laid-in yarn is primarily laid into one wale, and makes periodic excursions into an adjacent wale. The number of courses between the periodic excursions in each of the two sets of laid-in yarns is the same, but those excursions do not occur in the same course in both sets of laid-in yarns. The only further requirement to produce the advantageous twill, sharkskin, or pique effects of the present invention is that the length of the yarn laid-into each wale be short enough so that when the laid in yarn makes an excursion into or toward an adjacent wale, and when the fabric comes off the machine, the laps of the ground yarn around which the laid in yarn passed as it made the excursion into or toward the adjacent wale, are distended from their normal termination in the adjacent wale to an apparent termination closer to the wale in which the laid-in yarn primarily lies. It will also be appreciated that to effectively achieve these results, the excursions of the laid-in yarn should be coordinated with the ground fabric structure in such a way that the excursion or extended portion of the laid-in yarn passes around the base of laps which themselves otherwise extend in the opposite direction from the wale in which their associated laid-in yarn primarily lies.

Accompanying the distention of the pair of laps about which the laid-in yarn made the excursion, is the corresponding distortion or canting of the stitch loop which joins those two laps in the technical face of the fabric.

The types of yarns which may be used in the present invention may include any textile yarns capable of being knitted on a warp knitting machine a needle bar and a plurality of, usually at least three or four, guide bars. Since in the preferred fabrics of the present invention, the laid-in yarns, are almost entirely hidden or sandwiched within the wales of the fabrics, even yarns which have undesirable characteristics insofar as external appearance or effect is concerned, may be used as the laid-in yarn. For example, bare rubber of spandex elastic yarns have an undesirable clammy feeling when contacted by human skin, and typically give an undesirable "grin-through" in fabrics because such yarns are difficult to dye with dyes suitable for use in coloring more common textile yarns. But such yarns may be effectively covered when used as the laid-in yarns in the present invention. It is therefore clear that it is the ground fabric yarns which are exposed in the fabrics of the present invention, and which will provide those fabrics with desired esthetics such as hand and color. Similarly, it is the ground yarns, one of which is knit in every
course and every wale of the fabric, which will limit the ex tensibility of the fabrics of the present invention. But where relatively elastic yarns are used as the laid-in yarns, they provide good elastic elongation and stretch recovery to the inventive fabrics. In that regard it should be noted that a particularly preferred embodiment of the present invention is one wherein hard, or textured yarns are used in the ground fabric, and highly elastic yarns, such as spandex, are laid into such a ground fabric. In such combinations, the present invention provides highly desirable elastic warp knit twill, sharkskin, or pique fabrics.

Accordingly, yarns suitable for use as the ground structure yarns in the present invention, include any of the well known relatively inelastic yarns, such as nylon, polyester, acetate rayon, or other yarns, in either rigid or textured form, and may include any natural yarns such as cotton or silk. Similarly, any of the foregoing yarns may be used as the laid-in yarns in the present invention. Furthermore, relatively elastic yarns such as natural or synthetic rubber yarns, or any of the spandex yarns, such as Du Pont's Lycra, may be laid-in to provide elastic warp knit fabrics according to the present invention. The relatively elastic yarn in the present invention is usually used in its bare condition, without covering such as a spiral winding. The word "yarn" is used herein in the generic sense to include any sort of elongate flexible member which may be knit on a warp knitting machine, and may include threads, filaments, strands, or yarns, whether they be monofilament, multi filament, continuous filament, or comprise spun shorter fibers. It will of course be appreciated that the foregoing yarns are only representative of those useful in the present invention, and are in no way intended to limit the scope of application of the principles of the present invention.

During knitting of the fabrics of the present invention, the length of each set of yarns fed to the knitting machine (i.e., the runner length of each warp) need only be sufficient to accommodate the movements of the knitting elements of the machine without breaking yarn or breaking knitting elements. However, as mentioned earlier herein, the runner length of the laid-in yarns should be sufficiently short to cause the excursion portions of the laid-in yarns to pull the base of the laps of ground fabric yarn which the excursion loop around, out of their usual wale of termination and toward the wale in which the laid in yarn containing the excursion primarily lies, thereby also distending the stitch loop which connects those laps. Any combination of runner lengths and resultant tensions which provides the desired result may be used. After the fabric is removed from the knitting machine, it may be dyed and finished by any means which the user may desire.

One of the primary advantages of fabrics of the present invention is that while the inlaid yarns are typically never pulled into a stitch loop or knitted into any course of the fabric, they are virtually never exposed on either surface of the cloth, so that they cannot be easily snagged, picked, or otherwise pulled out of the fabric. They therefore provide the warp knit surface effect fabrics of the present invention another advantage over woven fabrics, since the yarns which cause the desired twill, sharkskin, and pique surface effects in the warp knit fabrics of the present invention, cannot be snagged, picked, pulled or run out of the fabric as is possible in the former woven fabrics.

The following examples are intended to illustrate various preferred embodiments of the present invention.

EXAMPLE I

A warp knit twill fabric is made by fully threading Bar 1 and Bar 2 of a Mayer 64 guage Raschel knitting machine with 1322 ends of 40 denier 13 filament Du Pont Antron nylon and threading the third and fourth bars one-in, one-out, each with 661 ends of 140 denier Du Pont T-127 Lycra spandex, and knitting those yarns together in the stitch pattern: Bar 1: 2-0, 2-4; Bar 2: 2-4, 2-0; Bar 3: 4-2, 2-4, 4-0, 4-4; and Bar 4: 4-4, 0-0, 4-4, 2-2. The Bar 1 runner length is about 55 inches per rack; Bar 2 runner length about 51 inches per rack; and Bars 3 and 4 each have runner lengths of about 54 inches per rack; the Lycra yarns being extended about 104 percent as warped on the beam. The fabric is knit at about 60 stitches per inch on the machine. The resultant fabric is an opaque, warp knit elastic twill fabric having a twill surface effect as shown in FIGS. 1 and 1B, wherein the relatively elastic yarns are substantially covered by the ground yarns. In this fabric, as in the other fabrics of the present invention, either the technical back side, or the technical face side of the fabric may be used as the desired exterior effect surface.

While the greige fabric embodies the present invention, after knitting the fabric may be finished by any desired technique, specific finishing techniques not being a part of the claimed invention. For example, the greige fabric taken from the knitting may then be run into a scray to relax the dry fabric. The fabric may then be removed from the scray and run through a wash box containing water at about 200°F with a small amount of detergent therein. The tension settings are set to run the fabric through the wash box in a relaxed condition. The fabric may be taken from the wash box and framed on a small tenterette, with overfeeds and tension controls set to wind the fabric onto a Burlington beam in a relaxed condition. The fabric may be Burlington beam machine dyed under atmospheric pressure, by steps which may include chemically scouring, rinsing, drying, heat fixation of the dye, and further rinsing. The fabric may then be extracted on a beam extractor, and heat set at a desired wale and course count.

EXAMPLE II

A warp knit sharkskin fabric is produced using a machine set up as described in Example I, except that in producing this fabric the Bar 2 runner length is about 48% inches per rack. The resultant fabric is a warp knit elastic sharkskin fabric having surface effects as shown in FIGS. 2 and 2B.

EXAMPLE III

A warp knit sharkskin fabric is produced using a setup quite similar to that described in Example I, except that the Bar 2 runner length is about 51¼ inches per rack, and instead of being threaded one-in, one-out, in each of Bars 3 and 4, the Lycra yarns are threaded two-in, two-out, in each of guide bars 3 and 4. The resultant fabric is a warp knit elastic sharkskin fabric having the surface effects shown in FIG. 3 and 3B.

EXAMPLE IV

A warp knit pique fabric is produced by fully threading the first and second bars of a Mayer 64 guage Raschel knitting machine with 1322 ends of 40 denier 13 filament R-25 Du Pont Antron nylon. Bars 3 and 4
were each threaded one-in, one-out, with 661 ends of 140 denier DuPont T-127 Lycra spandex yarns. These yarns were knit according to the stitch pattern: Bar 1: 2-0, 2-4, Bar 2: 2-4, 2-0, Bar 3: 4-4, 2-2, 4-4, 2-2, 4-4, 0-0; and Bar 4: 4-4, 2-2, 4-4, 0-0, 4-4, 2-2, 4-4, 2-2. The runner length of Bar 1 is about 52/5 inches per rack; Bar 2 about 44 inches per rack; and Bars 3 and 4 each about 6.2 inches per rack, the Lycra yarns being extended about 104 percent as wound on the beam. The fabric was knit at about 80 stitches per inch on the machine. The resultant fabric is a warp knit elastic pique fabric having the surface effects shown in FIG. 4 and 4B, and the knit structure of the fabric is shown in more detail in FIGS. 10 and 11.

**EXAMPLE V**

A warp knit pique fabric is produced using a machine setup as described in Example IV, except that the Lycra yarns in Bars 3 and 4 instead of being threaded one-in, one-out, are threaded two-in, two-out, in each of Bars 3 and 4. The resultant fabric is a warp knit elastic pique fabric having surface effects shown in FIG. 5 and 5B.

**EXAMPLE VI**

A warp knit pique fabric is produced using a machine setup as described in Example IV, except that the Lycra yarns in Bars 3 and 4 instead of being threaded one-in, one-out, are threaded three-in, three-out, in each of Bars 3 and 4. The resultant fabric is a warp knit elastic pique fabric having surface effects as shown in FIG. 6 and 6B.

Although specific components, proportions, and arrangements of elements have been stated in the above description of preferred embodiments of this invention, other equivalent components and arrangements of elements may be used with satisfactory results and various degrees of quality, or other modifications may be made herein to enhance the invention to thereby increase its utility. For example, the ground fabric may comprise a single bar fabric, or may be knit using open stitch loops in any or all courses and wales. Also, the patterns stated herein have been given in Raschel designations, but those skilled in the art can readily translate those patterns into tricot designations. It will be understood that such changes of details, materials, arrangements of parts, and uses of the invention described and illustrated herein, are intended to be included within the principles and scope of the claimed invention. Any greige or finished fabric meeting the limitations of the appended claims is intended to be within the scope of the present invention.

What is claimed is:

1. A warp knit fabric comprising a first set of yarns forming a knit ground structure containing stitch loops in every course and wale, and second and third sets of yarns laid into the ground structure; each respective yarns of said second set primarily lying in one respective wale of the ground structure and periodically extending toward an adjacent wale, passing around at least two lap portions of one of the yarns of the ground structure, which lap portions otherwise extend in directions away from the portion of the yarn of the third set which extends toward the adjacent wale, and displacing those laps toward the wale in which the yarn of said third set is primarily lying; the yarns of the second and third sets making all their periodic extensions in the same direction, but with the yarns of the third set making their periodic extensions in different courses from the courses in which the yarns of the second set make their periodic extensions; said second and third sets of yarns being substantially covered by the yarns of the ground structure, and said fabric having a surface effect on at least one face thereof which appears to extend along line oblique to the course and wale directions in the fabric.

2. The warp knit fabric of claim 1, wherein the stitch loops of yarn on the technical face of the fabric which join the two laps which are displaced by each of the extending portions of the laid-in yarns, are more oblique with respect to the directions of the wales than the other stitch loops which comprise said wales.

3. The warp knit fabric of claim 1, wherein the yarns of said second set are primarily laid into different wales from the wales in which the yarns of said third set are primarily laid-in.

4. The warp knit fabric of claim 2, wherein a surface effect which appears to extend generally along lines oblique to the course and wale directions in said fabric appears on both faces of the fabric.

5. The warp knit fabric of claim 1, wherein the yarns of said second and third sets alternate across the course-wise width of the fabric in such a way that at least one yarn of said second set alternates across the width of the fabric with at least one yarn of said third set.

6. The warp knit fabric of claim 1, wherein the yarns of said second and third sets alternate across the course-wise width of the fabric in such a way that more than one yarn of said second set alternates across the width of the fabric with more than one yarn of said third set.

7. The warp knit fabric of claim 1, wherein the ground structure additionally comprises another set of yarns, which knit is every course on every wale in said ground structure.

8. The warp knit fabric of claim 1, wherein the laid-in yarns of said second and third sets comprise relatively elastic yarns, and said fabric is elastic.

9. The warp knit fabric of claim 8, wherein said relatively elastic yarns comprise spandex yarns.

10. The warp knit fabric of claim 7, wherein in said ground structure comprises said first set of yarns knit in the fabric in the pattern: 2-0, 2-4, and said another set of yarns knit in the fabric in the pattern: 2-4, 2-0, said patterns being given in Raschel designations.

11. The warp knit fabric of claim 6, wherein the yarns of said second set of yarns are laid-into the fabric in the pattern: 4-4, 2-2, 4-4, 0-0, and the yarns of said third set are laid-into the fabric in the pattern: 4-4, 0-0, 4-4, 2-2, said patterns being given in Raschel designations.

12. The warp knit fabric of claim 6, wherein the yarns of said second set of yarns are laid-into the fabric in the pattern: 4-4, 2-2, 4-4, 2-2, 4-4, 0-0, and the yarns of said third set are laid-into the fabric in the pattern: 4-4, 2-2, 4-4, 4-4, 4-4, 0-0, said patterns being given in Raschel designations.
13. The warp knit fabric of claim 10, wherein the yarns of said second and third sets alternate across the coursewise width of the fabric in such a way that at least one yarn of said second set alternates across the width of the fabric with at least one yarn of said third set, and the yarns of said second set of yarns are laid-into the fabric in the pattern: 4-4, 2-2, 4-4, 0-0, and the yarns of said third set are laid-into the fabric in the pattern: 4-4, 0-0, 4-4, 2-2, said patterns being given in Raschel designations.

14. The warp knit fabric of claim 10, wherein the yarns of said second and third sets alternate across the coursewise width of the fabric in such a way that at least one yarn of said second set alternates across the width of the fabric with at least one yarn of said third set, and the yarns of said second set of yarns are laid-into the fabric in the pattern: 4-4, 2-2, 4-4, 2-2, 4-4, 0-0, and the yarns of said third set are laid-into the fabric in the pattern: 4-4, 2-2, 4-4, 0-0, 4-4, 2-2, 4-4, 2-2, said patterns being given in Raschel designations.

15. A method of manufacturing a warp knitted fabric, comprising the steps of:

1. fully threading a front guide bar of a warp knitting machine across an approximate desired fabric width with a first plurality of yarns;

2. fully threading a second guide bar of said warp knitting machine across said approximate desired fabric width with a second plurality of yarns;

3. partially threading a third guide bar of said warp knitting machine alternately across said approximate desired fabric width with a third plurality of yarns;

4. partially threading a fourth guide bar of said warp knitting machine across said approximate desired fabric width alternately in an arrangement complementary to the arrangement of yarns threaded through said third guide bar; and

5. operating said warp knitting machine, said guide bars feeding yarns to the needle bar of said machine according to the combination of bar movement patterns:

   front bar: 2-0, 2-4
   second bar: 2-4, 2-0
   third bar: 4-4, 2-2, 4-4, 0-0
   fourth bar: 4-4, 2-2, 4-4, 0-0, 4-4, 2-2, 4-4, 2-2, said patterns being given in Raschel designations.

16. The method of claim 15, wherein said third and fourth guide bars are threaded with yarns comprising bare relatively elastic yarns.

17. The method of claim 15, wherein each yarn of said third and fourth pluralities is laid-into primarily one wale of the resultant fabric, and the length of each of said third and fourth pluralities of yarns fed to the needle bar is sufficiently short so that as the fabric is manufactured portions of each one of said yarns of said third and fourth pluralities extend toward a wale adjacent to the wale in which said one yarn primarily lies, each said portion passing around two lap portions of a yarn from said first plurality of yarns displacing those lap portions toward the wale in which said one yarn primarily lies.

18. A method of manufacturing a warp knitted fabric, comprising the steps of:

1. fully threading a front guide bar of a warp knitting machine across an approximate desired fabric width with a first plurality of yarns;

2. fully threading a second guide bar of said warp knitting machine across said approximate desired fabric width with a second plurality of yarns;

3. partially threading a third guide bar of said warp knitting machine alternately across said approximate desired fabric width with a third plurality of yarns;

4. partially threading a fourth guide bar of said warp knitting machine across said approximate desired fabric width alternately in an arrangement complementary to the arrangement of yarns threaded through said third guide bar; and

5. operating said warp knitting machine, said guide bars feeding yarns to the needle bar of said machine according to the combination of bar movement patterns:

   front bar: 2-0, 2-4
   second bar: 2-4, 2-0
   third bar: 4-4, 2-2, 4-4, 2-2, 4-4, 0-0
   fourth bar: 4-4, 2-2, 4-4, 0-0, 4-4, 2-2, 4-4, 2-2, said patterns being given in Raschel designations.

19. The method of claim 18, wherein said third and fourth guide bars are threaded with yarns comprising bare relatively elastic yarns.

20. The method of claim 19, wherein each yarn of said third and fourth pluralities is laid-into primarily one wale of the resultant fabric, and the length of each of said third and fourth pluralities of yarns fed to the needle bar is sufficiently short so that as the fabric is manufactured portions of each one of said yarns of said third and fourth pluralities extend toward a wale adjacent to the wale in which said one yarn primarily lies, each said portion passing around two lap portions of a yarn from said first plurality of yarns displacing those lap portions toward the wale in which said one yarn primarily lies.

21. A method of knitting a warp knit fabric, comprising:

   knitting a first set of yarns forming a plurality of courses and wales of stitch loops in a ground fabric construction, with the yarns forming stitch loops in each course and each wale, and simultaneously laying complementary second and third sets of yarns into said ground construction, each respective yarn of said second and third sets being laid into primarily one respective wale of the ground fabric construction, and the length of each of said second and third sets of yarns laid-into the fabric being sufficiently short so that portions of each one of the yarns of said second and third sets extend in the same directions, but in different courses between sets, toward a wale adjacent to the wale in which said one yarn primarily lies, each said portion passing around two lap portions of a yarn from said first set of yarns, which lap portions extend in a direction away from said wale in which the inlaid yarn primarily lies, and displacing those lap portions toward the wale in which said one yarn primarily lies.

22. The method of claim 21, wherein said ground fabric construction is additionally formed by knitting together said first set of yarns with still another set of yarns, additionally forming at least one yarn of said additional set into a stitch loop in each course and each wale of the ground fabric construction.

23. The method of claim 21, wherein said second and third sets of yarns comprises bare, relatively elastic
yarns, and said bare, relatively elastic yarns are substantially covered by the yarns of said first set.

24. The method of claim 22, wherein said second and third sets of yarns comprise bare, relatively elastic yarns, and said bare, relatively elastic yarns are substantially covered by the yarns of said first set.

25. The method of claim 23, wherein said relatively elastic yarns are elastically elongated before being laid into the ground fabric construction.

26. The method of claim 22, wherein the fabric is knitted on a warp knitting machine, and said first set of yarns is supplied to the knitting needles through a front guide bar fully threaded across an approximate desired fabric width, said another set of yarns is supplied to said knitting needles through a second guide bar fully threaded across said approximate fabric width, said second set of yarns is supplied to said knitting needles through a third guide bar partially and alternately threaded across said approximate fabric width, said third set of yarns is supplied to said knitting needles through a fourth guide bar partially and alternately threaded in an arrangement complementary to the arrangement of yarns threaded through said third guide bar, and operating said machine so that the front and second guide bars feed yarns to the needles according to the bar movement patterns:

- front bar: 2-0, 2-4
- second bar: 2-4, 2-0

said patterns being given in Raschel designations.

27. The method of claim 26, additionally comprising operating said third and fourth guide bars to feed yarns to the needles, in synchronization with the bar movement patterns of said front and second bars, according to the bar movement patterns:

- third bar: 4-4, 2-2, 4-4, 0-0
- fourth bar: 4-4, 0-0, 4-4, 2-2

said patterns being given in Raschel designations.

28. The method of claim 26, additionally comprising operating said third and fourth guide bars to feed yarns to the needles, in synchronization with the bar movement patterns of said front and second bars, according to the bar movement patterns:

- third bar: 4-4, 2-2, 4-4, 2-2, 4-4, 2-2, 4-4, 0-0
- fourth bar: 4-4, 2-2, 4-4, 0-0, 4-4, 2-2

said patterns being given in Raschel designations.

29. The method of claim 26, wherein the arrangement of yarns in which said second and third sets of yarns are threaded through said third and fourth guide bars, respectively, is such that at least one yarn of said second set alternates with at least one yarn of said third set across said approximate fabric width as said second and third sets are laid into the ground construction.

30. The method of claim 29, wherein said second and said third sets of yarns comprise bare, relatively elastic yarns.

31. The method of claim 30, wherein said relatively elastic yarns are elastically elongated before being supplied through a guide bar.

32. The method of claim 21, wherein only one yarn is laid into each wale of the fabric.

33. The method of claim 26, wherein only one yarn is laid into each wale of the fabric.

34. The warp knit fabric of claim 1, wherein only one of the yarns laid into the fabric lies in each wale of the fabric.

* * * * *
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,922,888 Dated December 2, 1975

Inventor(s) Thomas E. Patterson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 11, the word "yarns" should read --yarns--.

Column 2, line 7, the word "effect" should read --effects--.

Column 3, line 26, the word "is" should read --in--.

Column 6, line 32, the word "illustrated" which appears after "FIG. 9" should read --illustrate--.

Column 8, line 17, the word "than" should read --that--.

Column 8, line 50, after "machine", insert --having--.

Column 11, line 58, the word "yarns" should read --yarn--.

Column 12, line 45, the word "is" should read --in--.

Signed and Sealed this Ninth Day of November 1976

[SEAL]

Attest:

RUTH C. MASON
Attending Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks