US 20190309452A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2019/0309452 A1
(43) Pub. Date: Oct. 10, 2019
LIAO et al.

(54) STRETCH CIRCULAR KNIT FABRICS CONTAINING ELASTOMERIC FIBER AND POLYESTER BI-COMPONENT FILAMENT, GARMENTS MADE THEREFROM AND A METHOD OF MAKING SAME

(71) Applicant: **A&AT LLC**, Wilmington, DE (US)

(72) Inventors: **Tianyi LIAO**, Chadds Ford, PA (US); **Geoffrey D. HIETPAS**, Newark, DE (US); **Fred C. WYNEGAR**, Wilmington, DE (US)

(73) Assignee: **A&AT LLC**, Wilmington, DE (US)

(21) Appl. No.: **16/345,442**

(22) PCT Filed: **Oct. 24, 2017**

(86) PCT No.: **PCT/US2017/057995**

§ 371 (c)(1),
(2) Date: **Apr. 26, 2019**

Related U.S. Application Data

(60) Provisional application No. 62/413,015, filed on Oct. 26, 2016.

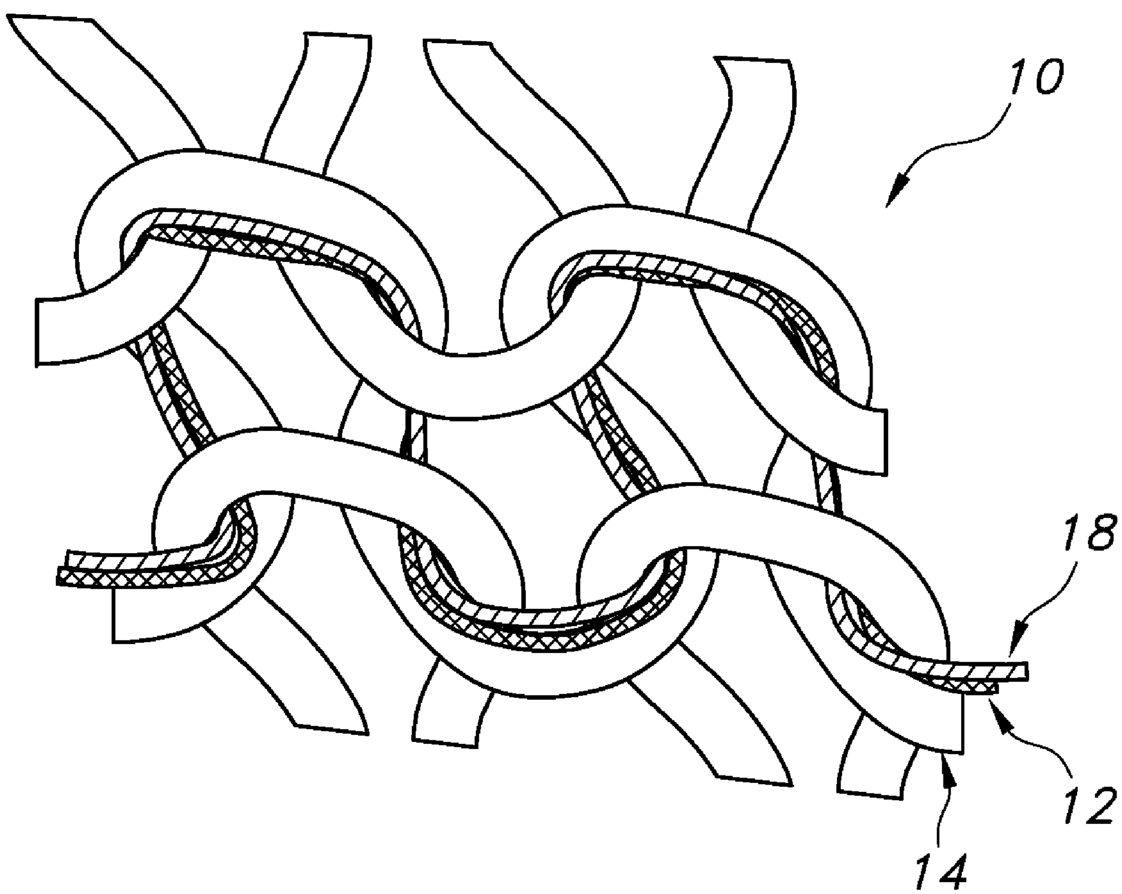
Publication Classification

(51) **Int. Cl.**
D04B 1/12 (2006.01)
D04B 1/18 (2006.01)

(52) **U.S. Cl.**
CPC ***D04B 1/123*** (2013.01); *D10B 2403/0241* (2013.01); *D10B 2403/0114* (2013.01); ***D04B 1/18*** (2013.01)

(57) **ABSTRACT**

Stretch circular knit fabric (**40**, **82**, **94**) containing two sets of different elastic fiber (**12**, **18**) and optionally hard yarn (**14**) and methods for their production are provided.



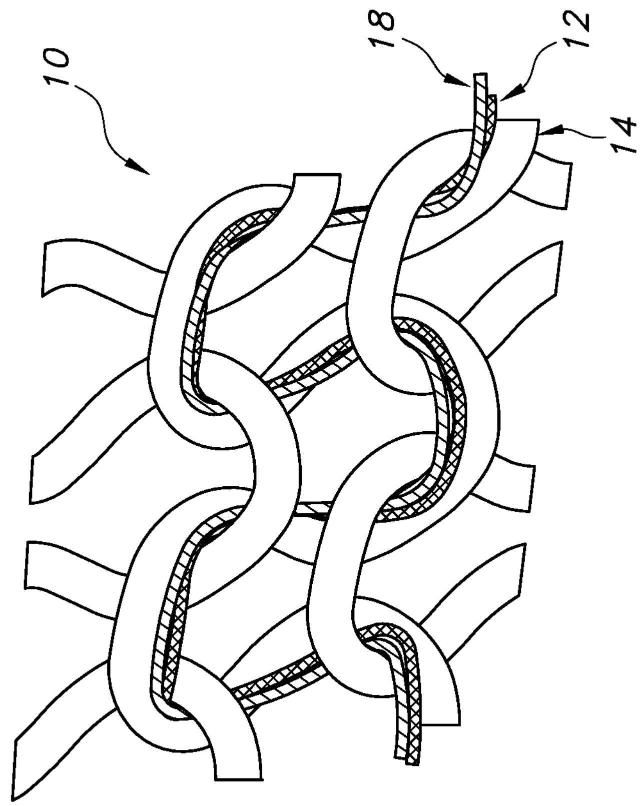


FIG. 1

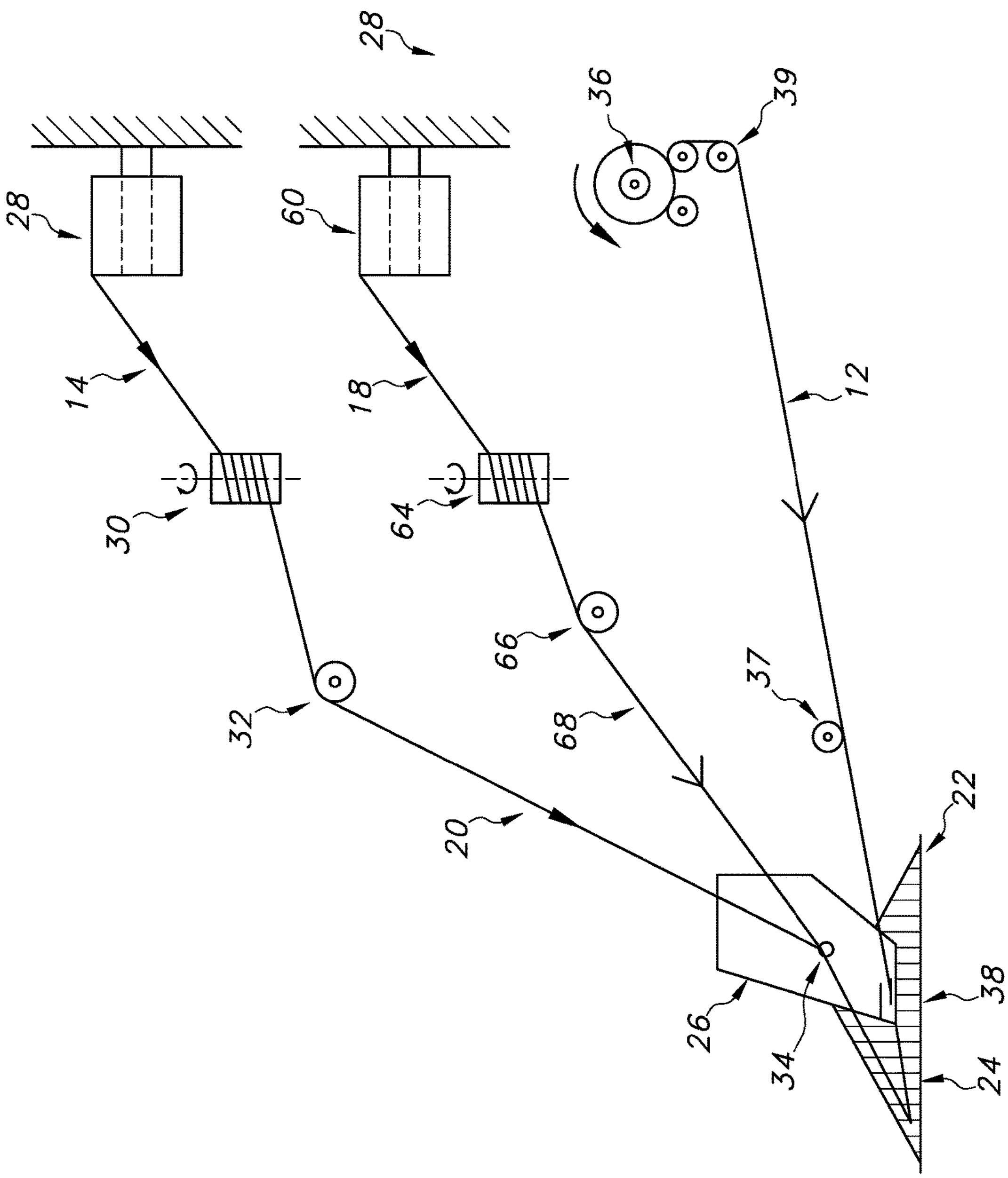


FIG. 2

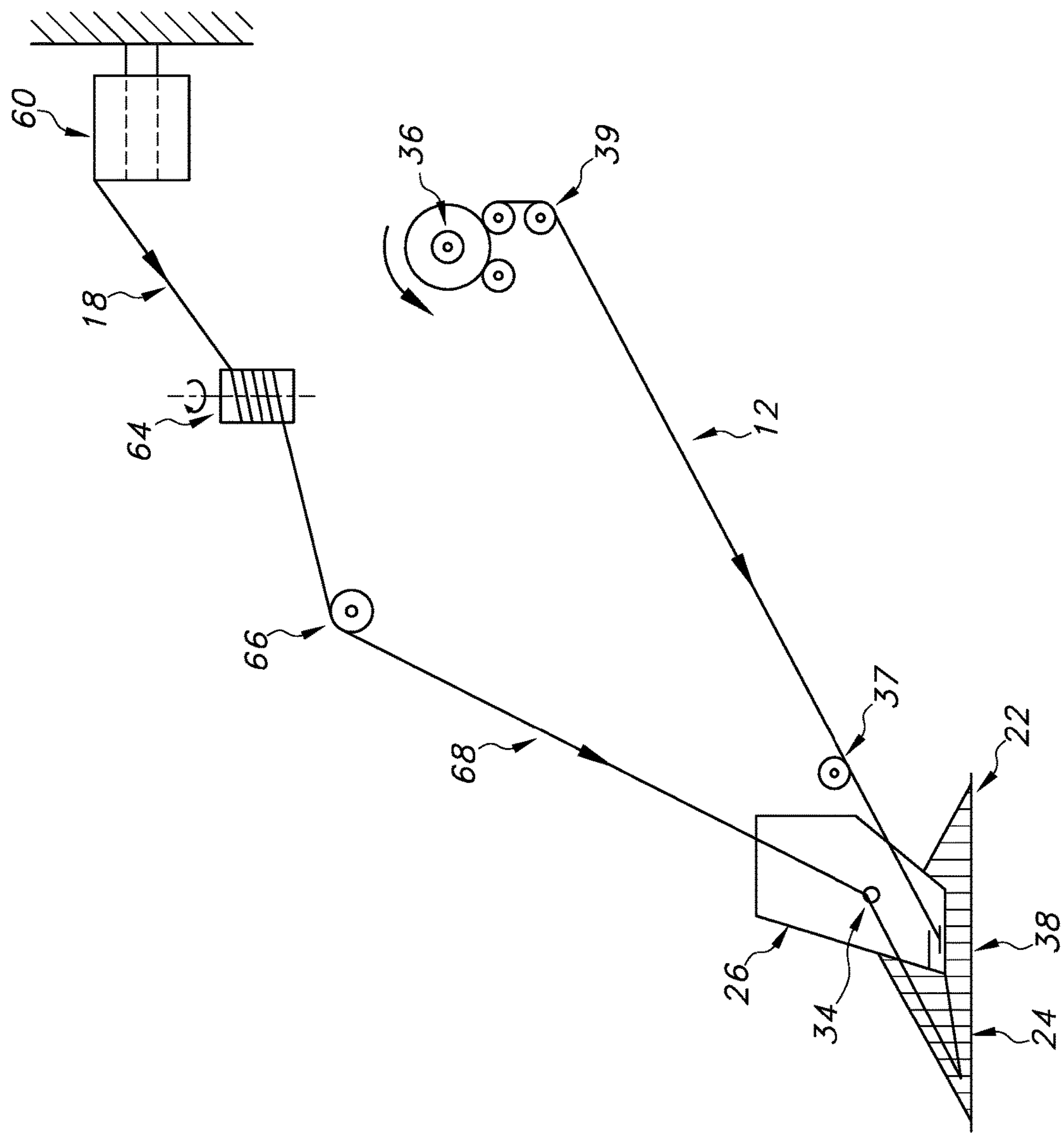


FIG. 3

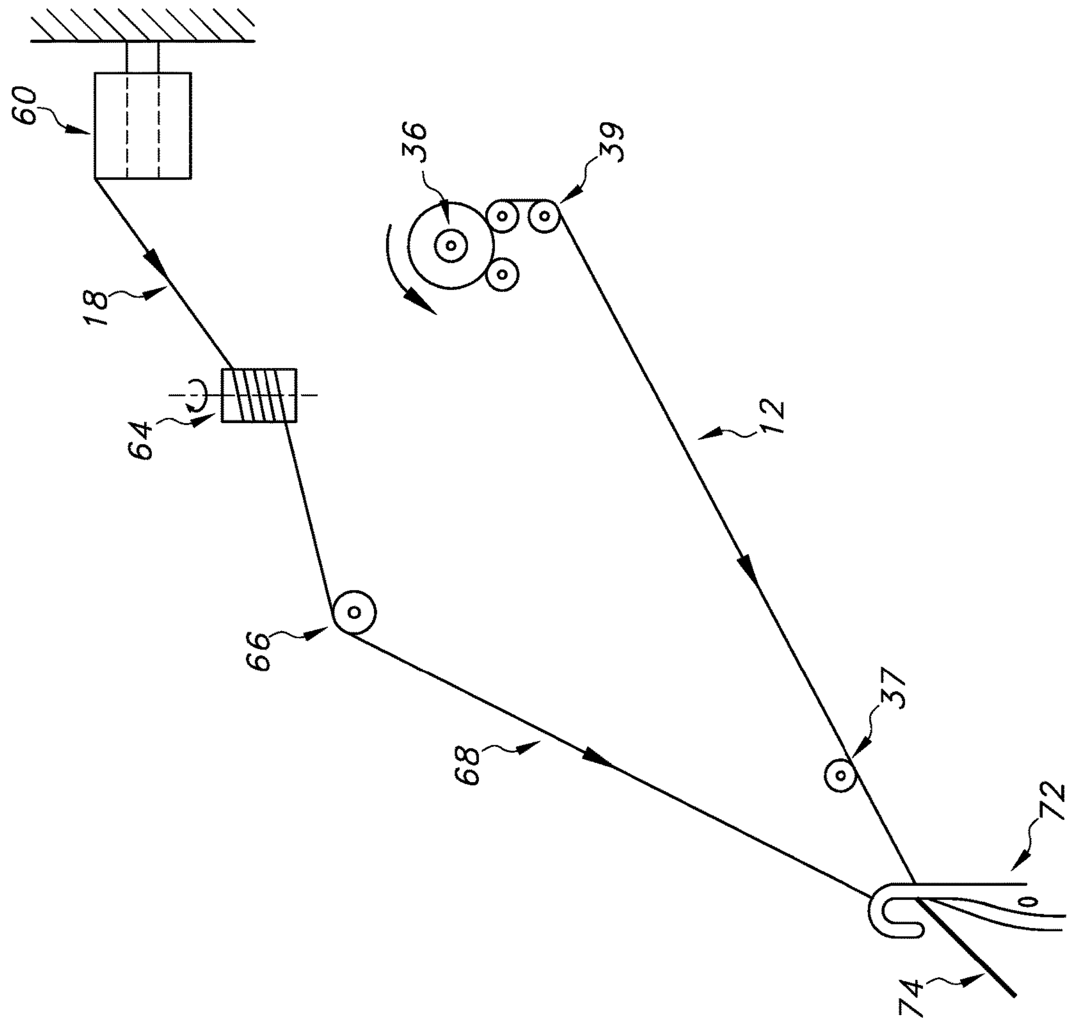


FIG. 4

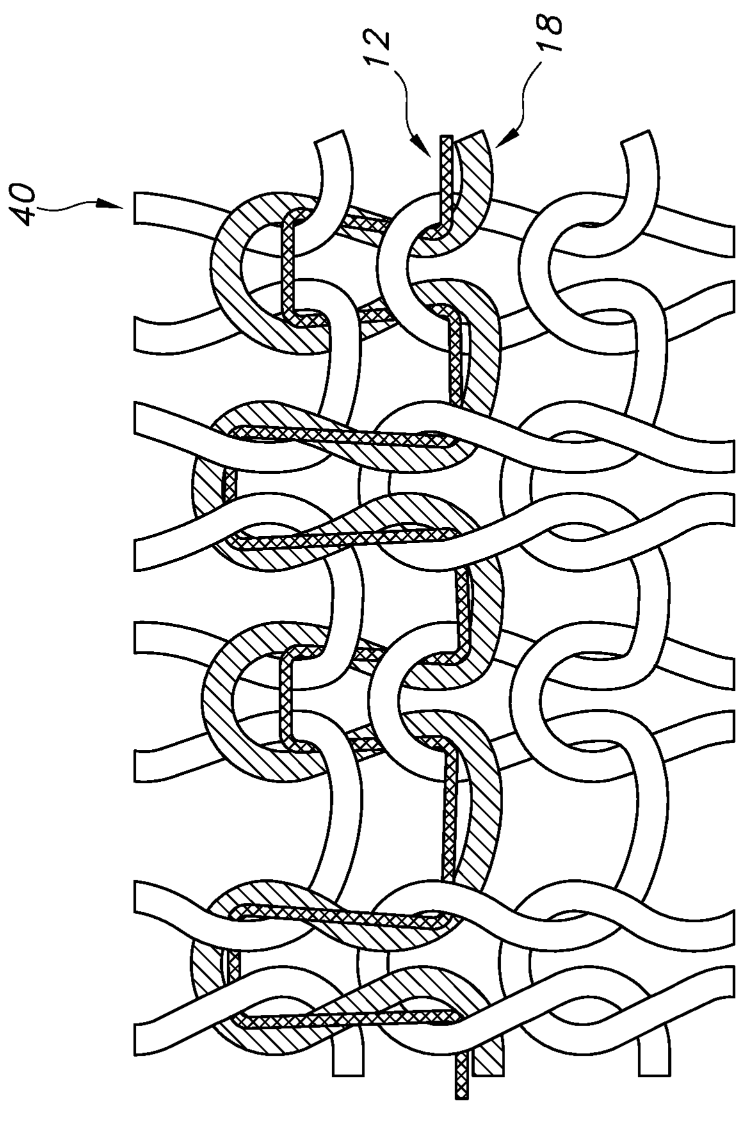


FIG. 5

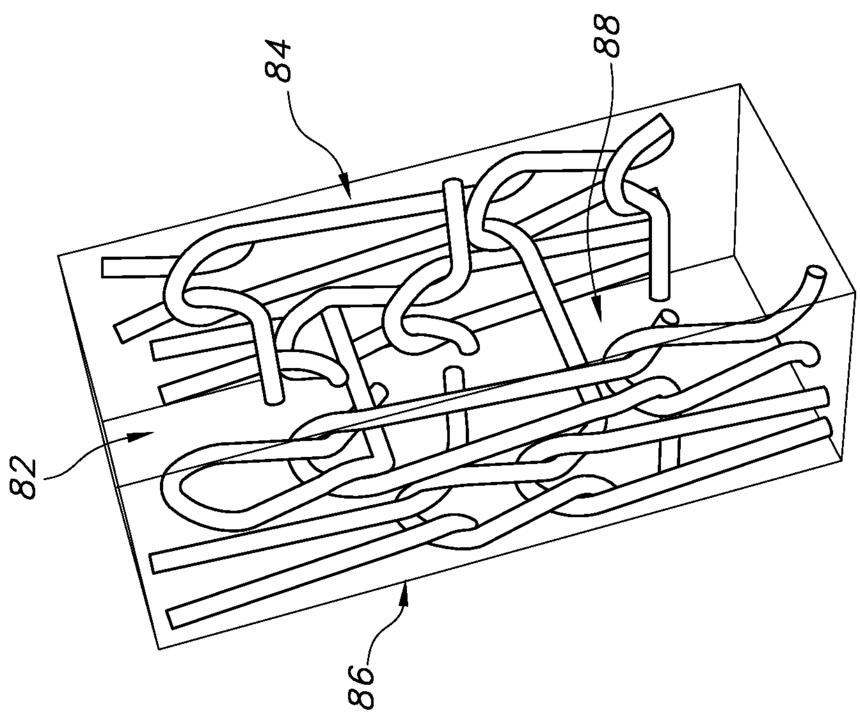


FIG. 6

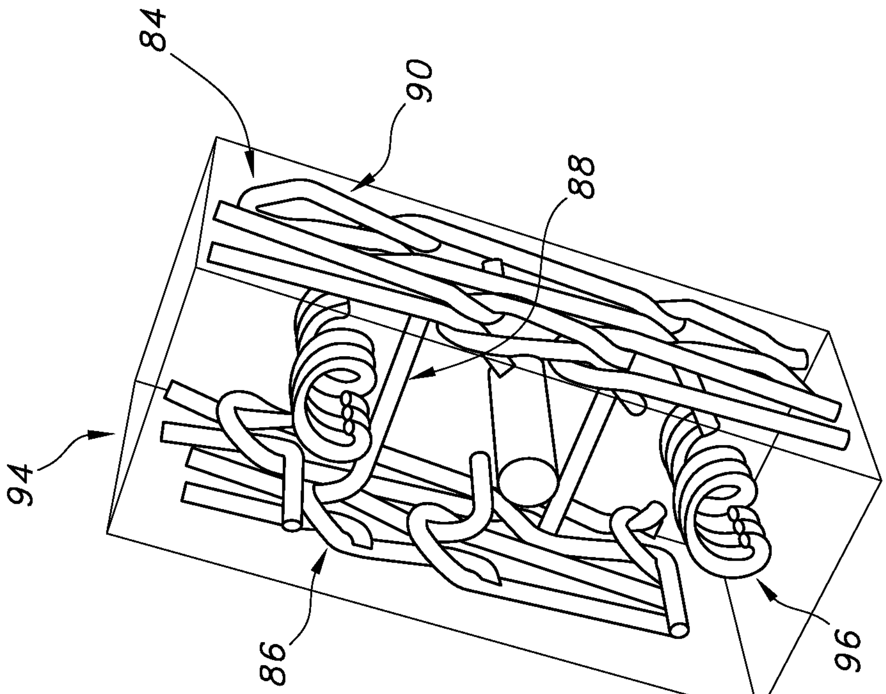


FIG. 7

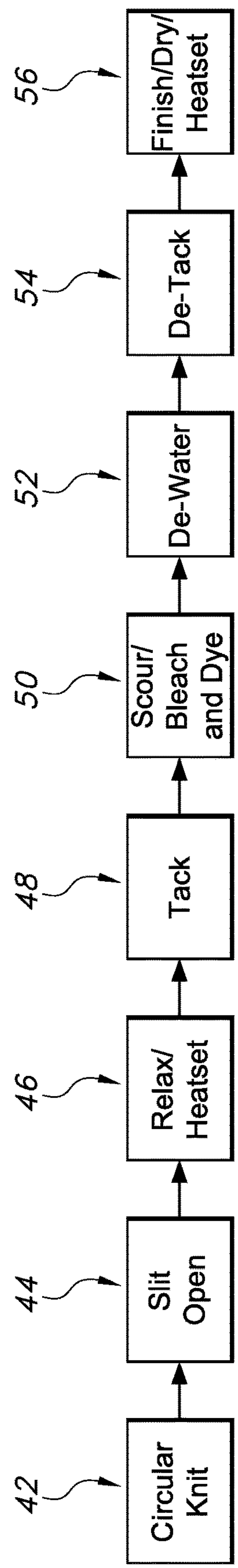

42
Circular Knit
44
Slit Open
46
Relax/ Heatset
48
Tack
50
Scour/ Bleach and Dye
52
De-Water
54
De-Tack
56
Finish/Dry/ Heatset

FIG. 8

STRETCH CIRCULAR KNIT FABRICS CONTAINING ELASTOMERIC FIBER AND POLYESTER BI-COMPONENT FILAMENT, GARMENTS MADE THEREFROM AND A METHOD OF MAKING SAME

FIELD OF INVENTION

[0001] The present invention relates to the manufacture of stretch circular knit fabric containing two sets of different elastic fibers with enhanced anti see-through, high holding force and recovery power. The elastic circular knit fabric is produced from elastomeric elastic fiber and polyester bi-component filament and optionally hard yarns.

BACKGROUND

[0002] Elastomeric fibers are commonly used to provide stretch and elastic recovery in knit fabrics and garments.

[0003] Most available stretch circular knit fabrics on the market are made with a single type of elastic fiber and hard fibers. Such fabrics are widely known as comfort fabrics as they can more easily deform and/or stretch during wear. The wearing comfort of garments made from these knit fabrics comes from their stitch rearrangement and elastic fiber extension. However, recovery by knit stitch rearrangement and single elastic fiber is generally incomplete because the yarns do not provide adequate recovery force to rearrange the stretched knit stitches. As a consequence, single elastic knit fabrics may experience permanent deformations or 'bagging' in certain garment areas, such as at the elbows of shirtsleeves, where more stretching occurs. Consumers thus see bagging and sagging issues after long time wear. Due to the loop structure, circular knit fabrics exhibit lower holding forces as high deformation as compared with woven fabrics, which limits the penetration of circular knits in bottom weights.

[0004] To improve the recovery performance of circular knit fabrics, it is now common to co-knit higher amounts of spandex fiber with the companion hard yarn. The higher spandex content provides for a fabric with higher stretch level and better recovery power. However, higher spandex content creates other quality issues such as high fabric shrinkage, edge curling, and rubber touch feeling. It is difficult to obtain fabrics which have easy stretch, high recovery, low shrinkage and good stability.

[0005] Another potential problem is the see-through issue for knit fabric, particularly in bottom wear such as yoga pants. Such fabrics may become too shear and therefore see-through when a wearer bends over or stretches thus revealing a wearer's undergarments and/or body parts. This problem may be difficult to detect when the wearer is simply standing. The issue oftentimes is not revealed until the wearer is in a yoga position or is stretching before exercise.

[0006] Polyester bi-component filament is an elastic filament based on polyester fiber with moderate elasticity, excellent recovery and other desirable fiber properties. It is used extensively in woven fabrics. When used in knitted fabrics, however, it has a tendency of showing severe, random, uneven surfaces making the fabric appearance as well as touch feeling undesirable.

[0007] Therefore, there is a need to produce stretch knit fabrics, which have easy stretch, easy process, low shrinkage, friendly garment making, excellent recovery power, good touch and appearance, and excellent warmth.

SUMMARY OF THE INVENTION

[0008] An aspect of the present invention relates to a method for making stretch circular knit fabric comprising elastomeric fiber and polyester bi-component filament.

[0009] In one nonlimiting embodiment of the method of the present invention, two sets of different elastic fiber are knitted together to form a single layer circular knit fabric. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex comprises bare spandex yarn with a count from 11 to 560 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex. In this nonlimiting embodiment, the knitted fabric comprises 100% elastic yarns and no hard fiber exists inside the knitted fabric.

[0010] In another nonlimiting embodiment of the method of the present invention, the fabric further comprises a hard fiber. In this nonlimiting embodiment, the elastomeric fiber may be a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn having a count from 11 to 560 dtex. In one nonlimiting embodiment, the hard fiber yarn has a count from 10 to 900 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

[0011] In another nonlimiting embodiment of the present invention, two sets of elastic fiber with different properties and a hard fiber are knitted together to form a double layer circular knit fabric. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn with a count from 11 to 560 dtex. In one nonlimiting embodiment, the hard fiber has a yarn count from 10 to 900 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

[0012] In yet another nonlimiting embodiment of the method of the present invention, two sets of elastic fibers with different properties and a hard fiber are knitted together to form a double layer spaced circular knit fabric. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn with a count from 11 to 560 dtex. In this nonlimiting embodiment, the polyester bi-component filaments are put into the center of spaced fabric as cushion yarn.

[0013] Another aspect of the present invention relates to stretch circular knit fabric comprising elastomeric fiber and polyester bi-component filament. Various forms of circular knit fabrics may be used including, but not limited to, single jersey, float jersey, rip and spaced fabric. Further processing of the fabric may include, but is not limited to, scouring, bleaching, dyeing, drying, sanforizing, singeing, de-sizing, mercerizing, and any combination of such steps.

[0014] In one nonlimiting embodiment, the fabric is a single layer circular knit fabric formed by knitting together the two sets of different elastic fiber. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex comprises bare spandex yarn with a count from 11 to 560 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex. In this nonlimiting embodiment, the knitted fabric comprises 100% elastic yarns and no hard fiber exists inside the knitted fabric.

[0015] In another nonlimiting embodiment, the stretch circular knit fabric further comprises a hard fiber. In this nonlimiting embodiment, the elastomeric fiber may be a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn having a count from 11 to 560 dtex. In one nonlimiting embodiment, the hard fiber yarn has a count from 10 to 900 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

[0016] In another nonlimiting embodiment of the present invention, the fabric is a double layer circular knit fabric formed by knitting together is two sets of elastic fiber with different properties and a hard fiber. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn with a count from 11 to 560 dtex. In one nonlimiting embodiment, the hard fiber has a yarn count from 10 to 900 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

[0017] In yet another nonlimiting embodiment, the fabric is a double layer spaced circular knit fabric form by knitting together the two sets of elastic fibers with different properties and a hard fiber. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn with a count from 11 to 560 dtex. In this nonlimiting embodiment, the polyester bi-component filaments are put into the center of spaced fabric as cushion yarn.

[0018] Another aspect of the present invention relates to garments produced from the fabrics of the present invention.

BRIEF DESCRIPTION OF THE FIGURES

[0019] FIG. **1** is a schematic diagram of a nonlimiting embodiment of fabric of the present invention showing plated knit stitches comprising elastomeric fiber, polyester bi-component filament and a hard yarn.

[0020] FIG. **2** is a schematic diagram of a portion of a circular knitting machine fed with a hard yarn feed, a polyester bi-component filament feed, and a spandex yarn feed in production of a nonlimiting fabric embodiment of the present invention.

[0021] FIG. **3** is a schematic diagram of a portion of a circular knitting machine fed with a polyester bi-component filament feed and a spandex yarn feed in production of a different nonlimiting fabric embodiment of the present invention.

[0022] FIG. **4** is another schematic diagram of a portion of a circular knitting machine fed with a polyester bi-component filament feed and a spandex yarn feed in production of a nonlimiting fabric embodiment of the present invention. In this embodiment, the polyester bi-component filament and a spandex yarn are fed and combined together in a knit needle.

[0023] FIG. **5** is a schematic diagram of a nonlimiting embodiment of fabric of the present invention showing 1×1 rib knit stitches comprising elastomeric fiber and polyester bi-component filament.

[0024] FIG. **6** is a schematic diagram of a nonlimiting embodiment of double knit fabric produced in accordance with the present invention.

[0025] FIG. **7** is a schematic diagram of a spaced fabric with polyester bi-component filament in center.

[0026] FIG. **8** is a flow chart showing a nonlimiting example of finish process steps which can be used for circular knit fabrics with two elastic yarns prepared in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0027] Provided by this disclosure are stretch circular knit fabrics containing two sets of different elastic fiber with enhanced anti see-through, high holding force and recovery power and methods for their production.

[0028] The elastic circular knit fabrics of the present invention comprise elastomeric elastic fiber and polyester bi-component filament and optionally hard yarns. Fabrics of the present invention are produced by knitting together by various methods and into various embodiments, the two sets of different elastic fibers and optionally a hard yarn.

[0029] The first set of fiber used in the fabrics of the present invention comprises an elastomeric fiber.

[0030] By "elastomeric fiber" or "elastomeric elastic fiber" as used herein, it is meant either a continuous filament or a plurality of filaments, free of diluents, which have a break elongation in excess of 100% independent of any crimp. In one nonlimiting embodiment, the elastomeric fiber comprises a coalesced multifilament. An elastomeric fiber when (1) stretched to twice its length; (2) held for one minute; and (3) released, retracts to less than 1.5 times its original length within one minute of being released. When used herein, "elastomeric fiber" or "elastomeric elastic fiber" means at least one elastomeric fiber or filament. Examples of elastomeric fiber useful in the present invention, include but are not limited to, rubber filament, biconstituent filament and elastoester, lastol, and spandex.

[0031] "Spandex" is a manufactured filament in which the filament-forming substance is a long chain synthetic polymer comprised of at least 85% by weight of segmented polyurethane.

[0032] "Elastoester" is a manufactured filament in which the fiber forming substance is a long chain synthetic polymer composed of at least 50% by weight of aliphatic polyether and at least 35% by weight of polyester.

[0033] "Bi-constituent filament" is a continuous filament comprising at least two polymers adhered to each other along the length of the filament, each polymer being in a different generic class, for example, an elastomeric polyetheramide core and a polyamide sheath with lobes or wings.

[0034] "Lastol" is a fiber of cross-linked synthetic polymer, with low but significant crystallinity, composed of at least 95 percent by weight of ethylene and at least one other olefin unit. This fiber is elastic and substantially heat resistant.

[0035] In one nonlimiting embodiment, the elastic fiber comprises a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex comprises bare spandex yarn with a count from 11 to 560 dtex.

[0036] Nonlimiting examples of spandex useful in the present invention include Lycra® (a registered trademark of Invista S. a r.l.) types 162, 169, 275 and 562.

[0037] In one nonlimiting embodiment, the elastomeric fiber has a denier between 10 denier and 450 denier.

[0038] The second set of fiber used in fabric of the present invention comprises polyester bi-component filament.

[0039] "Polyester bi-component filament" is a continuous filament comprised of two polymers of different chemical or physical properties extruded from the same spinneret with both polymers within the same filament. In one nonlimiting embodiment, the polyester bi-component filament comprises poly(trimethylene terephthalate) (PTT) and at least one polymer selected from the group consisting of poly (ethylene terephthalate) (PET), poly(trimethylene terephthalate) and poly(tetramethylene terephthalate) or a combination of such members, having an after heat-set crimp contraction value of from about 10% to about 80%. These yarns develop additional crimp upon exposure to hot and wet conditions.

[0040] A nonlimiting example of a polyester bi-component filament useful in the present invention is LYCRA® T400® fiber. LYCRA® T400® fiber is a commercial polyester bi-component filament made by Invista, S. a. r. L.

[0041] It is a melting spun side-by-side multicomponent filament of PTT/PET prepared by a conjugated fiber spinning process. LYCRA® T400® fiber develops crimps: (1) because of the asymmetric distribution of the two components in the fiber cross-section, and (2) the differential shrinkages of the PTT and PET components when the fibers are heat-treated. The off-package crimp is about ⅓ of total crimp onside fabric. Most of remaining crimp develops in hot wet environments such as fabric dyeing and finishing processes.

[0042] In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

[0043] In one nonlimiting embodiment, the bicomponent filament denier is from about 10 to about 450.

[0044] In one nonlimiting embodiment, the knitted fabric comprises 100% elastic yarns and no hard fiber exists inside the knitted fabric.

[0045] The elastomer fiber content with circular knit fabric with two elastic yarns are about 3% or higher, including from about 8% to about 35%, and about 10% to about 30% based on the weight of the fabric. Polyester bi-component filament content within the fabric may be about 5% or higher by weight based on the total fabric weight, including from about 10% to about 60%.

[0046] In another nonlimiting embodiment of the present invention, the fabric further comprises a hard yarn.

[0047] "Hard yarn" as used herein means a knitting yarn, which does not contain a high amount of elastic stretch, such as, but not limited to, cotton, wool, cellulosic fibers, polyester filament and Nylon filament. Textured polyester and nylon filaments are preferable. These hard yarns provide opportunity to add extra function into fabrics. For example, polyester and nylon filament will increase the tenacity of cotton fabrics and improve the wrinkle resistant abilities. Cotton and wool yarn increase the moisture of synthetic fabrics. Special function yarns can also be introduced. For example, Coolmax® fiber that helps absorb moisture from body and quick deliver to outside or conductible fiber that conducts the electricity may be used. Fibers with anti-biotic and micro-capsules also can be used to provide the fabrics with body care, freshness and easy care properties. The fibers with enhanced thermal performance are able to be used as well, such as, THERMOLITE® fiber that increase the thermal resistance and thermal insulation, and THERMOLITE® IR fiber that generate heat under infrared ray. Soft hand fiber, such as micro denier polyester and cotton-touch Supplex® nylon fiber, can be adopted to improve the fabric hand touch and appearance.

[0048] In one nonlimiting embodiment, the hard fiber yarn has a count from 10 to 900 dtex.

[0049] In one nonlimiting embodiment of the present invention, hard yarn is incorporated into the fabric via a pre-covered elastic yarn or pre-covered yarn.

[0050] A "pre-covered elastic yarn" or "pre-covered yarn" as used herein, is one surrounded by, twisted with, or intermingled with hard yarn before the core spun process. The hard-yarn covering serves to protect the elastomeric fibers from abrasion during textile processes. Such abrasion can result in breaks in the elastomeric fiber with consequential process interruptions and undesired fabric non-uniformities. Further, the covering helps to stabilize the elastomeric fiber elastic behavior, so that the elongation of pre-covered elastic yarn can be more uniformly controlled during textile processes than would be possible with bare elastomeric fibers. The pre-covered yarn also can increase the tensile modulus of the yarn and fabric, which is helpful to improve the fabric recovery power and dimensional stabilities.

[0051] Nonlimiting examples of pre-covered yarns include: (a) single wrapping of the elastomer fibers with a hard yarn; (b) double wrapping of the elastomer fibers with a hard yarn; (c) continuously covering (i.e., corespun or core-spinning) an elastomer fiber with staple fibers, followed by twisting during winding; (d) intermingling and entangling elastomer and hard yarns with an air jet; and (e) twisting an elastomer fibers and hard yarns together.

[0052] Fabric of the present invention comprising the two sets of elastic fibers of elastomeric elastic fiber and polyester bi-component filament and optionally hard yarns can be produced by circular knitting.

[0053] The term "circular knitting" as used herein means a form of weft knitting in which the knitting needles are organized into a circular knitting bed. Generally, a cylinder rotates and interacts with a cam to move the needles reciprocally for knitting action. The yarns to be knitted are fed from packages to a carrier plate that directs the yarn strands to the needles. The circular knit fabric emerges from the knitting needles in a tubular form through the center of the cylinder. Seamless knit machine and flat knit machine are also included in this innovation.

[0054] Circular knit, flat knit and Santoni seamless machines can all be used to make these circular knit fabrics comprising two sets of different elastic yarns with high stitch forming precision. If a Santoni seamless machine is used, the drafts and draft ratio of the two different sets of elastic yarns can be used in different portions of the garment. The garment exalts the body anatomy by using two elastic yarns with graduated compressions. The santoni seamless machines have the capability of producing shaped panels with the two elastic yarns. A wide variety of fabric structures and garments can be produced in a variety of diameters on circular knitting machines. Stitch structures including, but not limited to, tucks, floats, and false ribs, the lengths of stitches and unbalancing the structures are used to modify the shape of a tube.

[0055] Various embodiments of fabric of the present invention can be produced.

[0056] In one nonlimiting embodiment, two sets of different elastic fiber are knitted together to form a single layer circular knit fabric. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex comprises bare spandex yarn with a count from 11 to 560 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex. In this nonlimiting embodiment, the knitted fabric comprises 100% elastic yarns and no hard fiber exists inside the knitted fabric.

[0057] In another nonlimiting embodiment, the fabric further comprises a hard fiber. In this nonlimiting embodiment, the elastomeric fiber may be a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn having a count from 11 to 560 dtex. In one nonlimiting embodiment, the hard fiber yarn has a count from 10 to 900 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

[0058] In another nonlimiting embodiment of the present invention, two sets of elastic fiber with different properties and a hard fiber are knitted together to form a double layer circular knit fabric. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises a bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn with a count from 11 to 560 dtex. In one nonlimiting embodiment, the hard fiber has a yarn count from 10 to 900 dtex. In one nonlimiting embodiment, the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

[0059] In yet another nonlimiting embodiment of the method of the present invention, two sets of elastic fibers with different properties and a hard fiber are knitted together to form a double layer spaced circular knit fabric. In this nonlimiting embodiment, one set of elastic fiber comprises polyester bi-component filament and the second set of elastic fiber comprises bare elastomeric yarn. In one nonlimiting embodiment, the bare elastomeric yarn comprises the bare elastomeric yarn comprises spandex. In one nonlimiting embodiment, the spandex is bare spandex yarn with a count from 11 to 560 dtex. In this nonlimiting embodiment, the polyester bi-component filaments are put into the center of spaced fabric as cushion yarn.

[0060] Nonlimiting fabric embodiments of the present invention and methods for their production are set forth in FIGS. **1-7**.

[0061] For example, FIG. **1** provides a schematic of a nonlimiting embodiment of a circular knit fabric with two sets of elastic yarns, the first set being elastomeric yarn **12**, and the second set being polyester bi-component filament **18**. The elastic yarns are plated with a hard yarn **14**. For jersey knit constructions in circular knit machines, the process of co-knitting elastic fiber is called “plating.” With plating, the hard yarn **14** and the two sets of elastomeric yarns **12** and **18** are knitted parallel, in side-by-side relation, with the elastic yarns always kept on one side of the hard yarn, and hence on one side of the knitted fabric. FIG. **1** is a schematic representation of plated knit stitches **10** wherein the knitted yarn comprises elastomeric yarn **12**, polyester bi-component filament **18**, a hard yarn **14**.

[0062] FIG. **2** shows in schematic form a nonlimiting example of a feed position **20** of a circular knitting machine having a series of knitting needles **22** that move reciprocally as indicated by the arrow **24** in response to a cam (not shown) below a rotating cylinder (not shown) that holds the needles. In a circular knitting machine, there are multiple numbers of these feed positions arranged in a circle, so as to feed individual knitting positions as the knitting needles, carried by the moving cylinder, are rotated past the positions. The device shown in FIG. **2** can be used for producing knit fabrics with double elastic yarns where two elastic yarns and one hard yarn have the same stitch patterns. In the nonlimiting embodiment, three yarns are knitted together in the same routes. In one nonlimiting embodiment, this device and yarns are used to make single jersey structure as shown in FIG. **1**.

[0063] As shown in FIG. **2**, during plating knit operations, an elastomeric yarn **12**, a polyester bi-component filament **18**, and a hard yarn **14** are delivered to the knitting needles **22** by a carrier plate **26**. The carrier plate **26** simultaneously directs all three yarns to the knitting position. The elastomeric yarn **12**, polyester bi-component filament **18** and hard yarn **14** are introduced to the knitting needles **22** to form a single jersey knit stitch **10** like that shown in FIG. **1**.

[0064] In this nonlimiting embodiment, the hard yarn **14** is delivered from a wound yarn package **28** to an accumulator **30** that meters the yarn to the carrier plate **26** and knitting needles **22**. The hard yarn **14** passes over a feed roll **32** and through a guide hole **34** in the carrier plate **26**. Optionally, more than one hard yarn may be delivered to the knitting needles via different guide holes in the carrier plate **26**.

[0065] The polyester bi-component filament **18** is delivered from a wound yarn package **60** to an accumulator **64** that meters the yarn to the carrier plate **26** and knitting needles **22**. The polyester bi-component filament **18** passes over a feed roll **66** and through a guide hole **34** in the carrier plate **26**.

[0066] The elastomeric yarn **12** is delivered from a surface driven package **36** and past a broken end detector **39** and change of direction roll(s) **37** to a guide slot **38** within the carrier plate **26**. The feed tension of the elastomeric yarn **12** is measured between the detector **39** and drive roll **37**, or alternatively between the surface driven package **36** and roll **37** if the broken end detector is not used. The guide hole **34** and guide slot **38** are separated from one another in the carrier plate **26** so as to present the hard yarn **14**, polyester bi-component filament **18**, and elastomeric yarn **12** to the knitting needles **22** in side by side, generally parallel relation (plated).

[0067] The elastomeric yarn stretches, also referred to herein as drafts, when it is delivered from the supply package to the carrier plate and in turn to the knit stitch due to the difference between the stitch use rate and the feed rate from the elastomeric yarn supply package.

[0068] "Draft" refers to the amount of stretch applied to the elastomeric yarn. The draft of a fiber is directly related to the elongation (stretching) applied to the fiber (e.g. 100% elongation corresponds to 2× draft, 200% elongation corresponds to 3× draft, etc).

[0069] The ratio of the hard yarn supply rate (meters/min) to the elastomeric yarn supply rate is typically 1.5 to 4 times (1.5× to 4×) greater, and is known as the machine draft. This corresponds to elastomeric yarn elongation of 50% to 300%, or more. The feed tension in the elastomeric yarn is directly related to the draft of the elastomeric yarn. This feed tension is typically maintained at values consistent with high machine drafts for the elastomeric yarn. In the present invention, improved results were obtained when the total elastomeric yarn draft, as measured in the fabric, was kept to about 5× or less, typically 3× or less, for example 2.5× or less. This draft value is the total draft of the elastomeric yarn, which includes any drafting or drawing of the elastomeric yarn that is included in the supply package of as-spun yarn. The value of residual draft from elastomeric yarn is termed package relaxation, "PR", and it typically ranges from 0.05 to 0.15 for the elastomeric yarn used in circular knit, elastic, single jersey fabrics. The total draft of the elastomeric yarn in the fabric is therefore MD*(1+PR), where "MD" is the knitting machine draft. The knitting machine draft is the ratio of hard yarn feed rate to elastomeric yarn feed rate, both from their respective supply packages. Because of its stress-strain properties, elastomeric yarn drafts more as the tension applied to the elastomeric yarn increases; conversely, the more that the elastomeric yarn is drafted, the higher the tension in the yarn.

[0070] A typical elastomeric yarn path, in a circular knitting machine, is schematically shown in FIG. **2**. The elastomeric yarn **12** is metered from the supply package **36**, over or through a broken end detector **39**, over one or more change-of-direction rolls **37**, and then to the carrier plate **26**, which guides the elastomeric yarn to the knitting needles **22** and into the stitch. There is a build-up of tension in the elastomeric yarn as it passes from the supply package and over each device or roller due to frictional forces imparted by each device or roller that touches the elastomeric yarn. The total draft of the elastomeric yarn at the stitch is therefore related to the sum of the tensions throughout the elastomeric yarn path. The elastomeric yarn feed tension is measured between the broken end detector **39** and the roll **37** shown in FIG. **2**. Alternatively, the elastomeric yarn feed tension is measured between the surface driven package **36** and roll **37** if the broken end detector **39** is not used. The higher this tension is set and controlled, the greater the elastomeric yarn draft will be in the fabric, and vice versa. For example, this feed tension can range from 2 to 4 cN for 22 dtex elastomeric yarn and from 4 to 6 cN for 44 dtex elastomeric yarn in commercial circular knitting machines. With these feed tension settings and the additional tensions imposed by subsequent yarn-path friction, the elastomeric yarn in commercial knitting machines will be drafted significantly more than 3×. Minimizing the elastomeric yarn friction between the supply package and the knit stitch helps to keep the elastomeric yarn feed tensions sufficiently high for reliable elastomeric yarn feeding when the elastomeric yarn draft is 7× or less. For reliably feeding elastomeric yarn from the supply package to the knit stitch, the elastomeric yarn draft is typically 3× or less.

[0071] The polyester bi-component filament **18** is also stretched or drafted before it enters the knitting needle **22**. The yarn is stretched out through the speed difference between an accumulator **64** and the carrier plate **26** and in turn to the knit stitch. The ratio of the feed rate from the stitch use rate to the accumulator **64** (meters/min) is typically 1.01× times to 1.35× times (1.01× to 1.35×). Adjusting the speed of accumulator **64** gives the desired draft or stretch ratio. Too low a stretch ratio will result in low quality fabrics having grin-through. Too high a stretch ratio will result in breakage of the polyester bi-component filaments.

[0072] "Grin-through" is a term used to describe the exposure, in a fabric, of elastic yarn to view. Grin-through can manifest itself as an undesirable glitter. If a choice must be made, low grin through on the face side is more desirable than low grin-through on the back side.

[0073] FIG. **3** provides a schematic of an alternative feeding system for production of a fabric of the present invention. In this nonlimiting embodiment, the polyester bi-component filament **18** is delivered from a wound yarn package **60** to an accumulator **64** that meters the yarn to the carrier plate **26** and knitting needles **22**. The polyester bi-component filament **18** passes over a feed roll **66** and through a guide hole **34** in the carrier plate **26**. The elastomeric yarn **12** is delivered from a surface driven package **36** and past a broken end detector **39** and change of direction roll(s) **37** to a guide slot **38** within the carrier plate **26**. The guide hole **34** and guide slot **38** are separated from one another in the carrier plate **26** so as to present polyester bi-component filament **18**, and elastomeric yarn **12** to the knitting needles **22** in side by side, generally parallel relation.

[0074] In this embodiment, hard yarn **14** is fed into the machine by a separated carrier plate and a separated knitting needle. In this way, it is possible to make the fabrics with hard yarns only in selected courses. In other courses, there are only two elastic yarns. This embodiment provides more opportunities to make various circular knit fabrics. It is not required that all three yarns exist in all courses within fabrics.

[0075] FIG. **4** provides a schematic of yet another alternative feeding system for production of a fabric of the present invention. In this nonlimiting embodiment, both the polyester bi-component filament **18** and the elastomeric yarn **12** are merged together in knitting needles directly, without prior merging in carrier plate **26**. This embodiment provides for further flexibilities for knit designers to develop different style and different pattern fabrics, such as in, but not limited to, Santoni seamless machines.

[0076] As shown in FIG. **5**, the two sets of elastic yarns can also be used to produce elastic circular knit fabric used in production of a stretch fabric rib fabric. FIG. **5** shows a diagram of such fabrics made from elastomeric fiber **12** and polyester bi-component filament **18**. Rib fabrics **40** are made on two needle beds with the needles in a staggered formation. The loops are drawn in opposite directions so that face and back loops alternate in each course. Both sides of the fabric show only the face loops. The back loops are exposed only when the fabric is extended in the width direction. Rib fabrics with two elastic fibers are very extendible in the width direction and flat without curl. They could be used in pullovers, waistcoats, socks, underwear and collar.

[0077] In addition, as shown in FIG. **6**, the two sets of elastic yarns can be used in production of double layer knit fabric made on a circular knit machine with two needle beds. FIG. **6** shows a diagram of such fabrics. The double knit fabric **82** includes first layer Face I **84** and second layer Face II **86**, with the layers being secured together by a series of interlock yarns **88**. The interlock yarns maintain the fabric layers in a spacer relationship relative to each other.

[0078] Further, as shown in FIG. **7**, the two sets of elastic yarns can be used in production of double layer spaced knit fabrics. FIG. **7** demonstrates such fabric structure **94**. A polyester bi-component filament, such as LYCRA® T400® fiber **96**, is inserted between the two layers **84** and **86** of fabric **94** as a cushion yarn. Under heat and hot condition during the fabric finishing process, the polyester bi-component filament coil up and expand in fabric thick direction. These make the fabric with resilient/cushion property in all directions. The polyester bi-component filament also makes the fabric with more open space between two layers, resulting in high thermal insulation. The interlock yarn **88** and polyester bi-component cushion yarn **96** maintain the fabric layers in a spacer relationship relative to each other.

[0079] Additional exemplary steps for finishing an elastic circular-knit fabric produced in accordance with the present invention are outlined in FIG. **8**. After the fabric is knitted **42**, most in the form of a tube, it is collected under the knitting machine either as a roll on a rotating mandrel, as a flattened tube, or in a box after it is loosely folded back and forth. In open-width finishing, the knitted tube is then slit open **44** and laid flat. The open fabric is subsequently relaxed **46**, either by subjecting it to steam, or by wetting it by dipping and squeezing, also referred to as padding. The relaxed fabric is then applied to a tenter frame and heated for heat setting **46** in an oven. The tenter frame holds the fabric on the edges by pins, and stretches it in both the length and width directions in order to return the fabric to desired dimensions and basis weight. If wet, the fabric is first dried. Then heat setting is accomplished before subsequent wet processing steps. Consequently, heat setting is often also referred to as "pre-setting". At the oven exit, the flat fabric is released from the stretcher and then tacked **48**, also referred to as sewed, back into a tubular shape. The fabric then is processed in tubular form through wet processes of cleaning, scouring and optional bleaching/dyeing **50**, e.g., by soft-flow jet equipment, and then de-watered **52**, e.g., by squeeze rolls or in a centrifuge. The fabric is then de-tacked **54** by removing the sewing thread and re-opening the fabric into a flat sheet. The flat, still wet, fabric is then dried **56** in a tenter-frame oven under conditions of fabric overfeed, which is the opposite of stretching, so that the fabric is under no tension in the length or machine direction while being dried at temperatures below heat setting temperatures. The fabric is slightly tensioned in the width direction in order to flatten any potential wrinkling. An optional fabric finish, such as a softener, may be applied just prior to the drying operation **56**. In some cases a fabric finish is applied after the fabric is first dried by a belt or tenter-frame oven, so that the finish is taken up uniformly by fibers that are equally dry. This extra step involves re-wetting the dried fabric with a finish, and then drying the fabric again in a tenter-frame oven.

[0080] The single layer knit fabric formed by knitting together elastomeric fiber and polyester bi-component filament in accordance with the present invention exhibits a combination of good stretch, excellent recovery, nice hand feel and good appearance. The elastomeric fiber provides the fabric with a high stretch level that enables the fabric able to be stretched out easily and provide comfort for wearers. In contrast to the elastomeric yarn, the polyester bi-component filament has a higher stretch modulus. Under the same load force, the polyester bi-component filament is stretched out less than the elastomeric yarn, thus restraining the extension of the fabric and preventing the fabric from elongating excessively. The polyester bi-component filament also has higher recovery power than bare elastomeric fibers. Accordingly, the circular knit fabric of the present invention with two different sets of elastic fiber provides for soft touch, easy movement, high flexibility, high stretch modular and good shape retention. While polyester bi-component filament provide the fabric with high recovery power and low fabric growth, elastomeric yarn with low modulus provides the fabric with easy stretch and lower shrinkage, resulting in the fabric with easy stretch, high holding force and high dimension stability.

[0081] The inventors herein have also found that the circular knit fabrics with two sets of different elastic fibers can be made with a flat surface and reduced uneven appearance and shine resulting from the polyester bi-component. In knit fabrics comprising only polyester bi-component fiber as the stretch engine without elastomeric fiber, the bi-component fiber develops high frequency spatial helical crimp geometries similar to the appearance of a telephone wire. These crimps offer exceptional good stretch and wrinkle recoveries as well as bulk to the yarns and fabrics. However, these crimps develop a severe uneven appearance which prevents the penetration of polyester bi-component in knit application. The inventors herein have found that by adding elastomeric fiber into the fabric, the unevenness of polyester bi-component crimp is greatly improved. Fabric of the present invention exhibits a flat surface and a softer touch feeling.

[0082] In one nonlimiting embodiment of production of a fabric of the present invention, the two elastic fibers are stretched to different drafts of their original length during knitting process. The draft of elastomeric fiber can be selected between drafts 1.8× times to 5.0× times, while the draft of polyester bi-component filament can be selected from 1.01× to 1.35× times. For the two elastic fibers with different deniers or different filament numbers, the stretch ratio of polyester bi-component filament and elastomeric finer can be different from each other, depending upon the desired elastic fiber performances and requirement of fabric quality. In many cases, elastomeric fiber is drafted more to provide high stretch performance, while polyester bi-component filament is stretched less to provide the fabric with low shrinkage and high recovery power.

[0083] In one nonlimiting embodiment, the two sets of elastic fibers not only have different polymer compositions but also have different stress-strain behaviors and different thermal behaviors. For example, in one nonlimiting embodiment, the fabric may comprise spandex fibers LYCRA® fiber T162B as elastomeric yarn and to LYCRA® T400® polyester bi-component filament as polyester bi-component filament. In another nonlimiting embodiment, the two sets of elastic yarns may have different heatset efficiency such as

LYCRA® T400® fiber heatset at temperature 365° F. degree and T162B LYCRA® fiber heatset at 380° F. degree. In this nonlimiting embodiment, if the fabric is heatset at the temperature higher than LYCRA® T400® fiber heatset temperature, but lower than LYCRA® fiber T162B heatset temperature, the fabrics just get partial heatset which provide acceptable fabric shrinkage as well as good stretch and growth.

[0084] Another advantage of the fabric of the present invention is that polyester bi-component filament has better resistance to chemical and/or environmental elements than elastomeric fiber such as spandex. For example, polyester bi-component filament has better resistance to both chlorine and UV light as compared to spandex. Accordingly, fabric of the present invention exhibits high performance as swimming wear in pools containing chlorine and other outdoor active wear exposed to UV light.

[0085] In some embodiments of the present invention, the fabrics are comprised of only elastic fibers containing both elastomeric fiber and polyester bi-component filament. Because no hard fiber exists in this embodiment, this fabric shows excellent flexibility and superior recovery power. This fabric embodiment also has high breathability and is light weight. This fabric embodiment is therefore ideal for garments that need high holding power, full recovery and breathability, such as, but in no way limited to, bra wings, intimate body shaping wear, and sportswear.

[0086] Methods of the present invention have been found to be particularly useful in producing single layer jersey fabric with terry jersey fabric structure of good quality. Terry jersey or float jersey is a knit fabric that features float stitches or soft piles of yarn in the one side of the fabric which results in a very absorbent, moisture wicking material. Some types of float jersey fabric are heavier than a t-shirt, but lighter than most sweatshirts and have a good amount of stretch thus making them very comfortable to wear. Other types of float jersey fabric have a flat, clean look in both sides of the fabric with strong recovery power. Terry jersey fabrics typically have higher stretch and higher recovery force than single jersey fabrics in all directions.

[0087] Terry jersey fabrics can be knitted in accordance with the present invention by using the two sets of different elastomeric yarns, arranged alternatively in wale direction. The first set of yarns, referred to as the loop yarns, are knitted as single jersey in each wale. The second set of yarns, referred to as the float yarns, are knitted with float loop and intermeshed together with the first set of loop yarns. The float yarns can float over various wales, such as one wale, two wales or more wales. For fabrics of the present invention, either the elastomeric fiber or polyester bi-component filaments can be used either in the loop yarns or float yarns or they can be used together in both the loop yarns and float yarns. In one nonlimiting embodiment, a hard yarn can also be incorporated into the loop yarns and/or float yarns. The elastic fibers used in the present invention are more easily stretched out and have higher recovery power in the float loop structure with a flat fiber segment.

[0088] Fabrics of some embodiments of the present invention exhibit an elongation from about 20% to about 200% in the wales and/or course direction. Further, such fabrics may have shrinkage of about 15% or less during washing, for example less than 7% in both the length and width directions. The fabrics may have a weight between 100 grams/meter^2 and 600 grams/meter^2. In addition, the stretch fabric may have an excellent hand feel.

[0089] The present invention also relates to garments prepared from the fabrics described herein. While the characteristics of these fabrics make them particularly useful in garments of causal and leisurewear, the seamless fabrics comprising two different sets of two elastic yarns are also useful in outer wear. Further, the ability to alter the denier of the elastic yarns and the knit patterns renders such fabrics useful in specific areas of many garments. For example, in order to have better holding force in certain critical areas, such as in knee, inner thigh, the front panel of pants, a fabric of the present invention comprising a heavier denier and higher draft of elastomeric yarn can be incorporated into the garment, thus producing a garment having higher shaping function and high strain force. In other portions, a fabric of the present invention with less stretch and strain may be used, thus providing better comfort. Accordingly, the fabrics of the present invention are particularly useful in producing fine quality comfort garments of all types with spot shaping functions at critical areas, Nonlimiting examples of garments which can be made from the fabrics of the present invention include sportswear, active wear, swimming wear, bras, underwear, intimate wear, leggings, outwear and shoe fabrics.

[0090] The following section provides further illustration of the fabrics and methods for their production. The examples are illustrative only and is not intended to limit the scope of the invention in any way.

Analytical Methods

Yarn Recoverable Stretch

[0091] The recoverable stretch of elastic fibers used in the Examples was measured following ASTM D6720-07. Each yarn sample was formed into a skein of 5000+/−5 total denier (5550 dtex) with a skein reel at a tension of about 0.1 gpd (0.09 dN/tex). The skein was then immersed into water for 15 minutes at 100° C., after which the skein were removed from the water. Then, the skein was conditioned at 70° F. (+/−2° F.) (21°+/−1° C.) and 65% (+/−2%) relative humidity for a minimum of 16 hours for air dry.

[0092] The skein was hung stibstantially vertically from a stand. After three times cycling with 1030 grams hanging weight, a 1030 gram weight (206 mg/d; 185.4 mg/dtex) was hung from the bottom of the skein, and the length of the skein was measured to within 1 mm and recorded as "L_1". Next, a 6 mg/den (5.4 mg/dtex) weight (e.g. 30 grams for a 5550 dtex skein) was hung on the bottom of the skein, the weighted skein was allowed to come to an equilibrium length, and the length of the skein was measured to within 1 mm and recorded as "L_2". Yarn recoverable stretch (percent), "CC_a", was calculated according to the formula CC_a (%)=100*(L_1−L_2)/L_2.

Draft of Elastic Yarns

[0093] The following procedure was used to measure the elastic yarn drafts in the Examples. A yarn sample of more than 200 stitches (needles), with the beginning and end of the 200 stitched being marked, was de-knitted or unraveled from a single course and the elastic yarn and hard yarns of this sample were separated.

[0094] Each sample (elastic yarn or hard yarn) was then hung freely by attaching one end onto a meter stick with one marking at the top of the stick. A weight was attached to each sample (0.1 g/denier for hard yarn, 0.001 g/denier for spandex). The weight was slowly lowered, allowing the weight to be applied to the end of the yarn sample without impact. The length measured between the marks was then recorded. The measurements were repeated with 5 samples each of elastic yarn and hard yarn. The average draft was then calculated according to the following formula:

Draft=(Length of hard yarn between marks)÷(Length of elastic yarn between marks).

Elastomeric Fiber Content

[0095] Knit fabrics were weighed and then de-knit manually. The elastomeric fiber was separated from the companion hard yarn and weighed with a precision laboratory balance or torsion balance. The elastomeric fiber content is expressed as the percentage of elastomeric weight to fabric weight.

Fabric Elongation (Stretch)

[0096] Fabrics were evaluated for % elongation under a specified load (i.e., force) in the fabric stretch direction(s), which is the direction of the composite yarns (i.e., weft, warp, or weft and warp). Three samples of dimensions 60 cm×6.5 cm were cut from the fabric. The long dimension (60 cm) corresponds to the stretch direction. The samples were partially unraveled to reduce the sample widths to 5.0 cm. The samples were then conditioned for at least 16 hours at 20° C.+/−2° C. and 65% relatively humidity, +/−2%.

[0097] A first benchmark was made across the width of each sample, at 6.5 cm from a sample end. A second benchmark was made across the sample width at 50.0 cm from the first benchmark. The excess fabric from the second benchmark to the other end of the sample was used to form and stitch a loop into which a metal pin could be inserted. A notch was then cut into the loop so that weights could be attached to the metal pin.

[0098] The sample non-loop end was clamped and the fabric sample was hung vertically. A 17.8 Newton (N) weight (4 LB) was attached to the metal pin through the hanging fabric loop, so that the fabric sample was stretched by the weight. The sample was "exercised" by allowing it to be stretched by the weight for three seconds. The force was then manually relieved by lifting the weight. This cycle was carried out three times. The weight was allowed then to hang freely, thus stretching the fabric sample. The distance in millimeters between the two benchmarks was measured while the fabric was under load. This distance is designated ML. The original distance between benchmarks (i.e., unstretehed distance) was designated GL. The % fabric elongation for each individual sample as calculated as follows:

$$\% \text{ Elongation } (E\ \%)=((ML-GL)/GL)\times 100$$

[0099] The three elongation results were averaged for the final result.

Fabric Growth (Unrecovered Stretch)

[0100] After stretching, a fabric with no growth recovers exactly to its original length before stretching. Typically, however, stretch fabrics will not fully recover and will be slightly longer after extended stretching. This slight increase in length is termed "growth."

[0101] The above fabric elongation test must be completed before the growth test. Only the stretch direction of the fabric was tested. For two-way stretch fabric both directions were tested. Three samples, each 55.0 cm×6.0 cm, were cut from the fabric. These were different samples from those used in the elongation test. The 55.0 cm direction should correspond to the stretch direction. The samples were partially unraveled to reduce the sample widths to 5.0 cm. The samples were conditioned at temperature and humidity as in the above elongation test. Two benchmarks exactly 50 cm apart were drawn across the width of the samples.

[0102] The known elongation % (E %) from the elongation test was used to calculate a length of the samples at 80% of this known elongation. This was calculated as

$$E \text{ (length) at } 80\%=(E\ \%/100)\times 0.80\times L,$$

[0103] where L was the original length between the benchmarks (i.e., 50.0 cm). Both ends of a sample were clamped and the sample was stretched until the length between benchmarks equaled L+E (length) as calculated above. This stretch was maintained for 30 minutes, after which time the stretching force was released and the sample was allowed to hang freely and relax. After 60 minutes the % growth was measured as

$$\% \text{ Growth}=(L2\times 100)/L,$$

[0104] where L2 was the increase in length between the sample benchmarks after relaxation and L was the original length between benchmarks. This % growth was measured for each sample and the results averaged to determine the growth number.

Fabric Recovery

[0105] Fabric recovery means that fabric is capable of recovery to its original length after deformation from elongation or tension stress. It is expressed as a percentage ratio of the increased extended length of a fabric under tension to the length of the fabric following release of elongation or tension stress. It can be calculated from fabric stretch and fabric growth.

Fabric Shrinkage

[0106] Fabric shrinkage was measured after laundering. The fabric was first conditioned at temperature and humidity as in the elongation and growth tests. Two samples (60 cm×60 cm) were then cut from the fabric. The samples were taken at least 15 cm away from the selvage. A box of four sides of 40 cm×40 cm was marked on the fabric samples.

[0107] The samples were laundered in a washing machine with the samples and a loading fabric. The total washing machine load was 2 kg of air-dried material, and not more than half the wash consisted of test samples. The laundry was gently washed at a water temperature of 40° C. and spun. A detergent amount of 1 g/1 to 3 g/l was used, depending on water hardness. The samples were laid on a flat surface until dry, and then they were conditioned for 16 hours at 20° C.+/−2° C. and 65% relative humidity +/−2% rh.

[0108] Fabric sample shrinkage was then measured in the warp and weft directions by measuring the distances between markings. The shrinkage after laundering, C %, was calculated as

$$C\%=((L1-L2)/L1)\times 100,$$

[0109] where L1 was the original distance between markings (40 cm) and L2 is the distance after drying. The results are averaged for the samples and reported for both weft and warp directions. Negative shrinkage numbers reflect expansion, which was possible in some cases because of the hard yarn behavior.

Fabric Weight

[0110] Knit fabric samples were die-punched with a 10 cm diameter die. Each cut-out knit fabric sample was weighed in grams. The "fabric weight" was then calculated as grams/square meters.

Fabric Recovery Force

[0111] The fabric was cut 3×8 inches. By using a fabric marking pen, benchmark "A" was drawn one inch from one edge of each specimen. Benchmark "B" was drawn six inches from bench mark "A", resulting in two benchmarks that are six inches apart. The fabric specimens were then sewn into a loop by folding the two short edges together such that the benchmarks line up and a straight seam was sewn across the marks. The test loops were then conditioned for at least 16 hours at 70° F. temperature and 65% relative humidity. The specimens were exercised in an Instron machine with three cycling by extending to 75% elongation at 200% per minute and release. The fabric unload force at 30% elongation in third cycle was recorded as fabric recovery force. Fabric recovery force represents the fabric recovery power during garment wearing.

EXAMPLES

[0112] The following nonlimiting examples demonstrate the present invention and its capability for use in manufacturing a variety of fabrics. The invention is capable of other and different embodiments, and its several details are capable of modifications in various apparent respects, without departing from the scope and spirit of the present invention. Accordingly, the examples are to be regarded as illustrative in nature and not as restrictive.

[0113] Single layer circular knit fabrics of 28 gauge with two elastic yarns plated with hard yarn for the examples were knit on a Monarch Circular Knitting Machine Model VX-RDS, with 26 inch cylinder diameter, 28 gauge (needles per circumferential inch) and 2232 needles, and 42 yarn feed positions. The circular knit machine was operated at 16 revolutions per minute (rpm). Single layer circular knit fabrics of 44 gauge were knit in a Monarch Circular Knitting Machine, Model VX-3S, Diameter 30 Inches, Needles 4152, Feeders 90 and approximate RPM 20.

[0114] Double layer circular knit fabrics were made in a Terrot Circular Knitting Machine, Model RH-216 I, Cylinder Diameter 18 Inches, Gauge 24 Needles per Circumferential Cylinder Inch. There are also 24 needles per inch on the dial, technically making this a 48 gauge, but it is called 24, 1356 Needles in Cylinder and 1356 Needles in Dial, 30 Feeders and approximately 18 RPM.

[0115] The elastomeric fiber feed tension was measured between the elastomeric fiber supply package **36** and the roller guide **37** (FIG. **2**) with an Iro Memminger digital tension meter, model number, MER2. For the following examples, the elastomeric fiber feed tensions were maintained at 4 and 7 grams for 40 and 70-denier spandex. These tensions are sufficient for reliable and continuous feeding of this elastomeric yarn of spandex to the knitting needles. When the feed tensions are too low, the spandex yarn wraps around the roller guides at the supply package and cannot be reliably fed to the circular knitting machine. The tension device for the polyester bi-component filament yarn and hard yarn was IRO Memminger with MPF40 KIF model. The tension for polyester bi-component filament was around 8-9 grams. The tension for hard yarn was about 6-7 grams.

[0116] Seamless fabric examples of the present invention made by circular knitting using a SMA-8-TOP seamless, 28 inch body size, knitting machine from SANTONI (from GRUPPO LONATI, Italy) (hereinafter, "the SANTONI knitting machine"). A combination of different knitting constructions using various types of yarns was used. The machine has 8 yarn feed positions. It operated at 70 revolutions per minute (ipm). The elastomeric fiber feed tension was measured with an BTSR® digital tension meter, model number, KTF-100HP. For the following examples, the elastomeric feed tensions were maintained at 1 gram for each 10 denier spandex. The tension device for the polyester bi-component filament yarn and hard yarn was an IRO Memminger with model ROJ Tricot.

[0117] The knitted fabrics were preheated, scoured, dyed and dried. For seamless fabric, the fabric went through a finishing process without heatset. Fabrics were scoured and bleached in a 100-liter solution at 100° C. for 30 minutes. All wet, jet finishing and dyeing was done in a Thies, horizontal jet dye machine with soft flowers. The fabric was pre-scoured with a water solution containing Domoscour LFE810 (13 g) (scouring and emulsifying agent, made by M. Dohmen Company), Lurotex A-25 (100 g) (hydrophilic finishing and softener, made by BASF Cooperation) at 49° C. for 5 minutes.

[0118] The fabrics were dyed at 85° C. for 60 minutes, using direct dyestuffs and other constituents. The dye solution contained Solophenyl FGE 250 (made by Huntsmen Corp.) 85.8 grams, 0.5 weight % trisodium phosphate (adjusting PH), and common salt 45000 grams. Then, Burcofix 195 (color fixation made from M. Dohmen Company) 78 grams and Ultratex MES 65 grams and acetic acid 10 grams were added into the dyebath and run at 45° C. for 30 minutes. The bath was drained and the fabrics were unloaded from the vessel. The fabrics were then dried in a tenter (made by Kenyon Company) oven at 145° C. for about 30 seconds.

[0119] Table 1 lists the materials and process conditions that were used to manufacture the fabric samples with elastomeric and polyester bi-component filament. The elastic yarns used are available from Invista, s. á. r. L., of Wilmington, Del. and Wichita, Kans. The column headed elastic fiber **40*d*** means 40 denier; and 3.3× means the draft of the elastic imposed by the core spinning machine (machine draft). In the column headed 'Hard Yarn', 16's is the linear density of the spun yarn as measured by the English Cotton Count System. The rest of the items in Table 1 are clearly labeled.

TABLE 1

Single Layer CK Fabric Example List

Example	Hard Yarn Type	Elastomeric yarn,	Elastomeric yarn, draft	ElasticElastomeric yarn, content in fabric by % weight	Polyester bi-component filament	Polyester bi-component filament draft	Polyester bi-component filament content in fabric by % weight	knit machine	Knit machine gauge	Fabric Weight g/m 2	Available Elongation, % Length × Width	Recovery Force @ 30% extension, grams, Length × Width
1c	30S cotton	40d T162B LYCRA ® fiber	2.7x	7.70%	no	no	0	Single jersey	28	5.0	80.9 × 219.2	85.1 × 77.6
2	50S cotton	40d T162B LYCRA ® fiber	2.7x	4.6	50D/34f LYCRA ® T400 ® fiber	1.05X	28	Single jersey	28	5.4	85.3 × 116.4	205.9 × 146.2
3	50S cotton	40d T162B LYCRA ® fiber	2.7x	7.6	75D/34f LYCRA ® T400 ® fiber	1.10X	37.8	Single jersey	28	6.1	84.5 × 118.3	314.6 × 214.6
4	50S cotton	70d T162B LYCRA ® fiber	2.7x	14.4	50D/34f LYCRA ® T400 ® fiber	1.05X	26.3	Single jersey	28	6.5	100.8 × 97.3	290.2 × 249.7
5	No	40D T275B LYCRA ® fiber	1.8X	31.4	50D/34f LYCRA ® T400 ® fiber	1.05X	68.50	Single jersey	44	4.8	51.0 × 124.92	525.2 × 377.9
6	No	40D T275B LYCRA ® fiber	1.8X	43.2	30D/34f LYCRA ® T400 ® fiber	1.05X	56.80	Single jersey	44	4.3	105.6 × 122.6	218.9 × 309.1
7	40D Textured Nylon	40D T275B LYCRA ® fiber	2.0x	41.7	50D/34f LYCRA ® T400 ® fiber	1.05X	29.2	Terry jersey	44	6.1	92.3 × 126.1	211.7 × 260.2
8	No	40D T275B LYCRA ® fiber	1.8X	31.3	50D/34f LYCRA ® T400 ® fiber	1.05X	68.7	Terry jersey	44	5.3	69.3 × 91.5	329.7 × 416.7
9	No	70D T275Z LYCRA ® fiber	2.0X	42.6	50D/34f LYCRA ® T400 ® fiber	1.05X	57.4	Terry jersey	44	6.4	53.2 × 69.6	1009.7 × 602.5
10	No	40D T275B LYCRA ® fiber	1.8X	23	50D/34f LYCRA ® T400 ® fiber	1.05X	77	1×1 rib	44	7.5	113 × 304	459.2 × 133.3
11	No	40D T275B LYCRA ® fiber	1.8X	24.4	50D/34f LYCRA ® T400 ® fiber	1.05X	75.5	2×2 rib	44	7.5	99.2 × 286.1	534.2 × 120

Comparative Example 1C: Comparative Knit Fabric with One Spandex

[0120] A stretch circular single jersey knit fabric of spandex fiber only was made on 28 gauge machine. The fabric was made with 30s cotton spun yarn with 40D LYCRA® spandex fiber. The draft of the LYCRA® fiber was 2.7× during knitting. 30s cotton yarn was plated together with LYCRA® fiber to form single jersey fabric. This fabric has a very high stretch level of 219.2% in width direction, but low recovery force in both length and width directions (85.1 grams×77.6 grams). The fabric was easily stretched out, but exhibited difficult recovery. Such easy deformation and difficult recovery results in garments produced from the fabric exhibiting poor ability to maintain their garment shape and dimensional stability. The garments exhibit sagging and bagging during wear. The fabric contained 7.7% LYCRA® fiber and 92.3% cotton.

Example 2: Cotton Jersey Fabric with Two Different Elastic Fibers

[0121] This sample had the same fabric structure as in example 1C with the exception of the incorporation of 50D LYCRA® T400® fiber. The fabric contained two elastic yarns in accordance with the present invention: 40D LYCRA® spandex fiber and 50d/34f LYCRA® T400® polyester bi-component filament. The cotton yarn was 50 Ne count yarn. Table 1 summarizes the test results. It is clear that this sample had good stretch (length 85.3%×width 116.4%). The fabric also has low shrinkage. The fabric also has improved recovery power (length 205.9%×width 146.2%). Adding polyester bi-component filament significantly increased the jersey fabric holding force and limited the extra elongation in width direction, while at same time increasing the recovery force in both directions. Fabrics demonstrated high stable dimension and strong shape retention ability. The fabric contained 4.6% LYCRA® fiber, 28.0% LYCRA® T400® bi-component fiber and 67.4% cotton.

Example 3: Single Layer Knit Containing Double Elastic Fibers

[0122] This sample had the same fabric structure as in example 2 with the exception of the denier of LYCRA® T400® fiber: 40D T162B LYCRA® fiber with 2.7× draft and 75d/34f LYCRA® T400® fiber with 1.10× draft was used. The hard yarn was 50 Ne 100% cotton ring spun yarn with single jersey stitch structure. The finished fabric had a weight of 6.1 oz/yard^2 and 84.5% and 118.3% stretch in the length and width direction, respectively. The fabric recovery power was 314.6 grams×214.6 grams in length and width direction. As shown, the high denier of LYCRA® T400® fiber helped to increase the fabric recovery force in both directions. The fabric contains 7.6% LYCRA® fiber, 37.8% LYCRA® T400® bi-component fiber and 54.6% cotton.

Example 4: Single Layer Knit Containing Double Elastic Fibers

[0123] This sample had the same fabric structure as in example 2 with the exception of the denier of LYCRA® fiber: 70D T162B LYCRA® fiber, 2.7× draft and 1.05× draft for 70D LYCRA® fiber and 75d/34fLYCRA® T400® fiber were used. The hard yarn was 50 Ne 100% cotton ring spun yarn with single jersey stitch structure. The finished fabric had a weight of 6.5 oz/yard^2 and 100.8% and 97.3% stretch in length and width direction, respectively. The fabric recovery power was 290.2 grams×249.7 grams in length and width direction. As shown herein, the high denier of LYCRA® fiber increases the fabric recovery force in both directions. The fabric contains 14.4% LYCRA® fiber, 26.3% LYCRA® T400® bi-component fiber and 59.3% cotton.

Example 5: Single Layer Jersey Fabric with 100% Elastic Fiber

[0124] This sample was a single layer jersey fabric containing 100% elastic fiber: 40D T275B LYCRA® fiber and 50D/34f LYCRA® T400® polyester bi-component fiber. The fabric weight was 4.8 oz/yard^2 with 31.4% elastomeric fiber and 68.5% polyester bi-component fiber. Because no hard fiber exists, the fabric shows excellent flexibility and superior recovery power. The fabric also has high breathability and quick dry performance. It is an ideal material for garments that need high holding power, full recovery and breathability. It is also an excellent option for swimming wear. Polyester bi-component is chlorine proof. In the swimming pool, the fabric has better anti-chlorine performance than the stretch fabric only containing spandex fiber which loses recovery power after long time exposure in swimming pools with chlorine chemicals. This fabric also still has stretch and recovery properties in the bra cup area after modeling at high temperature. This can offer better comfort for bra wearers, especially for sports bras.

Example 6: Single Layer Jersey Fabric with 100% Elastic Fiber

[0125] This fabric had the same fabric structure as Example 5 with the exception of the denier of polyester bi-component filament LYCRA® T400® fiber being 30D/34f. The draft of bare 40D LYCRA® fiber was 1.8× and the draft of LYCRA® T4000 was 1.05×. This fabric used the same stitch structure as Example 5. Table 1 summarizes the test results. This sample also had good stretch of 105.6%×122.6% and good fabric recovery power of 218.9 g×309.1 g. Use of the lower denier LYCRA® T400® fiber made the fabric lighter in weight with a more open structure and soft hand.

Example 7: Single Layer Terry Jersey Fabric Containing Two Elastic Fibers

[0126] This sample was a terry jersey fabric and had float loops on one side of a single knit fabric. The loop yarns were 40D T275B LYCRA® elastomeric fiber and 50D/34f polyester bi-component filament of LYCRA® T400® fiber. The float yarns were 40D T275B LYCRA® elastomeric fiber and 40D textured nylon fiber. The surface side of the fabric looked like typical single jersey while the back side of the fabric had float loops with 1 loop skip. The float loops were formed by the knit loop stitch of the loop yarn. The LYCRA® fiber draft was 1.8× while the LYCRA® T400® fiber draft was 1.05×. The fabric weight was 6.1 oz/yd^2 and the fabric stretch was 92.3%×126.1%. The fabric had very high recovery power of 211.7 g×260.2 g in length×width direction, respectively. The fabric has had good nylon fiber touch and LYCRA® T400® fiber power performance.

Example 8: Single Layer Terry Jersey Fabric Containing 100% Elastic Fiber

[0127] This sample had float loops on one side of single knit fabric. Both loop yarns and float yarns were 40D T275B LYCRA® elastomeric fiber and 50D/34f polyester bi-component filament of LYCRA® T400® fiber. The surface side of the fabric looked like a typical single jersey while the back side of the fabric had float loops with 1 loop skip. The float loops were formed by the knit loop stitch of the loop yarn. The LYCRA® fiber draft was 1.8× while the LYCRA® T400® fiber draft was 1.05×. The fabric weight was 5.3 oz/yd^2 and the fabric stretch was 69.3%×91.5%. The fabric had a very high recovery power of 329.7 g×416.7 g in length×width directions, respectively.

Example 9: Single Layer Terry Jersey Fabric Containing 100% Elastic Fiber

[0128] This example had a similar fabric structure to Example 8. The fabric was made with 42.6% LYCRA® fiber and 57.4% LYCRA® T400® fiber with terry structure. The difference was 70D T275Z LYCRA® fiber was used to replace 40D T1275B LYCRA® fiber, both in loop yarn and float yarn. Higher denier LYCRA® fiber ensures higher weight and more power of the fabrics. This fabric can be used in intimate shaping wear with strong holding force.

Example 10: 1×1 Rip Fabric with Spandex and Polyester Bi-Component Filament

[0129] This sample was a 1×1 rip fabric made from double knit machine. 50d/34f LYCRA® T400® fiber and 40D LYCRA® fiber was plated together in each course. Both sides of the fabric have a similar appearance. As compared with jersey fabric, it is thicker and heavier. It can only be raveled at one end. The fabric laid flat without curl and exhibited excellent width way elasticity. The fabric is especially useful for underwear and T-shirts. The contents of LYCRA® fiber and LYCRA® T400® fiber are 23.0% and 77.0% of the inside fabric with total weight of 7.1 oz/yard^2.

Example 11: 2×2 Rip Fabric with Spandex and Polyester Bi-Component Filament

[0130] This sample was a 2×2 rip fabric made from a double knit machine. 50d/34f LYCRA® T400® fiber and 40D LYCRA® fiber was plated together in each course. Both sides of the fabric have a similar appearance. As compared with jersey fabric, this sample is thicker and heavier. It can only be raveled at one end. The fabric laid flat without curl and exhibited excellent width way elasticity. This fabric is especially useful in T-shirt collars due to its flat and no-curling benefits.

TABLE 2

Double Layer CK Fabric Example List

Sample Number	LYCRA ® fiber Content %	LYCRA ® T400 ® fiber Content %	Hard Fiber Content %	Face A yarn	Face B yarn
12	5.7	36.6	57.7	32S cotton + 70D LYCRA ® fiber	150D LYCRA ® T400 ® fiber
13	13.1	41.2	45.7	32S cotton + 70D LYCRA ® fiber	150D LYCRA ® T400 ® fiber
14	8.6	12	79.4	32S cotton + 40D LYCRA ® fiber	75D COOLMAX ® polyeseter fiber
15	9.2	13	77.8	150D Supplex ® Nylon + 70D LYCRA ® fiber	75D COOLMAX ® polyester fiber
16	8.3	11.6	80.1	30STencel ® fiber + 70D LYCRA ® fiber	75D LYCRA ® T400 ® fiber + 70D LYCRA ® fiber
17	12	6.4	81.6	(50s TENCEL ® fiber + 70D LYCRA ® fiber) + 50S TENCEL ® flebr alternative cause	50s TENCEL ® fiber 75D LYCRA ® fiber

Sample Number	Interlock yarn	Cushion Yarn	Fabric Thickness (mm)	Fabric Weight g/m^2	Fabric Clo
12	75D Polyester	no	2.13	212.23	0.31
13	70D LYCRA ® fiber	no	2.10	325.32	0.52
14	32s cotton	150D LYCRA ® T400 ® fiber	1.35	244	0.22
15	150D Supplex ® nylon	15D LYCRA ® T400 ® fiber	1.24	195.78	0.26
16	30s TENCEL ® fiber	150D LYCRA ® T400 ® fiber	1.69	355.54	0.24
17	50s Tencel ® fiber	75D LYCRA ® T400 ® fiber	1.52	217.38	0.26

Example 12: Double Layer Knit Fabric with Spandex and Polyester Bi-Component Filament

[0131] This sample was a knit fabric made with a double knit machine. The fabric has two faces, face A and face B, connected together with interlock yarn. Face A yarn is 32S cotton spun yarn with 70D LYCRA® fiber; face B yarn is

150D LYCRA® T400® fiber; and interlock yarn is 75D polyester. The fabric had a weight of 212.2 grams/m^2. 70D LYCRA® fiber provided stretch and recovery in face A. 150d/68f LYCRA® T400® fiber gave support and recovery force. As compared with the single layer knit fabric, LYCRA® T400® fiber has more open space in the double layer fabric which allows LYCRA® T400® fiber get full relaxation and coil up. Therefore, this fabric has high thickness and high warmth with a CLO value of 0.31. 75D polyester filament was used as an interlock yarn for connecting the two layers together.

Example 13: Double Layer Knit Fabric with Spandex and Polyester Bi-Component Filament

[0132] This sample was also a knit fabric made with a double knit machine. The fabric had two faces: face A and face B, connected together with interlock yarn. Face A yarn was 32S cotton spun yarn with 70D LYCRA® fiber; face B yarn was 150D LYCRA® T400® fiber; and interlock yarn was 70D LYCRA® fiber. The fabric had a weight of 325.3 grams/m2. Two threads of 70D LYCRA® fiber provided stretch and recovery in face A and interlock yarn 150d/68f LYCRA® T400® fiber gave support and recovery force. As compared with Example 11, 70D LYCRA® fiber in the interlock yarn provides more force in this double layer fabric, thus allowing all fiber to be pulled closed with significant high thickness and high warmth. This sample had a CLO value of 0.52.

Example 14: Double Layer Knit Fabric with LYCRA® T400® Fiber Cushion Yarn

[0133] This sample was knit fabric made with a double knit machine. The fabric had two faces: face A and face B, connected together with interlock yarn. Face A yarn was 32S cotton spun yarn with 40D LYCRA® fiber; face B yarn was 75D COOLMAX® polyester fiber; and interlock yarn was 32s cotton yarn. Fabric weight was 244 grams/m^2. 40D LYCRA® fiber provided stretch and recovery in face A; 150d/68f LYCRA® T400® fiber was inserted into the middle of face A and face B to give support and recovery force. LYCRA® T400® fiber was covered by two surface of fabrics so it is invisible from the surface and back of the fabric. LYCRA® T400® fiber shrink and coil up under heat conditions during fabric finishing process, thus making the whole piece of fabric swell up and expand in thickness direction and form a cushion touch feeling with high resilience in the thickness direction. Because LYCRA® T400® fiber is put in the center of the fabric and has more open space in this double layer fabric, the LYCRA® T400® fiber is allowed to get full relaxation and coil up. This fabric therefore has high thickness and high warmth and a CLO value of 0.32.

Example 15: Double Layer Knit Fabric with LYCRA® T400® Fiber Cushion Yarn

[0134] This sample was a double knit fabric with two faces, interlock yarn and cushion yarn. Face A yarn was 150D Supplex® Nylon filament and 70D LYCRA® fiber. Face B yarn was 75D COOLMAX® polyester fiber. 150D Supplex® nylon yarn was used as interlock yarn. 150d/68f T400 was plated into the center of the fabric between face A and face B. It is invisible but increases the fabric bulkiness and thickness with good cushion and resilience. It is an idea material for winter active wear with good protection and warmth. The fabric can also be molded into bra cups with good coverage, shape retention and comfort.

Example 16: Double Layer Knit Fabric with LYCRA® T400® Fiber Cushion Yarn

[0135] This fabric was a double layer interlock fabric with LYCRA® T400® fiber as cushion yarn. 30s TENCEL® fiber spun yarn was used as face A and interlock yarn. 70D LYCRA® fiber was used in both faces of the fabric. This fabric offers excellent soft touch and extremely good stretch and recovery. LYCRA® T400® fiber in the center and in face B provides cushion and 3D effects. The fabric contains 8.3% LYCRA® spandex fiber and 11.6% LYCRA® T400® polyester bi-component fiber.

Example 17: Double Layer Knit Fabric with 75D LYCRA® T400® Fiber Cushion Yarn

[0136] This sample was a double knit fabric with double face. Face A contained 50S TENCEL® spun yarn in every course and 70d LYCRA® fiber was plated in an alternative course. Face B yarn is 50s TENCEL® spun yarn with 70D LYCRA® fiber. 50s TENCEL® yarn was used as interlock yarn as well. 75D/34f LYCRA® T400® polyester bi-component filament was introduced into the center of the two faces to form space. This sample is particularly useful for leggings for fall and spring season.

1. A stretch circular knit fabric comprising elastomeric fiber and polyester bi-component filament.

2. The fabric of claim **1** wherein the elastomeric fiber comprises a bare elastomeric yarn.

3. The fabric of claim **1** wherein elastomeric fiber comprises spandex.

4. The fabric of claim **3** wherein the spandex comprises bare spandex yarn with a count from 11 to 560 dtex.

5. The fabric of claim **1** wherein the elastomeric fiber has a denier between 10 denier and 450 denier.

6. The fabric of claim **1** wherein the polyester bi-component filament comprises poly(trimethylene terephthalate) and at least one polymer selected from the group consisting of poly(ethylene terephthalate), poly(trimethylene terephthalate), and poly(tetramethylene terephthalate) or a combination thereof.

7. The fabric of claim **1** wherein the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

8.-**10**. (canceled)

11. The fabric of claim **1** further comprising a hard fiber.

12. The fabric of claim **7** wherein the hard fiber yarn has a count from 10 to 900 dtex.

13. The fabric of claim **7** wherein the hard yarn is selected from the group consisting of wool, linen, silk, polyester, nylon, olefin, cotton, and combinations thereof.

14. The fabric of claim **7** wherein the hard yarn is textured polyester filament.

15.-**26**. (canceled)

27. The fabric of claim **1** wherein the elastomeric fiber and polyester bi-component filament are combined together through a pre-covered yarn process before knitting.

28. The fabric of claim **1** having a weight between 100 grams/meter2 and 600 grams/meter2.

29. A garment prepared from the fabric of claim **1**.

30. The garment of claim **29** which is selected from the group consisting of sport wears, active wear, swimming wear, bras, underwear, intimate wear, leggings, outwear and shoe fabrics.

31. A method for making a circular knit fabric, said method comprising knitting together at least one elastomeric fiber and at least one polyester bi-component filament into a circular knit fabric.

32. The method of claim **31** wherein the elastomeric fiber comprises a bare elastomeric yarn.

33. The method of claim **31** wherein elastomeric fiber comprises spandex.

34. The method of claim **33** wherein the spandex comprises bare spandex yarn with a count from 11 to 560 dtex.

35. The method of claim **31** wherein the elastomeric fiber has a denier between 10 denier and 450 denier.

36. The method of claim **31** wherein the polyester bi-component filament comprises poly(trimethylene terephthalate) and at least one polymer selected from the group consisting of poly(ethylene terephthalate), poly(trimethylene terephthalate), and poly(tetramethylene terephthalate) or a combination thereof.

37. The method of claim **31** wherein the polyester bi-component filament has a count from 15 dtex to 900 Dtex.

38. The method of claim **31** wherein the polyester bi-component filament has a denier of from about 10 to about 450.

39. The method of claim **31** wherein the elastomeric fiber weight is about 3% or higher of total fabric weight, the polyester bi-component filament weight is about 5% or higher of total fabric weight; and fabric stretch level is at least 15% or higher in both wales and course direction.

40. The method of claim **31** wherein the fabric comprises 100% elastic yarns.

41. The method of claim **31** further comprising knitting a hard fiber into the circular knit fabric.

42. The method of claim **41** wherein the hard fiber yarn has a count from 10 to 900 dtex.

43. The method of claim **41** wherein the hard yarn is selected from the group consisting of wool, linen, silk, polyester, nylon, olefin, cotton, and combinations thereof.

44. The method of claim **41** wherein the hard yarn is textured polyester filament.

45. The method of claim **41** wherein the hard yarn is cotton spun yarn.

46.-**47**. (canceled)

* * * * *