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(54) **Knittable yarn and safety apparel**

Strickfähiges Garn und Schutzkleidung

Fil tricotable et vêtement de protection

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(73) Proprietor: **Whizard Protective Wear Corp.**
Birmingham, Ohio (US)

(72) Inventor: **Hummel, Joseph**
Amherst, Ohio 44001 (US)

(74) Representative: **Baillie, Iain Cameron et al**
Ladas & Parry,
Alzheimer Eck 2
80331 München (DE)

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Description

Technical Field

The invention relates to yarn suitable for machine knitting and to safety garments made with the yarn.

Background Art

Cut-resistant yarn utilizing stainless steel wire strands and high strength aramid strands, such as Kevlar made by E.I. DuPont de Nemours Corp., and gloves made therefrom are shown in the Byrnes et al. U. S. Patent No. 4,384,449 and in the Bettcher U. S. Patent No. 4,470,251. These gloves have proven highly successful. Another fiber, a high strength stretched polyethylene fiber manufactured and marketed by Allied Corporation, Morris Township, Morris County, N. J., U.S.A., has also provided good cut resistance when used in place of aramid fiber. The Allied fiber is sold under the name Spectra and is described in detail in U. S. Patent No. 4,413,110 to Kavesch et al. Applicant's copending application Serial No. 07/529,241 discloses and claims a cut-resistant composite yarn utilizing a high strength yarn or fiber strand or component, made from Vectra liquid crystal polymer sold by Hoechst Celanese Corporation, Charlotte, North Carolina, under the name Vectran HS. That yarn or fiber has substantially the same strength as high strength aramid fiber sold under the name Kevlar. Heretofore, in applicant's experience, normal strength fibers, when used in composite yarns, have not imparted as great a cut-resistance, along with other desirable characteristics, as high strength fibers have.

Disclosure of the Invention

The present invention provides a cut-resistant, knittable composite yarn that utilizes a yarn or fiber strand or component of normal strength, made from Vectra liquid crystal polymer, to provide a composite yarn of comparable high cut-resistance to composite yarns of similar construction that utilize high strength synthetic yarn or fiber. The yarn or fiber utilized in the invention is a high performance but normal strength multifilament yarn sold by Hoechst Celanese Corporation, Charlotte, North Carolina, under the name Vectran M. Normal strength spun yarn made from Vectra is also contemplated. For purposes of definition, normal strength fibers or yarns are those having a tenacity of no more than 10 grams per denier (gpd) and high strength yarns or fibers are those having a tenacity greater than 10 grams per denier, and typically 20 grams per denier or greater (e.g., Kevlar, Spectra and Vectran HS all have a tenacity greater than 20 grams per denier). High strength yarns or fibers also have higher tensile modulus than normal strength fibers, for example, at least 500 grams per denier.

Vectran M has a tenacity of about 9 grams per de-

nier and a tensile modulus of about 425 grams per denier. It has better abrasion resistance than high strength aramid fiber such as Kevlar and significantly better heat resistance than high strength stretched polyethylene fiber, such as Spectra, thus overcoming a different shortcoming of each of Kevlar and Spectra for use in a cut-resistant yarn used for apparel and particularly for cut-resistant gloves. At the same time, quite surprisingly, this normal strength synthetic material provides the substantial advantages that high strength synthetic fibers such as Kevlar, Spectra and Vectran HS have over other normal strength materials in terms of cut-resistance and other characteristics in a composite yarn. Thus, knit fabric suitable for gloves and other safety garments utilizing Vectran M fiber not only has comparable cut-resistance, but also has greater resistance to self-abrasion than similar fabric made with aramid fiber or a combination of aramid and nylon fiber, yet is itself nonabrasive and comfortable to wear. Further, such fabric can be laundered at high temperatures conventionally used for industrial fabrics without degrading the fabric, as occurs with cut-resistant fabric made from yarn that includes high strength stretched polyethylene. In addition, Vectran M has comparable or lower elongation under load to that of high strength fibers, which is advantageous when used in combination with a wire core strand in forming a composite yarn because it protects the wire strand from being broken during knitting or other sharp bending of the composite yarn. Vectran M is considerably less expensive than Vectran HS, presently about one-half the price.

The present invention provides cut-resistant yarn suitable for machine knitting. Preferred constructions are comprised of a core, a wrapping about the core and another, i.e., second, wrapping about the first and wound in the opposite direction, at least one of said core, first wrapping and second wrapping being comprised of liquid crystal polymer fiber having a tenacity of no more than 10 grams per denier. The denominations such as "first" wrapping and "second" wrapping as used above and in the claims are to differentiate plural wrappings and do not alone indicate that those wrappings are necessarily the first or second relative to the core. Advantageously, neither the core nor the wrappings need comprise a high strength synthetic fiber for the composite yarn to obtain high cut-resistance. Cut-resistance can be enhanced by including a flexible metal strand i.e., wire, as part of the yarn, either as a core element or as a wrapping.

One preferred cut-resistant yarn suitable for machine knitting constructed in accordance with the invention has a core comprised of synthetic fiber and means bundling the core fiber; a wrapping of wire about the bundled core; and two wrappings of synthetic fiber, each wound in an opposite direction over the wrapping of wire; said synthetic fiber of one of said synthetic fiber wrappings or the core or both being a liquid crystal polymer having a tenacity of no more than 10 grams per

denier. In a preferred embodiment the means bundling the core fiber comprises two relatively low denier synthetic wrappings each wound in an opposite direction.

Another preferred construction of a cut-resistant yarn embodying the invention has a core having glass fiber, and wrappings about the core, one or preferably two of said wrappings comprising a liquid crystal polymer fiber having a tenacity of no more than 10 grams per denier. Advantageously this yarn has and other preferred yarns have a covering wrap of nylon or polyester.

If a high strength cut-resistant synthetic fiber is desired in the yarn along with a normal strength liquid crystal polymer fiber, e.g., to impart a characteristic not common to the normal strength liquid crystal polymer, it can be selected from, e.g., high strength aramid such as Kevlar 29, high strength stretched polyethylene such as Spectra, and high strength liquid crystal polymer such as Vectran HS.

A further embodiment of the invention utilizes, in place of a strand or strands of flexible metal wire as found e.g. in the above-described embodiments, a limited number of filaments of significant denier (for example, 1 to 50 filaments of a denier of from 10 to 500 each) of liquid crystal polymer fiber having a tenacity of no greater than 10 grams per denier.

The invention further provides a cut-resistant machine-knitted article of apparel, one such article being a flexible glove, at least in part made of yarn having a construction as referred to above.

A glove or other article of apparel utilizing a preferred yarn construction has not only high resistance to cutting, but also good wear qualities and comfort, does not take a set during use, is non-abrasive, provides a good appearance, and is cleanable and long wearing.

The above and other features and advantages of the invention will become more apparent from the detailed description that follows.

Brief Description of the Drawings

Figure 1 is a fragmentary, diagrammatic, view of a yarn embodying the present invention;
 Figure 2 is a fragmentary, diagrammatic, view of a second yarn embodying the present invention;
 Figure 3 is a fragmentary, diagrammatic, view of a third yarn embodying the present invention;
 Figure 4 is a fragmentary, diagrammatic, view of a fourth yarn embodying the present invention;
 Figure 5 is a fragmentary, diagrammatic, view of a fifth yarn embodying the present invention;
 Figure 6 is a fragmentary, diagrammatic view of a sixth yarn embodying the present invention; and
 Figure 7 is a diagrammatic view of an article of apparel, i.e., a knitted glove, made of yarn embodying the present invention, such as any one of the yarns shown in Figures 1 to 6.

Best Mode for Carrying Out the Invention

The glove A depicted in Figure 6 is exemplary of a safety article of apparel embodying the present invention and is a safety or protective glove suitable to be worn by operatives in the food processing and other industries where sharp instruments or articles, such as knives, or material having sharp edges, for example, sheet metal, glass and the like, are handled, and is made of a composite multistrand yarn B, C, D, E, F or G (Figures 1-6) constructed in accordance with the present invention. The glove A has the usual finger and thumb stalls 4, 6 respectively, and a wrist part 8 incorporating an elastic thread or yarn and a cuff trim overwrapping 9. The glove is made using conventional methods and glove knitting machinery.

All of the yarns are constructed of a core and wrappings and fabricated using known upwinding techniques. The core is a central strand or strands that extends or extend longitudinally of the length of the yarn. The wrappings or wraps are strands wound about the core in successive turns that may or may not be in contact each to the next. All of the yarns utilize a strand of liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier. The preferred constructions of the yarns embodying this invention include no high strength synthetic fibers such as high strength aramid, high strength stretched or extended chain polyethylene, or high strength liquid crystal polymer, which provide only comparable cut-resistance and in many instances have disadvantages.

Metal wire, especially fully annealed stainless steel, is utilized in several of the preferred embodiments, as either a core element or as a wrapping, and could be used as both, to contribute to high cut-resistance. Number 304 stainless steel, fully annealed, which has a tensile strength of about 110,000 to 140,000 pounds per square inch**, is believed to have optimum flexibility and life. Other embodiments utilize glass fiber or a few high denier filaments of liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, sometimes in lieu of metal wire and its function.

The liquid crystal polymer fiber utilized in the embodiments of this invention and having a tenacity of no greater than 10 grams per denier, has a tensile strength greater than that of stainless steel wire and an elongation of less than that of the wire. Vectran M has an initial tensile modulus of about 400 to 500 grams per denier, typically 425 grams per denier. It has a tenacity (tensile strength at break) of from 8 to 10 grams per denier, typically 9, and its elongation at break is about 2.0 percent.

The overall diameter of the yarns of this invention should be no greater than 0.05 inch and preferably no greater than 0.03 inch* to facilitate machine knitting. In practice, a range of from 0.005 inch to 0.035 inch will provide cut-resistant yarn of desirable qualities.

**1 pound per square inch = 6894 Pa

* 1 inch = 25.4 mm

One preferred embodiment of the invention is shown in Figure 1 of the drawings. A yarn B suitable for being machine knit to form the glove A comprises a core part 10 and three windings 12, 14, 16 of synthetic fiber wound about the core in opposite directions, each successive one on top of the previous one. The fact that each successive wrapping 14, 16 is in a different direction from the previous one balances the forces incident to the wrappings so the yarn has no unusual twist or tendency to coil and assists in holding the wrappings in place on the core 10. The core 10 has a strand 18 of 900 or 1500 denier multifilament liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M, and a fully annealed stainless steel wire 20, 0.003 inch in diameter. The wrapping 12 is a strand of 440 denier multifilament liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier and wrapped at a rate of 8-10 turns per inch about the core, and the wrappings 14, 16 are each 420 denier nylon wrapped at the rate of 8-12 turns per inch, but alternatively can be polyester of that denier. The use of a multifilament normal strength liquid crystal polymer fiber strand, such as Vectran M fiber strand, in the core is advantageous. Multifilament strand is very linear and slides and/or flows well relative to any other part of the core during fabrication and subsequent use of an article of apparel produced therewith. The normal strength multifilament core strand, which is relatively unstretchable, takes a great deal if not the major part of the tensile load to which the yarn is subjected during knitting. It also appears to increase the flexibility of the core part of the yarn over an all metal core and in turn makes the yarn more easily knit, i.e., imparts to the yarn greater knittability. It also improves cut-resistance. The use of multifilament normal strength liquid crystal polymer fiber such as Vectran M fiber as a wrapping contributes significantly to the cut-resistance of the yarn. The first wrapping 12 provides a desirable rigid backup surface for the outer wrappings 14, 16, each of which tends to fill out the valleys of the wrapping immediately therebeneath. The multifilament wrappings 12, 14, 16 wind flat about the core, producing a yarn with a smooth surface that aids the knitting process and that has a good appearance, a non-abrasive surface, and that provides heat resistance and maximum comfort.

Another preferred embodiment of the invention is shown in Figure 2 of the drawings. A yarn C comprises a core part 30 and multiple wrappings 32, 34, 36, 38 and 40 applied one after the other and except for the wrapping 36, each is wound helically in an opposite direction from the preceding one, which helps balance forces incident to the wrappings so the yarn has no unusual twist or tendency to coil and assists in holding the wrappings in place on the core. The core part 30 is a multifilament strand of 750 denier liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M. The first two wrappings are identical but wound in opposite directions about the core 30 and are

each 70 denier multifilament nylon fiber and wrapped at a rate of six turns per inch along the core. These two wrappings bundle the filaments of the core so they present a unified mass rather than a spread out and thinner layer of fibers to a sharp object, to which the core may be exposed when the yarn is in use, and it is believed to be more difficult to cut through such an arrangement of bundled multiple filaments. The bundled core filaments also present a substantially cylindrical and desirably uniform shape about which to wind subsequent wrappings. The third wrapping 36 is two (or alternatively, preferred embodiments may use one to three) fully annealed stainless steel wires each 0.0016 inch in diameter that are together wound as a strand in one direction about the core 30 and the first two wrappings 32, 34 at a rate of 8 turns per inch, uniformly spaced. The length of this wire is approximately 35 percent greater than the length of the core strand, and hence greater by the same amount than the length a straight core wire would be if used, thereby providing an increased amount of steel in the yarn over a straight core wire of the same diameter. By virtue of the helical shape of the wire, a knife blade or other sharp object approaching the yarn at an angle other than that of the wire helix will tend to have to cut through the wire of each composite yarn strand at more than one location, thereby meeting increased resistance over a core wire that, being straight, only interrupts the cutting path once. The fourth wrapping 38 is a 400 denier strand of liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M, wrapped in the opposite direction from that of the wire and the wrapping 34, with each turn directly adjacent the next to provide a substantially complete covering to the third wrapping. The fifth wrapping 40 is a strand of 840 denier nylon, or alternatively polyester, fiber wrapped in the opposite direction to the fourth wrapping, with each turn directly adjacent the next to provide a substantially complete covering to the fourth wrapping. While of relatively low cut-resistant material, the fifth wrapping adds body to the yarn and provides good comfort and feel to a garment made from the yarn because the material is soft, flexible and non-abrasive. The finished diameter of the yarn is between 0.020 and 0.030 inch, and preferably not greater than 0.025 inch, to facilitate machine knitting on conventional knitting machines.

Another preferred embodiment of the invention is shown in Figure 3. A yarn D has a core strand 44 of 1500 denier liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M, a first and second wrapping 46, 48 each of a fully annealed stainless steel wire 0.003 inch in diameter and each wrapped in an opposite direction from the other about the core, eight turns per inch. Alternatively, one of the wire wrappings can be omitted for more flexibility where less cut-resistance is needed. A third wrapping 50 of 400 denier liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vec-

tran M, is wound about the core and wire with turns directly adjacent, each to the next, to substantially cover the core and wire. A fourth wrapping 52 of 630 denier nylon, or alternatively polyester, is wound about the third wrapping with turns directly adjacent, each to the next, and in an opposite direction from the turns of the third wrapping. Alternatively, the third and fourth wrappings 50, 52, can both be of 400 denier liquid crystal polymer fiber having a tensile modulus no greater than 10 grams per denier, wound about the core and wire, each in an opposite direction from the other, and each with turns directly adjacent to provide a substantially complete covering, to provide greater cut-resistance, but without the softness and flexibility of the yarn having a fourth wrapping of nylon or polyester.

Another preferred yarn E embodying the invention is shown in Figure 4. A core 56 of 600 denier glass fiber, E glass, or alternatively S glass, preferably filament, is wound with a first and a second wrapping 58, 59 each of 750 denier liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M, each wound in an opposite direction from the other and each with its turns directly adjacent so the first substantially covers the core and the second substantially covers the first, and a third wrapping 60 of 400 denier nylon fiber or alternatively polyester fiber having directly adjacent turns.

Another preferred yarn F embodying the invention is shown in Figure 5 and comprises a core part 70 and three windings 72, 74, 76 of synthetic fiber wound thereon in opposite directions each successive one on top of the previous one. The fact that each successive wrapping 74, 76 is in a different direction from the previous one balances the forces incident to the wrappings so the yarn has no unusual twist or tendency to coil and assists in holding the wrappings in place on the core 70. The core 70 has four filaments 78 of 200 denier liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M. In other preferred embodiments of similar construction, the core can have a total denier of 200 to 1500 comprised of from one to 50 filaments or ends, each of which has a denier of from about 4 to about 500. The use of relatively few filaments of relatively high denier, preferably at least 20 denier each, results in a core strand behaving somewhat like a monofilament core and allows the liquid crystal polymer to function similarly to a steel wire core element and thereby permits the elimination of the wire, e.g., the wire used in the embodiment of Figure 1, and without the need for another strand normal or high strength synthetic fiber of low elongation and high cut-resistance along with it, as required with a core wire to protect it from breakage. The wrapping 72 is a strand of 440 denier liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M, and wrapped at a rate of 8-10 turns per inch about the core, and the wrappings 74, 76 are each 440 denier nylon wrapped at the rate of 8-12 turns per inch, but alterna-

tively can be polyester of that denier.

Another preferred yarn G embodying the invention is shown in Figure 6 and comprises a core part 80 of 440 or 220 denier multifilament polyester fiber, two identical wrappings 82, 84 wound in opposite directions about the core 80, each of 70 denier multifilament nylon fiber and wrapped at a rate of six turns per inch, to bundle the filaments of the core. A third wrapping 86 is a single strand of 0.0016 inch diameter fully annealed stainless steel wire wrapped at a rate of 8 turns per inch, uniformly spaced. A fourth wrap 88 is 400 denier liquid crystal polymer fiber having a tenacity no greater than 10 grams per denier, such as Vectran M, wrapped in the opposite direction from that of the wire, with each turn directly adjacent the next to provide a substantially complete covering to the third wrapping. A fifth wrapping 90 is a strand of 1300 microdenier polyester wrapped in the opposite direction to the fourth wrapping with each turn directly adjacent the next to provide a substantially complete covering to the fourth wrapping. The finished diameter of the yarn is between 0.020 and 0.030 inch, and preferably not greater than 0.025 inch, to facilitate machine knitting on conventional knitting machines. The outer wrapping of microdenier polyester provides a soft and comfortable feel, is readily cleanable, is attractive and has good wear characteristics.

While specific deniers and other features of preferred embodiments have been set forth, different values can be selected within acceptable ranges to provide useful cut-resistant yarns. The specific values selected will of course cause a variation in cut-resistance, flexibility, weight and thickness of the yarn and the fabric knitted therefrom, and cost. It is contemplated that the normal strength liquid crystal polymer fiber, such as Vectran M, when used in the core or as a wrapping of a yarn embodying the invention, will have a denier of from 200 to 3000, and more typically from 200 to 1500. The nylon or polyester fiber used as an outer wrapping of a yarn embodying the invention will have a denier of from 200 to 2000 and more typically from 200 to 1500. When a synthetic fiber, such as nylon or polyester fiber is used as an inner wrapping to bundle the core fibers, it will have a denier of from 50 to 400 and more typically from 50 to 120. The cut-resistance of a yarn containing metal wire is in part a function of the quantity of metal wire in the yarn, and flexibility is in part a function of the diameter of the metal wire.

Multiple metal strands are advantageous for flexibility over one larger strand where increased cut-resistance is desired. Other kinds of metal wire strands, if desired for special purposes, may be used, such as aluminum, copper, bronze or steel. Stainless steel wire used as a core or wrapping will have a diameter from 0.001 to 0.010 inch and more typically from 0.001 to 0.006 inch. The various wrappings about the core will have from 2 to 20 turns per inch. Preferably, the stainless steel wrappings will have from 2 to 12 turns per inch and more preferably 4 to 12, the core-bundling wrappings will have

from 2 to 20 turns per inch and more preferably 4 to 20, the normal strength liquid crystal polymer fiber wrappings will have from 8 to 12 turns per inch, and the covering wrappings will have whatever number of turns is needed to provide adequate covering with each turn adjacent the next, typically 8 to 12.

The depicted glove A when knit from any of the yarns B-G is a safety glove especially advantageous for use in the food processing industries and is highly cut-resistant, abrasive-resistant, readily cleanable at high temperatures, comfortable to wear, nice appearing, flexible and relatively non-absorbent, all of which are important in food processing industries. The glove is highly chemical-resistant and fatigue resistant, and resistant to the transfer of heat or cold, is conformable, does not acquire a set during use, is non-shrinkable, is light in weight, and provides a secure grip. At the same time, gloves knit from yarn described above using normal strength liquid crystal polymer fibers, such as Vectra M fibers, in place of comparable quantities of high strength synthetic fibers, provide essentially equal or in some cases better, cut-resistance over gloves knit with yarn that utilizes comparable quantities of high strength fiber.

While the yarn of the invention has been described and shown incorporated into a knit safety glove, it is to be understood that the yarn of the present invention can be used to make other fabrics and articles of apparel, safety or otherwise, such as wrist guards, protective sleeves, gaiters, safety aprons, etc. for use in the meat processing and other industries.

It is apparent from the foregoing that variations in certain of the materials and sizes of the strands employed in preferred embodiments of the invention herein described can be made, the advantages of the invention heretofore enumerated and others have been accomplished, and there have been provided an improved knittable yarn and safety articles of apparel made therewith having superior qualities. While preferred embodiments of the invention have been described in considerable detail, various modifications or alterations may be made therein without departing from the scope of the invention set forth in the appended claims.

Claims

1. A cut-resistant yarn suitable for machine knitting, comprising a core, one wrapping about the core and another wrapping about the one, at least one of said core and two wrappings being comprised of liquid crystal polymer fiber characterised in that said fiber has a tenacity of no more than 10 grams per denier.
2. A cut-resistant yarn as set forth in claim 1 wherein the core is comprised of said liquid crystal polymer fiber.
3. A cut-resistant yarn as set forth in claim 1 or 2

wherein one or both of the wrappings is or are comprised of said liquid crystal polymer fiber.

4. A cut-resistant yarn as set forth in any of the preceding claims including a flexible metal strand having a diameter of from 0,0254-0,254 mm (0.001 to 0.010 inch).
5. A cut-resistant yarn as set forth in claim 4 wherein the metal strand is a core element.
6. A cut-resistant yarn as set forth in claim 4 wherein the metal strand is a wrapping.
7. A cut-resistant yarn as set forth in claim 1 wherein a flexible metal strand and a fiber strand comprise the core.
8. A cut-resistant yarn as set forth in any of the preceding claims including one or more additional wrappings of synthetic fiber none of which has a tenacity greater than 10 grams per denier.
9. A cut-resistant yarn as set forth in claim 8 wherein the metal strand is annealed stainless steel of a diameter from 0,025 - 0,15 mm (0.001 to 0.006 inch), the liquid crystal polymer fiber has a denier of from 200 to 3000, and each of the one or more additional wrappings of synthetic fiber has a denier of from 200 to 1500.
10. A cut-resistant yarn as set forth in claim 1 wherein the core is comprised of synthetic fiber, means bundling the core fiber, a wrapping of wire about the bundled core, and wherein the two wrappings are of synthetic fiber each wound in an opposite direction over the wrapping of wire.
11. A cut-resistant yarn as set forth in claim 10 wherein the core is comprised of a liquid crystal polymer having a tenacity of no more than 10 grams per denier and a denier of from 200 to 3000, said means bundling the core fiber comprises two wraps of fiber having a denier of from 70 to 120, said wrapping of wire comprises one strand or more of stainless steel each having a diameter of from 0,025 - 0,150 mm (0.001 to 0.006 inch), and one of said two wrappings of synthetic fiber is a liquid crystal polymer having a tenacity of no more than 10 grams per denier and a denier of from 200 to 1500.
12. A cut-resistant yarn as set forth in claim 10 wherein the fiber of either or both of said two wrappings is a liquid crystal polymer, an aramid, a high strength stretched polyethylene, a polyester, or a nylon.
13. A cut-resistant yarn as set forth in claim 1 wherein the core is partially or wholly glass fiber and one or

both of said wrappings about the core includes a liquid crystal polymer fiber having a tenacity of no more than 10 grams per denier.

14. A cut-resistant yarn as set forth in claim 13 wherein the glass fiber has a denier of from 400 to 1500 and a further wrapping is polyester or nylon, said wrappings each having a denier of from 200 to 1500. 5
15. A cut-resistant yarn as set forth in claim 1 wherein the core is 200 to 2000 denier comprised of synthetic fibers, the core fiber are retained in a bundle, one of said wrappings has a maximum diameter of 0.010 inch and is either metal wire or glass fiber, wrapped two to twelve turns per inch about the core, another wrapping is of 200 to 3000 denier liquid crystal polymer fiber having a tenacity of no more than 10 grams per denier with turns directly adjacent each other; and a further wrapping is provided of 200 to 2000 denier synthetic fiber with turns directly adjacent each other. 10
16. A cut-resistant yarn as set forth in claim 15 wherein the core fibers are retained in a bundle by two wrappings of synthetic fiber each having a denier of at least 50 and wrapped directly about the core fibers at least two turns per 25,4 mm (per inch). 25
17. A cut-resistant yarn as set forth in claim 2 wherein the core fiber is formed of from 1 to 50 filaments. 30
18. A cut-resistant yarn as set forth in claim 17 wherein the core is wire-free and each core filament has a denier of from 10 to 500. 35
19. A cut-resistant yarn set forth in any of the preceding claims wherein an outer wrapping is of microdenier nylon. 40
20. A yarn as set forth in anyone of claims 1-19, knitted to form an article of protective apparel. 45
21. A yarn as set forth in claim 20 wherein the article is a cut-resistant protective glove. 50

Patentansprüche

1. Gegen Schnitt widerstandsfähiges Garn, geeignet zum Maschinenstricken, umfassend einen Kern, eine Ummantelung um den Kern und eine weitere Ummantelung um die mindestens eine des Kerns und zwei Ummantelungen, die flüssigkristalline Polymerfaser aufweisen, dadurch gekennzeichnet, daß diese Faser eine Reißfestigkeit von nicht mehr als 10 Grammforce pro Denier hat. 55
2. Gegen Schnitt widerstandsfähiges Garn nach An-

spruch 1, bei welchem der Kern die flüssigkristalline Polymerfaser aufweist.

3. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 1 oder 2, bei welchem eine oder beide Ummantelungen die flüssigkristalline Polymerfaser aufweist oder aufweisen.
4. Gegen Schnitt widerstandsfähiges Garn nach einem der vorgenannten Ansprüche, einschließlich ein flexibles Metallfaserbündel mit einem Durchmesser von 0,0254 ... 0,254 mm (0,001 inch ... 0,010 inch).
5. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 4, bei welchem das Metallfaserbündel ein Kernelement ist. 15
6. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 4, bei welchem das Metallfaserbündel eine Umhüllung ist. 20
7. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 1, bei welchem ein flexibles Metallfaserbündel und ein Faserbündel den Kern ausmachen. 25
8. Gegen Schnitt widerstandsfähiges Garn nach einem der vorgenannten Ansprüche, einschließlich eine oder mehrere zusätzliche Ummantelungen aus synthetischer Faser, von denen keine eine höhere Reißfestigkeit von mehr als 10 Grammforce pro Denier hat. 30
9. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 8, bei welchem das Metallfaserbündel wärmebehandelter Stahl mit einem Durchmesser von 0,025 ... 0,15 mm (0,001 inch ... 0,006 inch) ist, die flüssigkristalline Polymerfaser 200 ... 3.000 Denier hat und jede der einen oder mehreren Ummantelungen der synthetischen Fasern 200 ... 1.500 Denier haben. 35
10. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 1, bei welchem der Kern synthetische Faser, Mittel zum Bündeln der Kernfaser, eine Ummantelung aus Draht um den gebündelten Kern umfaßt und bei welchem Garn die zwei Ummantelungen aus synthetischer Faser bestehen, die jede in einer entgegengesetzten Richtung über die Ummantelung aus Draht gewickelt sind. 40
11. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 10, bei welchem der Kern ein flüssigkristallines Polymer mit einer Reißfestigkeit von nicht mehr als 10 Grammforce pro Denier und einem Titer von 200 ... 3.000 Denier ist, wobei das Mittel zum Bündeln der Kernfaser zwei Ummantelungen aus Faser mit 70 ... 120 Denier umfaßt, wobei die Um-

mantelung aus Draht ein oder mehrere Faserbündel aus rostfreiem Stahl aufweist, von denen jedes einen Durchmesser von 0,025 ... 0,15 mm (0,001 inch ... 0,006 inch) hat und eine der zwei Ummantelungen aus synthetischer Faser ein flüssigkristallines Polymer mit einer Reißfestigkeit von nicht mehr als 10 Grammforce pro Denier und einem Titer von 200 ... 1.500 Denier ist.

12. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 10, bei welchem die Faser von einer oder den beiden Ummantelungen ein flüssigkristallines Polymer, ein Aramid, ein hochfestes verstrecktes Polyethylen, ein Polyester oder ein Nylon ist.

13. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 1, bei welchem der Kern teilweise oder ganz aus Glasfaser besteht und eine oder die beiden Ummantelungen um den Kern eine flüssigkristalline Polymerfaser einschließen, die eine Reißfestigkeit von nicht mehr als 10 Grammforce pro Denier hat.

14. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 13, bei welchem die Glasfaser 400 ... 1.500 Denier hat und eine weitere Ummantelung Polyester oder Nylon ist, wobei die Ummantelungen jede 200 ... 1.500 Denier haben.

15. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 1, bei welchem der Kern 200 ... 2.000 Denier hat und synthetische Fasern aufweist, die Kernfaser in einem Bündel gehalten wird, eine der Ummantelungen einen maximalen Durchmesser von 0,010 inch hat und entweder Draht oder Glasfaser ist, mit zwei bis zwölf Windungen um den Kern gewickelt ist, eine weitere Ummantelung eine flüssigkristalline Polymerfaser mit 200 ... 3.000 Denier und einer Reißfestigkeit von nicht mehr als 10 Grammforce pro Denier und direkt aneinander angrenzenden Windungen ist; wobei eine weitere Ummantelung aus synthetischer Faser mit 200 ... 2.000 Denier mit direkt aneinander angrenzenden Windungen vorgesehen wird.

16. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 15, bei welchem die Kernfasern in einem Bündel von zwei Ummantelungen aus synthetischer Faser gehalten werden, die jede mindestens 50 Denier haben und direkt um die Kernfasern gewickelt mit mindestens zwei Windungen pro 25,4 mm (1 inch) gewickelt sind.

17. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 2, bei welchem die Kernfasern aus 1 ... 50 Filamenten gebildet wird.

18. Gegen Schnitt widerstandsfähiges Garn nach Anspruch 17, bei welchem der Kern frei von Draht ist

und jedes Filament 10 ... 500 Denier hat.

19. Gegen Schnitt widerstandsfähiges Garn nach einem der vorgenannten Ansprüche, bei welchem eine äußere Ummantelung aus einem mikrotitrigen Nylon ist.

20. Garn nach einem der Ansprüche 1 bis 19, gewirkt, um einen Schutzkleidungsartikel zu erzeugen.

21. Garn nach Anspruch 20, bei welchem der Artikel ein Gegen Schnitt widerstandsfähiger Schutzhandschuh ist.

Revendications

1. Fil résistant au découpage, convenant au tricotage mécanique, comprenant une âme, un guipage autour de l'âme et un autre guipage autour du premier, au moins ladite âme ou l'un des deux guipages comportant une fibre de polymère à cristaux liquides, caractérisé en ce que ladite fibre a une ténacité inférieure ou égale à 100 g/denier.

2. Fil résistant au découpage selon la revendication 1, où l'âme comporte ladite fibre de polymère à cristaux liquides.

3. Fil résistant au découpage selon la revendication 1 ou 2, où l'un des deux guipages ou les deux comporte(nt) ladite fibre de polymère à cristaux liquides.

4. Fil résistant au découpage selon l'une quelconque des revendications précédentes, comprenant un brin métallique flexible ayant un diamètre de 0,0254 mm à 0,254 mm (0,001 à 0,010 pouce).

5. Fil résistant au découpage selon la revendication 4, où le brin métallique est un élément de l'âme.

6. Fil résistant au découpage selon la revendication 4, où le brin métallique est un guipage.

7. Fil résistant au découpage selon la revendication 1, où un brin métallique flexible et un brin fibreux forment l'âme.

8. Fil résistant au découpage selon l'une quelconque des revendications précédentes, comprenant un ou plusieurs guipages additionnels en fibre synthétique dont aucun n'a une ténacité supérieure à 10 g/denier.

9. Fil résistant au découpage selon la revendication 8, où le brin métallique est de l'acier inoxydable recuit de 0,025 à 0,15 mm (0,001 à 0,006 pouce) de diamètre, la fibre de polymère à cristaux liquides a une

masse linéique de 200 à 3 000 deniers et le guipage additionnel ou chacun des guipages additionnels en fibre synthétique a une masse linéique de 200 à 1 500 deniers.

10. Fil résistant au découpage selon la revendication 1, où l'âme comporte une fibre synthétique, un moyen d'emballage de la fibre formant l'âme, un guipage de fil métallique autour de l'âme emballée et où les deux guipages sont en fibre synthétique, enroulés chacun dans une direction opposée sur le guipage de fil métallique.

11. Fil résistant au découpage selon la revendication 10, où l'âme comporte un polymère à cristaux liquides ayant une ténacité inférieure ou égale à 10 g/denier et une masse linéique de 200 à 3 000 deniers, ledit moyen d'emballage de la fibre formant l'âme comprend deux enveloppes de fibre ayant une masse linéique de 70 à 120 deniers, ledit guipage de fil métallique comprend un ou plusieurs brins en acier inoxydable ayant chacun un diamètre de 0,025 à 0,15 mm (0,001 à 0,006 pouce) et un desdits deux guipages en fibre synthétique est un polymère à cristaux liquides ayant une ténacité inférieure ou égale à 10 g/denier et une masse linéique comprise entre 200 et 1 500 deniers.

12. Fil résistant au découpage selon la revendication 10, où la fibre de l'un desdits deux guipages ou des deux est un polymère à cristaux liquides, un aramide, un polymère haute résistance étiré, un polyester ou un Nylon.

13. Fil résistant au découpage selon la revendication 1, où l'âme est partiellement ou totalement une fibre de verre et un desdits guipages ou les deux entourant l'âme comprend une fibre de polymère à cristaux liquides ayant une ténacité inférieure ou égale à 10 g/denier.

14. Fil résistant au découpage selon la revendication 13, où la fibre de verre a une masse linéique de 400 à 1 500 deniers et un guipage supplémentaire est en polyester ou Nylon, lesdits guipages ayant chacun une masse linéique de 200 à 1 500 deniers.

15. Fil résistant au découpage selon la revendication 1, où l'âme a une masse linéique de 200 à 2 000 deniers et comporte des fibres synthétiques, les fibres formant l'âme sont retenues dans un faisceau, un desdits guipages a un diamètre maximal de 0,0010 pouce et est soit un fil métallique, soit une fibre de verre, enroulé à raison de 2 à 12 tr/pouce autour de l'âme, un autre guipage est une fibre de polymère à cristaux liquides de 200 à 3 000 deniers ayant une ténacité inférieure ou égale à 10 g/denier, les tours étant directement adjacents les uns aux autres, et

il est prévu un guipage supplémentaire en fibre synthétique de 200 à 2 000 deniers, dont les tours sont directement adjacents les uns aux autres.

5 16. Fil résistant au découpage selon la revendication 15, où les fibres de l'âme sont retenues dans un faisceau par deux guipages en fibre synthétique dont chacun a une masse linéique d'au moins 50 deniers et est enroulé directement autour des fibres de l'âme à raison d'au moins 2 tours par 25,4 mm (par pouce).

10 17. Fil résistant au découpage selon la revendication 2, où la fibre de l'âme est constituée de 1 à 50 filaments.

15 18. Fil résistant au découpage selon la revendication 17, où l'âme est dépourvue de fil métallique et chaque filament de l'âme a une masse linéique de 10 à 500 deniers.

20 19. Fil résistant au découpage selon l'une quelconque des revendications précédentes, où un guipage externe est en Nylon à microdeniers.

25 20. Fil selon l'une quelconque des revendications 1 à 19, tricoté pour former un vêtement protecteur.

30 21. Fil selon la revendication 20, où le vêtement est un gant de protection résistant au découpage.

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