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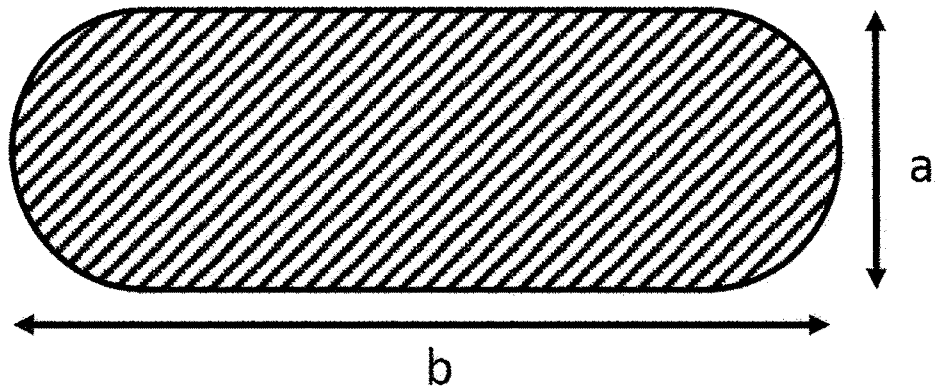
(54) **POLYAMIDE MULTIFILAMENT AND COVERING ELASTIC YARN**

(57) The present invention addresses the problem of providing a high-strength polyamide multifilament from which stockings having excellent wearability and also having excellent transparency and texture can be produced. The problem can be achieved by a polyamide multifilament having a total fiber fineness of 6 to 20 dtex, loop strength of 12 cN/dtex or more, and a degree of flatness, which is represented by the ratio (b/a) of a longer diameter b of a transverse section of a single fiber to a shorter diameter a of the transverse section, of 1.5 to 5.0.

FIG. 6



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Description

TECHNICAL FIELD

[0001] The present invention relates to a polyamide multifilament and a covering elastic yarn suitable for a stocking. More particularly, the present invention relates to a polyamide multifilament and a covering elastic yarn being, when the polyamide multifilament is used for a stocking, capable of providing a stocking having excellent durability, high transparency, and good texture.

BACKGROUND ART

[0002] Polyamide fibers and polyester fibers, which are synthetic fibers, are in extensive use in clothing applications and industrial applications because of their excellent characteristics regarding mechanical and chemical properties. In particular, polyamide fibers are excellent in terms of the peculiar softness, high strength, colorability in dyeing, heat resistance, hygroscopicity, etc. For this reason, polyamide fibers are in extensive use in general clothing applications including stockings, innerwear, and sportswear.

[0003] As consumer needs for stockings, there has been a demand for stockings with high transparency and soft texture, and many techniques for improvement have been proposed. For example, Patent Literature 1 proposes an oval-shaped or convex lens-shaped polyamide multifilament having a flatness of 1.5 to 5.0 in which a fiber cross-sectional shape is line symmetric with respect to a major axis, and a stocking using the same.

[0004] Further, Patent Literature 2 proposes a high strength polyamide multifilament having a total fineness of 4.0 to 6.0 dtex and a strong-elongation product of 9.1 cN/dtex or more, and a stocking using the same. Further, as a manufacturing method for improving the strong-elongation product of the polyamide multifilament, it has been proposed to apply a cooling condition in which the polymer orientation relaxation is promoted and the solidification point is lowered, for example, by maintaining the atmosphere temperature under a spinneret at a high temperature.

CITATION LIST

PATENT LITERATURE

[0005]

Patent Literature 1: JP 2009-203563 A
Patent Literature 2: WO 2016/076184 A1

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] However, in Patent Literature 1, the durability of a stocking decreases as the fineness increases. Further, since the flat short axis becomes smaller than the round cross section diameter due to the flattening of the cross section, there has always been problems that the yarn strength is lowered and the durability of the stocking is lowered as compared with the round cross section.

[0007] In addition, even in the case where the conditions for promoting the orientation relaxation of the polymer and decreasing the solidification point, such as maintaining the atmosphere temperature under the spinneret at a high temperature in order to increase the strong-elongation product as described in Patent Literature 2, are applied to Patent Literature 1, the flatness is lowered in forming a flat cross section due to the decreasing of the solidification point. In such a case, the texture and the aesthetics of the obtained stocking could not be satisfied.

[0008] In addition, although the flat cross section has the texture and the aesthetics, the flat short axis is smaller than the round cross section diameter as compared with the round cross section, so that it cannot be denied that the durability of the stocking is lowered, and further improvement in durability is desired.

[0009] An object of the present invention is to solve the above problems, and an object of the present invention is to provide a flat polyamide multifilament and a covering elastic yarn having excellent durability, transparency, soft texture, and aesthetics when used for stockings.

SOLUTION TO PROBLEM

[0010] In order to solve the above problems, the present invention adopts the following configurations.

(1) A polyamide multifilament having a total fineness of 6 to 20 dtex, a hook strength of 12 cN/dtex or more, and a flatness represented by a ratio (b/a) of a major diameter b to a minor diameter a of a single fiber transverse section of 1.5 to 5.0.

(2) The polyamide multifilament according to (1), having a tensile strength at 15% elongation of 5.0 cN/dtex or more.

(3) A covering elastic yarn, in which the polyamide multifilament according to (1) or (2) is arranged as a cover yarn.

ADVANTAGEOUS EFFECTS OF INVENTION

[0011] The polyamide multifilament of the present invention is a polyamide multifilament having high flatness and high hook strength. Furthermore, in the case where the polyamide multifilament and the covering elastic yarn of the present invention are used for stockings, it is possible to obtain a stocking having excellent durability, transparency, soft texture, and aesthetics.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

FIG. 1 is a schematic view showing one embodiment of a manufacturing device that can be preferably used in a method for manufacturing a polyamide multifilament according to the present invention.

FIG. 2 is a schematic view showing one embodiment of a manufacturing device used in a manufacturing method exemplified as a comparison of the method for manufacturing a polyamide multifilament according to the present invention.

FIG. 3 is a schematic cross-sectional model diagram showing a spinneret and a heating cylinder that can be preferably used in the method for manufacturing a polyamide multifilament according to the present invention.

FIG. 4(a) and FIG. 4(b) show an embodiment of a swirling nozzle that can be preferably used in the method for manufacturing a polyamide multifilament of the present invention, in which FIG. 4(a) is an overall schematic view of the swirling nozzle, and FIG. 4(b) is a cross-sectional view taken along line A-A' of FIG. 4(a).

FIG. 5 is a view showing an embodiment of an ejection hole shape of a spinneret which can be preferably used in the method manufacturing for a polyamide multifilament of the present invention.

FIG. 6 is a cross-sectional view of a polyamide multifilament according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0013] Hereinafter, the present invention will be described in more detail. In the present description, "mass" has the same meaning as "weight".

[Polyamide Multifilament]

[0014] The polyamide constituting the polyamide multifilament according to the embodiment of the present invention is a resin formed of a high molecular weight polymer in which so-called hydrocarbon groups are linked via an amide bond in the main chain. Polyamide is excellent in yarn-manufacturing properties and mechanical properties. Examples of the polyamide include polycaproamide (nylon 6) and polyhexamethylene adipamide (nylon 66). Polycaproamide (nylon 6) is preferable since it is less likely to gel and has good yarn-manufacturing properties.

[0015] Here, the above-mentioned polyamide may contain 80 mol% or more of a component as a unit which mainly constitutes the polyamide. Preferably, the above-mentioned polyamide contains 90 mol% or more of a component as a unit. In polycaproamide, ε-caprolactam, which mainly constitutes polycaproamide, is a component as a unit. In polyhexamethylene adipamide, hexamethylene diammonium adipate, which mainly constitutes polyhexamethylene adipamide, is a component as a unit.

[0016] Other components contained in the polyamide are not particularly limited, and examples thereof include an aminocarboxylic acid, a dicarboxylic acid, and a diamine, and the like which are monomers constituting polydodecanamide, polyhexamethylene adipamide, polyhexamethylene azelamide, polyhexamethylene sebacamide, polyhexamethylene dodecanamide, polymetaxylylene adipamide, polyhexamethylene terephthalamide, polyhexamethylene isophthalamide, and the like.

[0017] In order to effectively exhibit the effects of the present invention, it is preferable that the polyamide does not contain various additives such as a matting agent represented by titanium oxide. However, additives such as a heat resistant agent may be contained, if necessary, as long as the effects of the present invention are not impaired. The content of the additives is preferably in the range of 0.001 wt% to 0.1 wt% with respect to the polymer (polyamide).

[0018] The polyamide multifilament according to the embodiment of the present invention has a total fineness of 6 to

20 dtex, a hook strength of 12 cN/dtex or more, and a ratio (b/a, hereinafter referred to as "flatness") of a major diameter b to a minor diameter a of a single fiber transverse section of 1.5 to 5.0. By lowering the total fineness of the polyamide multifilament and increasing the flatness, a stocking with high transparency and the soft texture can be obtained. On the other hand, in the polyamide multifilament having a low total fineness and a high flatness, since the flat short axis is smaller than the round cross section diameter, the yarn strength is lowered as compared with the round cross section, and the durability is lowered in the case of using in stockings. Here, due to the structure of the stocking, the stress applied to the intersection of the hook points of the needle loop and the sinker loop becomes large, so that the durability of the stocking can be evaluated by the hook strength. As a result, the inventors of the present invention have diligently studied and found setting the total fineness, the hook strength, and the flatness within such ranges in order to provide a stocking with excellent transparency, texture and durability.

[0019] The polyamide multifilament according to the embodiment of the present invention has a total fineness of 6 dtex to 20 dtex. In the case where the total fineness is in such a range, the stocking has high transparency and a soft texture. In the case where the total fineness is 20 dtex or less, the transparency and texture of the stocking are improved. In the case where the total fineness is 6 dtex or more, the durability of the stocking is improved. The total fineness is more preferably 6 dtex to 11 dtex.

[0020] The polyamide multifilament according to the embodiment of the present invention has a hook strength of 12 cN/dtex or more. In the case of the hook strength in such a range, the durability of the stocking can be improved, and flattening for improving transparency and texture can be achieved. In the case where the hook strength is 12 cN/dtex or more, the durability, transparency, and aesthetics of the stocking are improved. Further, the higher the hook strength is, the more preferable, but the upper limit value in the present invention is about 17 cN/dtex. The hook strength is preferably 13 cN/dtex or more. Note that the hook strength is measured according to "8.7 hook strength" of JIS L1013 (2010).

[0021] The breakage of the stocking often occurs when the stocking is worn by strongly pulling from the toes to the thighs. At this time, in a stocking knitted fabric, as the degree of fineness and the flatness of the polyamide multifilament become higher, the filament cannot withstand the stress applied to the hooking points of the needle loop and the sinker loop, and the filament is likely to be broken. Therefore, it has been found that increasing not only the strength (tensile strength) in the fiber axis direction but also the hook strength are important to improve the durability of the stocking. That is, in addition to the strength (tensile strength) of the polyamide filament in the fiber axis direction in related art, the strength (hook strength) of the stress concentration portion of the hooking points of the needle loop and the sinker loop is improved, and the durability of the stocking is improved.

[0022] The polyamide multifilament according to the embodiment of the present invention has a flat fiber transverse section having a flatness of 1.5 to 5.0 represented by a ratio (b/a) of a major diameter b to a minor diameter a. In the case where the flatness is within such a range, the bending softness of the fiber is improved, and the stocking having excellent texture can be obtained. In addition, the coverability of the covering yarn is made uniform due to a high degree of bending softness, and a stocking having excellent transparency and aesthetics can be obtained. In the case where the flatness is 1.5 or more, the texture, transparency, and aesthetics of the stocking are improved. In the case where the flatness is 5.0 or less, the orientation crystallization of the polymer (polyamide) is not too low while the texture, transparency, and aesthetics of the polymer (polyamide) are excellent, and the durability of the stocking can be sufficiently improved. Preferably, the flatness is 2.5 to 4.0. FIG. 6 shows an embodiment of the fiber transverse section of the polyamide multifilament according to the embodiment of the present invention.

[0023] The cross-sectional shape of the polyamide multifilament according to the embodiment of the present invention is not particularly limited as long as the polyamide multifilament has a flat shape, and the surface form is not particularly limited. For example, the polyamide multifilament according to the embodiment of the present invention may have a lens-shaped cross section, a bean-shaped cross section, and a modified cross section having the same number of concave portions as three to eight convex portions.

[0024] The polyamide multifilament according to the embodiment of the present invention preferably has a tensile strength at 15% elongation (hereinafter referred to as "15% strength"), which is one index of raw yarn properties, of 5.0 cN/dtex or more. The 15% strength is measured according to "8.5 tensile strength and elongation percentage" of JIS L1013 (2010). A tensile strength-elongation curve is drawn, and a value obtained by dividing the tensile strength (cN) at 15% elongation by the fineness is defined as 15% strength. The 15% strength is a value that simply represents the fiber modulus, and when the high 15% strength is high, the gradient of the tensile strength-elongation curve is high and the fiber modulus is high, and when the 15% strength is low the gradient of the tensile strength-elongation curve is low and the fiber modulus is low.

[0025] As will be described later, the polyamide multifilament according to the embodiment of the present invention can realize a high fiber modulus without fluffing by performing multi-stage and high-ratio drawing. By setting the 15% strength in such a range, ballooning in the covering process can be stabilized without slack, and the coverability can be made uniform. That is, by obtaining the covering yarn having excellent uniform coverability, a stocking having excellent transparency and excellent beautiful aesthetics of the knitted fabric can be obtained. More preferably, the 15% strength is 5.5 cN/dtex to 6.5 cN/dtex.

[0026] The polyamide multifilament according to the embodiment of the present invention preferably has a tensile strength of 6.5 cN/dtex or more. In the case where the tensile strength is 6.5 cN/dtex or more, the orientation crystallization of the polymer (polyamide) is good, leading to improvement of the hook strength. More preferably, the tensile strength is 6.8 cN/dtex to 7.3 cN/dtex.

[Method for manufacturing polyamide multifilament]

[0027] Next, an example of a method for manufacturing a polyamide multifilament according to an embodiment of the present invention will be described in detail. FIG. 1 is a schematic view showing an embodiment of a manufacturing device preferably used in a method for manufacturing a polyamide multifilament according to an embodiment of the present invention.

[0028] In the production of the polyamide multifilament according to the embodiment of the present invention, first, the polyamide polymer is melted, weighed and transported by a gear pump, and finally extruded from an ejection hole provided in a spinneret 1, so that each filament is formed. As shown in FIG. 1, each filament ejected from the spinneret 1 in this manner passes through a gas feeder 2 for blowing out steam to inhibit stains on the spinneret, a heating cylinder 3 provided so as to surround the entire circumference for slow cooling, and is further cooled and solidified to room temperature by passing through the cooling device 4. Thereafter, each filament is applied with an oil agent by the oiling device 5, and each filament is converged to form a multifilament, and convergence is given by the fluid swirling nozzle device 6. Thereafter, the multifilament is drawn in two stages in a take-up roller 7, a first drawing roller 8, and a second drawing roller 9, and relaxed by a relaxing roller 10. The relaxed multifilament is entangled by an entanglement imparting device 11, and is wound by a winding device 12.

[0029] In the production of the polyamide multifilament according to the embodiment of the present invention, the sulfuric acid relative viscosity of the polyamide is preferably from 2.5 to 4.0. In the case where the sulfuric acid relative viscosity of the polyamide is within such a range, a polyamide multifilament having high hook strength, 15% strength, and high tensile strength can be obtained.

[0030] The melting temperature when melting the polyamide is preferably higher than a temperature (Tm + 20°C) of 20°C higher than the melting point (Tm) of the polyamide and lower than a temperature of (Tm + 95°C).

[0031] In the production of the polyamide multifilament according to the embodiment of the present invention, in order to realize desired flatness and high strength, it is necessary to optimize the ejection hole of the spinneret 1 and set the ejection linear velocity to an appropriate value. FIG. 5 shows an embodiment of the hole shape of the ejection hole. By designing the single-hole ejection area of the spinneret 1 to be small, the ejection linear velocity of the polymer can be increased. Therefore, stress can be reduced between the spinneret surface and the take-up roller, polymer orientation can be reduced, the mechanical draw ratio can be increased, and high strength can be likely to be realized. The ejection linear velocity is a value obtained by dividing the ejection amount by the ejection hole area, and is preferably 25 m/min to 50 m/min, and more preferably 30 m/min to 40 m/min.

[0032] Conventionally, in a spinneret, in order to realize a desired flatness, it is necessary to lengthen the ejection hole length N in the major diameter direction of the ejection hole (prior art). In this case, the single-hole ejection area of the spinneret 1 increases, and as a result, the ejection linear velocity of the polymer decreases, and a desired strength cannot be obtained. On the other hand, by minimizing the ejection hole width H in the minor diameter direction without lengthening the ejection hole length N in the major diameter direction, it is possible to remarkably improve the flatness. According to this method, it is possible to reduce the single-hole ejection area of the spinneret 1 while improving the flatness, and it is possible to adopt a desired range of the ejection linear velocity. As a result, it is possible to increase the strength of the yarn. The preferable ejection hole width H is 0.060 mm to 0.080 mm, more preferably 0.065 mm to 0.075 mm.

[0033] In order to achieve a high flatness with respect to the cooling condition of each filament, it is common to set a condition (rapid cooling condition) for increasing the solidification point. In order to achieve high strength, as described in Patent Literature 2, it is common to accelerate the orientation relaxation of the polymer, such as maintaining the atmosphere temperature under the spinneret at a high temperature, and to set a condition (slow cooling condition) for lowering the solidification point. That is, conventionally, in order to simultaneously achieve high flatness and high strength as in the polyamide multifilament of the present invention, a contradiction occurs in the method. Therefore, in the present invention, in order to realize desired flatness and high strength, a preferable manufacturing condition is found by analyzing a detailed temperature profile: in the preferable manufacturing condition, a slow cooling region is set up under the spinneret to maintain the atmosphere temperature high, and after the orientation relaxation of the polymer is sufficiently promoted, the filament is rapidly solidified in the cooling region.

[0034] In the production of the polyamide multifilament according to the embodiment of the present invention, as shown in FIG. 3, the heating cylinder 3 is provided on the upper side of the cooling device 4 so as to surround the entire circumference of each filament. In the case where the heating cylinder 3 is provided on the upper side of the cooling device 4 and the atmosphere temperature in the heating cylinder 3 is preferably in the range of 280°C to 310°C, the orientation relaxation of the polyamide ejected from the spinneret 1 can be improved. By promoting the orientation relaxation in the slow cooling region from the spinneret surface to the lower surface of the heating cylinder, it is possible to realize high strength such as desired hook strength. In the case where the heating cylinder 3 is not provided, the slow cooling region is absent, and the orientation relaxation from the spinneret surface to the cooling is insufficient, so that it becomes difficult to achieve high strength such as the desired hook strength.

[0035] Although depending on the fineness of the multifilament, the heating cylinder length L is preferably 30 mm to 90 mm. In the case where the heating cylinder length L is 30 mm or more, the distance is sufficient to promote the orientation relaxation of the polymer, and the high strength is likely to be achieved. In addition, by setting the heating cylinder length L to 90 mm or less, a desired flatness is likely to be realized. The heating cylinder length L is more preferably 40 mm to 70 mm.

[0036] The heating cylinder 3 is preferably a multilayer. In the fine fineness region such as the polyamide multifilament according to the embodiment of the present invention, in the case where the temperature distribution in the heating cylinder 3 is constant, the thermal convection is prone to be disordered to affect the solidification of the filaments and this is a factor of deterioration of the yarn unevenness (U%). The heating cylinder 3 having a multilayer configuration is disposed and temperatures are set so as to decline stepwise from upper layers to lower layers. Thus, thermal convection from upper layers to lower layers is intentionally generated. Then, a descending air flow in the same direction as the flow accompanying the filaments is produced. As a result, disorder of the thermal convection in the heating cylinder 3 is prevented and filament oscillation is reduced, thereby obtaining a multifilament having a small yarn unevenness (U%). It is preferable that the multilayer heating cylinder has two or more layers, and the single-layer length of the multilayer heating cylinder is preferably within the range of 10 mm to 25 mm.

[0037] In the production of the polyamide multifilament according to the embodiment of the present invention, as the cooling device 4, use can be made of any of a cooling device configured to eject cooling/rectifying air from a certain direction, an annular cooling device configured to eject cooling/rectifying air from the peripheral side toward the center, an annular cooling device configured to eject cooling/rectifying air from the center side toward the periphery, and the like.

[0038] In order to achieve a desired flatness, it is necessary to increase the solidification point of the polymer (polyamide). This is because the working time should be shortened since the elastic force acting on the polymer (polyamide) acts in a direction in which the surface area is minimized. That is, the solidification point of the polymer (polyamide) coming out of the lower surface of the heating cylinder 3 and entering the cooling region needs to be as close as possible to the upper end of the cooling region. It is preferable that the vertical distance LS (hereinafter referred to as cooling start distance LS) from the lower surface of the spinneret 1 to the upper end of the cooling-air ejection portion of the cooling device 4 shown in FIG. 1 is within a range of 130 mm or less, in view of obtaining a desired flatness. In addition, from the viewpoint of the Nusselt heat exchange formula, as an effective method for bringing the solidification point close to the upper end, it is preferable to increase the cooling air velocity, and the velocity is preferably, depending on the range of single-filament fineness, in the range of 30.0 m/min to 40.0 m/min in terms of the average for the zone from the upper end surface to the lower end surface of the cooling region. In the case where the cooling air velocity is 30.0 m/min or more, the heat exchange rate of the polymer (polyamide) increases, and the solidification point approaches the upper end surface of the cooling region. Thus, the desired flatness is more likely to be achieved. On the other hand, from the viewpoint of operability, the cooling air velocity is preferably 40 m/min or less.

[0039] Similarly to the cooling air velocity, the cooling air temperature in the cooling region is also an important factor in heat exchange. The cooling air temperature is preferably 20°C or less. In the case where the cooling air temperature is 20°C or less, the heat exchange rate of the polymer (polyamide) increases, and the solidification point approaches the upper end surface of the cooling region. Thus, the desired flatness is more likely to be achieved.

[0040] In the production of the polyamide multifilament according to the embodiment of the present invention, the position of the oiling device 5, that is, the vertical distance Lg (hereinafter referred to as "oiling position Lg") from the lower surface of the spinneret 1 to the position of the oiling nozzle of the oiling device 5 in FIG. 1, is preferably 800 mm to 1,500 mm, depending on the single-filament fineness and the efficiency of cooling of the filaments by the cooling device 4. The oiling position Lg is more preferably 1000 mm to 1300 mm. In the case where the oiling position Lg is 800 mm or more, the temperature of the filaments falls to a temperature suitable for the oiling. In the case where the oiling position Lg is 1,500 mm or less, the filament oscillation due to the descending air flow is small and a multifilament having a small yarn unevenness (U%) can be obtained. In addition, in the case where the oiling position Lg is 1,500 mm or less, the distance from the solidification point to the oiling position is short, resulting in a diminished accompanying flow and a reduced spinning tension. As a result, the spinning orientation is reduced and the drawability is excellent, which is preferable from the viewpoint of increasing the strength such as improving the hook strength. In the case where the oiling position Lg is 800 mm or more, the bending of the filaments in the zone from the spinneret to the oiling guide is appropriate and the filaments are less apt to be affected by scratching on the guide. Thus, there is less reduction in high strength such as improvement in hook strength.

[0041] In the production of the polyamide multifilament according to the embodiment of the present invention, the fluid swirling nozzle device 6 is preferably provided before the take-up roller 7. The fluid swirling type nozzle (swirling nozzle) has a shape as indicated by reference numeral 6a in FIGs. 4(a) and 4(b), and convergence is imparted to the yarn by the swirling flow W from one direction in the cylinder. The length LA of the swirling nozzle is, depending on the fineness of the multifilament, preferably 5 mm to 50 mm from the viewpoint of imparting convergence.

[0042] The ejection pressure of the swirling flow W is preferably 0.05 MPa to 0.20 MPa. By setting the ejection pressure in such a range, an appropriate convergence property can be imparted to the filament, drawability does not decrease during the drawing under a high tension, and a single yarn disengagement does not occur during the drawing. Therefore, a polyamide multifilament with less fluffing can be obtained while the enhancement of the fineness is ensured.

[0043] In the production of the polyamide multifilament according to the embodiment of the present invention, the drawing is preferably multi-stage drawing having two or more stages. In the case of one-stage drawing, when high-ratio drawing is applied to obtain a raw yarn having a high fiber modulus and high strength, the drawing tension is high and the draw point is located on the take-up roller. As a result, the drawability is deteriorated, the strength is lowered, and fluffing is likely to occur. With the multi-stage drawing having two or more stages, the load applied to the yarn during the drawing is dispersed, and the draw point is stable between rollers. Therefore, the drawability is stable, the hook strength, the 15% strength, and the tensile strength are high, the high fiber modulus fibers are likely to be obtained, and a polyamide multifilament without fluffing is likely to be obtained.

[0044] In the production of the polyamide multifilament according to the embodiment of the present invention, it is preferable that the total draw ratio is in a range of 3.5 times to 5.0 times in view of achieving a hook strength of 12 cN/dtex or more. The total draw ratio is more preferably 3.8 times to 4.7 times. The draw ratio at the first stage is preferably 2.5 times to 3.5 times, and more preferably 2.7 times to 3.3 times. During the drawing, the take-up roller 7 is preferably heated to 40°C to 60°C, the first drawing roller 8 is preferably heated to 130°C to 170°C, and the second drawing roller 9 is preferably heated to 150°C to 200°C. The speed of the take-up roller 7 is preferably 500 m/min to 1,300 m/min, and more preferably 700 m/min to 1,100 m/min.

[0045] In the production of the polyamide multifilament according to the embodiment of the present invention, the relaxing ratio [(speed of second drawing roller - speed of relaxing roller) / (speed of relaxing roller) × 100] between the second drawing roller 9 and the relaxing roller 10 is preferably 0 to 1.5%. By setting the relaxing ratio in such a range, the relaxing ratio is lower than a case of producing a typical polyamide multifilament, and the heat setting is performed in a state of less relaxation. For this reason, the linearity of the molecular chain is improved, and an amorphous portion in the fiber is uniformly and moderately stretched. Therefore, a high strength such as a hook strength is likely to be realized. In the case where the relaxing ratio is larger than 1.5%, the heat set is performed in a state of large relaxation, such that the linearity of the molecular chain is lowered, and high strength such as improvement of the hook strength is difficult to achieve.

[0046] For example, in the case where the conditions in the direct spinning drawing method as shown in FIG. 1 is adopted, a polyamide multifilament having a total fineness of 6 dtex to 20 dtex, a high hook strength of 12 cN/dtex or more, and a high flatness of 1.5 to 5.0 can be obtained.

[Covering Elastic Yarn]

[0047] The polyamide multifilament according to the embodiment of the present invention can be used as a cover yarn of a covering yarn.

[0048] A covering elastic yarn (hereinafter, also simply referred to as a "covering yarn") according to an embodiment of the present invention is a covering elastic yarn in which the above-described polyamide multifilament is disposed as a cover yarn. Examples of the covering yarn include a single covering yarn in which an elastic yarn is used as a core yarn and a cover yarn is wound in a single layer, and a double covering yarn in which a cover yarn is doubly wound.

[0049] A polyurethane-based elastic fiber, a polyamide-based elastomer elastic fiber, a polyester-based elastomer elastic fiber, a natural rubber-based fiber, a synthetic rubber-based fiber, a butadiene-based fiber, or the like may be used as the elastic yarn, and may be appropriately selected depending on the elastic characteristics, heat setting property, durability or the like. Among them, the polyurethane-based elastic fiber and the polyamide-based elastomer elastic fiber are preferred from the above characteristics.

[0050] The thickness of the elastic yarn varies depending on the kind of the stocking and the setting of the fastening pressure, but in order to achieve both durability, transparency and softness, it is typically about 8 dtex to 40 dtex. In particular, the preferred thickness of the elastic yarn is 14 dtex to 25 dtex. In the case where the thickness of the elastic yarn is within such a range, the drawability, durability, softness, and transparency as stockings can be likely to be realized.

[0051] The covering twist number may be designed in consideration of the fineness, the shrinkage ratio, the product texture, the transparency, and the durability of the cover yarn. In the case where the covering twist number is increased, the apparent thickness is reduced, so that the transparency is improved, but when the number is too high, the elastic yarn is too tightened to reduce the durability, or the productivity of the covering process is likely to be lowered. Further, in the case where the covering twist number is too low, the coverability is lowered, and the durability, the transparency, and the softness are likely to be lowered. Therefore, for example, in the case where a cover yarn of 6 dtex is used as a single covering yarn, it is preferable to design the covering twist number to be 2000 T/m to 2600 T/m as a guide. Further, in the case of forming a double covering yarn, the upper twist number may be set to 0.7 times to 0.95 times as large as the lower twist number. As the twist direction, the lower twist and the upper twist can be set in either the same direction or the opposite direction, but it is preferable to cover in the opposite direction in order to reduce the torque. For example, the draft magnification may be designed according to the target wearing pressure, and for example, the draft magnification is preferably set to 2.5 times to 3.5 times.

[0052] In the case of producing the covering elastic yarn according to the embodiment of the present invention, a conventional covering process may be performed. For example, the process described in Encyclopedia of fibers (published by Maruzen Co., Ltd., Japan, published on March 25, 2002, p. 439) may be performed. That is, for example, in a state where the elastic yarn is drawn at a constant velocity and a constant draft is applied between the two rollers, the cover yarn previously wound around the H-bobbin is wound around the elastic yarn at a constant covering twist number, and the obtained covering elastic yarn is cheese-wound.

[0053] The polyamide multifilament according to the embodiment of the present invention and the covering elastic yarn according to the embodiment of the present invention can be used for a stocking in which these are partially used. Among these, as the stocking, it is preferably used for leg portions by taking advantage of the transparency, barefoot feeling and glossiness with excellent shadow effect thereof. Here, the stocking as used herein refers to a stocking product, which is represented by, for example, pantyhose, long stocking, or short stocking, and the leg portion refers to a range from a garter portion to the toes in the case of pantyhose, for example.

[0054] In addition, as a knitting machine for the stocking, an ordinary sock knitting machine can be used, and there are no particularly limitation. For example, the knitting may be performed by a usual method in which a knitting machine having a two or four yarn feeders is used to feed and knit the covering yarn. In the case of the single covering yarn, a method of alternately knitting the single covering yarn of the S-direction covering and the single covering yarn of the Z-direction covering is preferred. Examples of other methods include a cross-knitting of a single covering yarn and a raw yarn, a cross-knitting of a double covering yarn and a raw yarn, and a Zocki-knitting of a double covering yarn and a double covering yarn. Further, the number of stitches of the knitting machine is generally 360 to 474, and as the number of needles is smaller, the transparency tends to be higher, but the durability tends to be inferior. As the number of stitches increases, the durability improves, but the transparency tends to be lowered. Therefore, the number of stitches can be selected depending on the fineness of the cover yarn and the elastic yarn to be used, the target durability, the transparency, and the softness. For example, it is preferable to set the number of stitches to 400 to 440 by using the cover yarn of 6 dtex to 20 dtex.

[0055] Further, dyeing after knitting or subsequent post-processing and final set conditions may also be performed according to a known method. An acid dye or a reactive dye may be used as the dye. Of course, the color and the like are not limited.

[Examples]

[0056] Hereinafter, the present invention will be described in more detail with reference to Examples.

[0057] Hereinafter, the evaluation method for each evaluation item will be described.

A. Tensile Strength, Strength-elongation Product, and 15% Strength

[0058] A fiber sample was examined in accordance with "8.5 tensile strength and elongation" of JIS L1013 (2010) to draw a tensile strength-elongation curve. The test conditions included a constant-rate extension type tester, a distance between chucks of 50 cm, and a tensile speed of 50 cm/min. In the case where the tensile strength at break was lower than the maximum strength, the maximum tensile strength and the corresponding elongation were measured.

[0059] The elongation, the tensile strength, the strength-elongation product and the 15% strength were determined using the following equations.

$$\text{Elongation} = \text{elongation at break (\%)}$$

$$\text{Tensile strength} = [\text{tensile strength at break (cN)}]/[\text{total fineness (dtex)}]$$

$$\text{Strong elongation product} = \{\text{tensile strength (cN/dtex)}\} \times \{\text{elongation (\%)} + 100\}/100$$

$$\text{15\% strength} = [\text{tensile strength at 15\% elongation (cN)}]/[\text{Total fineness (dtex)}]$$

B. Hook Strength

[0060] In accordance with "8.7 hook strength" of JIS L1013 (2010), a hook portion was formed in the middle of the gap between the chucks of the sample, and the measurement was performed under the same conditions as the above strength and elongation measurement. The hook strength was determined by the following equation.

$$\text{Hook strength} = [\text{tensile strength at break (cN)}]/[\text{total fineness (dtex)}]$$

C. Total Fineness and Single-filament Fineness

[0061] A fiber sample (multifilament) was set on a sizing reel having a circumference of 1.125 m, and the sizing reel was rotated to make 500 rotations to produce a looped hank. The hank was dried in a hot-air drying oven (105±2°C × 60 min) and weighed with a balance. The measured weight was multiplied by a standard moisture regain, and the fineness was calculated from the resultant value. The standard moisture regain was assumed to be 4.5%. The value obtained by dividing the calculated total fineness by the number of filaments was defined as a single-filament fineness.

D. Sulfuric Acid Relative Viscosity (ηr)

[0062] A polyamide chip sample in an amount of 0.25 g was dissolved in sulfuric acid having a concentration of 98 mass%, so that the sample amount was 1 g per 100 mL of the sulfuric acid. Using an Ostwald viscometer, the solution was examined for a flow time (T1) at 25°C. Subsequently, the sulfuric acid having a concentration of 98 mass% alone was examined for a flow time (T2). The ratio of T1 to T2, i.e., T1/T2, was taken as the sulfuric acid relative viscosity.

E. Yarn Unevenness (U%)

[0063] Using USTER (registered trademark) TESTER IV, manufactured by Uster Technologies, a fiber sample was examined under the conditions of: sample length, 500 m; test yarn speed V, 100 m/min; twister (rotation speed), S-twisting at 30,000/min; and 1/2 Inert.

F. Flatness and Cross-sectional Shape

[0064] A thin piece was cut out in the transverse-sectional direction at an arbitrary position of the fiber used for the cover yarn, all the filaments of the transverse section of the fiber were photographed by a transmission microscope, printed out from a printer (SCT-P66, manufactured by Mitsubishi Electric Corporation) at a magnification of 1000 times, and then taken in by using a scanner (GT-5500 WINS, manufactured by Seiko Epson Corporation) (monochrome photograph, 400 dpi), the ratio L/S of the diameter L of the circumscribed circle OL to the diameter S of the inscribed circle IC was calculated using image processing software (WinROOF manufactured by Mitani Corporation) in a state of being magnified 1500 times on the display, and the flatness = b/a was determined from the number average value of the values obtained from all the filaments. Further, it was visually confirmed whether or not the fiber has a flat fiber transverse section (oval cross-sectional shape) from the photograph.

G. Stocking Evaluation

(a) Durability

[0065] Bursting strength was evaluated in the following manner. Arbitrarily selected three portions were examined for bursting strength by the bursting strength test method according to JIS L1096 (2010), Mullen type method (method A), and an average value of the measured values was evaluated in the following four grades. A and B were considered to have passed the durability.

A: 1.6 kg/cm^2 or more
B: 1.4 kg/cm^2 or more and less than 1.6 kg/cm^2
C: 1.2 kg/cm^2 or more and less than 1.4 kg/cm^2
D: Less than 1.2 kg/cm^2

(b) Softness

[0066] The stocking product was evaluated for softness by inspectors (five persons) rich in experiences in evaluating texture. Using a nylon 6 multifilament having fineness of 11 dtex, 8 filaments, and a round cross section, relative evaluation was performed using a lace knitted fabric produced in the same manner as in Example 1 as a reference. As a result, the grades evaluated by the inspectors were averaged, and the average was rounded off to the nearest whole number. Grades 5, 4, 3, and 1-2 on average were indicated by A, B, C and D, respectively. A and B were considered to have passed the softness.

5: highly excellent
4: slightly excellent
3: fair
2: slightly poor
1: poor

(c) Transparency

[0067] As an evaluation sample, a sample obtained by refining and performing a subsequent finishing step without dyeing was evaluated as a white cloth. A and B were considered to have passed the transparency.

A: highly excellent
B: slightly excellent
C: fair
D: slightly poor

(d) Stitch Aesthetics

[0068] As an evaluation sample, a sample obtained by refining and performing a subsequent finishing step without dyeing was evaluated as a white cloth. A and B were considered to have passed the stitch aesthetics.

A: highly excellent
B: slightly excellent
C: fair
D: slightly poor

[Example 1]

(Production of Polyamide Multifilament)

[0069] Nylon-6 chips having a sulfuric acid relative viscosity (ηr) of 3.3 and a melting point of 225°C, as a polyamide, were dried in an ordinary method so as to result in a moisture content of 0.03 mass% or less. The nylon-6 chips thus obtained were melted at a spinning temperature (melting temperature) of 298°C and ejected from the spinneret 1 (ejection amount 18.9 g/min). As shown in FIG. 5, the spinneret 1 used had 36 holes, was for producing six yarns per spinneret, and had ejection holes having round holes at both ends of the slit (when the ejection hole width was H, the ejection hole length was N, and the diameter of the round hole was D, N/H = 4.9, D/H = 1.4, and the ejection hole width H was 0.07 mm). The spinning was conducted using a spinning machine having the configuration shown in FIG. 1. The heating cylinder 3 used was a heating cylinder having a heating cylinder length L of 50 mm, and the temperature was set such that the atmosphere temperature of the heating cylinder 3 was 290°C. The filaments ejected from the spinneret 1 were passed through the cooling device 4 having a cooling start distance LS of 102 mm and supplying 18°C cool air at a speed of 38 m/min. Thus, the filaments were cooled to room temperature and solidified. Thereafter, the filaments were collected, while being oiled at an oiling position Lg of 1,300 mm in terms of distance from the spinneret surface by the oiling device 5, thereby forming a multifilament. The fluid swirling nozzle device 6 having a swirling nozzle length LA of 25 mm was used to impart convergence. The convergence was imparted by injecting high-pressure air (swirling flow W) to the running yarn (multifilament 20) in the fluid swirling nozzle device 6 in the direction of the arrow as shown in FIG. 4. The pressure of the air (swirling flow) injected was 0.1 MPa (flow rate: 15 L/min). Thereafter, the multifilament was subjected to a first stage drawing such that the draw ratio between the take-up roller 7 and the first drawing roller 8 was 2.9 times, and was then subjected to a second drawing such that the draw ratio between the first drawing roller 8 and the second drawing roller 9 was 1.5 times. Subsequently, 2.0% of relaxation heating was conducted between the second drawing roller 9 and the relaxing roller 10, the yarn was entangled by the entanglement imparting device 11, and then wound by the winding device 12 at 3000 m/min. At this time, the total draw ratio represented by a ratio of the take-up speed (the speed of the take-up roller 7) to the draw speed (the speed of the second drawing roller 9) was adjusted to 4.3 times. The surface temperature of each roller was set such that the take-up roller was 40°C, the first drawing roller was 155°C, and the second drawing roller was 185°C, and the relaxing roller was equal to room temperature. The entanglement treatment was performed by injecting high-pressure air from the direction perpendicular to the running yarn (multifilament) in the entanglement imparting device 11. The pressure of the air injected was 0.2 MPa. Thus, a nylon 6 multifilament having a total fineness of 9 dtex, including six filaments and having an oval cross-sectional shape was obtained. The results of evaluation of the obtained nylon 6 multifilament are shown in Table 1.

(Production of Stocking)

[0070] The obtained multifilament was used as a cover yarn of a covering elastic yarn, a 18-denier polyurethane elastic yarn (MOBILON (registered trademark) K-L22T, manufactured by Nisshinbo-textile Co., Ltd.) was used as a core yarn, a draft was set to 3.5 times, and covering was performed at a covering twist number of 2400 t/m.

[0071] Using the above covering elastic yarn, the S-direction single covering yarn and the Z-direction single covering yarn were alternately supplied to the yarn feeder of the knitting machine by a Super-4 knitting machine (400 stitches) manufactured by Nagata Seiki Co., Ltd., and the leg portion knitted fabric was knitted only with the covering yarn. Subsequently, a soaping agent (NEW SUNLEX (registered trademark) E; 2 g/L (manufactured by Nicca Chemical Co., Ltd.)) was used to perform refining at 60°C × 30 minutes; an acidic half milling dye (Telon Red A2R; 0.14% owf, Telon Yellow A2R; 0.16% owf, Telon Blue A2R; 0.12% owf (manufactured by DyStar Co., Ltd., Telon is a registered trademark)), a leveling agent (SeraGalN-FS; 0.5% owf (manufactured by DyStar Co., Ltd.)), and a pH slide agent (ammonium sulfate: 4.0% owf) were used to perform dyeing in beige which is a general color of pantyhose at a bath ratio of 1: 50, 100°C × 60 minutes; a fixing agent (Hifix (registered trademark) SW-A; 5% owf (manufactured by NAGASE-OG COLORS & CHEMICALS Co., Ltd.)), a scum preventive agent (NWH 201; 1% owf (manufactured by Senka Corporation)), and sodium carbonate were used to perform a fixing treatment at 90°C × 45 minutes, and final set was performed at 120°C for 30 seconds, thereby obtaining a pantyhose product. The results of the evaluation of the leg portions of the obtained pantyhose product are shown in Table 1.

[0072] The obtained pantyhose was extremely excellent in all of the durability, the softness, the transparency, and the stitch aesthetics.

[Example 2]

[0073] A nylon 6 multifilament having a total fineness of 6 dtex and including four filaments and a stocking were obtained in the same manner as in Example 1, except that the number of holes and the ejection amount of the spinneret were changed. The evaluation results are shown in Table 1.

[Example 3]

[0074] A nylon 6 multifilament having a total fineness of 20 dtex and including 14 filaments and a stocking were obtained in the same manner as in Example 1, except that the number of holes and the ejection amount of the spinneret were changed. The evaluation results are shown in Table 1.

[Example 4]

[0075] The multifilament was subjected to a first stage drawing such that the draw ratio between the take-up roller 7 and the first drawing roller 8 was 2.9 times, and was then subjected to a second drawing such that the draw ratio between the first drawing roller 8 and the second drawing roller 9 was 1.2 times. The total draw ratio represented by a ratio of the take-up speed (the speed of the take-up roller 7) to the draw speed (the speed of the second drawing roller 9) was adjusted to 3.5 times. A nylon 6 multifilament having a total fineness of 9 dtex and including 6 filaments and a stocking were obtained in the same manner as in Example 1 except for the above. The evaluation results are shown in Table 1.

[Example 5]

[0076] The multifilament was subjected to a first stage drawing such that the draw ratio between the take-up roller 7 and the first drawing roller 8 was 3.4 times, and was then subjected to a second drawing such that the draw ratio between the first drawing roller 8 and the second drawing roller 9 was 1.4 times. The total draw ratio represented by a ratio of the take-up speed (the speed of the take-up roller 7) to the draw speed (the speed of the second drawing roller 9) was adjusted to 5.0 times. A nylon 6 multifilament having a total fineness of 9 dtex and including 6 filaments and a stocking were obtained in the same manner as in Example 1 except for the above. The evaluation results are shown in Table 1.

[Example 6]

[0077] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the ejection hole of the spinneret was changed to N/H = 3.9 when the ejection hole width was H and the ejection hole length was N. The evaluation results are shown in Table 1.

[Example 7]

[0078] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the ejection hole of the spinneret was changed to N/H = 8.8 when the ejection hole width was H and the ejection hole length was N. The evaluation results are shown in Table 1.

[Example 8]

[0079] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the ejection hole width H of the spinneret was changed to 0.08 mm. The evaluation results are shown in Table 1.

[Example 9]

[0080] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1 except that the ejection hole width H of the spinneret was changed to 0.06 mm. The evaluation results are shown in Table 1.

[Example 10]

[0081] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the cooling air speed was changed to 30 m/min. The evaluation results are shown in Table 1.

[Example 11]

[0082] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the heating cylinder length L was changed to 75 mm. The evaluation results are shown in Table 1.

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11
Spinning Conditions	Ejection Hole Width H	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.06	0.07	0.07
	Ejection Linear Velocity	36.7	36.7	36.7	36.7	36.7	36.7	36.7	28.1	50.0	36.7	36.7
	Heating Cylinder Length L (mm)	50	50	50	50	50	50	50	50	50	50	75
	Cooling Air Velocity (m/min)	38	38	38	38	38	38	38	38	38	30	38
	Number of Drawing Stages	2	2	2	2	2	2	2	2	2	2	2
	Total Drawing Ratio	4.3	4.3	4.3	3.5	5.0	4.3	4.3	4.3	4.3	4.3	4.3

(continued)

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11
Raw Yarn Characteristics	Total Fineness (dtex)	9	6	20	9	9	9	9	9	9	9	9
	Number of Filaments	6	4	14	6	6	6	6	6	6	6	6
	Single-Filament Fineness	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Elongation (%)	32	32	32	36	24	32	32	32	32	32	32
	Tensile Strength (cN/dtex)	7.0	6.8	7.2	6.7	7.4	7.2	6.8	6.6	7.3	7.3	7.3
	Strong-Elongation Product (cN/dtex)	9.2	9.0	9.5	9.1	9.2	9.5	9.0	9.2	9.2	9.2	9.2
	Hook Strength (cN/dtex)	15.7	14.3	16.3	12.2	16.9	16.8	12.3	12.2	16.9	16.9	16.9
	15% Strength (cN/dtex)	6.3	6.1	6.5	5.1	6.7	6.3	6.1	6.1	6.5	6.5	6.5
	U%	0.6	0.9	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Cross-Sectional Shape	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval
	Flatness	3.0	3.0	3.0	3.0	3.0	1.5	5.0	3.0	3.0	1.7	1.6
Stocking Evaluation	Durability	A	B	A	B	A	A	B	B	A	A	A
	Softness	A	A	B	A	A	B	A	A	A	B	B
	Transparency	A	A	B	A	A	B	A	A	A	B	B
	Stitch Aesthetics	A	A	B	A	A	B	A	A	A	B	B

[Comparative Example 1]

[0083] As shown in FIG. 2, the drawing ratio between the take-up roller 7 and the first drawing roller 8 was set to 2.7 times in the take-up roller 7 and the first drawing roller 8 without providing the second drawing roller 9 and the relaxing roller 10. A spinneret having an ejection hole width H of 0.10 mm was used as the spinneret 1, and each filament ejected from the spinneret 1 was passed through the cooling device 4 at an air speed of 25m/min. A nylon 6 multifilament having a total fineness of 9 dtex and including 6 filaments and a stocking were obtained in the same manner as in Example 1 except for the above. The evaluation results are shown in Table 2.

[0084] The flatness of the multifilament of Comparative Example 1 produced under the condition in which a condition to increase a strong-elongation product as described in Patent Literature 2 was only applied to Patent Literature 1 was lowered. In addition, the hook strength was low. For this reason, the softness, the transparency, the stitch aesthetics and the durability of the stocking were poor.

[Comparative Example 2]

[0085] A nylon 6 multifilament having a total fineness of 5 dtex and including three filaments and a stocking were obtained in the same manner as in Example 1, except that the number of holes and the ejection amount of the spinneret were changed. The evaluation results are shown in Table 2.

[0086] Since the multifilament obtained in Comparative Example 2 had a small fineness, not only the yarn strength was low, but also the hook strength was low. Therefore, the obtained stocking was poor in durability.

[Comparative Example 3]

[0087] A nylon 6 multifilament having a total fineness of 22 dtex and including 17 filaments and a stocking were obtained in the same manner as in Example 1, except that the number of holes and the ejection amount of the spinneret were changed. The evaluation results are shown in Table 2.

[0088] Since the multifilament obtained in Comparative Example 3 had a high fineness, the obtained stocking was poor in terms of softness and transparency.

[Comparative Example 4]

[0089] The multifilament was subjected to a first stage drawing such that the draw ratio between the take-up roller 7 and the first drawing roller 8 was 2.7 times, and was then subjected to a second drawing such that the draw ratio between the first drawing roller 8 and the second drawing roller 9 was 1.2 times. The total draw ratio represented by a ratio of the take-up speed (the speed of the take-up roller 7) to the draw speed (the speed of the second drawing roller 9) was adjusted to 3.2 times. A nylon 6 multifilament having a total fineness of 9 dtex and including 6 filaments and a stocking were obtained in the same manner as in Example 1 except for the above. The evaluation results are shown in Table 2.

[0090] The multifilament obtained in Comparative Example 4 had a low total draw ratio, and thus had a low hook strength, and the obtained stocking was poor in durability.

[Comparative Example 5]

[0091] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the ejection hole of the spinneret was changed to N/H = 3.5 when the ejection hole width was H and the ejection hole length was N. The evaluation results are shown in Table 2.

[0092] Since the multifilament obtained in Comparative Example 5 had a low flatness, the obtained stocking was poor in terms of the softness, transparency, and stitch aesthetics.

[Comparative Example 6]

[0093] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the ejection hole of the spinneret was changed to N/H = 10.7 when the ejection hole width was H and the ejection hole length was N. The evaluation results are shown in Table 2.

[0094] The multifilament obtained in Comparative Example 6 had a high flatness, and thus had a low hook strength, and the obtained stocking was poor in durability.

[Comparative Example 7]

[0095] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1 except that the ejection hole width H of the spinneret was changed to 0.09 mm. The evaluation results are shown in Table 2.

[0096] As for the multifilament obtained in Comparative Example 7, since the ejection hole width H was large, the ejection linear velocity was lowered and the hook strength was lowered. Therefore, the obtained stocking was poor in durability.

[Comparative Example 8]

[0097] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the heating cylinder length L was changed to 25 mm. The evaluation results are shown in Table 2.

[0098] As for the multifilament obtained in Comparative Example 8, since the heating cylinder length L was short, the atmosphere temperature was 250□, and the orientation relaxation of the polyamide polymer in the slow cooling region from the spinneret surface to the lower surface of the heating cylinder was insufficient. As a result, the flatness also increased and the hook strength was lowered. Therefore, the obtained stocking was poor in durability.

[Comparative Example 9]

[0099] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the heating cylinder length L was changed to 100 mm. The evaluation results are shown in Table 2.

[0100] As for the multifilament obtained in Comparative Example 9 since the heating cylinder length L was long, the cooling start distance LS was long and the flatness was low. For this reason, the obtained stocking was poor in terms of softness, transparency, and stitch aesthetics.

[Comparative Example 10]

[0101] A nylon 6 multifilament having a total fineness of 9 dtex and including six filaments and a stocking were obtained in the same manner as in Example 1, except that the cooling air speed was changed to 25 m/min. The evaluation results are shown in Table 2.

[0102] As for the multifilament obtained in Comparative Example 10, since the cooling air speed was slow, the solidification point did not become the upper end surface of the cooling region, and the flatness was low. For this reason, the obtained stocking was poor in terms of softness, transparency, and stitch aesthetics.

[Table 2]

		Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6	Comp. Ex. 7	Comp. Ex. 8	Comp. Ex. 9	Comp. Ex. 10
Spinning Conditions	Ejection Hole Width H	0.10	0.07	0.07	0.07	0.07	0.07	0.09	0.07	0.07	0.07
	Ejection Linear Velocity	18.0	36.7	36.7	36.7	36.7	36.7	22.2	36.7	36.7	36.7
	Heating Cylinder Length L (mm)	50	50	50	50	50	50	50	25	100	50
	Cooling Air Velocity (m/min)	25	38	38	38	38	38	38	38	38	25
	Number of Drawing Stages	1	2	2	2	2	2	2	2	2	2
	Total Drawing Ratio	2.7	4.3	4.3	3.2	4.3	4.3	4.3	4.3	4.3	4.3

(continued)

		Comp.Ex. 1	Comp.Ex. 2	Comp.Ex. 3	Comp.Ex. 4	Comp.Ex. 5	Comp.Ex. 6	Comp.Ex. 7	Comp.Ex. 8	Comp.Ex. 9	Comp. Ex. 10
Raw Yarn Characteristics	Total Fineness (dtex)	9	5	22	9	9	9	9	9	9	9
	Number of Filaments	6	3	17	6	6	6	6	6	6	6
	Single-Filament Fineness	1.5	1.7	1.3	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Elongation (%)	44	32	32	44	32	32	28	28	28	28
	Tensile Strength (cN/dtex)	6.4	6.6	7.2	6.3	7.4	6.5	6.3	6.3	7.3	7.1
	Strong-Elongation Product (cN/dtex)	9.2	8.7	9.5	9.1	9.8	8.6	9.2	9.2	9.2	9.2
	Hook Strength (cN/ dtex)	11.5	11.8	17.3	11.0	17.4	11.5	11.0	11.1	17.2	15.8
	15% Strength (cN/ dtex)	3.9	5.9	6.8	4.9	6.5	5.8	5.9	4.9	6.5	6.3
	U%	0.6	0.9	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Cross-Sectional Shape	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval
	Flatness	1.4	3.0	3.0	3.0	1.2	6.0	3.0	5.2	1.3	1.3
Stocking Evaluation	Durability	C	C	A	D	A	C	C	C	A	A
	Softness	C	A	D	A	C	A	A	A	C	C
	Transparency	C	A	C	C	C	A	A	A	C	C
	Stitch Aesthetics	C	A	B	C	C	A	A	A	C	C

[0103] Although the present invention has been described in detail with reference to specific embodiments, it is obvious to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the present invention. The present application is based on Japanese Patent Application No. 2018-218431 filed on November 21, 2018, the contents of which are incorporated herein by reference.

REFERENCE SIGNS LIST

[0104]

1: spinneret
2: gas feeder
3: heating cylinder
4: cooling device
5: oiling device
6: fluid swirling nozzle device
6a: swirling nozzle
7: take-up roller
8: first drawing roller
9: second drawing roller
10: relaxing roller
11: entanglement imparting device
12: winding device
20: multifilament
a: minor diameter
b: major diameter
D: diameter of round hole
H: ejection hole width
L: heating cylinder length
LS: cooling start distance
Lg: oiling position
LA: length of swirling nozzle
N: ejection hole length
W: swirling flow

Claims

1. A polyamide multifilament having a total fineness of 6 to 20 dtex, a hook strength of 12 cN/dtex or more, and a flatness represented by a ratio (b/a) of a major diameter b to a minor diameter a of a single fiber transverse section of 1.5 to 5.0.

2. The polyamide multifilament according to claim 1, having a tensile strength at 15% elongation of 5.0 cN/dtex or more.

3. A covering elastic yarn, wherein the polyamide multifilament according to claim 1 or 2 is arranged as a cover yarn.

FIG. 1

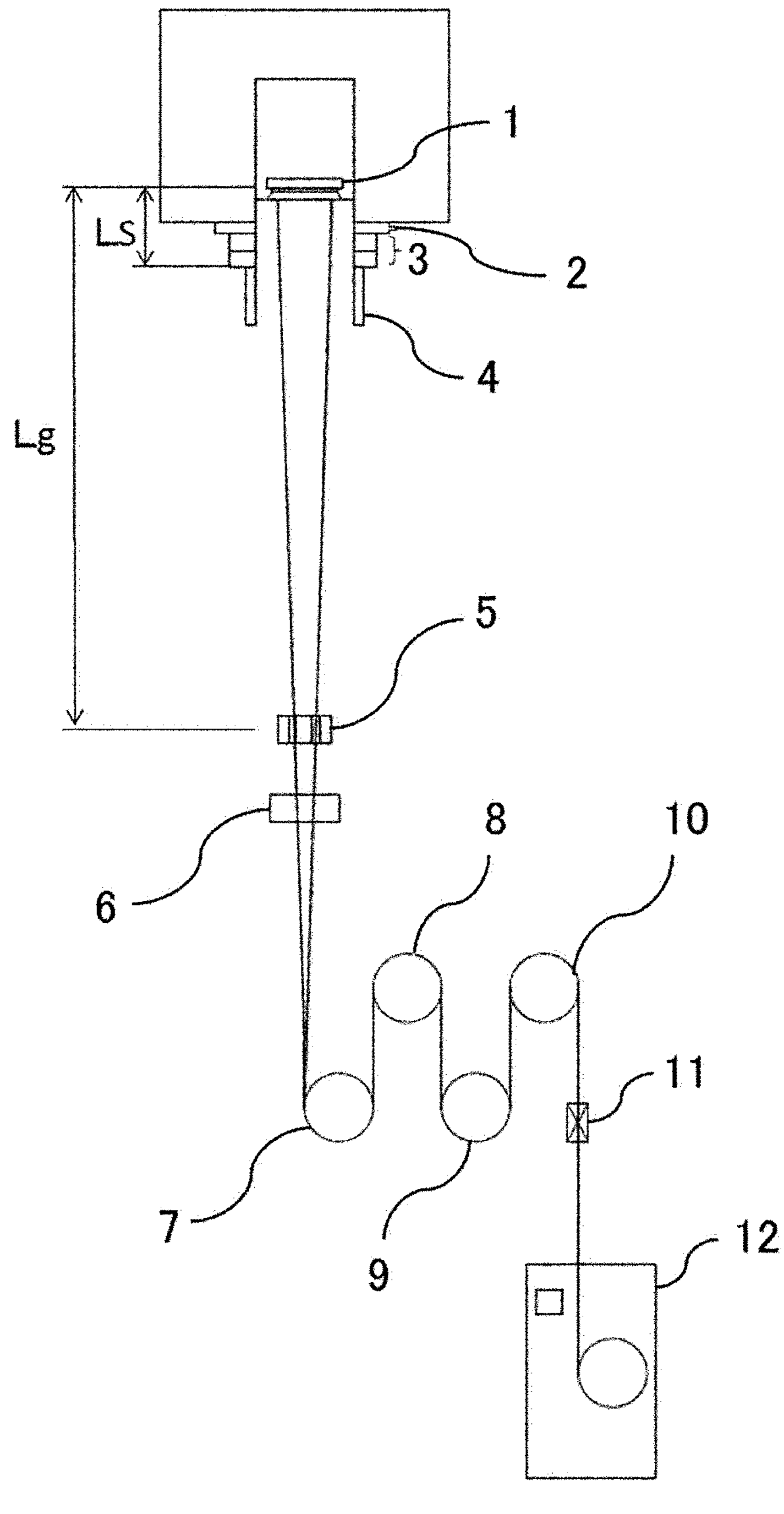


FIG. 2

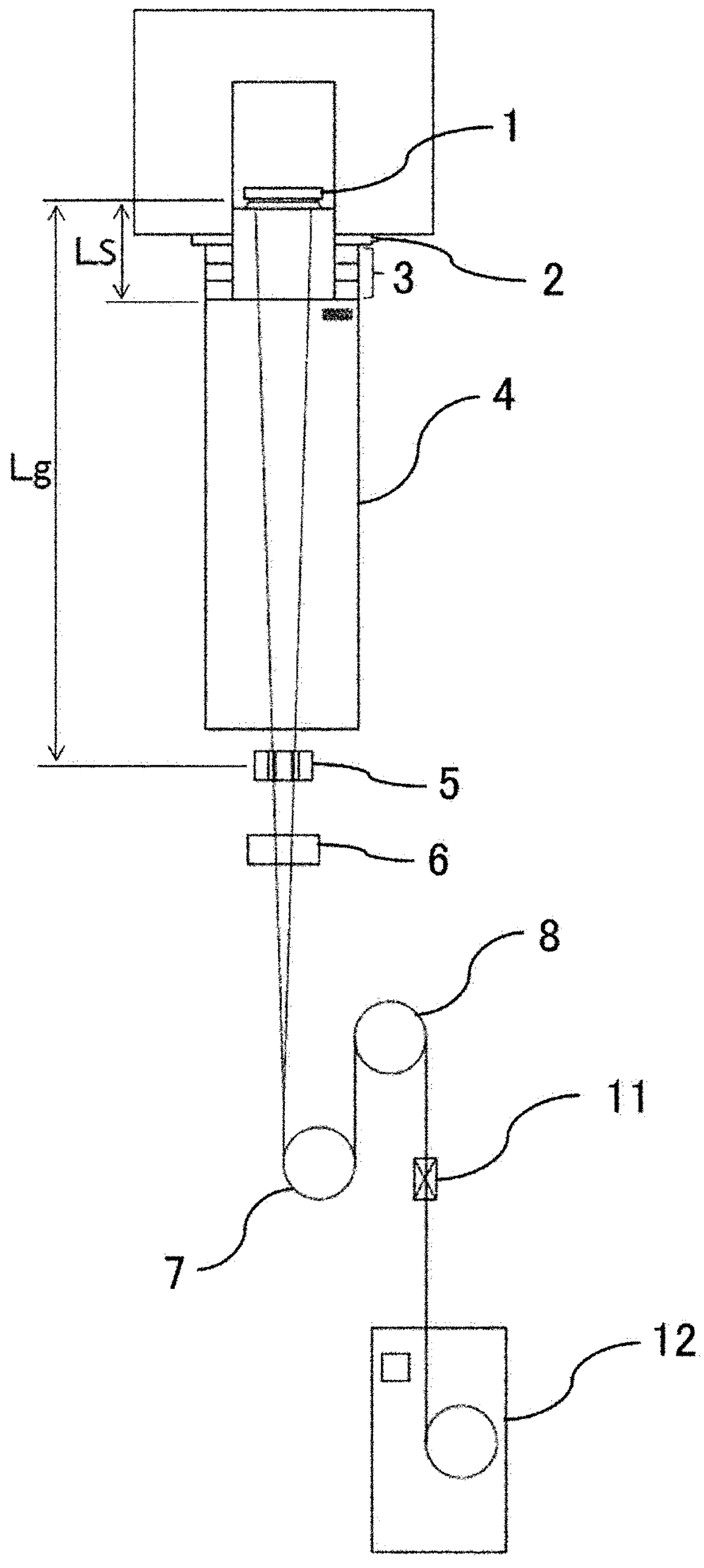


FIG. 3

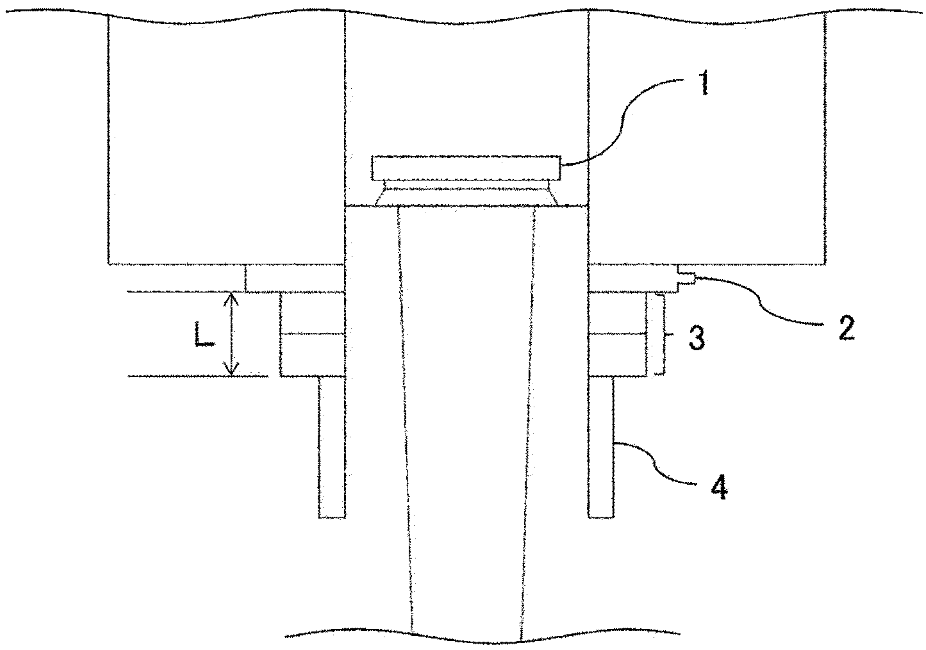
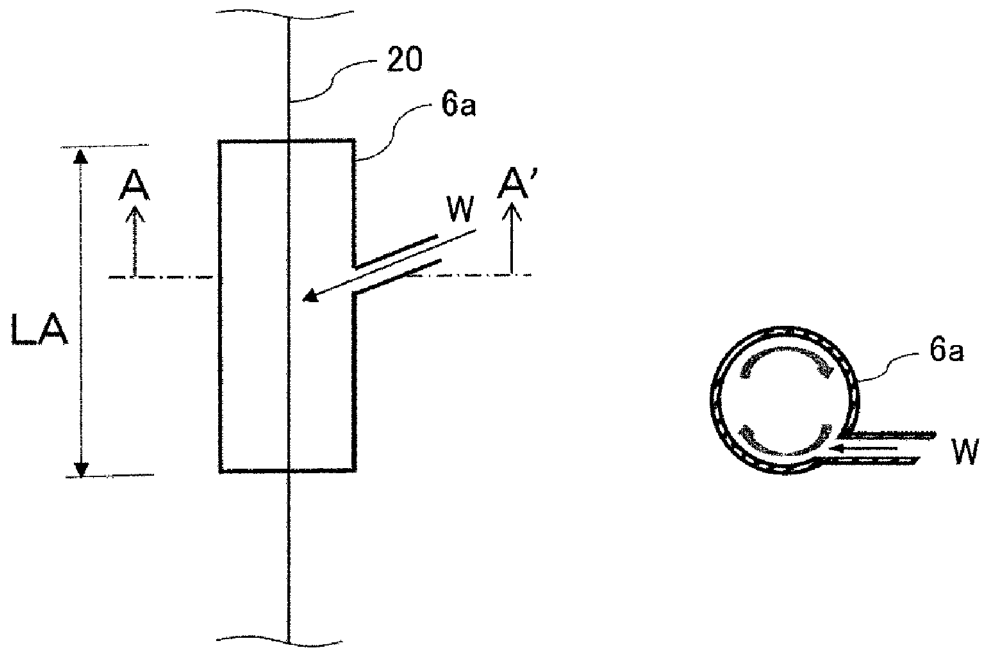


FIG. 4



(a) (b)

FIG. 5

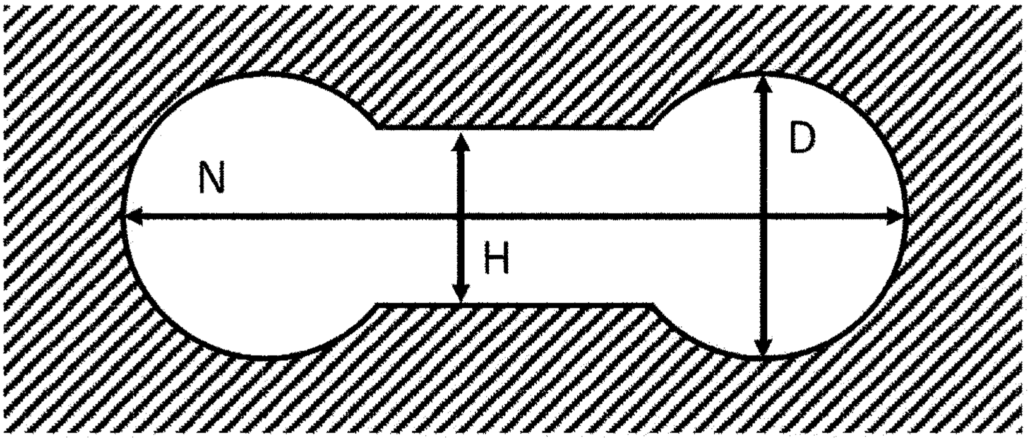
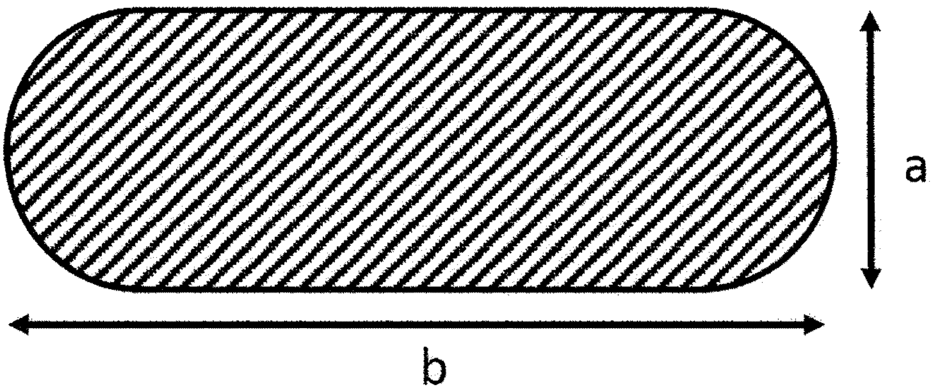


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/045282

A. CLASSIFICATION OF SUBJECT MATTER
D01F 6/60(2006.01)i; D02G 3/32(2006.01)i; D02G 3/38(2006.01)i; A41B 11/14(2006.01)n; D04B 1/24(2006.01)n
FI: D01F6/60 321A; D01F6/60 311C; D02G3/32; D02G3/38; A41B11/14 E; D04B1/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
D01F1/00-6/96 9/00-9/04; D02G1/00-3/48; D02J1/00-13/00; A41B11/00-11/14; D04B1/00-1/28, 21/00-21/20; D01D1/00-13/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 7-157902 A (TORAY INDUSTRIES, INC.) 20.06.1995 (1995-06-20) claims 1, 6	1-3
A	JP 2002-146626 A (ASAHI KASEI CORPORATION) 22.05.2002 (2002-05-22) claims 1, 3, examples	1-3
A	JP 2009-275294 A (SEIREN CO., LTD.) 26.11.2009 (2009-11-26) claim 1, paragraphs [0021], [0023], examples	1-3
A	WO 2018/021011 A1 (TORAY INDUSTRIES, INC.) 01.02.2018 (2018-02-01) claims 1, 6, paragraphs [0038], [0046]-[0055], examples	1-3
P, X	JP 2019-135337 A (TEIJIN LTD.) 15.08.2019 (2019-08-15) claims 1, 3, paragraph [0030], examples 2, 3	1, 2

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 February 2020 (07.02.2020)	18 February 2020 (18.02.2020)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2019/045282

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 7-157902 A	20 Jun. 1995	US 5823014 A claims 1, 5 EP 648873 A1 DE 69415266 C CN 1112406 A	
JP 2002-146626 A	22 May 2002	(Family: none)	
JP 2009-275294 A	26 Nov. 2009	(Family: none)	
WO 2018/021011 A1	01 Feb. 2018	US 2019/0174837 A1 claims 7, 12, paragraphs [0044], [0052]-[0061], examples EP 3492636 A1 CN 109477250 A KR 10-2019-0032373 A	
JP 2019-135337 A	15 Aug. 2019	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009203563 A **[0005]**
- WO 2016076184 A1 **[0005]**
- JP 2018218431 A **[0103]**

Non-patent literature cited in the description

- Encyclopedia of fibers. Maruzen Co., Ltd, 25 March 2002, 439 **[0052]**