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(54) **WOVEN FABRIC FOR SWIMWEAR AND SWIMWEAR USING SAME**

(57) There is provided swimwear which satisfies the stretchability, strength, ease of movement, and the like desired for swimwear, has superior water repellency, and reduces friction resistance between a surface of the swimwear and water. The woven fabric for swimwear according to the present invention has a weave structure in which covering coated threads are arranged in at least a part of a warp or weft yarn, the covering coated threads each including an elastic fiber as a core yarn and a syn-

thetic fiber filament as a sheath yarn, where, in a woven fabric structure, one of the warp yarn and the weft yarn has a larger number of float yarns. A direction with a large number of float yarns is defined as a body length (height) direction of the swimwear, a ratio of resistance yarn in a direction perpendicular to the body length (height) direction is 40% or less. The woven fabric is suitably used for swimwear.

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**Description**

## TECHNICAL FIELD

5 **[0001]** The present invention relates to a woven fabric for swimwear and swimwear using the same.

## BACKGROUND ART

10 **[0002]** In swimming races to compete on the speed of swimming, improvements in swimming skills and physical strength in swimmers are the most important factors in order to break the speed record, and a reduction in resistance of competition swimwear to water is also an important issue. Accordingly, smoothness in surfaces of fabrics for swimwear, improvement in stitching, and the like have been promoted.

15 **[0003]** In order to reduce friction resistance to water, there has been proposed swimwear using the Toms effect in which an aqueous solution of a high-molecular-weight linear organic polymer is applied to a fiber surface of the swimwear, and the polymer melts into water, thereby reducing the friction resistance (Patent Document 1). Certainly, the water friction resistance is reduced, but there is pointed out a problem that the melted polymer contaminates the pool water.

20 **[0004]** In addition, there is also proposed that the resistance to water is reduced by smoothing a woven fabric surface and providing a water-repellent portion and a non-water-repellent portion to make it difficult for water to enter the inside of swimwear and to simultaneously make it easy to discharge water that has entered the swimwear (Patent Document 2). However, the arrangement ratio of the water-repellent portion and the non-water-repellent portion as well as the shape after wearing the swimwear are different from person to person. Therefore, unless production is based on individualized patterns, a sufficient effect may not be exhibited and an opposite effect may be obtained.

25 **[0005]** There has also been proposed woven fabric swimwear including, as warp and weft yarns, coated threads including a core yarn: a spandex fiber and a sheath yarn: a synthetic fiber, in which a surface of the woven fabric is smoothed and subjected to water repellent finishing in order to achieve both motion follow-up property as swimwear and compression function under appropriate stress (Patent Document 3). However, it is difficult to achieve both smoothness and stretchability, and either the smoothness or the stretchability is often sacrificed. When the smoothness by calendaring or the like is improved to prioritize the water friction resistance, the stretch of yarn and the slippage between weaving yarns are deteriorated, resulting in a decrease in the stretchability. A decrease in the stretchability causes a  
30 wearer to become difficult to move, unless the shape of the swimwear is individually adjusted to the body shape of the wearer, and this inhibits the mobility.

35 **[0006]** Further, there is a proposal that water repellent finishing is applied to swimwear, and exhaled breath of a swimmer is blown into the swimwear to form a thin air flow on a surface of a fabric, whereby the water friction resistance is reduced by the air film and bubbles (Patent Document 4), and a new attempt (Patent Document 5) has been made such that recesses are formed on the back surface (skin side) of water-repellent swimwear by a woven fabric structure or embossing, air flows out from the recesses in water, and the surface of the swimwear is covered with air bubbles, resulting in a reduction in water friction resistance.

40 **[0007]** Developments in these techniques for reducing the water friction resistance by the air film and air bubbles have been advanced in ship technology, but have not reached a level at which competition swimwear can be used in an actual race. In the technique described in Patent Document 4, in order to catch the exhaled breath of the swimmer on the surface of the swimwear, it is necessary to adjust the position where air is exhaled in the water, the orientation of the body, and the like, and thus it is not possible to allow the swimmer to accurately perform such adjustment during a competitive race. In the technique described in Patent Document 5, it is necessary to increase the area and volume of the recess in order to store the air, and the thickness of the woven or knitted fabric inevitably increases, as a result of  
45 which the water friction resistance may increase, and the mobility of the body may be inhibited.

## PRIOR ART DOCUMENTS

## PATENT DOCUMENTS

50 **[0008]**

Patent Document 1: Japanese Patent Laid-open Publication No. 1-213403

Patent Document 2: Japanese Patent Laid-open Publication No. 8-311751

55 Patent Document 3: Japanese Patent Laid-open Publication No. 2011-256483

Patent Document 4: Japanese Patent Laid-open Publication No. 8-41708

Patent Document 5: International Publication No. 2012-073648

## SUMMARY OF THE INVENTION

## PROBLEMS TO BE SOLVED BY THE INVENTION

5 **[0009]** In order to solve the above-described problems in the related art, an object of the present invention is to provide a woven fabric for swimwear which satisfies the stretchability, strength, ease of movement, and the like desired for swimwear, and reduces water friction resistance applied to a woven fabric surface of the swimwear in the case of fast swimming such as a swimming race as well as swimwear using the same.

## 10 SOLUTIONS TO THE PROBLEMS

**[0010]** In order to solve the above problems, the present invention has the following configuration.

15 (1) A woven fabric for swimwear that is a stretch woven fabric in which covering coated threads are arranged in at least a part of a warp or weft yarn, the covering coated threads each including an elastic fiber as a core yarn and a synthetic fiber filament as a sheath yarn,

the woven fabric including a weave structure in which one of the warp yarn and the weft yarn has a large number of float yarns on a surface of the woven fabric,  
 20 in which a direction with a large number of float yarns is defined as a body length(height) direction of the swimwear, a ratio of resistance yarn in a direction perpendicular to the body length(height) direction is 40% or less, and the ratio is represented by the following Formula (I):

$$25 \quad R_r = (F/P) \times 100 \quad \dots \quad (I)$$

R<sub>r</sub>: the ratio of resistance yarn (%)

F: the number (pieces) of squares of float yarns in the direction perpendicular to the body length (height) direction of swimwear in one weave repeat

30 P: the number (pieces) of squares of one weave repeat

(2) The woven fabric for swimwear according to (1), in which the woven fabric for swimwear is the stretch woven fabric, a total cover factor represented by the following Formula (II) is 2800 or more, and a cover factor in a direction with a large number of float yarns in either the warp yarn or the weft yarn and a cover factor in a direction with a small number of float yarns in either the warp yarn or the weft yarn on the surface of the woven fabric satisfy the following Formula (III):

$$35 \quad cf = [\sqrt{D_x} \times M_y] + [\sqrt{D_y} \times M_y] \quad \dots \quad (II)$$

40

$$cf_x \geq cf_y \quad \dots \quad (III)$$

cf: total cover factor

45  $cf_x = [\sqrt{D_x} \times M_y]$ : cover factor in the direction with a large number of float yarns

$cf_y = [\sqrt{D_y} \times M_y]$ : cover factor in the direction with a small number of float yarns

D<sub>x</sub>: fineness (dtex) of weaving yarns in the direction with a large number of float yarns

D<sub>y</sub>: fineness (dtex) of weaving yarns in the direction with a small number of float yarns

M<sub>x</sub>: weaving density in the direction with a large number of float yarns (yarns/2.54 cm)

50 M<sub>y</sub>: weaving density in the direction with a small number of float yarns (yarns/2.54 cm)

(3) The woven fabric for swimwear according to (1) or (2), in which the covering coated threads are arranged in the direction with a large number of float yarns in the warp yarn and the weft yarn at least on the surface of the woven fabric.

55 (4) The woven fabric for swimwear according to any one of (1) to (3), in which the synthetic fiber filament is a synthetic fiber filament having a plurality of grooves in a surface in a fiber length direction.

(5) The woven fabric for swimwear according to (4), in which the grooves of the synthetic fiber filament have a depth of 1.0 μm to 10.0 μm, inlets of the grooves have a width of 1.0 μm to 10.0 μm, and protrusions have a width of 10.0 μm or less.

(6) The woven fabric for swimwear according to (4) or (5), in which in a transverse sectional shape of the synthetic fiber filament, a groove portion is a groove having a wide part and satisfying the following Formulae (IV) and (V):

$$(SW_{max}) / (SW_{min}) \geq 1.3 \quad \dots \quad (IV)$$

$$0.15 \leq (SH/D) \leq 0.25 \quad \dots \quad (V)$$

(SW<sub>min</sub>): width of the inlet of groove (μm)  
 (SW<sub>max</sub>): width of the wide part of groove (μm)  
 D: fiber diameter (μm)  
 SH: groove depth (μm)

- (7) The woven fabric for swimwear according to any one of (1) to (6), in which the synthetic fiber filament is a polyamide fiber.  
 (8) The woven fabric for swimwear according to any one of (1) to (7), in which at least a part of the weave structure is a stretch woven fabric of 1/2 weft twill weave.  
 (9) The woven fabric for swimwear according to any one of (1) to (8), in which at least a part of the weave structure is a stretch woven fabric of 5-harness satin weave.  
 (10) The woven fabric for swimwear according to any one of (1) to (9), in which the woven fabric for swimwear is subjected to water repellent finishing.  
 (11) Swimwear including the woven fabric for swimwear according to any one of (1) to (10), in which the direction with a large number of float yarns is a body length (height) direction of the swimwear.  
 (12) The swimwear according to (11), in which the swimwear is a competition swimwear.

#### EFFECTS OF THE INVENTION

**[0011]** According to the present invention, in order to solve the above-described problems in the related art, it is possible to provide swimwear which satisfies the stretchability, strength, ease of movement, and the like desired for swimwear, has superior water repellency, and reduces water friction resistance applied to a surface of the swimwear (friction resistance generated between a woven fabric surface and water).

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0012]**

- Fig. 1 is a diagram showing one weave repeat of 1/2 weft twill weave at the front side.  
 Fig. 2 is a diagram showing one weave repeat of 1/2 weft twill weave at the back side.  
 Fig. 3 is a diagram showing one weave repeat of 2/1 warp twill weave at the front side.  
 Fig. 4 is a diagram showing one weave repeat of plain weave.  
 Fig. 5 is a diagram showing one weave repeat of 5-harness satin weave at the front side.  
 Fig. 6 is an external schematic view illustrating a passing water tank.  
 Fig. 7 is a side view of an apparatus for explaining water friction resistance measurement using a smooth sample plate in the passing water tank.  
 Figs. 8a and 8b are schematic views for explaining a method of sewing a sample to be attached to the smooth sample plate.  
 Fig. 9 is a side sectional view of an apparatus for explaining measurement of a peeling angle of a boundary layer of flowing water using a cylindrical sample mounting stage in the passing water tank.  
 Fig. 10 is a schematic view for explaining a method of sewing a sample to be attached to the cylindrical sample mounting stage.  
 Figs. 11a is a schematic sectional view showing an example of a cross-sectional shape of star-shaped cross-sectional yarn (V-shaped groove) single fiber constituting a synthetic fiber multifilament used for the woven fabric for swimwear of the present invention. Fig. 11b is a schematic sectional view showing an example of a cross-sectional shape of a single fiber which is also a yarn having a circular cross section and has constriction type grooves.  
 Figs. 11c and 11d are enlarged views of the constriction type groove portions in Fig. 11b.  
 Figs. 12a and 12b are photographs showing an example of evaluating the peeling angle of the boundary layer of water, and Fig. 12a is a photograph of a woven fabric which has been set and photographed for measurement of

the peeling angle according to a method of measuring the peeling angle of the boundary layer of flowing water in a cylindrical sample mounting stage (10) described in Examples. However, light in a room is not turned off and the laser beam is not emitted. Fig. 12b is a photograph taken after turning off the light in the room in the same state to make the room dark, and then irradiating the dark room with laser beam (the peeling angle of the boundary layer is measured using this photograph).

## EMBODIMENTS OF THE INVENTION

**[0013]** Hereinafter, the present invention will be described in detail.

**[0014]** The woven fabric for swimwear of the present invention is a woven fabric for swimwear in which covering coated threads including: a sheath yarn (a synthetic fiber filament such as a polyester filament, a polyamide filament, a polypropylene filament or a polyethylene filament); and a core yarn (an elastic fiber such as polyurethane spandex, a polyether-ester elastic fiber or a polybutylene terephthalate fiber or a polytrimethylene terephthalate fiber) are arranged in at least a part of a warp or weft yarn.

**[0015]** Covering coated threads formed by using, particularly, polyurethane spandex among elastic fibers as a core yarn and a synthetic fiber filament as a sheath yarn are superior in elongation rate and elongation recovery rate, and also have the strength required for swimwear, particularly swimwear in the case of fast swimming, which is preferable.

**[0016]** A method of producing covering coated threads using an elastic fiber such as spandex as a core and a synthetic fiber filament as a sheath is not particularly limited. Covering coated threads formed using a covering machine are excellent in coatability of the elastic fiber, and color unevenness and gloss unevenness are less likely to occur when the covering coated threads are formed into a woven fabric, which is preferable.

**[0017]** As a covering method, either a single covering method in which a core yarn is covered by twisting a sheath yarn in one direction or a double covering method in which a core yarn is covered by twisting two sheath yarns in S and Z directions can be used. In the present invention, the single covering method is preferable in view of reducing the weight per area and cost. In covering, an elastic fiber such as spandex is appropriately drafted, but the draft ratio is 3 times or more, more preferably 3.5 times or more, and the upper limit is preferably 4 times or less in order to achieve high stretch performance. Too low a draft ratio makes it impossible to achieve high stretch performance. Conversely, too high a draft ratio results in yarn breakage during the production stage of covering coated threads, and the yield decreases.

**[0018]** In a case in which a 2-way stretch woven fabric using elastic fibers for both warp and weft is used for swimwear, snagging is likely to lead to a problem. Therefore, the twist coefficient of the covering coated threads is preferably set to a range of 4500 to 15000, and more preferably set to a range of 7500 to 12000.

**[0019]** The twist coefficient is calculated by the following formula:

$$\text{Twist coefficient} = (\text{SS} \div \text{D} + \text{SC})^{1/2} \times \text{R}$$

SS: fineness of spandex (dtex)

SC: fineness of sheath yarn (dtex)

D: draft ratio of spandex (times)

R: covering number (T/m)

**[0020]** Preferably, the elastic fiber in the core yarn has a fineness of 33 dtex or more. As long as only the motion follow-up property is desired, it is sufficient that the fiber is stretched by a small force and has superior recovery property. Thus, there is no problem in a case where the fineness is 22 dtex or less from the viewpoint of lightweight. In the case of swimwear in which the wearing compression applied when the swimwear is put on and the prevention of looseness are required, the fineness is preferably 33 dtex or more and 156 dtex or less. Too high a fineness results in too high a weight per area.

**[0021]** Preferable examples of commercially available spandex suitable for swimwear, particularly for swimwear in the case of fast swimming such as swimming race include "ROICA SP" from Asahi Kasei Corporation and "LYCRA-176B" and "LYCRA-254B" from TORAY OPELONTEX CO., LTD., which are superior in chlorine resistance.

**[0022]** As the synthetic fiber filament used for the sheath yarn, a filament obtained by melt spinning, such as a polyester filament, a polyamide filament, a polypropylene filament, or a polyethylene filament may be used.

**[0023]** The fineness is preferably as low as possible from the viewpoint of obtaining lightness. However, when the fineness is too low, the strength is too low and a problem of transparency occurs, so the fineness is preferably 11 dtex or more and more preferably 16 dtex or more. Meanwhile, when the thickness is too large, the weight per area is increased, and thus the fineness is preferably 156 dtex or less, and more preferably 110 dtex or less. Furthermore, the synthetic fiber filament preferably has a single yarn fineness of 2 dtex to 6 dtex from the viewpoint of productivity. The single yarn fineness is more preferably in a range of 3 dtex to 5 dtex. A fineness of lower than 2 dtex results in an

excessively precise and complicated cross-sectional shape, and the production stability tends to be poor. A fineness of higher than 6 dtex results in a rough and hard texture.

**[0024]** As the cross-sectional shape of the synthetic fiber filament, any shape such as a circle, a triangle, a square, an ellipse, and a hollow may be used according to the purpose. In addition, a matting agent such as titanium oxide may be arbitrarily added to the synthetic fiber filament for use. Since the yarn is used for swimwear, a semi-dull yarn or a full-dull yarn, having little transparency, is preferably used. Furthermore, any yarn processing, such as false twisting with a single stage heater or brillia processing with a two-stage heater can be performed. From the viewpoint of imparting stretchability, the yarn is preferably used as a false-twisted yarn.

**[0025]** In the use in swimwear in which the mixing ratio of elastic fibers is as high as 15% or more, there is concern about elastic fibers such as spandex made of polyurethane that the sublimation of a disperse dye is problematic or the dye fastness decreases due to contamination. Therefore, as the sheath yarn, a polyamide filament using an acidic dye can be preferably used rather than a polyester filament mainly dyed with a disperse dye. There is a problem that the polypropylene filament and the polyethylene filament cannot be dyed. Basically, it is inconvenient to use a spun-dyed yarn. The problem of dye fastness can also be improved by using a cationic dye-dyeable polyester.

**[0026]** Furthermore, in the present invention, the woven fabric structure is important. As for the woven fabric structure, it is necessary to form a weave structure in which one of the warp yarn and the weft yarn has a larger number of float yarns, and it is necessary to allow the ratio of resistance yarn in the direction perpendicular to the direction with a large number of float yarns (ratio of resistance yarn) to be at least 40% or less, more preferably 35% or less. The ratio of resistance yarn is expressed by the following formula:

$$Rr = (F/P) \times 100$$

Rr: the ratio of resistance yarn (%)

F: the number (pieces) of squares of float yarns in the direction perpendicular to the body length (height) direction of swimwear in one weave repeat

P: the number (pieces) of squares of one weave repeat

**[0027]** Considering the friction resistance force between the surface of the swimwear and water during a swimming race, among weaving yarns of a woven fabric used for swimwear, the weaving yarns in the body length direction parallel to the direction of forward swimming have a small water friction resistance force, but the water friction resistance force increases as the ratio of resistance yarn arranged in the direction perpendicular to the forward direction increases.

**[0028]** In the case of plain weave used in known competition swimwear, the ratio of resistance yarn is 50%, and one-half of the total yarns includes the yarns arranged parallel to the direction of forward swimming and the other half includes the yarns arranged in the direction perpendicular to the forward direction. When the ratio of resistance yarn is higher than 50% due to the weave structure, the water friction resistance force between the woven fabric surface and water increases, which affects the speed during a swimming race and results in a poor record. As long as the warp yarn and the weft yarn can be interlaced to maintain the form of the woven fabric, the ratio of resistance yarn is preferably as small as possible. Meanwhile, too small a ratio of resistance yarn results in a decrease in the number of interlacing points between the warp yarn and the weft yarn, and thus the weaving yarns are twisted. Furthermore, the crimping rate of the weaving yarns becomes unstable, and conversely, the water friction resistance force may increase, so the ratio of resistance yarn is preferably in a range of 40 to 10%, and more preferably in a range of 35 to 15%.

**[0029]** In covering threads obtained using the covering machine, a synthetic fiber filament as a sheath yarn is wound around a core yarn with an oblique twisting angle with respect to the direction of weaving yarn due to the influence of the number of twists of twisted yarn. Thus, when the sheath yarn alone is viewed, the sheath yarn is not exactly parallel to the forward direction due to the influence of the twisting angle. As long as the sheath yarn as the covering thread for the entire weaving yarn is used so as to be parallel to the forward direction, the water friction resistance decreases.

**[0030]** A method of calculating the ratio of resistance yarn will be described in more detail with reference to the diagram showing one weave repeat of 1/2 weft twill weave in Fig. 1. The term "one weave repeat" means the smallest unit of the structure as the base of the woven fabric, and this structure is repeatedly woven from front to back and from side to side. A weave pattern in which a warp yarn lies above a weft yarn (the warp yarn floats) is painted black. A weave pattern in which a warp yarn lies below a weft yarn (the weft yarn floats) is represented in white. The structure of 1/2 weft twill weave in Fig. 1 is one weave repeat with 9 squares of 3 warp yarns and 3 weft yarns. The number of squares of one weave repeat is 9, and the direction with a large number of float yarns is the weft direction. Therefore, assuming that the weft direction is the body length (height) direction of the swimwear, the number of squares of the resistance yarn perpendicular to the weft direction is 3 (black warp yarns). Consequently, the ratio of resistance yarn (Rr) is 33.3% as in the following formula. This calculation result can be used as an indicator of water friction resistance. Since the ratio of resistance yarn is lower than 40%, this structure can reduce the water friction resistance when the weft direction with

a large number of float yarns is used as the body length direction of swimwear.

F: the number (pieces) of squares of float yarns in the direction perpendicular to the body length (height) direction of swimwear in one weave repeat: 3 (pieces)

P: the number (pieces) of squares of one weave repeat: 9 (pieces)

$$R_r = (F/P) \times 100 = (3/9) \times 100 = 33.3\%$$

**[0031]** When the front and back of the woven fabric having the structure of Fig. 1 are changed and the back side is used as the surface of the swimwear, the twill weave line is oriented from lower right to upper left as shown in Fig. 2 in the weave structure diagram, and the structure is one weave repeat with 9 squares of 3 warp yarns and 3 weft yarns as described above. However, when the weft direction is used for the surface in the body length (height) direction of the swimwear, the number of black squares of the resistance yarn perpendicular to the body length (height) direction is 6. Therefore, the ratio of resistance yarn is 66.6%. The proportion of yarns parallel to the direction of forward swimming decreases, the proportion of yarns perpendicular to the forward direction increases, resulting in an increase in the water friction resistance. In this case, the warp direction of the woven fabric is used for the surface in the body length (height) direction of the swimwear instead of using the weft direction for the surface in the body length (height) direction of the swimwear, whereby the ratio of resistance yarn becomes the same as that in Fig. 1. In the case of twill weave (diagonal weave) or satin weave, the ratio of resistance yarn is reversed depending on the use of the front side or the back side of the woven fabric, and thus care needs to be taken when sewing the swimwear. In the case of using the back side of the weft twill woven fabric as the surface of the swimwear, the warp direction of the woven fabric is used as the body length (height) direction of the swimwear, whereby the ratio of resistance yarn becomes 33.3% and the friction resistance force decreases. When the woven fabric is cut into sewn parts, the warp direction and the weft direction are reversed, and the warp direction is used as the body length (height) direction of the swimwear, so that the woven fabric can be used as a woven fabric with low friction resistance.

**[0032]** In the case of 2/1 warp twill weave in Fig. 3, the ratio of resistance yarn is 33.3% when the warp direction with a large number of float yarns is the body length (height) direction of the swimwear. However, when the weft direction is the body length (height) direction of the swimwear, the ratio of resistance yarn is 66.6%. Therefore, when the warp direction is the body length (height) direction of the swimwear, the water friction resistance can be reduced.

**[0033]** In the case of diagonal weave or satin weave, it is important to determine whether to use the front side or the back side, and which of the warp direction and the weft direction is used as the body length (height) direction of the swimwear.

**[0034]** The weft twill weave is a name of a woven fabric in which many weft yarns appear on a surface, and the warp twill weave is a name of a woven fabric in which many warp yarns appear on a surface, and each of the names is also another name of diagonal weave.

**[0035]** Similarly, in the satin woven fabric, floating and sinking of the warp yarn and the weft yarn are reversed depending on the front and back. In the present invention, it is important to provide a woven fabric for swimwear in which the ratio of resistance yarn in the direction perpendicular to the direction with a large number of float yarns is 40% or less, and the direction with a large number of float yarns is used as the body length (height) direction of the swimwear. In order to satisfy this requirement, the front, back, warp, and weft of the woven fabric are selected so that the cut-out performance of the parts at the time of sewing becomes advantageous and production is conducted, which allows for a reduction in production cost.

**[0036]** Fig. 4 is a diagram showing one weave repeat of plain weave. The total number of squares of one weave repeat is 4, and the number of squares of resistance yarn perpendicular to the direction with a large number of float yarns is 2. In the case of plain weave, the ratio of resistance yarn is 50% in any direction of front direction, back direction, warp direction, and weft direction, and the water friction resistance is large.

**[0037]** Fig. 5 is a diagram showing one weave repeat of 5-harness satin weave. In this case, the warp direction is used as a water flow direction, i.e., body length (height) direction, the ratio of resistance yarn is 20%, and the water friction resistance can be reduced.

**[0038]** In the present invention, the weave structure is not limited to twill weave (diagonal weave) and satin weave, and any structure such as dice weave and derivative weave can be used as long as the ratio of resistance yarn is 40% or less. From the viewpoint of patterns and designs, in a dobby woven fabric or a jacquard woven fabric in which a plain weave portion, a twill weave (diagonal weave) portion, and a satin weave portion are combined, the ratio of resistance yarn in the direction perpendicular to the direction with a large number of float yarns in one weave repeat is set to 40% or less, and the direction with a large number of float yarns is used as the body length (height) direction of the swimwear, so that it is possible to reduce the friction resistance force between the woven fabric surface and water.

**[0039]** Furthermore, the total area of the woven fabric parts used in the area of a piece of swimwear is calculated so

that the ratio of resistance yarn is 40% or less, and thus the water friction resistance can be maintained low, and the object of the present invention can be satisfied.

**[0040]** In the present invention, the total cover factor represented by the following formula is preferably 2800 or more. When the total cover factor decreases, the number of interlacing points decreases, the restraint of the weaving yarn decreases, and problems such as seam twisting and snagging occur. Therefore, the cover factor is more preferably 3000 or more. Still more preferably, the cover factor is 3200 or more.

$$cf = [\sqrt{Dx} \times My] + [\sqrt{Dy} \times My] \dots \quad (II)$$

$$cfx \geq cfy \dots \quad (III)$$

cf: total cover factor

cfx =  $[\sqrt{Dx} \times My]$ : cover factor in the direction with a large number of float yarns

cfy =  $[\sqrt{Dy} \times My]$ : cover factor in the direction with a small number of float yarns

Dx: fineness of yarn in the direction with a large number of float yarns: fineness (dtex) of covering thread having spandex as the core yarn and the synthetic fiber filament as the sheath yarn

Dy: fineness of yarn in the direction with a small number of float yarns: fineness (dtex) of covering thread having spandex as the core yarn and the synthetic fiber filament as the sheath yarn

Mx: weaving density in the direction with a large number of float yarns (counts/2.54 cm)

My: weaving density in the direction with a small number of float yarns (counts/2.54 cm)

**[0041]** From the viewpoint of further reducing the friction resistance between the woven fabric surface and water, it is preferable to allow the cover factor in the direction with a large number of float yarns in either the warp yarn or the weft yarn to be larger than the cover factor in the direction with a small number of float yarns in either the warp yarn or the weft yarn, on the surface of the woven fabric, and it is preferable to satisfy Formula (III).

**[0042]** Here, the direction with a large number of float yarns is a direction where the number of floats of yarns on the woven fabric surface is large in a diagram showing one weave repeat structure. Therefore, the direction becomes the warp direction or the weft direction depending on the weave structure and the front and back of the woven fabric. Particularly, at the time of sewing, it is necessary to pay sufficient attention to the point that the direction with a large number of float yarns is used for the surface in the body length (height) direction of the swimwear.

**[0043]** The cover factor in the body length (height) direction is made larger than the cover factor in the body width direction perpendicular to the body length (height) direction, whereby the water friction resistance is further reduced together with the effect of reducing the ratio of resistance yarn to 40% or less as described above.

**[0044]** More preferably, the ratio obtained by dividing the cover factor in the direction with a large number of float yarns by the total cover factor is set to 55% or more, whereby the water friction resistance is further reduced. More preferably, the ratio is set to 60% or more. However, when the ratio is set to too large a value, the warp/weft balance of the woven fabric is deteriorated, seam twisting and seam dislocation are likely to occur, and the warp/weft balance of the stretch power in the swimwear is deteriorated.

**[0045]** The fineness of the warp yarn and the fineness of the weft yarn expressed by the mathematical formula described above indicate the total fineness after yarns obtained by combining a core yarn and a sheath yarn are formed into a woven fabric and dyed. In the case of using single yarns without using the covering coated threads, the fineness is obtained after forming single yarns into a woven fabric and dyeing them. In the case of using paralleled yarns or doubling and twisting yarns, the fineness is obtained after forming paralleled yarns or doubling and twisting yarns into a woven fabric and dyeing them. Hence, the fineness is an apparent fineness resulted from the measurement of fibers obtained by unweaving a woven fabric as a final product by a method described in Examples.

**[0046]** The weaving density is the weaving density of yarns after forming the yarns into a woven fabric and dyeing them in a similar manner as described above.

**[0047]** In addition, in a case where the density is partially changed to a coarse portion and a dense portion in a structure such as ripstop, it is possible to achieve low water resistance, which is the object of the present invention, by setting the density of the coarse portion or the dense portion occupying 50% or more of the area of one weave repeat portion to the above-described range.

**[0048]** When two or more kinds of covering coated threads are arranged as weaving yarns for use, the total cover factor and the cover factor may be determined using the fineness and density calculated by simply averaging the number and fineness of fibers arranged in one weave repeat portion.

**[0049]** Even in a case where the structure is partially changed, such as a dobby woven fabric or a jacquard woven fabric, when the total cover factor of one weave repeat that is repeated is 2800 or more, the cover factor in the body

length (height) direction is made larger than the cover factor in the body width direction that is the direction perpendicular to the body length (height) direction, the ratio of resistance yarn in the direction perpendicular to the direction with a large number of float yarns is 40% or less, it is possible to reduce the friction resistance between the woven fabric surface and water.

**[0050]** The weight per area of the woven fabric for swimwear of the present invention is preferably as small as possible. From the viewpoint of transparency and strength, the weight per area is preferably 50 g/m<sup>2</sup> or more, and more preferably 70 g/m<sup>2</sup> or more. Since the water resistance increases when the weight per area is large, the weight per area is preferably 200 g/m<sup>2</sup> or less.

**[0051]** The thickness of the woven fabric for swimwear of the present invention is preferably as small as possible, and is preferably 0.15 mm or more, and more preferably 0.2 mm or more from the viewpoint of transparency and strength. In addition, the thickness is preferably 0.7 mm or less because an increase in the thickness results in an increase in water resistance. The woven fabric for swimwear of the present invention is preferably subjected to water repellent finishing. The water repellent used in water repellent finishing may be any one of fluorine-based, silicone-based, paraffin-based water repellents. Among them, a fluorine-based water repellent is preferable from the viewpoint of water repellent performance. Particularly, a fluorine-based water repellent having 8 or more carbon atoms (so-called C8 water repellent) is preferable in terms of performance. More preferred is a PFOA-free fluorine-based water repellent having 6 carbon atoms (C6 water repellent) in which there is no possibility of generating perfluorooctanoic acid (PFOA). Furthermore, in view of the market demand for free fluorine, it is more preferable to use a silicone-based water repellent or a paraffin-based water repellent singly or in combination with a C0 water repellent.

**[0052]** In order to improve the durability of the water-repellent performance, the water repellent is preferably used in combination with a cross-linker. As the cross-linker, at least one of a melamine-based resin, a blocked isocyanate-based compound, a glyoxal-based resin, and an imine-based resin can be used, and the cross-linker is not particularly limited.

**[0053]** Furthermore, in the present invention, the friction resistance between the surface of the woven fabric and water can be further reduced by using covering coated threads formed by using, as a sheath yarn, a synthetic fiber filament having a plurality of grooves in the surface in the length direction of the fiber and using, as a core yarn, an elastic fiber. The cross-sectional shape and the number of grooves of the synthetic fiber filament having a plurality of grooves can be arbitrarily set, and the number of grooves in a circular cross section is preferably 6 to 15, and more preferably 6 to 10, from the viewpoint of cost and production stability.

**[0054]** Figs. 11a and 11b are each a schematic sectional view showing an example of a cross-sectional shape of single fiber constituting a synthetic fiber multifilament used for the woven fabric for swimwear of the present invention. Fig. 11a is a so-called octa-foliate star-shaped cross section, and has void portions 13 of V-shaped grooves formed by protrusions of 8 leaves and recesses adjacent to the protrusions in a polymer portion 14.

**[0055]** In addition, Fig. 11b shows a circular cross section having constriction type grooves to be described later, and the cross section has the polymer portion 14 and the void portions 13 of constriction type grooves, similarly to the star-shaped cross section.

**[0056]** Furthermore, the above-described synthetic fiber filament having a plurality of grooves in the surface in the length direction of the fiber can be easily produced by eluting an easy-to-elute component using a fiber produced by core-sheath composite spinning using a two-component polymer to be described later to form slit-shaped grooves. This method is desirable because a precise cross-sectional shape can be produced. The yarn may be produced as a yarn with a modified cross-section using a spinneret for a modified cross-section of one component melt spinning.

**[0057]** The depth of the groove in the transverse section of the above synthetic fiber filament is preferably 1.0 μm to 10.0 μm. When the depth is shallower than 1.0 μm, the effect of improving water repellency by the lotus effect is less likely to be exhibited, whereas when the depth is deeper than 10.0 μm, the strength of the fiber is reduced. When a center point 12 of the transverse section in the direction perpendicular to the longitudinal direction of the synthetic fiber filament is connected to a perpendicular line 16 from the straight line 15 connecting the ends of protrusions present across a groove, a groove depth (star-shaped cross section) 17 of the star-shaped cross-sectional yarn is defined as a void portion depth from an intersection between the straight line 15 connecting the ends of the protrusions on the perpendicular line 16 and the perpendicular line 16 to the polymer portion 14 of the fiber. The center point is defined as a center point of a circle circumscribed most frequently at two or more points at the tip of the protrusion in the transverse section that is the fiber polymer cross section.

**[0058]** The width of the groove is preferably 1.0 μm to 10.0 μm. When the width is narrower than 1.0 μm, the lotus effect is less likely to be exhibited, whereas when the width is wider than 10.0 μm, water easily enters the grooves. The width of the groove is defined as the length of a straight line 15 connecting the ends of adjacent protrusions observed when observing the transverse section that is the fiber polymer cross section, in a direction perpendicular to the longitudinal direction of the fiber of the synthetic fiber filament.

**[0059]** In addition, the width of a protrusion formed between two adjacent grooves is defined by a length 25 of a straight line connecting a protrusion 24, which is an end of a protrusion at the side of a groove A in the case of the circular cross section with constriction type grooves in Fig. 11d, and a protrusion which is an end of a protrusion at the side of a groove

adjacent to the groove A across the protrusion in the protrusion formed between two adjacent grooves. In the octa-foliate star-shaped cross section in Fig. 11a, protrusions that are both the ends of protrusions are close to or overlap with each other, and as a result, the width of the protrusion is close to 0. From the viewpoint of water friction resistance, the width of the protrusion is preferably as close as possible to 0, and it is desirable that the protrusion has a vertex shape.

**[0060]** The grooves in the fiber surface result in formation of irregularities on the fiber surface, high water-repellent performance is exhibited due to the lotus effect to be described later, the grooves are filled with air in water, and the individual wall of the fiber surface does not come into contact with the water due to the air film. Consequently, the friction resistance between the water and the fiber is eliminated. Only a part of the individual wall of the protrusion on the fiber surface comes into contact with water. The water friction resistance is reduced by making the protrusion exposed to water as small as possible. However, when the protrusion has an acute angle, the fiber surface is fibrillated by friction between the fiber surface and each of various individual surfaces at the time of wearing, and single yarn cracking tends to occur. The width of the protrusion is preferably 1.0 μm or more, and preferably 10.0 μm or less because a problem that cracks are generated and the fiber surface is whitened easily occurs. When the width of the protrusion is wider than 10.0 μm, the lotus effect to be described later is hardly exhibited, and high water repellency cannot be maintained. In a product in consideration of wearing durability, it is preferable to widen the width of the protrusion and improve the resistance to abrasion. Furthermore, the width of the protrusion can be arbitrarily set according to the purpose, for example, in a case where the speed record is prioritized, rather than the wearing durability during a swimming race, the width of the protrusion is reduced.

**[0061]** In the present invention, as the synthetic fiber filament having a plurality of grooves in the fiber surface, a synthetic fiber filament having constriction type grooves is preferably used in order to make it difficult for water to enter the grooves and to prevent fibrillation due to abrasion. Preferable examples of the constriction type grooves include a groove having a wide part on the outer circumference of a single fiber when the transverse section in a direction perpendicular to the length direction of the fiber is observed, and a plurality of such grooves.

**[0062]** Specifically, a synthetic fiber filament in which the width of an inlet of the groove portion (SWmin), the width of a wide part of groove (SWmax), and the groove depth (SH) with respect to the fiber diameter (D) satisfy the following formula can be suitably used.

**[0063]** The constriction type referred to herein is a form in which the width of the void in the groove is wider than the width of the inlet of groove in the fiber surface in the transverse section of the fiber (an example is shown in Fig. 11b).

$$(SW_{\max}) / (SW_{\min}) \geq 1.3$$

$$0.15 \leq (SH/D) \leq 0.25$$

**[0064]** In the above, the width of the inlet of groove (SWmin), the width of the wide part of groove (SWmax), the fiber diameter (D), and the groove depth (SH) are obtained as follows.

**[0065]** Specifically, the width of the inlet of groove (SWmin) is defined as the length of the straight line 15 connecting the ends of adjacent protrusions observed when observing the transverse section that is the fiber polymer cross section, in a direction perpendicular to the fiber direction of the synthetic fiber filament, similarly to the width of the inlet of the V-shaped groove of the star-shaped cross-sectional yarn shown in Fig. 11a as described above. Therefore, in the case of the constriction type groove, the length is a length connecting the ends of the protrusions of the adjacent protrusions. Further, a width of wide part of groove 18 (SWmax) is the maximum section when the length orthogonal to the center line of the groove is measured toward the center of the fiber from the outer circumference along a center line 19. The diameter of a circumscribed circle 22 of the protrusion is defined as a fiber diameter (D) 20. A groove depth 21 (SH) of the yarn having constriction type grooves and having a circular cross section means a distance between intersections of the circumscribed circle 22 of the protrusion and an inscribed circle 23 of the groove portion at the center line of the groove. The circumscribed circle 22 referred to herein is a perfect circle circumscribed most frequently at two or more points at the tip of the protrusion in the cross section of the core-sheath composite fiber, and the inscribed circle 23 is a perfect circle inscribed most frequently at two or more points at the tip (bottom) of the groove portion.

**[0066]** As the circular cross section having constriction type grooves in the present invention, a preferably used one is a synthetic fiber filament in which the width of the void in the groove satisfies the following formula. In other words, it is possible to use a synthetic fiber filament in which the ends of the protrusion that form the inlet of groove portion have an acute angle, and the width between the adjacent protrusions (Pout), the width of the inlet of groove (SWmin), the width between the adjacent protrusions (Pout), and the width between the bottom surfaces of the adjacent grooves (Pmin) satisfy the following formula. The width between the protrusions (Pout) refers to a distance obtained by connecting a tip of one protrusion 24 of a certain groove and a tip of a protrusion closer to the protrusion 24 among protrusions of grooves adjacent thereto with a straight line, and is indicated by a width 25 of the protrusion in Fig. 11d. In addition, a

width 26 of the bottom surface of each of the adjacent grooves (Pmin) means a distance between points corresponding to contact points with the inscribed circle 23 of each of the adjacent groove portions with the protrusion interposed therebetween.

$$(P_{out}) / (SW_{min}) = 2 \text{ to } 10$$

$$(P_{out}) / (P_{min}) \geq 1.3$$

**[0067]** The synthetic fiber filament having these grooves is obtained by eluting the sheath component of the fiber produced by core-sheath composite spinning as described above using a solvent. As the core component, polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, polyamide, or the like can be used. From the viewpoint of simplifying the step of eluting the sheath component, the sheath component is preferably a copolymerized polyester, polylactic acid, polyvinyl alcohol, or the like that is soluble in an aqueous solvent, hot water, or the like. Particularly, it is preferable to use a polyester copolymerized singly or in combination with polyethylene glycol or sodium sulfoisophthalic acid, or polylactic acid, from the viewpoint of handleability and easy dissolution in an aqueous solvent.

**[0068]** In particular, when false twisting is performed, false twisting is performed on the core-sheath composite fiber containing the eluted component, and the eluted component is eluted in the dyeing step after weaving. Thus, even in the case of textured yarn, a slit portion of a groove can be maintained without crushing the groove during false twisting. A slit yarn can be obtained by normal spinning without using a composite spinning machine, but groove is often crushed during false twisting. In the core-sheath composite fiber in which the groove is filled with the eluted component even during false twisting, the groove is prevented from being crushed, and the shape of the groove is maintained by eluting the eluted component in the dyeing step after weaving.

**[0069]** In a preferred elution method and a preferred dyeing method, a gray fabric is scoured, relaxed, and dried, and then the width is thermally fixed in the intermediate setting step, and then the component in the groove is eluted. Thereafter, the fabric is dyed, and is subjected to reduction cleaning if the fabric is a polyester material, and is subjected to a fixing treatment if the fabric is a nylon material, washed with hot water and water, and dried. Then, a finishing set step is performed by subjecting the fabric to water repellent treatment or various functional processes as necessary.

**[0070]** In the woven fabric of the present invention, since elastic fibers such as polyurethane spandex are integrated with the core yarn, it is preferable to use polyamide that can be dyed with an acid dye having few problems in the dyeing step.

**[0071]** When the synthetic fiber filament used for covering coated threads is a core-sheath composite fiber, the dyeing step after weaving the gray fabric can be performed by an ordinary method in consideration of the elution of the sheath component and the use of elastic fibers such as spandex. For example, in scouring and relaxation, the conditions of temperature and width are adjusted in about three stages while the spread state is maintained in order to prevent embossment. Then, the width is fixed with a tenter, and the sheath polymer of the core-sheath composite fiber is removed with a caustic soda solution or the like to produce a groove of the synthetic fiber. After that, the fabric is dried after dyeing and fixing treatment, subjected to water repellent finishing, and subjected to finishing set step to obtain a woven fabric for swimwear.

**[0072]** On the surface of the woven fabric, irregularities of the surface of the woven fabric due to the woven fabric structure and irregularities between single yarns of the filament yarn are provided, in addition to this, a slit-shaped groove or the like is provided on the surface of the fiber, whereby more complicated irregularities are exhibited. As for the droplet contact angle of water on the surface of the woven fabric, as described in the following Wenzel formula, when the contact angle of the fiber surface is 90° or more, the apparent droplet contact angle of a material having larger surface irregularities becomes larger, and water is easily repelled. This effect is referred to as "lotus effect".

"Wenzel Formula"

$$r \times \cos\theta = \cos\theta'$$

r: true surface area/apparent surface area

θ: true droplet contact angle

θ': apparent droplet contact angle

**[0073]** However, the woven fabric when worn as the swimwear is stretched in the warp direction and the weft direction, and the structure of the woven fabric and the irregularities between single yarns of the filament yarn are flattened without

limitation, as a result of which the lotus effect is reduced without limitation, and water is hardly repelled as compared with before wearing. Particularly, in recent years, in order to improve the smoothness of the surface of the woven or knitted fabric used as the competition swimwear, swimmers tend to purposely wear the swimwear having a size which is one size smaller than the actual size in a swimming race in which the speed of swimming is necessary, and thus there is a phenomenon in which the surface irregularities of the woven or knitted fabric reduce and the apparent water repellency decreases.

**[0074]** However, a plurality of grooves is provided in the fiber surface, as a result of which a decrease in water repellency can be suppressed even when the woven fabric is stretched. Although the woven fabric structure and the textured yarn structure are stretched and flattened even when the crimps of the woven fabric or the crimps due to yarn processing are stretched during wearing, the plurality of grooves themselves provided on the fiber surface are not stretched and flattened. Accordingly, the lotus effect can be maintained and the water repellency can be maintained high.

**[0075]** Particularly, in a preferred embodiment of the present invention, as the synthetic fiber filament of the sheath yarn, a fiber having a plurality of grooves in the surface in the length direction of the fiber is used for at least a part of a warp yarn and at least a part of a weft yarn. It is preferable to use this fiber so as to be arranged on the woven fabric surface, and is particularly preferable to use the fiber in a direction in which the warp yarn or the weft yarn has a larger number of float yarns. In other words, the fiber is used in the body length (height) direction of the woven fabric used for the swimwear, and as a result, the grooves on the fiber surface are arranged parallel to the forward direction of swimming, i.e., the water flow direction. Thus, it is possible to increase the effect of reducing the friction resistance force between the woven fabric surface of the swimwear and water.

**[0076]** Grooves are formed in the length direction of the fiber described above, and when the fiber subjected to water repellent finishing is in water, the insides of the grooves are filled with air, and thus an air film is formed.

**[0077]** Thus, as for the flow of water on the fiber surface of the swimwear, the water is in the form as if the water floating in the air slips on the air film of the groove portion, the friction resistance is smaller than the friction resistance force of the peripheral fiber surface portion with no groove, and the flow is faster than the water layer on the fiber surface with no groove. As a result, the low-speed water on the fiber surface portion is caught in the flow of water on the upper portion of the air film in the groove portion. This is considered to be a phenomenon in which water flowing on the fiber surface with no groove portion flows over the air film in the groove and collides and repeats dispersion.

**[0078]** Repeating of the collision and dispersion as described above promotes turbulent flow, and peeling of the boundary layer of water on the surface of the swimwear is suppressed as in the dimple effect caused in the golf ball dent, and the shape (pressure) resistance force is also reduced.

**[0079]** The peeling angle of the boundary layer of water showing this phenomenon can be measured by providing a cylindrical sample stage in the passing water tank shown in Examples and attaching a tubular woven fabric sample to the sample stage. Fig. 6 is an external schematic view illustrating the concept of the passing water tank. The passing water tank includes two water tanks positioned at the top and bottom and two pipes for circulating water in the water tank. Arrows in Fig. 6 indicate water flow directions. Several grams of nylon fine particles are mixed as tracer fine particles in a passing water tank, and a photograph of a peeling angle of a water boundary layer from a cylindrical sample is taken by irradiation with laser beam in a dark room state, and a comparative evaluation is conducted (an example is shown in Fig. 12b). Figs. 12a and 12b are photographs showing an example of evaluating the peeling angle of the boundary layer of water, and Fig. 12a is a photograph of a woven fabric which has been set and photographed for measurement of the peeling angle according to a method of "measuring the peeling angle of the boundary layer of flowing water in a cylindrical sample mounting stage (10)" described in Examples. However, light in a room is not turned off and the laser beam is not emitted. Fig. 12b is a photograph taken after turning off the light in the room in the same state to make the room dark, and then irradiating the dark room with laser beam (the peeling angle of the boundary layer is measured using this photograph). Figs. 12a and 12b each show a surface 27 as seen from the upper portion of the cylindrical sample mounting stage. The peeling angle of the water boundary layer is measured as a peeling angle 28 of the water boundary layer, where the peeling angle is an angle formed by a line parallel to the flow passing through the center point of the circle and a line connecting the center point with the flow peeling point, as seen from the top of the cylindrical sample mounting stage placed in the water flow flowing from right to left, which is the direction indicated by the arrow in Fig. 12b. The woven fabric samples are replaced and measured under identical measurement conditions such as water temperature and flow rate (at identical Reynolds numbers), and comparative evaluations can be conducted based on the magnitude of the peeling angle 28. The larger the peeling angle 28 is, the more the peeling of the boundary layer is suppressed, whereby vortices are less likely to be generated in the wake flow and the negative pressure is reduced. As a result, the shape (pressure) resistance force is reduced.

**[0080]** In Examples, the peeling angle of the boundary layer at a flow rate of 1.0 m/sec (Reynolds number:  $8.3 \times 10^4$ ) is  $124^\circ$  in Example 1 in which a woven fabric satisfying the definition of the present invention is placed on a cylindrical sample mounting stage 5 (diameter: 7.5 cm, height: 28.0 cm), whereas the peeling angles of the boundary layers measured under the same conditions as those in Example 1 are as low as  $113$  to  $120^\circ$  in Comparative Examples 1, 2, and 3 in which a woven fabric having a ratio of resistance yarn of 50% or more and not satisfying the definition of the

present invention is placed. That is, the shape (pressure) resistance is increased. Particularly, in Comparative Example 3 in which the ratio of resistance yarn is 66.6% which is the highest value, the peeling angle of the boundary layer is 113° which is the smallest value, and the shape (pressure) resistance exhibits the highest value.

**[0081]** At the same time, the water friction resistance force in Comparative Examples 1, 2, and 3 is in a range of 7.4 to 7.8 N/m<sup>2</sup>, which is higher than the water friction resistance force (7.0 N/m<sup>2</sup>) in Example 1.

**[0082]** As known from the dimple effect of the golf ball, in a case where there are appropriate dents, the peeling angle of the boundary layer increases and the shape resistance (pressure resistance) decreases. However, the presence of dents results in poor smoothness of the surface, and further results in an increase in surface area as compared with the surface area of the surface with no dents, whereby the friction resistance force increases. The friction resistance with a significant influence on the smoothness of the surface is a characteristic contradictory to the shape (pressure) resistance influenced by the peeling angle of the boundary layer due to the appropriate irregularities. However, not only a reduction in friction resistance, but also a reduction effect in shape (pressure) resistance are recognized in the woven fabric for swimwear of the present invention having a ratio of resistance yarn of 40% or less. Furthermore, in the case of using a fiber obtained by forming grooves in the length direction of the fiber and subjecting the fiber to water repellent finishing, an air layer is formed in each of the grooves and water slides on the upper portion of the air layer, whereby the friction area with the fiber surface is substantially reduced, the friction resistance is further reduced, and the shape resistance (pressure resistance) can also be reduced.

**[0083]** Hence, the present invention is particularly effective in female swimwear in which the difference in sectional area of the human body is particularly large with respect to the forward direction during a swimming race. Not only the friction resistance but also the shape (pressure) resistance can be reduced by arranging a woven fabric using the direction with a large number of float yarns as the forward direction, at a site where the boundary layer of water is easily peeled, such as a chest, a waist, or buttocks.

**[0084]** Covering coated threads including an elastic fiber as a core yarn and a synthetic fiber filament as a sheath yarn are arranged in at least the direction with a large number of float yarns in the warp yarn or the weft yarn on the surface of the woven fabric, and the direction with a large number of float yarns is defined as the body length (height) direction of the swimwear, so that the friction resistance and the shape (pressure) resistance can be extremely reduced. This is preferable. Furthermore, covering coated threads including a synthetic fiber filament having grooves as a sheath yarn and an elastic fiber such as spandex as a core yarn are used in the direction with a large number of float yarns, and the direction is used as the forward direction to form a woven fabric, so that the friction resistance and shape (pressure) resistance can be further reduced. This is more preferable.

**[0085]** In the case of the woven fabric of the present invention having a characteristic of reducing both the two resistance forces: the water friction resistance force and the shape (pressure) resistance force positioned by the characteristics of the peeling angle of the boundary layer by one material, when being sewn into the swimwear, one material can be used for all places of the swimwear regardless of the sewing portion, and is easily used. It is not necessary to change the material depending on the sewing portion, and it is possible to reduce the number of stitches.

**[0086]** A material with a low friction resistance force is selected for a front body including a relatively smooth abdomen, a waist, and thighs among body parts in water during a swimming race. The boundary layer is peeled off and the shape resistance (pressure resistance) is increased in a part having a large change in shape, such as a chest or buttocks. Thus, a plurality of materials is used according to the part, for example, a material for preventing the peeling of the boundary layer is selected for this part. In this case, it is necessary to change the material. As a result, the number of stitches increases, and the water resistance increases due to an increase in the number of stitches, which is problematic. The woven fabric for swimwear of the present invention in which the number of stitches can be reduced has an effect of reducing the resistance due to the stitches, which is preferable.

**[0087]** The woven fabric for swimwear of the present invention can adjust a body shape by superior stretchability, has an effect of reducing the friction resistance force between the woven fabric surface and water, can also reduce the shape resistance (pressure resistance) by an effect of increasing the peeling angle of the water boundary layer due to an effect of holding air in the groove provided in the synthetic fiber filament to form an air film, and can be suitably used for swimwear such as competition swimwear or a wet suit.

## EXAMPLES

**[0088]** Hereinafter, the present invention will be more specifically described with reference to examples, but the present invention is not limited to these examples. Each evaluation in Examples was obtained by the following method.

### (1) Weight per Area

**[0089]** As the weight per area, a mass per unit area in a standard state (20°C and 65% RH) was measured in accordance with Method A of 8.3.2 of JIS L 1096: 2010. Specifically, 3 test pieces of 200 mm × 200 mm are taken, and the mass

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(g) after allowing each of the test pieces in each standard state to stand for 1 day is weighed, the mass (g/m<sup>2</sup>) per 1 m<sup>2</sup> is determined by the following equation, and the average value thereof is calculated and rounded to one decimal place.

$$S_m = W/A$$

where,  $S_m$ : mass per unit area in the standard state (g/m<sup>2</sup>)

W: mass of test piece in the standard state (g)

S: area of test piece (m<sup>2</sup>).

### (2) Thickness

**[0090]** The thicknesses at 5 different points of the sample subjected to humidity conditioning by Method A were measured under constant pressure after applying a pressure of 23.5 kpa for 10 seconds using a thickness measuring instrument, in accordance with 8.4 of JIS L 1096: 2010, and the average value was calculated.

### (3) Ratio of Resistance Yarn

**[0091]** In the diagram showing one weave repeat of the woven fabric, a square in which a warp yarn lies above a weft yarn is painted black, and a square in which a warp yarn lies below a weft yarn is white outlined. Then, the direction with a large number of float yarns is confirmed. When the weft yarn has a large number of floats, the weft direction is defined as the body length (height) direction, and the number of squares (F) perpendicular to the body length direction is counted. All squares (P) are counted, and the ratio of resistance yarn is calculated by the following formula:

$$R_r = (F/P) \times 100$$

$R_r$ : the ratio of resistance yarn (%)

F: the number (pieces) of squares of float yarns in the direction perpendicular to the body length (height) direction of swimwear in one weave repeat

P: the total number (pieces) of squares of one weave repeat

### (4) Cover Factor

#### (4-1) Apparent Fineness of Yarns Obtained by Unweaving Woven Fabric

**[0092]** The warp yarn and the weft yarn are taken out from the woven fabric, and the apparent fineness thereof is measured in accordance with "Method for Measuring the Apparent Fineness of Fibers Taken from the Fabric" in JIS L 1096, Appendix H (2010).

**[0093]** In the case of a finished product subjected to resin coating or laminated with a film, the fineness is measured by the method described in "Chapter 3. Measurement of the Apparent Fineness of Fibers Taken from the Fabric after Removal of Non-Fibrous Material" in which the non-fibrous material is removed by the method described in ISO 1833-1. In the case of a dyed and finished product without resin finishing (including water repellent finishing and soft finishing), measurement is performed by the method described in "Chapter 2. Measurement of the Apparent Fineness of Fibers Taken from the Fabric without Removal of Non-Fibrous Material".

**[0094]** In this regard, the mass of the yarn is measured by adjusting the yarn to a moisture equilibrium in a standard state (at 20°C and 65% RH) and measuring it by Method A, and the resultant mass is calculated by the following formula. The number n of measurements is 40 or more.

$$L_d = W_s/L \times n$$

$L_d$ : apparent fineness (tex) of the yarn adjusted in the standard state

$W_s$ : mass (g) of the yarn taken from the fabric

L: average value of lengths of yarns pulled straight (m)

n: number of weighed yarns

**[0095]** In the case of the covering thread, the apparent fineness is measured in a state where the yarn extracted from

the fabric is covered without being separated into a core yarn: elastic fiber and a sheath yarn: synthetic elastic fiber filament.

#### (4-2) Density

- 5 **[0096]** The density of the woven fabric is converted to the density per inch (2.54 cm) by measuring the number of yarns per cm by Method B (Lunometer) in JIS L 1096, Appendix F (2010).  
**[0097]** The number of measurements is an average of warp and weft measurements at three times.

#### (4-3) Cover Factor

- 10 **[0098]** Calculation is performed by substituting the measurement results of the apparent fineness and the density into the following formula:

$$15 \quad cf = [\sqrt{Dx} \times My] + [\sqrt{Dy} \times My]$$

cf: total cover factor

cfx =  $[\sqrt{Dx} \times My]$ : cover factor in the direction with a large number of float yarns

cfy =  $[\sqrt{Dy} \times My]$ : cover factor in the direction with a small number of float yarns

20 Dx: fineness (dtex) of weaving yarns in the direction with a large number of float yarns

Dy: fineness (dtex) of weaving yarns in the direction with a small number of float yarns

Mx: warp weaving density in the direction with a large number of float yarns (counts/2.54 cm)

My: weaving density in the direction with a small number of float yarns (counts/2.54 cm)

#### 25 (5) Groove Depth of Surface of Single Yarn of Fiber, Width of Protrusion, and Width of Inlet of Groove ( $\mu\text{m}$ )

**[0099]** (SWmax): width of wide part of groove, fiber diameter ( $\mu\text{m}$ ), (SWmax)/(SWmin) (ratio of width of wide part of groove/width of inlet of groove)

- 30 **[0100]** A cross section of a yarn was photographed at a magnification of 1500 with a scanning electron microscope (S-3400 N type, manufactured by Hitachi High-Tech Corporation). At the time of photographing, an instruction operation was performed to measure the height of the recess and the protrusion, the interval between the adjacent protrusions, the width of the protrusion, and the like. Measurement was performed up to the order of 0.01  $\mu\text{m}$ . The values were rounded to unit, and expressed as an average value of 10 measurement results.

#### 35 (6) Water Repellency

- [0101]** The water repellency is measured according to Water Repellency Test (Spray Test) of JIS L 1092, 7.2 (2009). Three samples of about 200 mm  $\times$  200 mm are collected, a water repellency tester is used, 250 ml of water is poured into a funnel so that the warp direction of the samples is parallel to the flow of water, and the water is sprayed onto the samples in 20 to 25 seconds. Next, a sample holding frame is removed from the tester, one end of the sample is held horizontally, the front side of the test piece is directed downward, the other end of the test piece is once lightly pressed against a hard object to drop a water droplet. One end of the test piece rotated through 180° is taken and subjected to the same operation as described above to drop extra water droplets. The wet state of the sample while the sample is attached to the holding frame is compared with the comparative sample and determined.

- 45 **[0102]** In accordance with washing conditions according to 142 (Method C4M) of JIS L0001-2014, washing is performed using a pulsator type washing machine under mild stirring conditions with a washing water temperature of 40°C. The water repellency of the sample before washing and after washing 20 times was measured.

Grade 1: a sample with a whole wet surface

50 Grade 2: a sample with a half-wet surface in which small individual wetting shows a state of wetting the fabric

Grade 3: a sample with a surface wet with small individual water droplets

Grade 4: a sample with a surface without wetting and with adhesion of small water droplets

Grade 5: a sample with a surface without wetting or adhesion of water droplets

#### 55 (7) Elongation Rate

**[0103]** The elongation rate was measured in accordance with Tensile Elongation Method A (Cut Strip Method) of JIS L 1096 (2010) 8.14. Specifically, 3 test pieces each having a width of 50 mm and a length of 300 mm were taken in each

of the warp direction and the weft direction from a sample whose temperature and humidity had been controlled to the standard state, and the elongation rate, as measured at a load of 14.7 N, a grip interval of 200 mm, and a tensile speed of 200 mm/min using a constant rate of elongation tensile tester was determined by the following formula:

$$E_p = (L_1 - L) / L$$

$E_p$ : elongation at the constant load (%)

$L$ : length between original marks (mm), 200 mm

$L_1$ : length at 14.7 N load (mm)

#### (8) Evaluation of Abrasion Resistance

**[0104]** As for the abrasion test, the base area of the upper holder was set to about 13 cm<sup>2</sup>, the number of rubs was set to 90 rpm, the pressing load was set to 7.36 N, the woven fabric for the test was fixed on the upper holder and the lower friction plate. Then, the woven fabric was abraded for 10 minutes using an appearance retention tester described in JIS L 1076 (2012) "Testing methods for pilling of woven fabrics and knitted fabrics". After abrasion, the surface change of the woven fabric set in the upper holder as well as the presence or absence of occurrence of fibrillation were observed with a stereoscopic microscope.

#### (9) Measurement of Water Friction Resistance Force in Smooth Sample Mounting Plate

**[0105]** The water friction resistance was measured when the woven fabric for swimwear was stretched by 15% in each of a flowing direction and a direction perpendicular to the flowing direction using the passing water tank shown in Fig. 7. Fig. 7 is a side view of an apparatus for explaining the water friction resistance measurement using the smooth sample plate in the passing water tank, and Figs. 8 are schematic views for explaining a method of sewing a sample to be attached to the smooth sample plate.

**[0106]** First, the woven fabric sample is cut into a quadrangle with a length of 0.867 m in the body length (height used for swimwear) direction and a length of 0.634 m in the body width (width used for swimwear) direction. Next, as shown in Fig. 8a, the woven fabric sample with the surface facing inward was folded in two at the central part in a body width (width) direction 7 used for the swimwear, and overlapped. Then, as shown in Fig. 8b, a margin to seam of 0.6 cm was applied to ends 8 to be sewn in a direction perpendicular to a body length (height) direction 6 used for the swimwear, and the ends were overlock-sewn into a bag shape using a nylon textured yarn for sewing.

**[0107]** The sewn margin to seam is pressed with a smoothing iron in a one-sided manner, turned over, and the margin to seam is put inside the bag-shaped sample, and the surface of the woven fabric is used as the front side of the woven fabric sample. In addition, a portion 10 cm above the bottom is marked with a fixed sample line 9 using an oil-based marker pen or the like. Then, an opening 10 of the sample sewn into a bag shape is inserted into a smooth sample mounting plate 1 (draft depth: 0.25 m, length: 1.0 m, thickness: 0.006 m) made of stainless steel, and the sample is set while being stretched so as to cover the smooth sample mounting plate 1.

**[0108]** When the sample is attached so that the fixed sample line 9 marked above the bottom of the sample reaches the sample fixing position of the smooth sample mounting plate 1, the woven fabric as the sample is stretched by 15% in both the flowing direction and the direction perpendicular to the flowing direction. In this state, the opening 10 at the upper portion is fixed to the smooth sample mounting plate 1 made of stainless steel with a rubber band, a clip, or the like. A smooth plate and a load cell (stress meter) 2 capable of measuring the shear stress of the water flow are attached to a portion where the smooth sample mounting plate is fixed.

**[0109]** The passing water tank has a top lid for preventing waves in which holes having a diameter of about 5 cm penetrate through the lid at several places, and is provided with long holes having a length of 1.1 m and a width of 0.015 m so that the upper portion of the stainless-steel smooth sample mounting plate does not come into contact with the top lid. Water is poured up to about 3 to 5 cm above the position of the top lid. Due to the presence of the top lid, even when the speed of flowing water in the passing water tank is increased, generation of waves at the front portion of the smooth plate can be prevented, and the friction resistance force of the smooth plate covered with the woven fabric sample can be measured without being affected by the waves.

**[0110]** The flow rate of water in the passing water tank can be arbitrarily set by rotation of a screw incorporated in a lower portion of the passing water tank. The flow rate can be measured by a pitot tube 3 attached to the water tank. Furthermore, a water temperature meter is attached thereto, and the water temperature can be measured. In this state, the passing water tank is installed in a room in which the temperature and humidity of the room can be arbitrarily set. The water temperature in the water tank can be arbitrarily set by adjusting the temperature and humidity in the room.

**[0111]** The total resistance force (RT) of the smooth sample mounting plate 1 covered with the woven fabric sample

is measured at a water temperature of 25°C and a flow rate of 2.0 m/s.

**[0112]** Three bag-shaped woven fabric samples are prepared, and the resistance force at a flow rate of 2.0 m/s is measured three times to calculate an average value of measured data. The value converted at the draft areas on both sides by the following formula is defined as a friction resistance force RF (unit: N/m<sup>2</sup>).

$$RF = (RT - RD) / A$$

RF: friction resistance force (N/m<sup>2</sup>)

A: total area of the front and back of the immersed portion of the smooth plate  $0.25 \times 1.0 + 0.25 \times 1.0 = 0.5 \text{ m}^2$  (m<sup>2</sup>)

RT: total resistance force (N) of the smooth plate to which the woven fabric sample is attached

RD: increase in resistance due to thickness (N)

$$RD = 0.486 \times \rho \cdot x \cdot V^2 / 2$$

$\rho$ : density of water at 25°C 997 (kg/m<sup>3</sup>)

x: projected area of the plane perpendicular to the flow (thickness  $\times$  draft)  $0.006 \times 0.25 = 0.0015 \text{ m}^2$  (m<sup>2</sup>)

V: velocity of water 2.0 (m/s)

**[0113]** The Reynolds number indicating the flow state of the fluid was obtained by the following formula.

$$Re = VL / \nu$$

Re: Reynolds number (-)

V: average velocity of fluid (m/s)

L: representative length: length of the flat plate (m)

$\nu$ : coefficient of kinematic viscosity of water (m<sup>2</sup>/sec)

#### (10) Measurement of Peeling Angle of Boundary Layer of Flowing Water in Cylindrical Sample Mounting Stage

**[0114]** The passing water tank used for measurement of the water friction resistance was used. The peeling angle of the boundary layer of flowing water was measured when the woven fabric for swimwear was stretched by 15% in each of the flowing direction and the direction perpendicular to the flowing direction with the apparatus in which the cylindrical sample mounting stage 5 (diameter: 7.5 cm, height: 28.0 cm) made of vinyl chloride resin shown in Fig. 9 was attached to the top lid 4 at the position of the central part of the water tank. Fig. 9 is a side sectional view of an apparatus for explaining measurement of a peeling angle of a boundary layer of flowing water using a cylindrical sample mounting stage in the passing water tank.

**[0115]** The top lid 4 has several holes with a diameter of about 5 cm, and water is poured up to about 3 to 5 cm above the position of the top lid 4. The top lid 4 is used to eliminate the influence of the wave-making resistance, and the top lid 4 can prevent the generation of waves even in the case of increasing the speed of flowing water in the passing water tank, and thus it is possible to eliminate the influence of waves.

**[0116]** First, the woven fabric sample is cut into a quadrangle with a length of 21.7 cm in the body length (height) direction 6 used for swimwear and a length of 29.3 cm in the body width (width) direction 7 used for swimwear. Next, as shown in Fig. 10a, the woven fabric with the surface facing inward is folded in two at the central part in the body width (width) direction 7 used for the swimwear, and overlapped. Then, as shown in Fig. 10b, a margin to seam of 0.6 cm is applied to the ends 8 to be sewn in the width (width) direction 7 used for the swimwear, and the ends are overlock-sewn into a tubular shape in which both the upper portion and the lower portion are in the form of an open 11 using a nylon textured yarn for sewing.

**[0117]** The margin to seam is pressed with a smoothing iron in a one-sided manner, turned over, and the margin to seam is put inside the tubular sample, and the surface of the woven fabric is used as the front side of the woven fabric sample. Furthermore, a portion 5.0 cm below the woven fabric sample is marked with the fixed sample line 9 using an oil-based marker pen or the like in order to achieve the position adjustment to the cylindrical sample mounting stage 5. Then, the sample sewn into a tubular shape is set while being stretched so as to cover the cylindrical sample mounting stage 5. The end of the woven fabric is attached to the upper end of the cylindrical sample mounting stage 5 and firmly fixed with a rubber band. Then, the woven fabric sample is attached to the lower portion of the cylindrical sample mounting stage 5 so that the fixed sample line 9 marked on the woven fabric sample overlaps with the lower end of the cylindrical

sample mounting stage 5, and firmly fixed with a rubber band. In this state, the woven fabric sample is stretched by 15% in both the flowing direction and the direction perpendicular to the flowing direction.

[0118] The water tank is the same water tank as in the friction resistance measurement using the smooth sample mounting plate 1, and the handling is the same as that in this case.

[0119] The peeling angle of the boundary layer of flowing water is measured when the water temperature is set to 25°C and the flow rate is set to 1.0 m/sec. In a normal illumination state, it is difficult to see the peeling state of the boundary layer of water as in the photograph shown in Fig. 12a. Thus, an appropriate amount of tracer microparticles (polyamide 10 μm fine particles, specific gravity: 1.02) is added to flowing water, and the light in the room with the passing water tank installed is turned off in order to make the room dark. Then, the cylindrical sample mounting stage 5 is irradiated with a laser beam (PIV Laser G150, manufactured by KATOKOKEN CO., LTD) in a direction of slicing the cylindrical sample mounting stage 5 from the outside of the transparent window of the passing water tank, a camera is set in the upper portion of the passing water tank, and the flowing water state in the vicinity of the surface 27 viewed from the top of the cylindrical sample mounting stage is photographed as shown in Fig. 12b. The exposure and the shutter speed of the camera at the time of photographing are appropriately adjusted. As shown in Fig. 12b, an angle formed by a line parallel to the flow passing through the center point of the circle and a line connecting the center point with the flow peeling point is defined as the peeling angle 28 of the boundary layer.

[0120] Three tubular woven fabric samples were produced and measured three times to calculate an average value of measured data, and the resultant value was used as the peeling angle (°) of the boundary layer.

[0121] The Reynolds number indicating the flow state of the fluid was obtained by the following formula.

$$Re = VL/\nu$$

Re: Reynolds number (-)

V: average velocity of fluid (m/s)

L: representative length: diameter of the cylinder (m)

ν: coefficient of kinematic viscosity of water (m<sup>2</sup>/sec)

[Example 1]

[0122] For a warp yarn, a core yarn: chlorine-resistant LYCRA ("LYCRA-25B" 44 dtex (PU44) manufactured by TORAY OPELONTEX CO., LTD.) and a sheath yarn: a nylon false-twisted yarn (nylon yarn 1) with 17 dtex, 7 filaments, semi-dull, circular cross section were used to produce a single covering thread with a draft ratio of the core yarn of 3.5 (times), a number of twists of 1800 T/M, and a twist coefficient of 9788. For a weft yarn, a core yarn: chlorine-resistant LYCRA ("LYCRA-25B" 33dtex (PU33) manufactured by TORAY OPELONTEX CO., LTD.) and a sheath yarn: a nylon false-twisted yarn (nylon yarn 1) with 17 dtex, 7 filaments, semi-dull, circular cross section, as the same as the warp yarn, were used to produce a single covering thread with a number of twists of 1900 T/M, and a twist coefficient of 9768. A 1/2 weft twill woven fabric was produced with a rapier loom, and the woven fabric in a spread state was subjected to three-stage relaxation and scouring, and then preset. Then, the fabric was dyed with an acid dye using a jet dyeing machine, and then dried. Thereafter, the fabric was immersed in a non-fluorine water repellent finishing solution with the following formulation, squeezed with a mangle at a squeezing rate of 60%, dried at 130°C for 2 minutes, and further subjected to final setting at 160°C without applying unnecessary tension for curing.

[0123] The obtained woven fabric was a 1/2 weft twill woven fabric in which the warp density was 216 yarns/2.54 cm, the weft density was 270 yarns/2.54 cm, the number of floats in the warp yarn was 3, and the number of floats in the weft yarn was 6 in one weave repeat in the weave structure diagram shown in Fig. 1.

[0124] The weft direction was used as the body length (height) direction of the swimwear, as a result of which a woven fabric for swimwear having low water friction resistance was obtained. The cover factor, weight per area, thickness, water repellency, and elongation rate of the obtained woven fabric were measured. Furthermore, a bag-shaped sample was produced from the obtained woven fabric, the sample was stretched by 15% in each of the flowing direction and the direction perpendicular to the flowing direction so as to wrap a smooth sample plate, and the water friction resistance force was measured using the passing water tank. In addition, a tubular sample was produced in a similar manner to the above, the sample was stretched by 15% in each of the flowing direction and the direction perpendicular to the flowing direction so as to cover the cylindrical sample mounting stage with the sample, and the peeling angle of the boundary layer was measured. The results of the evaluation are shown in Table 1.

[0125] There is no problem in the evaluation of abrasion resistance, and the sample has low friction resistance to water, and has superior performance as a woven fabric for swimwear such as athletic swimwear or training swimwear.

[Formulation of Water Repellent Finishing]

**[0126]**

- 5 wt% of "NEOSEED" NR-158 (manufactured by NICCA CHEMICAL CO., LTD.)
- 0.3 wt% of "BECKAMINE" M-3 (manufactured by DIC Corporation)
- 0.3 wt% of "CATALYST" ACX (manufactured by DIC Corporation)
- 1 wt% of isopropyl alcohol
- Treatment liquid mixed with 93.5 wt% of water

[Example 2]

**[0127]** A core component: nylon 6 formed into a star-shaped core part shown in Fig. 11a and a sheath component: polyethylene terephthalate (melt viscosity: 45 Pa·s) copolymerized with 8.0 mol% of 5-sodium sulfoisophthalic acid and 10 wt% of polyethylene glycol having a molecular weight of 1000 were used to form a core-sheath composite fiber (star-shaped composite yarn 1) of 56 dtex/18 filament (30 wt% of the core part, 70 wt% of the sheath part, 16.8 dtex/18 filament after elution of the sheath component) in such a manner that 8 V-shaped grooves were formed in the vicinity of the outer circumference of the transverse section in a direction perpendicular to the length direction of one core-sheath composite fiber. Then, two of the core-sheath composite fibers were paralleled and used for a sheath yarn, and, for a core yarn, chlorine-resistant LYCRA ("LYCRA-25B" 33 dtex (PU33) manufactured by TORAY OPELONTEX CO., LTD.) were used to produce a single covering thread with a draft ratio of the core yarn of 3.5 (times), a number of twists of 1480 T/M, and a twist coefficient of 16280 coefficient (where, the coefficient after the elution of the sheath component in composite spinning was 9768). The single covering thread was used for a warp yarn and a weft yarn, a 1/2 weft twill woven fabric was produced with a rapier loom in a similar manner to Example 1, and the woven fabric in a spread state was subjected to three-stage relaxation and scouring, and then preset. Then, 100% of the polyethylene terephthalate component was subjected to sea component removal with a 1 wt% sodium hydroxide solution using a jet dyeing machine, thereby obtaining a woven fabric in which covering coated threads including a sheath yarn: the star-shaped cross-sectional yarn shown in Fig. 11b and a core yarn: polyurethane spandex were used for a warp yarn and a weft yarn. Thereafter, the fabric was dyed with an acid dye using a jet dyeing machine, dried, and then immersed in a non-fluorine water repellent finishing solution similar to Example 1, squeezed with a mangle at a squeezing rate of 60%, dried at 130°C for 2 minutes, and further subjected to final setting at 160°C without applying unnecessary tension for curing.

**[0128]** The obtained woven fabric was a 1/2 weft twill woven fabric in which the warp density was 208 yarns/2.54 cm, the weft density was 220 yarns/2.54 cm, the number of floats in the warp yarn was 3, and the number of floats in the weft yarn was 6 in one weave repeat in the weave structure diagram shown in Fig. 1.

**[0129]** The grooves in the fiber cross section of the core-sheath composite fiber after elution of the sheath component were observed with a scanning electron microscope. The results are as described below.

**[0130]** There were 8 grooves, and each of the grooves had a V-shape, a width of inlet of 9.2 μm, a fiber diameter of 18.5 μm, a groove depth of 6.1 μm, and a desired shape capable of maintaining a large number of air layers. In addition, the protrusion had a sharp acute angle, and the width of the protrusion (vertex) was not observable and almost 0 μm.

**[0131]** The weft direction was used as the body length (height) direction of the swimwear, as a result of which a woven fabric for swimwear having low water friction resistance was obtained. The cover factor, weight per area, thickness, water repellency, and elongation rate of the obtained woven fabric were measured. Furthermore, a bag-shaped sample was produced from the obtained woven fabric. The weft direction of the woven fabric was used as the flowing direction, the sample was stretched by 15% in each of the direction perpendicular to the flowing direction so as to wrap a smooth sample plate, and the water friction resistance force was measured using the passing water tank. In addition, a tubular sample was produced in a similar manner to the above, the sample was stretched by 15% in each of the flowing direction and the direction perpendicular to the flowing direction so as to cover the cylindrical sample mounting stage with the sample, and the peeling angle of the boundary layer was measured. The results of the evaluation are shown in Table 1.

**[0132]** Although fibrillation was slightly observed in the protrusion as a result of evaluating the abrasion resistance, the area occupied by the groove portion on the yarn surface of the woven fabric was large. Thus, the result was the most superior from the viewpoint of the friction resistance with water and low water resistance because the peeling angle of the boundary layer was large. Although the resistance to abrasion is slightly poor, it is excellent as a woven fabric for swimwear of a top swimmer.

[Example 3]

**[0133]** A core component: nylon 6, a sheath component: polyethylene terephthalate copolymerized with 8.0 mol% of 5-sodium sulfoisophthalic acid and 10 wt% of polyethylene glycol having a molecular weight of 1000 (melt viscosity: 45

Pa-s) were used to form a core-sheath composite fiber of 84 dtex/24 filament (80 wt% of the core part, 20 wt% of the sheath part, 67 dtex/24 filament after elution of the sheath component) in such a manner as in Fig. 11b in which a constriction type groove portion having a narrow inlet and a wide inner portion was formed at 8 locations in one core-sheath composite fiber. Then, a sheath yarn: a textured yarn (constriction type composite yarn 2) false-twisted using the core-sheath composite fiber and a core yarn: chlorine-resistant LYCRA ("LYCRA-25B" 78 dtex (PU78) manufactured by TORAY OPELONTEX CO., LTD.) were used to produce a single covering thread with a draft ratio of the core yarn of 3.5 (times), a number of twists of 1035 T/M, and a twist coefficient of 9780. The single covering thread was used for a warp yarn and a weft yarn, a 1/2 weft twill woven fabric was produced with a rapier loom in a similar manner to Example 1, and the woven fabric in a spread state was subjected to three-stage relaxation and scouring, and then preset. Then, 100% of the polyethylene terephthalate component was subjected to sea component removal with a 1 wt% sodium hydroxide solution using a jet dyeing machine, thereby obtaining a woven fabric of 100% nylon. Thereafter, the fabric was dyed with an acid dye using a jet dyeing machine, and then dried. Then, the fabric was immersed in a non-fluorine water repellent finishing solution similar to Example 1, squeezed with a mangle at a squeezing rate of 60%, dried at 130°C for 2 minutes, and further subjected to final setting at 160°C without applying unnecessary tension for curing.

**[0134]** The obtained woven fabric was a 1/2 weft twill woven fabric in which the warp density was 138 yarns/2.54 cm, the weft density was 144 yarns/2.54 cm, the number of floats in the warp yarn was 3, and the number of floats in the weft yarn was 6 in one weave repeat in the weave structure diagram shown in Fig. 1.

**[0135]** The grooves in the fiber cross section of the core-sheath composite fiber after elution of the sheath component were observed with a scanning electron microscope. The results are as described below.

**[0136]** There were 8 grooves, the inlet of groove portion had a width of 0.9  $\mu\text{m}$ , the wide part of groove had a width of 1.6  $\mu\text{m}$  (SWmax/SWmin: 1.8), and the inlet of groove was narrow and widened toward the center of the fiber cross section. The fiber had a diameter of 15.9  $\mu\text{m}$  and a groove depth of 3.1  $\mu\text{m}$  (SH/D: 0.19), and had a desired shape capable of sufficiently maintaining the air layer. The protrusion had a width of 7.8  $\mu\text{m}$ . As a result of evaluating the abrasion resistance, even when forced abrasion was applied, peeling or collapse of the protrusion was not observed, and occurrence of fibrillation on the sample surface was not observed.

**[0137]** The weft direction was used as the body length (height) direction of the swimwear, as a result of which a woven fabric for swimwear having low water friction resistance was obtained. The cover factor, weight per area, thickness, water repellency, and elongation rate of the obtained woven fabric were measured. Furthermore, a bag-shaped sample was produced from the obtained woven fabric. The weft direction of the woven fabric was used as the flowing direction, the sample was stretched by 15% in each of the direction perpendicular to the flowing direction so as to wrap a smooth sample plate, and the water friction resistance force was measured using the passing water tank. In addition, a tubular sample was produced in a similar manner to the above, the sample was stretched by 15% in each of the flowing direction and the direction perpendicular to the flowing direction so as to cover the cylindrical sample mounting stage with the sample, and the peeling angle of the boundary layer was measured. The results of the evaluation are shown in Table 1.

**[0138]** There is no problem in abrasion resistance, and constriction type grooves are present on the yarn surface of the woven fabric, air is captured in the grooves even in water, and the friction resistance with water and the peeling angle of the boundary layer are large. Thus, the woven fabric is excellent as competition swimwear having both low water resistance and durability.

[Example 4]

**[0139]** For a warp yarn, a core yarn: chlorine-resistant LYCRA ("LYCRA-25B" 44 dtex (PU44) manufactured by TORAY OPELONTEX CO., LTD.) and a sheath yarn: a nylon false-twisted yarn (nylon yarn 2) with 33 dtex, 24 filaments, semi-dull, circular cross section were used to produce a single covering thread with a draft ratio of the core yarn of 3.5 (times), a number of twists of 1500 T/M, and a twist coefficient of 9780. For a weft yarn, the single covering thread obtained in Example 2, i.e., two of the core-sheath composite fibers (star-shaped composite yarn 1) of 56 dtex/18 filament (30 wt% of the core part, 70 wt% of the sheath part, 16.8dtex/18 filament after elution of the sheath component) were paralleled and used for a sheath yarn: core yarn: chlorine-resistant LYCRA ("LYCRA-25B" 33 dtex (33PU) manufactured by TORAY OPELONTEX CO.,LTD.) were used to produce a single covering thread with a draft ratio of the core yarn of 3.5 (times), a number of twists of 1480 T/M, and a twist coefficient of 16280 coefficient (where, the coefficient after the elution of the sheath component in composite spinning was 9768). A 5-harness satin woven fabric was produced with a rapier loom. Subsequently, in a similar manner to Example 2, the woven fabric in a spread state was subjected to three-stage relaxation and scouring, and then preset. Then, 100% of the polyethylene terephthalate component was subjected to sea component removal with a 1 wt% sodium hydroxide solution using a jet dyeing machine, thereby obtaining a woven fabric of 100% nylon. Thereafter, the fabric was dyed with an acid dye using a jet dyeing machine, dried, and then immersed in a non-fluorine water repellent finishing solution similar to Example 1, squeezed with a mangle at a squeezing rate of 60%, dried at 130°C for 2 minutes, and further subjected to final setting at 160°C without applying unnecessary tension for curing. This resulted in a 5-harness satin woven fabric in which the warp density was 206 yarns/2.54 cm, the

weft density was 190 yarns/2.54 cm, the number of floats in the warp yarn was 20, and the number of floats in the weft yarn was 5 in one weave repeat in the weave structure diagram shown in Fig. 5.

**[0140]** The warp direction was used as the body length (height) direction of the swimwear, as a result of which a woven fabric for swimwear having low water friction resistance was obtained. The cover factor, weight per area, thickness, water repellency, and elongation rate of the obtained woven fabric were measured. Furthermore, a bag-shaped sample was produced from the obtained woven fabric, the sample was stretched by 15% in each of the flowing direction and the direction perpendicular to the flowing direction so as to wrap a smooth sample plate, and the water friction resistance force was measured using the passing water tank. In addition, a tubular sample was produced in a similar manner to the above, the sample was stretched by 15% in each of the flowing direction and the direction perpendicular to the flowing direction so as to cover the cylindrical sample mounting stage with the sample, and the peeling angle of the boundary layer was measured. The results of the evaluation are shown in Table 1.

**[0141]** Although fibrillation was slightly observed in the protrusion as a result of evaluating the abrasion resistance, the length of the weaving yarn parallel to the water flow direction was long, the weaving yarn had grooves, and the ratio of resistance yarn perpendicular to the water flow direction was as low as 20%. Thus, the result was superior from the viewpoint of the friction resistance with water and low water resistance because the peeling angle of the boundary layer was large. Although the resistance to abrasion is slightly poor, it is excellent as a woven fabric for swimwear of a top swimmer.

[Comparative Example 1]

**[0142]** A plain weave fabric having a warp density of 240 yarns/2.54 cm and a weft density of 230 yarns/2.54 cm was obtained in a similar manner to Example 1 except that the weave structure of Example 1 was plain weave and the density was changed. The cover factor, weight per area, thickness, water repellency, and elongation rate of the woven fabric were measured in a similar manner to Example 1. Further, in the passing water tank, the weft direction was used as the body length (height) direction of swimwear, and the water friction resistance force by a smooth sample plate and the peeling angle of the boundary layer using a cylindrical sample mounting stage were measured. The results of the evaluation are shown in Table 1.

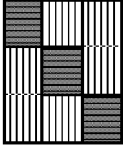
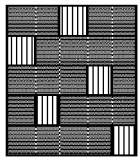
[Comparative Example 2]

**[0143]** A plain weave fabric having a warp density of 143 yarns/2.54 cm and a weft density of 140 yarns/2.54 cm was obtained in a similar manner to Example 3 except that a nylon false-twisted yarn (nylon yarn 3) with 67 dtex, 24 filaments, semi-dull, circular cross section was used as a sheath yarn of a single covering thread and the weave structure was plain weave. The cover factor, weight per area, thickness, water repellency, and elongation rate of the woven fabric were measured in a similar manner to Example 3. Further, in the passing water tank, the weft direction was used as the (body length) height direction of swimwear, and the water friction resistance force by a smooth sample plate and the peeling angle of the boundary layer using a cylindrical sample mounting stage were measured. The results of the evaluation are shown in Table 1.

[Comparative Example 3]

**[0144]** A 2/1 warp twill weave fabric having a warp density of 216 yarns/2.54 cm and a weft density of 270 yarns/2.54 cm was obtained in a similar manner to Example 1 except that the weave structure of Example 1 was changed to 2/1 warp twill weave fabric and the density was changed. The cover factor, weight per area, thickness, water repellency, and elongation rate of the woven fabric were measured in a similar manner to Example 1. Further, in the passing water tank, the weft direction was used as the body length (height) direction of swimwear, and the water friction resistance force by a smooth sample plate and the peeling angle of the boundary layer using a cylindrical sample mounting stage were measured. The results of the evaluation are shown in Table 1.

[Table 1-1]

| Measurement item                                         | Unit                                                                                                                                                                                                                                                                        | Example 1                                                                                                                                                                                                           | Example 2                                                                                                                                                                                                         | Example 3                               | Example 4                                 |
|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------|
| Use of yarn                                              | Warp yarn                                                                                                                                                                                                                                                                   | Nylon yarn 1/PU44                                                                                                                                                                                                   | Star-shaped composite yarn 1/2 yarns/PU33                                                                                                                                                                         | Constriction type composite yarn 2/PU78 | Nylon yarn 2/PU44                         |
|                                                          | Weft yarn                                                                                                                                                                                                                                                                   | Nylon yarn 1/PU33                                                                                                                                                                                                   | Star-shaped composite yarn 1/2 yarns/PU33                                                                                                                                                                         | Constriction type composite yarn 2/PU78 | Star-shaped composite yarn 1/2 yarns/PU33 |
| Weave structure                                          |  The warp yarn lying above the weft yarn (floated)<br> The warp yarn lying below the weft yarn (sunk) |  Water flow direction<br> 1/2 weft twill weave |  Water flow direction<br> 5-harness satin weave |                                         |                                           |
| Fineness of yarns obtained by unweaving the woven fabric | Warp x Weft (dtex)                                                                                                                                                                                                                                                          | 73.2 × 60.0                                                                                                                                                                                                         | 80.1 × 80.3                                                                                                                                                                                                       | 175.5 × 176.0                           | 94.0 × 81.0                               |
| Density                                                  | Warp x Weft (yarns/2.54 cm)                                                                                                                                                                                                                                                 | 216 × 270                                                                                                                                                                                                           | 208 × 220                                                                                                                                                                                                         | 138 × 144                               | 206 × 190                                 |
| Height direction                                         |                                                                                                                                                                                                                                                                             | Weft direction                                                                                                                                                                                                      | Weft direction                                                                                                                                                                                                    | Weft direction                          | Warp direction                            |
| Ratio of resistance yarn                                 | (%)                                                                                                                                                                                                                                                                         | 33.3                                                                                                                                                                                                                | 33.3                                                                                                                                                                                                              | 33.3                                    | 20.0                                      |
| Total cover factor                                       | (-)                                                                                                                                                                                                                                                                         | 3939                                                                                                                                                                                                                | 3833                                                                                                                                                                                                              | 3738                                    | 3708                                      |

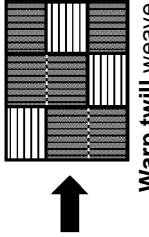
(continued)

| Measurement item                                                 | Unit                    | Example 1                   |                             | Example 2                  |                             | Example 3              |                     | Example 4           |
|------------------------------------------------------------------|-------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|------------------------|---------------------|---------------------|
| Cover factor in the direction with a large number of float yarns | (-)                     | 2091/weft direction (53.1%) | 1971/weft direction (51.4%) | 1910/weft direction (520%) | 1998/warp direction (53.8%) |                        |                     |                     |
| Cover factor in the direction with a small number of float yarns | (-)                     | 1848/warp direction         | 1862/warpl direction        | 1828/warp direction        | 1710/weft direction         |                        |                     |                     |
| Weight per area                                                  | (g/m <sup>2</sup> )     | 98                          | 175                         | 185                        | 141                         |                        |                     |                     |
| Thickness                                                        | (mm)                    | 0.24                        | 0.44                        | 0.58                       | 0.48                        |                        |                     |                     |
| Groove                                                           | Warp yarn and weft yarn | Warp yarn                   | Warp yarn                   | Warp yarn                  | Warp yarn                   | Warp yarn              | Warp yarn           | Warp yarn           |
|                                                                  | Number of yarns         | 0 (no groove)               | 8 (V-shaped groove)         | 8 (constricted groove)     | 8 (V-shaped groove)         | 8 (constricted groove) | 8 (V-shaped groove) | 8 (V-shaped groove) |
|                                                                  | Depth                   | ( $\mu\text{m}$ )           | 6.1                         | 3.1                        | 6.1                         | 3.1                    | 3.1                 | 6.1                 |
|                                                                  | Fiber diameter          | ( $\mu\text{m}$ )           | 18.5                        | 15.9                       | 18.5                        | 15.9                   | 15.9                | 18.5                |
|                                                                  | SH/D (depth/diameter)   | (-)                         | 0.33                        | 0.19                       | 0.33                        | 0.19                   | 0.19                | 0.33                |
|                                                                  | Width of inlet          | ( $\mu\text{m}$ )           | 9.2                         | 0.9                        | 9.2                         | 0.9                    | 0.9                 | 9.2                 |
|                                                                  | Width of wide part      | ( $\mu\text{m}$ )           | None                        | 1.6                        | None                        | 1.6                    | 1.6                 | None                |
|                                                                  | Width of protrusion     | ( $\mu\text{m}$ )           | 0                           | 7.8                        | 0                           | 7.8                    | 7.8                 | 0                   |
|                                                                  | SWmax/Swmin             | (-)                         | -                           | 1.8                        | -                           | 1.8                    | 1.8                 | -                   |
|                                                                  |                         |                             |                             |                            |                             |                        |                     |                     |

(continued)

| Measurement item                  | Unit                 | Example 1                         | Example 2                                   | Example 3                         | Example 4                                   |
|-----------------------------------|----------------------|-----------------------------------|---------------------------------------------|-----------------------------------|---------------------------------------------|
| Water repellency                  | (Grade)              | 4-5/3                             | 4-5/3                                       | 4-5/3                             | 4-5/3                                       |
| Elongation rate                   | (%)                  | 65 × 55                           | 28 × 23                                     | 38 × 30                           | 32 × 26                                     |
| Abrasion resistance               | (Visual observation) | No surface change/no fibrillation | Surface change: small/occurred fibrillation | No surface change/no fibrillation | Surface change: small/occurred fibrillation |
| Water flow/direction              | (-)                  | Weft direction                    | Weft direction                              | Weft direction                    | Warp direction                              |
| Water frictional resistance force | (N/m <sup>2</sup> )  | 7.0/weft direction                | 6.3/weft direction                          | 6.6/weft direction                | 6.3/warp direction                          |
| Peeling angle of boundary layer   | (°)                  | 124/ weft direction               | 134/weft direction                          | 132/weft direction                | 134/warp direction                          |

[Table 2-1]

| Measurement item                                                 | Unit                                                                                                                                                                                               | Comparative Example 1                                                                                                             | Comparative Example 2                                                                                                                 | Comparative Example 3       |
|------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Use of yarn                                                      | Warp yarn                                                                                                                                                                                          | Nylon yarn 1/PU44                                                                                                                 | Nylon yarn 3/PU78                                                                                                                     | Nylon yarn 1/PU44           |
|                                                                  | Warp yarn                                                                                                                                                                                          | Nylon yarn 1/PU33                                                                                                                 | Nylon yarn 3/PU78                                                                                                                     | Nylon yarn 1/PU33           |
| Weave structure                                                  |  <p>The warp yarn lying above the weft yarn (floated)</p> <p>The warp yarn lying below the weft yarn (sunk)</p> |  <p>Water flow direction</p> <p>Plain weave</p> |  <p>Water flow direction</p> <p>Warp twill weave</p> |                             |
| Fineness of yarns obtained by unweaving the woven fabric         | Warp x Weft                                                                                                                                                                                        | 73.5 × 60.1                                                                                                                       | 175.2 × 175.3                                                                                                                         | 73.2 × 60.0                 |
| Density                                                          | Warp x Weft                                                                                                                                                                                        | 240 × 230                                                                                                                         | 143 × 140                                                                                                                             | 216 × 270                   |
| Height direction                                                 |                                                                                                                                                                                                    | Weft direction                                                                                                                    | Weft direction                                                                                                                        | Weft direction              |
| Ratio of resistance yarn                                         |                                                                                                                                                                                                    | 50.0                                                                                                                              | 50.0                                                                                                                                  | 66.6                        |
| Total cover factor                                               |                                                                                                                                                                                                    | 3840                                                                                                                              | 3747                                                                                                                                  | 3939                        |
| Cover factor in the direction with a large number of float yarns |                                                                                                                                                                                                    | 2057/warp direction (53.6%)                                                                                                       | 1893/warp direction (50.5%)                                                                                                           | 2091/weft direction (53.1%) |
| Cover factor in the direction with a small number of float yarns |                                                                                                                                                                                                    | 1783/weft direction                                                                                                               | 1854/weft direction                                                                                                                   | 1848/warp direction         |
| Weight per area Thickness                                        | (g/m <sup>2</sup> ) (mm)                                                                                                                                                                           | 92 0.21                                                                                                                           | 183 0.51                                                                                                                              | 98 0.24                     |

(continued)

| Measurement item                           | Unit                 |                                   | Comparative Example 1 |                                   | Comparative Example 2 |                                   | Comparative Example 3 |
|--------------------------------------------|----------------------|-----------------------------------|-----------------------|-----------------------------------|-----------------------|-----------------------------------|-----------------------|
|                                            |                      | Warp yarn                         | Weft yarn             | Warp yarn                         | Weft yarn             | Warp yarn                         |                       |
| Warp yarn and weft yarn                    |                      | Warp yarn                         | Warp yarn             | Warp yarn                         | Warp yarn             | Warp yarn                         | Warp yarn             |
| Number of yarns                            | (yarns)              | 0 (no groove)                     | 0 (no groove)         | 0 (no groove)                     | 0 (no groove)         | 0 (no groove)                     | 0 (no groove)         |
| Depth                                      | ( $\mu\text{m}$ )    | -                                 | -                     | -                                 | -                     | -                                 | -                     |
| Fiber diameter                             | ( $\mu\text{m}$ )    | -                                 | -                     | -                                 | -                     | -                                 | -                     |
| SH/D (depth/diameter)                      | (-)                  | -                                 | -                     | -                                 | -                     | -                                 | -                     |
| Width of inlet                             | ( $\mu\text{m}$ )    | -                                 | -                     | -                                 | -                     | -                                 | -                     |
| Width of wide part                         | ( $\mu\text{m}$ )    | -                                 | -                     | -                                 | -                     | -                                 | -                     |
| Width of protrusion                        | ( $\mu\text{m}$ )    | -                                 | -                     | -                                 | -                     | -                                 | -                     |
| SWmax/Swmin                                | (-)                  | -                                 | -                     | -                                 | -                     | -                                 | -                     |
| Initial state/state after washing 20 times | (Grade)              | 4/2-3                             |                       | 4/2-3                             |                       | 4/2-3                             |                       |
| Elongation rate                            | (%)                  | 44 $\times$ 70                    |                       | 33 $\times$ 28                    |                       | 27 $\times$ 24                    |                       |
| Abrasion resistance                        | (Visual observation) | No surface change/no fibrillation |                       | No surface change/no fibrillation |                       | No surface change/no fibrillation |                       |
| Water flow/direction                       | (-)                  | Weft direction                    |                       | Weft direction                    |                       | Weft direction                    |                       |
| Water frictional resistance force          | (N/m <sup>2</sup> )  | 7.4/weft direction                |                       | 7.6/weft direction                |                       | 7.8/weft direction                |                       |
| Peeling angle of boundary layer            | (°)                  | 120/weft direction                |                       | 118/weft direction                |                       | 113/weft direction                |                       |

## DESCRIPTION OF REFERENCE SIGNS

**[0145]**

- 5 1: Smooth sample mounting plate  
 2: Load cell (stress meter)  
 3: Pitot tube  
 4: Top lid  
 5: Cylindrical sample mounting stage  
 10 6: Body length (height) direction used for swimwear  
 7: Body width (width) direction used for swimwear  
 8: End to be sewn  
 9: Fixed sample line  
 10: Opening  
 15 11: Opened upper portion and lower portion 12: Center point  
 13: Void portion  
 14: Polymer portion  
 15: Straight line  
 16: Perpendicular line  
 20 17: Groove depth (star-shaped cross section)  
 18: Width of wide part of groove  
 19: Center line  
 20: Fiber diameter  
 21: Groove depth (circular cross section with constriction type grooves)  
 25 22: Circumscribed circle  
 23: Inscribed circle  
 24: Protrusion  
 25: Width of protrusion  
 26: Width of bottom surface of groove  
 30 27: Surface viewed from top of cylindrical sample mounting stage  
 28: Peeling angle

**Claims**

- 35 1. A woven fabric for swimwear that is a stretch woven fabric in which covering coated threads are arranged in at least a part of a warp or weft yarn, the covering coated threads each including an elastic fiber as a core yarn and a synthetic fiber filament as a sheath yarn,
- 40 the woven fabric comprising a weave structure in which one of the warp yarn and the weft yarn has a large number of float yarns on a surface of the woven fabric, wherein a direction with a large number of float yarns is defined as a body length (height) direction of the swimwear, a ratio of resistance yarn in a direction perpendicular to the body length (height) direction is 40% or less, and the ratio is represented by the following Formula (I):

$$Rr = (F/P) \times 100 \dots (I)$$

- 45
- Rr: the ratio of resistance yarn (%)  
 50 F: the number (pieces) of squares of float yarns in the direction perpendicular to the body length (height) direction of swimwear in one weave repeat  
 P: the number (pieces) of squares of one weave repeat

- 55 2. The woven fabric for swimwear according to claim 1, wherein the woven fabric for swimwear is the stretch woven fabric, a total cover factor represented by the following Formula (II) is 2800 or more, and a cover factor in a direction with a large number of float yarns in either the warp yarn or the weft yarn and a cover factor in a direction with a small number of float yarns in either the warp yarn or the weft yarn on the surface of the woven fabric satisfy the following Formula (III):

$$cf = [\sqrt{D_x} \times M_y] + [\sqrt{D_y} \times M_y] \dots (II)$$

5

$$cf_x \geq cf_y \dots (III)$$

cf: total cover factor

$cf_x = [\sqrt{D_x} \times M_y]$ : cover factor in the direction with a large number of float yarns

$cf_y = [\sqrt{D_y} \times M_y]$ : cover factor in the direction with a small number of float yarns

10

$D_x$ : fineness (dtex) of weaving yarns in the direction with a large number of float yarns

$D_y$ : fineness (dtex) of weaving yarns in the direction with a small number of float yarns

$M_x$ : weaving density in the direction with a large number of float yarns (counts/2.54 cm)

$M_y$ : weaving density in the direction with a small number of float yarns (counts/2.54 cm)

15 3. The woven fabric for swimwear according to claim 1 or 2, wherein the covering coated threads are arranged in at least the direction with a large number of float yarns in the warp yarn or the weft yarn on the surface of the woven fabric.

4. The woven fabric for swimwear according to any one of claims 1 to 3, wherein the synthetic fiber filament is a synthetic fiber filament having a plurality of grooves in a surface in a fiber length direction.

20

5. The woven fabric for swimwear according to claim 4, wherein the grooves of the synthetic fiber filament have a depth of 1.0  $\mu\text{m}$  to 10.0  $\mu\text{m}$ , inlets of the grooves have a width of 1.0  $\mu\text{m}$  to 10.0  $\mu\text{m}$ , and protrusions have a width of 10.0  $\mu\text{m}$  or less.

25 6. The woven fabric for swimwear according to claim 4 or 5, wherein in a transverse sectional shape of the synthetic fiber filament, a groove portion is a groove having a wide part and satisfying the following Formulae (IV) and (V):

$$(SW_{\max}) / (SW_{\min}) \geq 1.3 \dots (IV)$$

30

$$0.15 \leq (SH/D) \leq 0.25 \dots (V)$$

( $SW_{\min}$ ): width of the inlet of groove ( $\mu\text{m}$ )

35

( $SW_{\max}$ ): width of the wide part of groove ( $\mu\text{m}$ )

D: fiber diameter ( $\mu\text{m}$ )

SH: groove depth ( $\mu\text{m}$ )

40 7. The woven fabric for swimwear according to any one of claims 1 to 6, wherein the synthetic fiber filament is a polyamide fiber.

8. The woven fabric for swimwear according to any one of claims 1 to 7, wherein at least a part of the weave structure is a stretch woven fabric of 1/2 weft twill weave.

45 9. The woven fabric for swimwear according to any one of claims 1 to 8, wherein at least a part of the weave structure is a stretch woven fabric of 5-harness satin weave.

10. The woven fabric for swimwear according to any one of claims 1 to 9, wherein the woven fabric for swimwear is subjected to water repellent finishing.

50

11. Swimwear comprising the woven fabric for swimwear according to any one of claims 1 to 10, wherein the direction with a large number of float yarns is a body length (height) direction of the swimwear.

55

FIG. 1

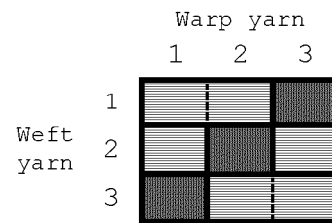


FIG. 2

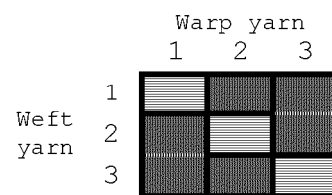


FIG. 3

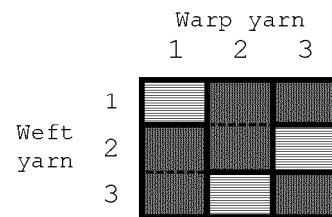


FIG. 4

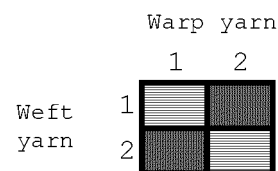
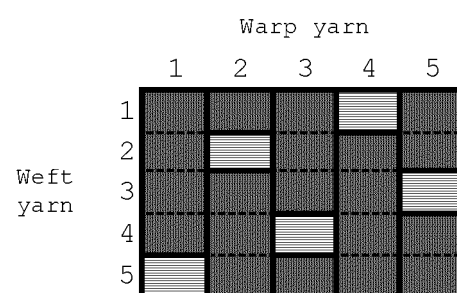


FIG. 5



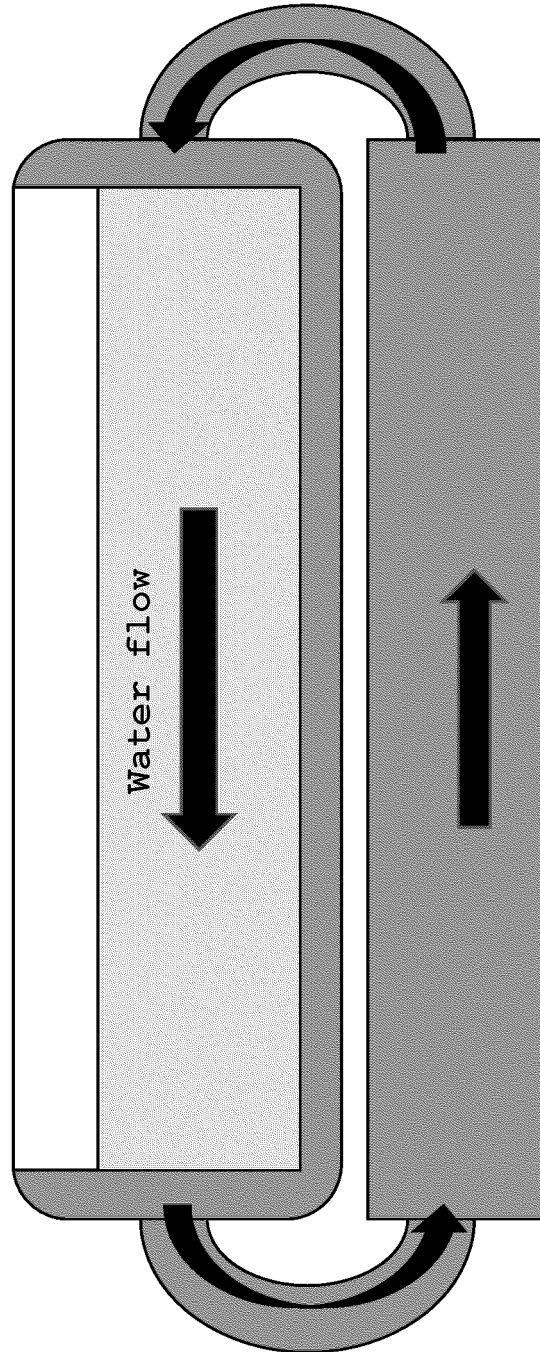


FIG. 6

FIG. 7

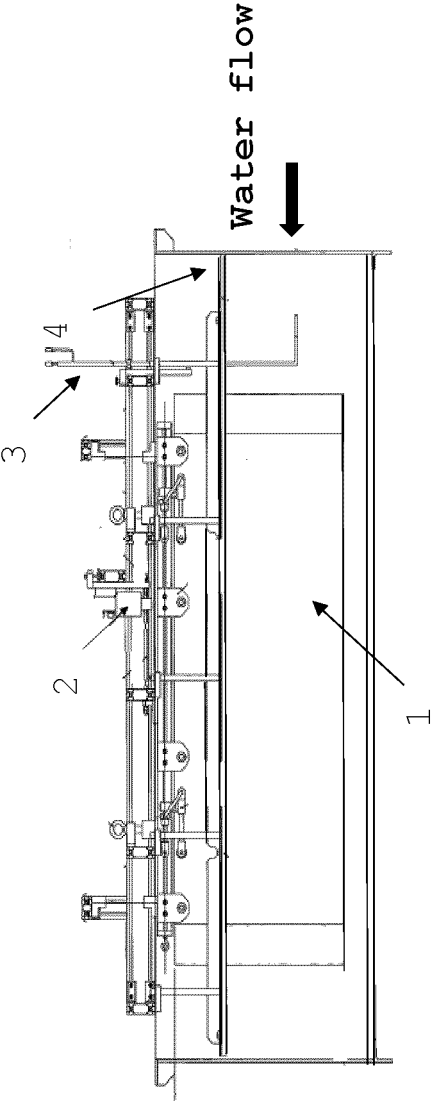
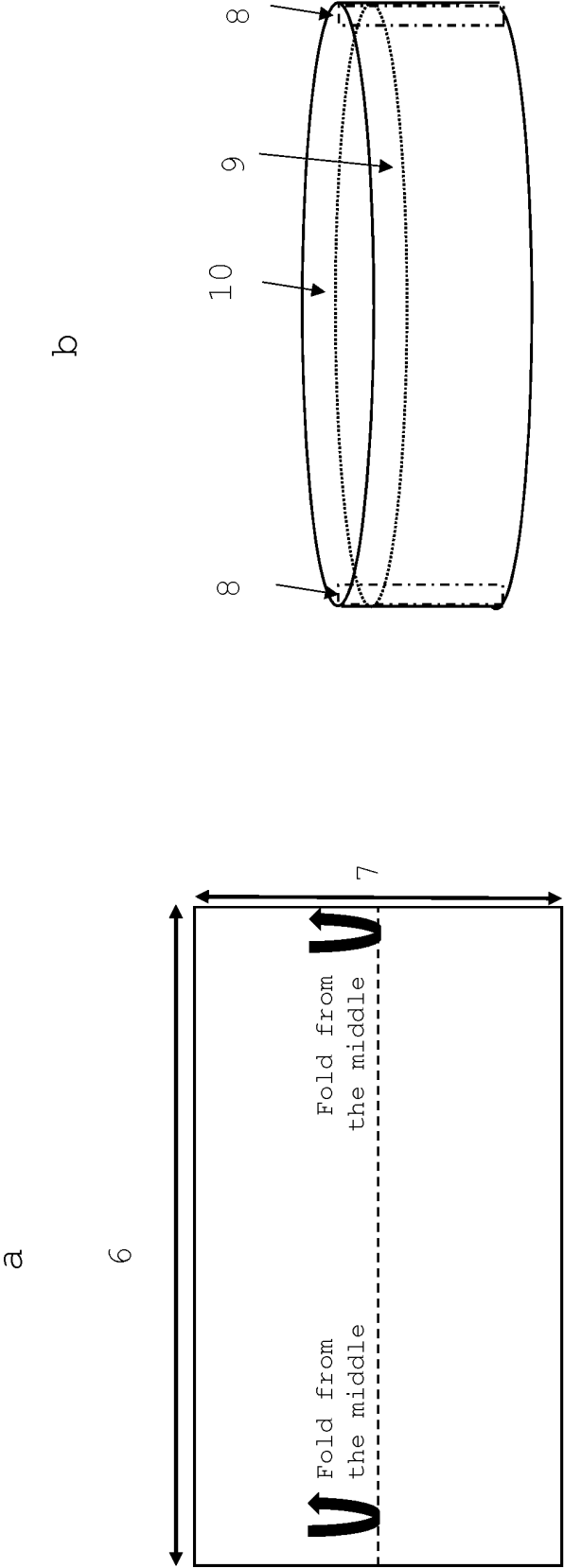


FIG. 8



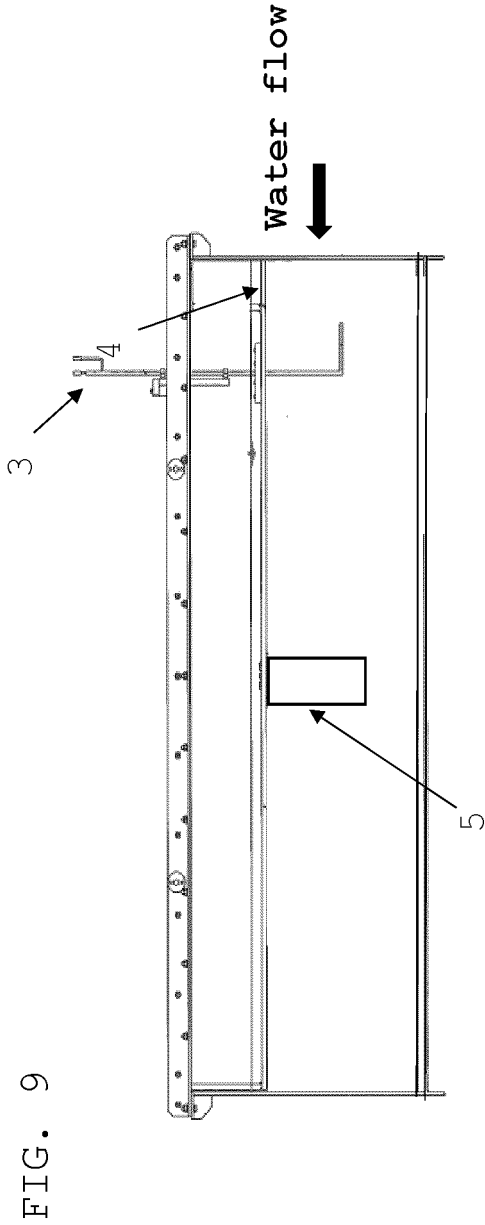


FIG. 10

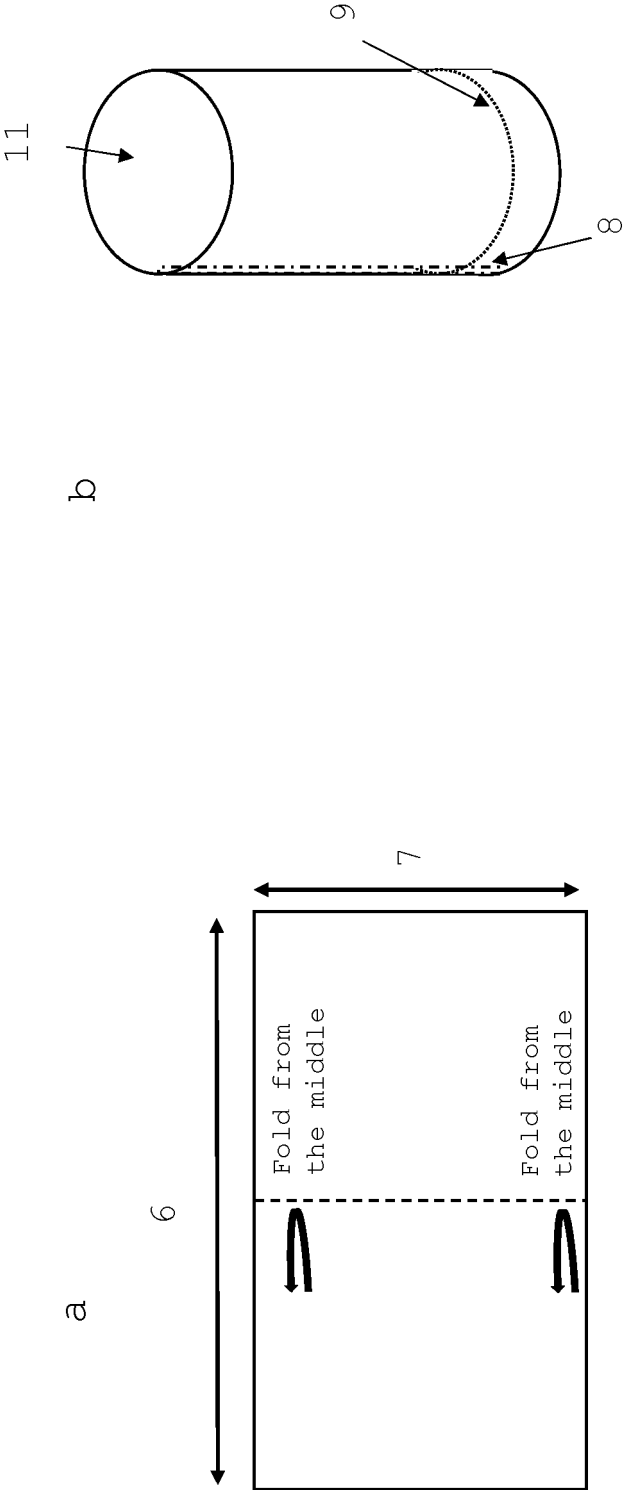
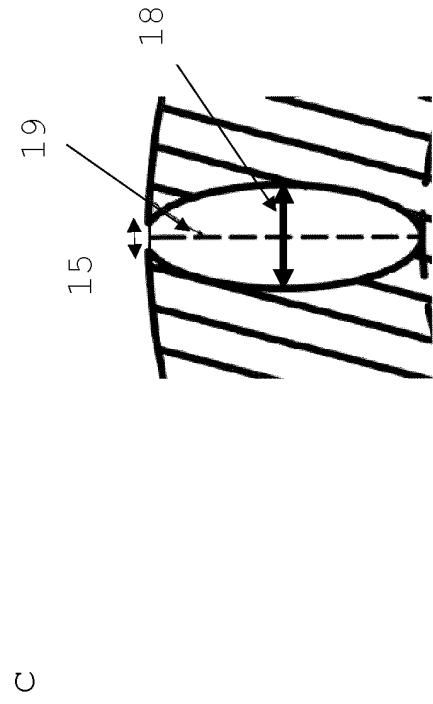
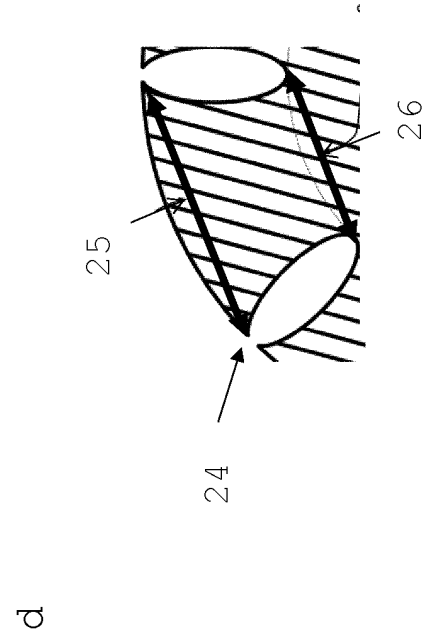
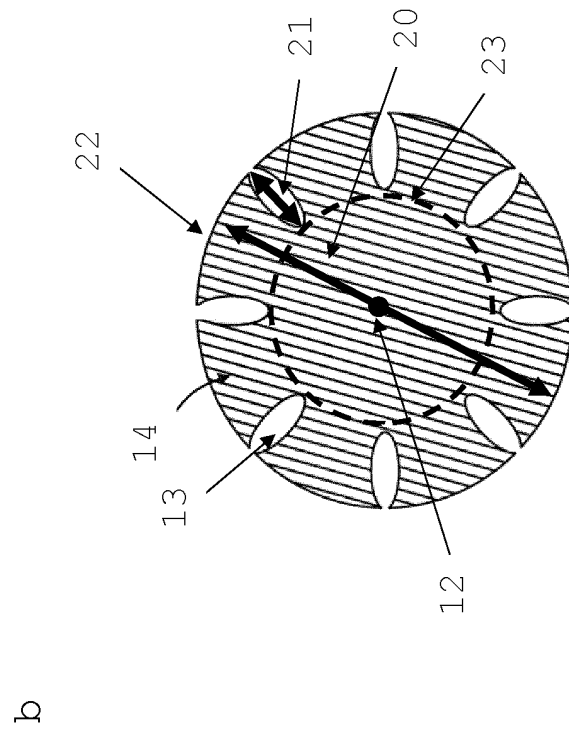
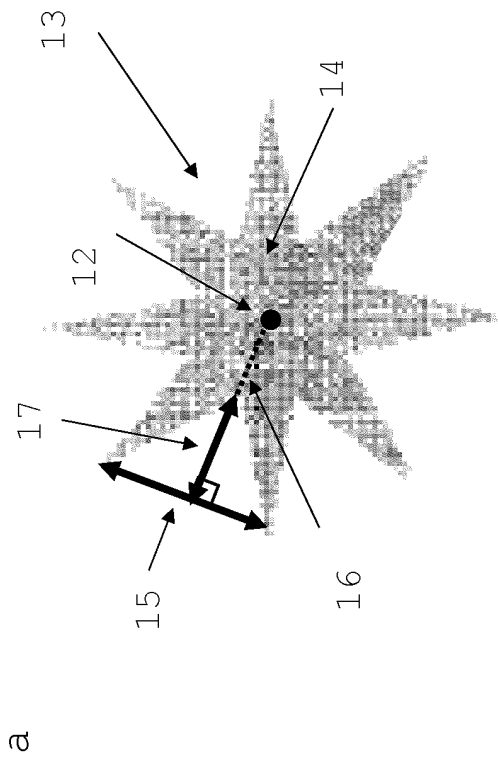
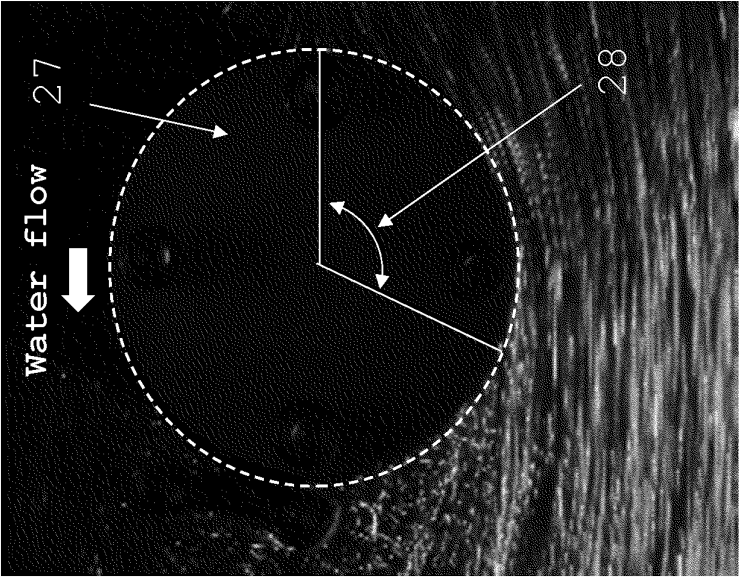


FIG. 11a



b



a

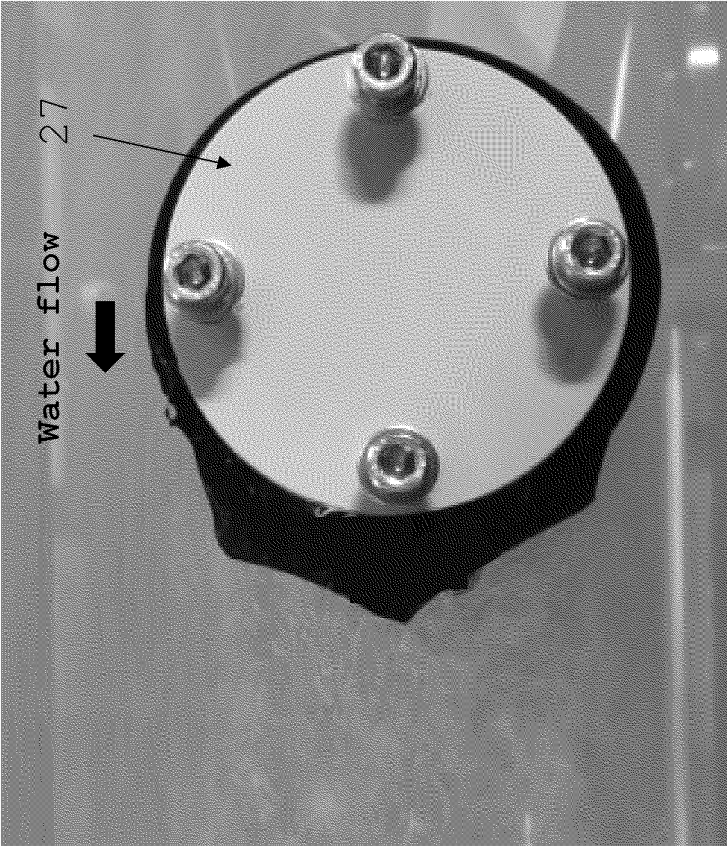


FIG. 12

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/043211

## A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. D03D15/40 (2021.01) i, A41D7/00 (2006.01) i, D03D15/56 (2021.01) i  
 FI: D03D15/00C, D03D15/08, A41D7/00B

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)

Int.Cl. D03D1/00-27/18, A41D7/00, D02G1/00-3/48, D02J1/00-13/00

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. |
|-----------|------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y<br>A    | WO 2011/152059 A1 (SEIREN CO., LTD.) 08 December 2011 (2011-12-08), example 1, paragraphs [0030], [0035], [0037] | 1-3, 7-11<br>4-6      |
| Y<br>A    | WO 2012/073648 A1 (TORAY INDUSTRIES, INC.) 07 June 2012 (2012-06-07), example 2                                  | 1-3, 7-11<br>4-6      |
| Y<br>A    | WO 2016/194763 A1 (MIZUNO CORP.) 08 December 2016 (2016-12-08), example 2                                        | 1-3, 7-11<br>4-6      |



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  
16 December 2020

Date of mailing of the international search report  
28 December 2020

Name and mailing address of the ISA/  
Japan Patent Office  
3-4-3, Kasumigaseki, Chiyoda-ku,  
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/043211

WO 2011/152059 A1 08 December 2011 (Family: none)

WO 2012/073648 A1 07 June 2012

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**REFERENCES CITED IN THE DESCRIPTION**

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- JP 1213403 A [0008]
- JP 8311751 A [0008]
- JP 2011256483 A [0008]
- JP 8041708 A [0008]
- JP 2012073648 A [0008]