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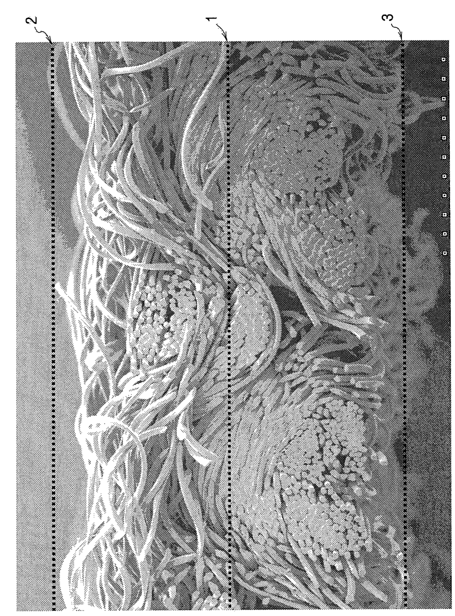
(54) FIBER STRUCTURE

(57) Provided is a fabric having a ground weave to which a hygroscopic polymer is fixed, and the fabric generates heat under moisture absorbing conditions and provides a more comfortable feeling to a person by temperature drop in moisture desorption conditions. A fiber structure is prepared by fixing a hygroscopic polymer to fibers of the fabric, and the front layer on the front surface side and the back layer on the back surface side have different fiber densities where the boundary between the front layer and the back layer is on the center line of a cross section of the fiber structure.

[Fig.1]



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Description

TECHNICAL FIELD

[0001] The present invention relates to a fiber structure of which temperature changes by moisture absorption and desorption of the structure.

BACKGROUND ART

[0002] Fabrics having heat retaining and generating properties have been proposed. The fabrics are produced by fixing hygroscopic polymers and generate heat when absorbing moisture.

[0003] For example, a knitted fabric disclosed in Patent Literature 1 comprises, in a layer to come into contact with the skin, synthetic fiber multifilaments having a larger single fiber fineness than that in a layer opposite to the layer to come into contact with the skin and is a fabric having a function of adsorbing a large amount of water.

[0004] Patent Literature 2 proposes an interior material having a sheet-like structure to which highly hygroscopic microparticles are fixed, and the temperature of the interior material rises by 3°C or higher when the interior material absorbs moisture.

[0005] In contrast, there has been no study about temperature drop by discharging water vapor from fabrics or about a woven fabric structure or a knitted fabric structure readily discharging water vapor.

[0006] In the field of automobiles, as pure electric vehicles and hybrid electric vehicles have been popularized, there is a demand for saving power consumption of the vehicles as much as possible and increasing travel distance and fuel efficiency. A way to achieve such electric power saving is to elevate the temperature setting of an air-conditioner in summer. In such a circumstance, in order to suppress uncomfortable feelings caused by an elevation in the temperature setting of an air-conditioner, automobile interior materials are required to have a function of dropping temperature. Unfortunately, fiber structures comprising conventional hygroscopic materials have insufficient temperature drop effect.

CITATION LIST

PATENT LITERATURE

[0007]

Patent Literature 1: Japanese Unexamined Patent Application Publication (Kokai) No. 2002-327316
Patent Literature 2: Japanese Unexamined Patent Application Publication (Kokai) No. 2003-96672

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0008] The present invention has an object to provide a fiber structure that can more greatly change the surface temperature of a fabric by moisture absorption or moisture desorption.

SOLUTION TO PROBLEM

[0009] The present invention adopts the means below in order to solve the problems. In order to solve the problems, the present invention comprises the aspects below.

[1] A fiber structure prepared by fixing a hygroscopic polymer to fibers of a fabric, a front layer on a front surface side of the fiber structure and a back layer on a back surface side of the fiber structure having different fiber densities, a boundary between the front layer and the back layer being on a center line of a cross section of the fiber structure.
[2] The fiber structure according to the above [1], wherein the fabric is in the form of a woven fabric or a knitted fabric, and the fabric has a ground weave in the back layer side.
[3] The fiber structure according to the above [1] or [2], wherein the hygroscopic polymer is a polymer of one or more monomers selected from sodium acrylamido-2-propanesulfonate, sodium styrenesulfonate, sodium isoprenesulfonate, sodium allylsulfonate, and sodium methallylsulfonate or a copolymer of one or more of the monomers and an additional monomer except the monomers.
[4] The fiber structure according to any one of the above [1] to [3], wherein the hygroscopic polymer is fixed to the fabric in a fixing ratio of 4 to 20% by mass.

[5] The fiber structure according to any one of the above [1] to [4], wherein the number of cross section fibers contained in the back layer divided by the number of cross section fibers contained in the front layer (the ratio of the numbers of cross section fibers) ranges from 2 to 10, where the fiber structure is cut in the direction perpendicular to a weaving or knitting direction of the fiber structure, and the center line of the cross section is the boundary between the front layer on the front surface side and the back layer on the back surface side.
[6] The fiber structure according to any one of the above [1] to [5], wherein the fabric has a weave selected from the following groups a to c:

group a: a warp knit that is produced with a knitting machine equipped with two or more reeds and has a two needle swing weave or a three needle swing weave for the back layer;
group b: a weft knit that is produced with an interlock knitting machine and has a patterned weave for the front layer; and
group c: a pile fabric having a ground weave.

[7] A vehicle interior material comprising the fiber structure according to any one of the above [1] to [6].

ADVANTAGEOUS EFFECTS OF INVENTION

[0010] The present invention provides a fiber structure that is in the form of a woven fabric or a knitted fabric, and the temperature of the fabric greatly changes by moisture absorption or moisture desorption.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

Fig. 1 is a cross-sectional photograph of a fiber structure in Example 1.
Fig. 2 is a cross-sectional photograph of a fiber structure in Example 2.
Fig. 3 is a cross-sectional photograph of a fiber structure in Example 3.
Fig. 4 is a cross-sectional photograph of a fiber structure in Comparative Example 1.
Fig. 5 is a cross-sectional photograph of a fiber structure in Comparative Example 2.

DESCRIPTION OF EMBODIMENTS

[0012] A fabric of the present invention will be described first. The fabric of the present invention may be in any form of a nonwoven fabric, a woven fabric, and a knitted fabric but is preferably in the forms of a woven fabric and a knitted fabric.
[0013] The fabric preferably has a ground weave, which affects physical properties such as breaking strength and tearing strength of the fabric, in the back layer. Such a structure allows the front layer to provide comfortable texture, touch, appearance, and other characteristics of the fabric.
[0014] In a fiber structure of the present invention, a front layer on a front surface side of the fiber structure and a back layer on a back surface side of the fiber structure have different fiber densities, and the boundary between the front layer and the back layer is on the center line of a cross section of the fiber structure.
[0015] The ground weave differs from a pile weave or a patterned weave in woven fabrics and knitted fabrics and is a weave that greatly affects physical properties such as breaking strength and tearing strength of a fabric. The ground weave for a warp knit produced with two or more reeds is a two needle swing weave or a three needle swing weave. The ground weave for a weft knit is a weave knitted with an interlock knitting machine. The ground weave for a woven fabric is a weave that fixes pile in a woven fabric having the pile, such as a moquette pile fabric. In the present invention, the ground weave is used as the back layer to come into contact with the skin, and the back layer of the fabric has a high fiber density. As a result, when a liquid containing a hygroscopic polymer or a raw material of a hygroscopic polymer is infiltrated into fibers by capillarity and the hygroscopic polymer is fixed to the fabric, a larger amount of the hygroscopic polymer can be fixed onto the fibers in the back layer than that onto the fibers in the front layer.
[0016] The fibers constituting the back layer preferably have a total fineness ranging from 30 to 500 dtex. Fibers having a total fineness of less than 30 dtex reduce the mechanical strength of the ground weave, and thus may cause broken thread or other defects when actually used as a vehicle interior material such as fabrics for seats. Fibers having a total fineness of more than 500 dtex excessively increase the amount of the fibers per unit volume of the back layer side, and thus are likely to make a whole fabric have a hard texture when a hygroscopic polymer is fixed to such a fabric. The single fiber fineness is preferably 0.8 to 5 dtex.
[0017] The fibers constituting the back layer preferably have a strength of 2.0 cN/dtex or more, more preferably 2.5 cN/dtex or more. In order to fix an appropriate amount of the hygroscopic polymer, the single fiber fineness is 0.5 to 5.0

dtex, preferably not less than 0.8 dtex and 5.0 dtex or less. These fibers are preferably in the forms of multifilaments and spun yarn.

[0018] In a preferred embodiment of the present invention, the number of cross section fibers contained in the back layer divided by the number of cross section fibers contained in the front layer (the ratio of the numbers of cross section fibers) preferably ranges from 2 to 10, where the fiber structure is cut in the direction perpendicular to a weaving or knitting direction of the fiber structure, and the center line of the cross section is the boundary between the front layer on the front surface side (the side not to come into contact with the skin) and the back layer on the back surface side (the side to come into contact with the skin). The ratio of the numbers of cross section fibers is more preferably 2.5 or more, even more preferably 3.0 or more and is more preferably 9.5 or less, even more preferably 9.0 or less.

[0019] The calculation method of the ratio of the numbers of cross section fibers will be described with reference to Figs. 1 to 5. Figs. 1 to 5 are cross-sectional photographs of fiber structures each cut in the direction perpendicular to a weaving or knitting direction of the fiber structure. The cross section of the fiber structure is divided along the center line 1 into a side on the front surface 2 and another side on the back surface 3. An area from the center line 1 to the front surface 2 is regarded as a front layer, and another area from the center line 1 to the back surface 3 is regarded as a back layer. The number of fibers contained in each layer is counted as the number of cross section fibers in a corresponding layer.

[0020] A fiber structure having a ratio of the numbers of cross section fibers ranging from 2 to 10 lowers the relative humidity in an environment and has a much lower temperature than an environmental temperature. The inventors of the present invention suppose that the reason is as below.

[0021] For the fixation of a hygroscopic polymer to a fabric, to a fabric containing a larger number of fibers per unit volume, a larger amount of the hygroscopic polymer is fixed among the fibers. Thus, in a fabric that comprises the back layer containing a larger number of cross section fibers than the number of cross section fibers contained in the front layer, a larger amount of the hygroscopic polymer is present in the back layer than in the front layer. The back layer, which contains a larger amount of the hygroscopic polymer, discharges a larger amount of water vapor. The water vapor discharged from the hygroscopic polymer in the back layer is discharged from the surface of the back layer and also passes among the fibers of the fabric. The front layer contains a smaller number of the fibers and a larger space than those in the back layer. This structure allows the water vapor to readily pass through the front layer, and thus the water vapor is readily discharged from the surface of the front layer into air. The water vapor reached form the back layer to the front layer is discharged from the surface of the front layer into air. This phenomenon lowers the humidity in the fabric, and the heat of vaporization of the water vapor discharged into to air lowers the temperature of the fabric.

[0022] In a fabric having a ratio of the numbers of cross section fibers of about 1, the amount of the fixed polymer in the front layer is substantially equal to that of the fixed polymer in the back layer. This structure reduces the difference in discharge amount of water vapor between the back layer and the front layer and also reduces the difference in volume of space, through which water vapor passes, between the back layer and the front layer, and thus the water vapor discharged from the back layer is unlikely to vaporize from the surface of the front layer. In addition, the water vapor supplied from the back layer is absorbed by the polymer in the front layer, and thus the temperature of the fabric is unlikely to drop.

[0023] A fabric having an excessively large ratio of the numbers of cross section fibers disadvantageously reduces the heat of vaporization of water vapor discharged through the front layer into air, and thus the temperature of the fabric is unlikely to drop. For the reasons above, the ratio of the numbers of cross section fibers (the number of cross section fibers contained in the back layer/the number of cross section fibers contained in the front layer) is preferably 2 to 10. The ratio of the numbers of cross section fibers is more preferably 2.5 or more, even more preferably 3.0 or more and is more preferably 9.5 or less, even more preferably 9.0 or less.

[0024] In an embodiment of the fiber structure of the present invention, the weave is one selected from the groups a to c. Also in the fiber structure, the front layer on the front surface side and the back layer on the back surface side have different fiber densities, where the boundary between the front layer and the back layer is on the center line of the cross section of the fiber structure.

[0025] Group a: a warp knit that is produced with a knitting machine equipped with two or more reeds and has a two needle swing weave or a three needle swing weave for the back layer.

[0026] Group b: a weft knit that is produced with an interlock knitting machine and has a patterned weave for the front layer.

[0027] Group c: a pile fabric having a ground weave.

[0028] The fiber structure also preferably has a ratio of the numbers of cross section fibers of 2 to 10. The ratio of the numbers of cross section fibers is more preferably 2.5 or more, even more preferably 3.0 or more and is more preferably 9.5 or less, even more preferably 9.0 or less. The fiber structure also has a much lower temperature than an environmental temperature due to a reduction in relative humidity in an environment. The reason is the same as the above.

[0029] The group a is preferably a warp knit that is produced with a knitting machine equipped with two or more reeds and has a two needle swing weave or a three needle swing weave as the ground weave to be the back layer. Examples of the ground weave for the two needle swing weave include 1-0/2-3, 2-3/1-0, 0-1/3-2, and 3-2/0-1. Examples of the ground weave for the three needle swing weave include 1-0/3-4, 3-4/1-0, 0-1/4-3, and 0-1/3-4. The ground weave containing at least one or more of the weaves may be combined with other weaves. The front layer constituting the group a may have a one to three needle swing weave, an atlas weave, and other derivative weave, and a weave without threads in which no needle is threaded is also preferred.

[0030] The group b is a weft knit that is produced with an interlock knitting machine and has a patterned weave for the front layer. The ground weave constituting the back layer is preferably a tight weave such as a plain knitting weave and a rib knitting weave, and the front layer of the weft knit preferably has a patterned weave as a little loose weave.

[0031] The group c is a pile fabric having a ground weave and is preferably a moquette pile fabric comprising rayon fibers in the ground weave and a velvet fabric as a double-woven fabric.

[0032] The fabric having the fiber structure of the present invention preferably has a surface temperature drop of 1.5°C to 4°C when an air-conditioner is operated in an atmosphere at 40°C and a relative humidity of 80%, which should be the atmosphere in a car in summer, and the temperature and humidity conditions are changed from the atmosphere condition to an atmosphere at 35°C and a relative humidity of 70% within 10 minutes. When the temperature and humidity conditions are changed from an atmosphere at 40°C and a relative humidity of 80% to an atmosphere at 35°C and a relative humidity of 70% within 10 minutes, the fiber structure of the present invention to which a hygroscopic polymer is fixed preferably has a surface temperature 1.5°C to 4.0°C lower than that of a fiber structure to which no hygroscopic polymer is fixed. The lower limit is more preferably 1.7°C or more, even more preferably 1.9°C or more.

[0033] The hygroscopic polymer fixed onto fibers of the fabric of the present invention preferably has an increase in mass by moisture absorption (hereinafter called moisture absorption ratio) of 10 to 75%, more preferably 15% or more, even more preferably 20% or more when the temperature and humidity conditions are changed from an atmosphere at 20°C and a relative humidity of 65% to an atmosphere at 30°C and a relative humidity of 90%, in terms of hygroscopic properties. The moisture absorption ratio is more preferably 70% or less, even more preferably 65% or less. The hygroscopic polymer satisfying such hygroscopic properties is preferably a polymer of a monomer selected from vinyl group-containing monomers having, as a functional group, a sulfo group, a carboxy group, a hydroxy group, an amido group, or alkali metal salts (preferably a sodium salt) of them or a copolymer containing at least one or more of such monomers. Examples of the polymer having a sulfo group preferably include poly(sodium acrylamido-2-propanesulfonate), poly(sodium styrenesulfonate), poly(sodium isoprenesulfonate), poly(sodium allylsulfonate), and poly(sodium methallylsulfonate). Examples of the polymer having a carboxy group preferably include poly(sodium acrylate). Examples of the polymer having a hydroxy group preferably include polyethylene glycol and polyvinyl alcohol. Examples of the polymer having an amido group preferably include poly(N-methylolacrylamide) and polyacrylamide. Among these hygroscopic monomers, sodium 2-acrylamido-2-methylsulfonate is particularly preferred in terms of high hygroscopicity.

[0034] In addition to these polymers, a copolymer containing additional monomer units may be used.

[0035] In the present invention, in order to improve the fixing properties of the hygroscopic polymer to fibers, a cross-linking agent is preferably used to make the hygroscopic polymer have a cross-linked structure. Examples of the cross-linking agent include polyfunctional epoxy compounds, polyfunctional isocyanate compounds, urea resins, melamine resins, and compounds having at least two polymerizable double bonds.

[0036] Examples of the compound having polymerizable double bonds include compounds prepared by esterifying terminal hydroxy groups of polyethylene glycols (for example, having a number average repeat unit of 250) with (meth)acrylic acid. For example, a compound prepared by esterifying a polyethylene glycol having an average repeat of ethylene oxide of 9 to 23 with two methacrylic acids can be used.

[0037] The monomers can be polymerized on fibers constituting the fabric to yield the hygroscopic polymer. The monomer to yield the hygroscopic polymer and, as necessary, a polymerization initiator can be infiltrated among fibers constituting the fabric. As necessary, a cross-linking agent may also be infiltrated. Examples of the polymerization initiator preferably include inorganic polymerization initiators such as ammonium persulfate, potassium persulfate, and hydrogen peroxide and organic polymerization initiators such as 2,2'-azobis(2-amidinopropane) dihydrochloride, 2,2'-azobis(N,N-dimethylene isobutylamidine) dihydrochloride, and 2-(carbamolyazo)isobutyronitrile.

[0038] As for the method for fixing the hygroscopic polymer to fibers, a treatment liquid containing a monomer, a cross-linking agent (as necessary), a polymerization initiator (as necessary), and a solvent or a dispersion medium is applied to fibers by padding and then the fibers are heated and dried. Subsequently, the fibers are maintained under a high temperature condition with steam or a similar means, thus the monomer and the like are polymerized, and the resulting hygroscopic polymer is fixed onto the fiber surface. Another method for fixing the hygroscopic polymer to fibers is exemplified by a method of impregnating a fabric with a solution of a polymer such as poly(sodium acrylamido-2-propanesulfonate), sodium styrenesulfonate, sodium isoprenesulfonate, sodium allylsulfonate, and sodium methallylsulfonate and drying the fabric.

[0039] In the padding, the treatment liquid for polymerization preferably has a concentration of monomer to yield the hygroscopic polymer of 20 to 150 g/L. For the polymerization with a cross-linking agent, the treatment liquid preferably has a cross-linking agent concentration of 20 to 150 g/L. For the polymerization with a polymerization initiator, the treatment liquid preferably has a polymerization initiator concentration of 1 to 10 g/L, more preferably 3 g/L or more, even more preferably 5 g/L or more.

[0040] For the treatment with a solution of the hygroscopic polymer, the polymer solution preferably has a concentration of 20 to 150 g/L. In each case of polymerization and using a polymer solution, a treatment liquid having a low concentration results in a reduction in amount of the hygroscopic polymer fixed, and this deteriorates cooling performance. A treatment liquid having a high concentration causes the hygroscopic polymer to be fixed in an excess amount, and this hardens the texture of the fiber structure.

[0041] For the heat treatment, in order to maintain the activity of the polymerization initiator, a normal-pressure steamer or a high-pressure steamer is preferably used, and the temperature for the steam treatment is preferably 80°C to 170°C.

[0042] The heat treatment time is arbitrary and is preferably 5 minutes to 15 minutes. The heat treatment time is more preferably 6 to 15 minutes, even more preferably 7 to 15 minutes. The steam pressure is arbitrary and is preferably in a range from 0.09 to 0.50 MPa in order to accelerate polymerization.

[0043] The processing method for fixing the hygroscopic polymer to fibers of the fabric is preferably padding, spraying, and roll coating and is specifically preferably padding capable of infiltrating an agent into the fabric.

[0044] The hygroscopic polymer is preferably fixed to fibers of the fabric in a fixing ratio of 4 to 20% by mass relative to the fabric. A fabric containing fibers to which the hygroscopic polymer is fixed in a ratio of less than 4% by mass obtains insufficient hygroscopic properties and thus fails to achieve a large temperature change. A fabric containing fibers to which the hygroscopic polymer is fixed in a ratio of more than 20% by mass gives the impression of hard texture. The fixing ratio of the hygroscopic polymer to fibers of the fabric is more preferably 5 to 18% by mass.

[0045] Examples of the fibers constituting the fabric of the present invention include synthetic fibers such as polyester fibers and polyamide fibers, natural fibers such as cotton, and rayon, and these fibers may be used singly or as a mixture of two or more of them. From the viewpoint of the reduction in consumption of oil resources, the fibers used are preferably biomass fibers formed of materials derived from plants, such as polyethylene terephthalate fibers, polytrimethylene terephthalate fibers, polyamide fibers, and polylactic acid fibers. In particular, the polytrimethylene terephthalate fibers provide good texture, touch, and a comfortable feeling for sitting due to a low Young's modulus and thus are specifically preferably used. The polylactic acid fibers can be produced from 100% plant materials, are most contributable fibers to the reduction in consumption of oil resources, and thus are preferred.

[0046] The fibers are used in the forms of multifilaments, spun yarns, and the like. For fibers required to achieve fabric strength or abrasion resistance, the multifilaments are preferred. The preferred total fineness and single fiber fineness of the biomass fibers are as described in paragraph [0013].

[0047] The fibers may contain dulling agents such as titanium oxide powder, dyes, pigments, flame retardants, moisture absorbents, heat stabilizers, ultraviolet absorbers, antimicrobial agents, fungicides, deodorants, and other additives as long as the effect of the invention is not impaired.

[0048] The light fastness of the fiber structure of the present invention is preferably the fourth or higher class. When the light fastness of a fiber structure is lower than the fourth class, which is determined on the basis of the grey scale for color change after irradiation with a fade meter at 83°C for 200 hours, the fiber structure causes color fading or other defects when used for car seats.

[0049] The fiber structure of the present invention is preferably used for clothing such as underwear, sportswear, and shirts; interior goods such as chair upholstery; and vehicle interior materials. The fiber structure particularly preferably used for vehicle interior materials, specifically for seats. The fiber structure used for seats is preferably used for main materials, frames, back linings, headrests, seat covers, headrest covers, and other parts.

EXAMPLES

[0050] The present invention will now be described in further detail with reference to examples. The present invention is not limited to the following examples, and various modifications and changes may be made without departing from the technical scope of the present invention. Each evaluation in the following examples and comparative examples is carried out by the methods below.

<u>Measurement method</u>

(1) Tensile strength (cN/dtex) and elongation (%)

[0051] The tensile strength (cN/dtex) and the elongation (%) of a thread were determined under the constant-rate extension conditions in accordance with JIS L 1013 (8.5.1) (2010) with TENSILON (registered trademark) UCT-100 manufactured by ORIENTEC Co, Ltd. For the measurement, the sample length was 200 mm, and the tensile speed was 200 m/min. The tensile strength was determined by dividing a maximum strength on a stress-strain curve by a total fineness, and the elongation was determined as an elongation at the maximum strength on the stress-strain curve.

(2) Weight per unit area (g/m^2)

[0052] In accordance with the method specified in JIS L 1096 (8.4.2) (2010), the weight unit area (g/m^2) of a fabric was determined.

(3) Fixing ratio of hygroscopic polymer

[0053] From a fabric to which no hygroscopic polymer was fixed, a square sample having a size of 30 cm × 30 cm was prepared. The sample was left in a constant temperature and humidity room controlled at a temperature of 24°C and a relative humidity of 60% for 24 hours, and the fabric weight (g) before the treatment (before the fixation of a hygroscopic polymer) was determined. The fabric weight (g) after the treatment of fixing a hygroscopic polymer was then determined under the same constant temperature and humidity condition as that for the fabric before the treatment. The fixing ratio of the hygroscopic polymer was calculated in accordance with the following equation:

Fixing ratio of hygroscopic polymer (%) = [fabric weight after treatment (g) - fabric weight before treatment (g)]/fabric weight before treatment (g) × 100

(4) Moisture absorption ratio of fabric (%)

[0054] From a fabric before the treatment (before the fixation of a hygroscopic polymer), about 1.0 g of sample was prepared. The sample was dried in a hot-air drier at 105°C for 24 hours and then weighed (W1). Next, the sample was left in a thermo-hygrostat controlled at 20°C and a relative humidity of 65% for 24 hours and then was weighed (W2). Subsequently, the sample was left in a thermo-hygrostat controlled at 30°C and a relative humidity of 90% for 24 hours and then was weighed (W3). From the test results, the moisture absorption ratio of the fabric was calculated in accordance with the following equation:

Moisture absorption ratio of fabric (%) = [(W3 - W1)/W1 - (W2 - W1)/W1] × 100

(5) Moisture absorption ratio of hygroscopic polymer

[0055] The moisture absorption ratio of a fabric after the treatment (after the fixation of a hygroscopic polymer) was calculated from W1, W2, and W3 under the same conditions as in paragraph [0047]. On the basis of the moisture absorption ratio of the fabric after the treatment, the moisture absorption ratio of the fabric before the treatment calculated in paragraph [0047], and the fixing ratio of the hygroscopic polymer calculated in paragraph [0046], the moisture absorption ratio of the hygroscopic polymer was calculated in accordance with the following equation:

Moisture absorption ratio of hygroscopic polymer (%) = (moisture absorption ratio of fabric after treatment - moisture absorption ratio of fabric before treatment) × 100/fixing ratio of hygroscopic polymer

(6) Ratio of the numbers of cross section fibers

[0056] A fabric was cut in the direction perpendicular to a weaving or knitting direction. The cut sample was subjected to metal deposition with a metal deposition apparatus (trade name: E1010) manufactured by Hitachi, Ltd. The sample was then installed in a scanning electron microscope (trade name: S-3500) manufactured by Hitachi, Ltd. and photographed at a magnification of 30 to 100. As shown in Fig. 1 to Fig. 5, the cross section in each micrograph was divided along the center line 1 into a side on the front surface 2 and another side on the back surface 3. Each number of fibers contained in a front layer from the center line 1 to the front surface 2 and in a back layer from the center line 1 to the back surface 3 was counted as the number of cross section fibers. The equation for calculating the ratio of the numbers of cross section fibers is shown below.

[0057] The ratio of the numbers of cross section fibers = (the number of cross section fibers contained in the back layer)/(the number of cross section fibers contained in the front layer)

(7) Surface temperature drop of fabric

[0058] From each of a fabric (A) after the fixation of a hygroscopic polymer and a fabric (B) before the fixation of the hygroscopic polymer, a square sample having a size of 25 cm × 25 cm was prepared. The sample was hung in a constant temperature and humidity room controlled at a temperature of 40°C and a relative humidity of 80% and left for 3 hours. The temperature and humidity conditions in the constant temperature and humidity room were then changed to 35°C and a relative humidity of 70%. When a hygrothermograph in the constant temperature and humidity room indicated 35°C and a relative humidity of 70%, each surface temperature of the fabric (A) and the fabric (B) was determined with a thermographic camera (manufactured by NEC Avio Infrared Technologies Co., Ltd., model: TH7102MX) installed in the constant temperature and humidity room. The surface temperature drop of the fabric was calculated in accordance with the following equation:

Surface temperature drop of fabric = surface temperature of (B) - surface temperature of (A)

(8) Coolness during sitting

[0059] The fabric of the present invention was bonded to a car seat so that the front surface will come into contact with a person. The car seat was placed in a constant temperature and humidity room controlled at 40°C and a relative humidity of 80%, which should be the atmosphere in a car in summer. A test subject sit on the seat for 5 minutes. The temperature and humidity conditions were then changed to 25°C and a relative humidity of 40%. The test subject sit for another 3 minutes and carried out a sensory evaluation of the coolness of the seat surface after sitting. Ten test subjects evaluated the coolness. A sample evaluated to have coolness by eight or more test subjects is indicated by "very good," a sample evaluated to have coolness by four to seven test subjects is indicated by "good," and a sample evaluated to have coolness by three or less test subjects is indicated by "poor."

(9) Texture

[0060] The fabric of the present invention was used, and ten panelists evaluated the sense of touch of the fabric. The total score from the respective panelists gives a comprehensive evaluation.

Evaluation standards

[0061]

Score 3: A soft touch fabric having high surface smoothness.
Score 2: A fabric having average softness and average surface smoothness.
Score 1: A fabric having rough, hard feeling and a rough surface.

Comprehensive evaluation

[0062]

Very good: 25 to 30 points
Good: 17 to 24 points
Poor: 10 to 16 points

(10) Light fastness

[0063] A fabric was irradiated with an ultraviolet autofade meter (manufactured by Suga Test Instruments Co., Ltd., model: U48AUHB) for 200 hours under a condition at a black-panel temperature of 83°C, and then the change in color was classified into the first to fifth classes using a grey scale for color change in accordance with JIS L 0804 (2010).

Reference Example 1

Core-sheath composite drawn yarn

[0064] Core-sheath composite drawn yarn with 84T48F was produced from polyethylene terephthalate (PET) as the core and polytrimethylene terephthalate (PTT) as the sheath at a mass ratio of 3:7. The core-sheath composite drawn yarn was specifically produced as below.

[0065] The materials were supplied into a melt spinning machine at the ratio and processed in a spinneret into a core-sheath structure having a single core. The composite was spun at a spinning temperature of 280°C. The spun yarn was preheated at a rotation speed of the first roll of 2,700 m/min and a roll temperature of 40°C, then drawn with heat at a rotation speed of the second roll of 4,050 m/min and a roll temperature of 150°C, and wound up at a winding speed of 3,700 m/min, yielding core-sheath composite drawn yarn with 84 dtex-48 f (filament). The core-sheath composite drawn yarn had a tensile strength of 3.3 cN/dtex and an elongation of 45%.

Reference Example 2

Polyethylene terephthalate false-twisted yarn

[0066] Production methods of polyethylene terephthalate false-twisted yarn with 84T36F and polyethylene terephthalate false-twisted yarn with 167T48F will be described. Melt spinning was carried out at a spinning temperature of 284°C and a spinning speed of 3,000 m/min using a spinneret having a size and a shape suitable for each false-twisted yarn, and the resulting undrawn yarn was wound. Next, false twisting was performed at a first heater (noncontact type) temperature of 230°C, an overfeed ratio of 0.9, a second heater (noncontact type) temperature of 200°C, a draw ratio of 1.69, and a machining speed of 600 m/min, yielding polyethylene terephthalate false-twisted yarn with 84 dtex-36 f (filament) and polyethylene terephthalate false-twisted yarn with 167 dtex-48 f (filament). The polyethylene terephthalate false-twisted yarn with 84T36F had a tensile strength of 3.6 cN/dtex and an elongation of 23%, and the polyethylene terephthalate false-twisted yarn with 167T48F had a tensile strength of 4.0 cN/dtex and an elongation of 22%.

Reference Example 3

Polyethylene terephthalate drawn yarn

[0067] A production method of polyethylene terephthalate drawn yarn with 84T48F (84 dtex-48 f (filament)) will be described. Melt spinning was carried out at a spinning temperature of 290°C and a spinning speed of 1,500 m/min, and the resulting undrawn yarn was wound. Next, the undrawn yarn was drawn with a drawing machine at a preheat roller temperature of 90°C, a heat treatment roller temperature of 150°C, a draw ratio of 3.01, and a machining speed of 970 m/min, yielding polyethylene terephthalate drawn yarn with 84 dtex-48 f. The drawn yarn had a tensile strength of 4.0 cN/dtex and an elongation of 35%.

Example 1

[0068] A 28-gauge tricot machine was used. With four reeds, the core-sheath composite drawn yarn with 84 dtex-48 f (filament) of Reference Example 1 was supplied to L1 (for a ground weave) in a full set thread arrangement, the polyethylene terephthalate false-twisted yarn with 84 dtex-36 f (filament) of Reference Example 2 was supplied to L2 (for a ground weave) in a full set thread arrangement, the core-sheath composite drawn yarn with 84 dtex-48 f (filament) of Reference Example 1 was supplied to L3 and L4 in a thread arrangement in which a thread is alternately pushed in and pulled out, and the yarns were knitted at a course density on the machine of 42 C/2.54 cm to prepare a gray fabric in the form of weave 1.

Weave 1, Weave of group a

[0069]

L1: 84 dtex-48 f (PET/PTT core-sheath composite drawn yarn), 1-2/1-0 (threading: full set)
L2: 84 dtex-36 f (PET false-twisted yarn), 3-4/1-0 (threading: full set)
L3: 84 dtex-48 f (PET/PTT core-sheath composite drawn yarn), 2-3/2-1 1-0/1-2 (threading: a thread is alternately pushed in and pulled out)
L4: 84 dtex-48 f (PET/PTT core-sheath composite drawn yarn), 1-0/1-2 2-3/2-1 (threading: a thread is alternately pushed in and pulled out)

[0070] The warp knitted fabric obtained was dyed using a jet dyeing machine with 0.24% owf "Dianix" (registered trademark, hereinafter the same applies) KIS-U, 0.11% owf "Dianix" AM-2R, and 0.24% owf "Dianix" GL-FS as dyes and with 1% owf fast-P (trade name) manufactured by Ciba as a light stabilizer while the temperature was increased from room temperature to a dyeing temperature of 130°C at a temperature increase rate of 1°C and maintained at a dyeing temperature of 130°C for 25 minutes.
[0071] The warp knitted fabric dyed as above was next immersed in a treatment liquid prepared in accordance with the formulation 1 to infiltrate a hygroscopic polymer. The fabric was then squeezed with a mangle so as to give a pick up ratio of 90% and dried in a dryer at 120°C for 2 minutes.

<u>Formulation 1</u>

[0072]

* Sodium 2-acrylamido-2-methylpropane sulfonate (trade name: Gracet T505, manufacturer: Hokko Chemicals Co., Ltd.): 120 g/L
* A dimethacrylate of "polyethylene glycol having a number average degree of polymerization of 23" (trade name: Gracet T303, manufacturer: Hokko Chemicals Co., Ltd.) as a cross-linking agent: 120 g/L
* Ammonium persulfate (manufacturer: Nacalai Tesque) as a polymerization initiator: 5 g/L
* Water

[0073] After the warp knitted fabric dyed was impregnated with the hygroscopic polymer and then dried as above, the fabric was treated with a normal-pressure steamer at 105°C for 10 minutes, then washed with hot water, and dried. Next, the dried fabric was further dried in a dryer at 160°C for 1 minute, giving a fiber structure of Example 1 having a weight per unit area of 310 g/m^2, a fixing ratio of the hygroscopic polymer of 7.3%, a moisture absorption ratio of the fabric of 2.4%, and a moisture absorption ratio of the hygroscopic polymer of 32.8%.
[0074] The fiber structure was cut in a direction perpendicular to the knitting direction, and the cross-section was observed under an electron microscope. Fig. 1 is the electron micrograph (×50). The observation result indicated that the number of cross section fibers contained in the front layer was 235, the number of cross section fibers contained in the back layer was 850, and the ratio of the numbers of cross section fibers was 3.62. The result also revealed that the hygroscopic polymer was fixed onto the fibers of the knitted fabric.
[0075] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 2.1°C, the coolness during sitting was "very good", the texture was "very good", the light fastness was class 4, and the fabric provided a highly comfortable feeling when a person sit.

<u>Example 2</u>

[0076] A 28-gauge tricot machine and four reeds were used, the polyethylene terephthalate false-twisted yarn with 167 dtex-48 f (filament) of Reference Example 2 was supplied to L1 (ground weave) in a full set thread arrangement, the core-sheath composite drawn yarn with 84 dtex-48 f (filament) of Reference Example 1 was supplied to L2 and L3 in a thread arrangement in which a thread is alternately pushed in and pulled out, and the yarns were knitted at a course density on the machine of 50 C/2.54 cm to prepare a knitted fabric in the form of weave 2.

<u>Weave 2, Weave of group a</u>

[0077]

L1: 167 dtex-48 f (PET false-twisted yarn), 1-0/3-4 (threading: full set)
L2: 84 dtex-48 f (PET/PTT core-sheath composite drawn yarn), 2-3/2-1 1-0/1-2 (threading: a thread is alternately pushed in and pulled out)
L3: 84 dtex-48 f (PET/PTT core-sheath composite drawn yarn), 1-0/1-2 2-3/2-1 (threading: a thread is alternately pushed in and pulled out)

[0078] The knitted fabric was then dyed in the same manner as in Example 1, and a hygroscopic polymer was fixed onto the fabric, giving a fiber structure of Example 2 having a weight per unit area of 275 g/m^2, a fixing ratio of the hygroscopic polymer of 12.3%, a moisture absorption ratio of the fabric of 3.0%, and a moisture absorption ratio of the hygroscopic polymer of 24.3%.

[0079] The fiber structure was cut in a direction perpendicular to the knitting direction, and the cross-section was observed under an electron microscope. Fig. 2 is the electron micrograph (×100). The observation result indicated that the number of cross section fibers contained in the front layer was 121, the number of cross section fibers contained in the back layer was 485, and the ratio of the numbers of cross section fibers was 4.01. The result also revealed that a large amount of the hygroscopic polymer was fixed to the ground weave of the knitted fabric.

[0080] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 1.9°C, the coolness during sitting was "very good", the texture was "very good", the light fastness was class 4, and the fabric provided a highly comfortable feeling when a person sit.

<u>Example 3</u>

[0081] A 28-gauge tricot machine and three reeds were used, the core-sheath composite drawn yarn with 84 dtex-48 f (filament) of Reference Example 1 was supplied to L1 (ground weave) and L2 (ground weave) in a full set thread arrangement, the polyethylene terephthalate false-twisted yarn with 84 dtex-36 f (filament) of Reference Example 2 was supplied to L3 in a full set thread arrangement, and the yarns were knitted at a course density on the machine of 64 C/2.54 cm to prepare a gray fabric in the form of weave 3.

<u>Weave 3, Weave of group a</u>

[0082]

L1: 84 dtex-48 f (PET/PTT core-sheath composite drawn yarn), 2-3/1-0 (threading: full set)
L2: 84 dtex-48 f (PET/PTT core-sheath composite drawn yarn), 1-0/1-2 (threading: full set)
L3: 84 dtex-36 f (PET false-twisted yarn), 1-0/3-4 (threading: full set)

[0083] Next, the knitted fabric was dyed in the same manner as in Example 1 and then was raised with a raising machine. A hygroscopic polymer was fixed to the raised fabric in the same manner as in Example 1, giving a fiber structure of Example 3 having a weight per unit area of 330 g/m^2, a fixing ratio of the hygroscopic polymer of 12.5%, a moisture absorption ratio of the fabric of 3.0%, and a moisture absorption ratio of the hygroscopic polymer of 24.0%.

[0084] The fiber structure was cut in a direction perpendicular to the knitting direction, and the cross-section was observed under an electron microscope. Fig. 3 is the electron micrograph (×50). The observation result indicated that the number of cross section fibers contained in the front layer was 220, the number of cross section fibers contained in the back layer was 1,380, and the ratio of the numbers of cross section fibers was 6.27. The result also revealed that the hygroscopic polymer was fixed to the ground weave of the knitted fabric.

[0085] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 2.3°C, the coolness during sitting was "very good", the texture was "very good", the light fastness was class 4, and the fabric provided a highly comfortable feeling when a person sit.

<u>Example 4</u>

[0086] A 28-gauge tricot machine and four reeds were used to prepare a gray fabric in the form of weave 4 by knitting in the same condition as in Example 1 except that the polyethylene terephthalate drawn yarn with 84 dtex-48 f (filament) of Reference Example 3 was supplied to L1 (ground weave), L3, and L4.

<u>Weave 4, Weave of group a</u>

[0087]

L1: 84 dtex-48 f (PET drawn yarn), 1-2/1-0 (threading: full set)
L2: 84 dtex-36 f (PET false-twisted yarn), 3-4/1-0 (threading: full set)
L3: 84 dtex-48 f (PET drawn yarn), 2-3/2-1 1-0/1-2 (threading: a thread is alternately pushed in and pulled out)
L4: 84 dtex-48 f (PET drawn yarn), 1-0/1-2 2-3/2-1 (threading: a thread is alternately pushed in and pulled out)

[0088] Next, the knitted fabric was dyed in the same manner as in Example 1, and a hygroscopic polymer was fixed to the fabric, giving a fiber structure of Example 4 having a weight per unit area of 318 g/m^2, a fixing ratio of the hygroscopic polymer of 7.0%, a moisture absorption ratio of the fabric of 2.3%, and a moisture absorption ratio of the hygroscopic polymer of 32.8%. The fiber structure was cut in a direction perpendicular to the knitting direction, and the cross-section was observed under an electron microscope. The observation result indicated that the number of cross section fibers contained in the front layer was 245, the number of cross section fibers contained in the back layer was 854, and the ratio of the numbers of cross section fibers was 3.49.

[0089] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 2.0°C, the coolness during sitting was "very good", the texture was "good", the light fastness was class 4, and the fabric provided a comfortable feeling when a person sit.

Example 5

[0090] A 28-gauge tricot machine and three reeds were used to prepare a gray fabric in the form of weave 5 by knitting in the same condition as in Example 3 except that the polyethylene terephthalate drawn yarn with 84 dtex-48 f (filament) of Reference Example 3 was supplied to L1 (ground weave) and L2 (ground weave).

Weave 5, Group a

[0091]

L1: 84 dtex-48 f (PET drawn yarn), 2-3/1-0 (threading: full set)
L2: 84 dtex-48 f (PET drawn yarn), 1-0/1-2 (threading: full set)
L3: 84 dtex-36 f (PET false-twisted yarn), 1-0/3-4 (threading: full set)

[0092] Next, the knitted fabric was dyed in the same manner as in Example 1 and then was raised with a raising machine. A hygroscopic polymer was fixed to the raised fabric in the same manner as in Example 1, giving a fiber structure of Example 5 having a weight per unit area of 340 g/m^2, a fixing ratio of the hygroscopic polymer of 12.6%, a moisture absorption ratio of the fabric of 2.9%, and a moisture absorption ratio of the hygroscopic polymer of 23.0%. The fiber structure was cut in a direction perpendicular to the knitting direction, and the cross-section was observed under an electron microscope. The observation result indicated that the number of cross section fibers contained in the front layer was 231, the number of cross section fibers contained in the back layer was 1,417, and the ratio of the numbers of cross section fibers was 6.13.

[0093] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 2.4°C, the coolness during sitting was "very good", the texture was "good", the light fastness was class 4, and the fabric provided a comfortable feeling when a person sit.

Example 6

[0094] A 28-gauge interlock circular knitting machine was used. Polyethylene terephthalate false-twisted yarn with 84 dtex-72f (filament) was supplied to the back fabric (ground weave), the polyethylene terephthalate false-twisted yarn with 84 dtex-36 f (filament) of Reference Example 2 was supplied to the front fabric, and the yarns were knitted at a course density on the machine of 38 course/2.54 cm to prepare a gray fabric where the front fabric was a patterned weave and the back fabric was a plain knitted weave. The knitted fabric had a structure of group b.

[0095] Next, the knitted fabric was dyed in the same manner as in Example 1, and then a hygroscopic polymer was fixed to the fabric, giving a fiber structure of Example 6 having a weight per unit area of 232 g/m^2, a fixing ratio of the hygroscopic polymer of 8.6%, a moisture absorption ratio of the fabric of 2.0%, and a moisture absorption ratio of the hygroscopic polymer of 23.2%. The fiber structure was cut in a direction perpendicular to the knitting direction, and the cross-section was observed under an electron microscope. The observation result indicated that the number of cross section fibers contained in the front layer was 161, the number of cross section fibers contained in the back layer was 322, and the ratio of the numbers of cross section fibers was 2.00.

[0096] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 2.6°C, the coolness during sitting was "very good", the texture was "good", the light fastness was class 4, and the fabric provided a comfortable feeling when a person sit.

Example 7

[0097] Polyethylene terephthalate drawn yarn with 167 dtex-72f (filament) was used as the warp and the weft to yield a double-woven fabric having a weave density of the warp of 250/cm and a weft weave density of the weft of 220/cm in both the ground weave and the pile.

[0098] The obtained woven fabric was dyed in the same condition as in Example 1 and then was sheared with a shearing machine to give a pile length of 1.8 mm, yielding a velvet fabric. A hygroscopic polymer was then fixed to the fabric in the same manner as in Example 1, giving a fiber structure of Example 7 having a fixing ratio of the hygroscopic polymer of 10.5%, a moisture absorption ratio of the fabric of 3.5%, and a moisture absorption ratio of the hygroscopic polymer of 33.3%. The woven fabric had a structure of group c.

[0099] The fiber structure was cut in a direction perpendicular to the weaving direction, and the cross-section was observed under an electron microscope. The observation result indicated that the number of cross section fibers contained in the front layer was 230, the number of cross section fibers contained in the back layer was 980, and the ratio of the numbers of cross section fibers was 4.26.

[0100] Table 1 shows the result of the performance evaluation. The knitted fabric had a surface temperature drop of 2.3°C, the coolness during sitting was "very good", the texture was "very good", the light fastness was class 4, and the woven fabric provided a comfortable feeling when a person sit.

Comparative Example 1

[0101] The weaves for the front fabric and the back fabric in Example 6 was exchanged, that is, a 28 gauge interlock circular knitting machine was used, the polyethylene terephthalate false-twisted yarn with 84 dtex-72f (filament) was supplied to the front fabric, the polyethylene terephthalate false-twisted yarn with 84 dtex-36 f (filament) of Reference Example 2 was supplied to the back fabric (ground weave), and the yarns were knitted at a course density on the machine of 38 course/2.54 cm to prepare a gray fabric where the front fabric was a plain knitted weave the back fabric was a patterned weave.

[0102] Next, the knitted fabric was dyed in the same manner as in Example 1, and then a hygroscopic polymer was fixed to the fabric, giving a fiber structure of Comparative Example 1 having a weight per unit area of 232 g/m^2, a fixing ratio of the hygroscopic polymer of 8.6%, a moisture absorption ratio of the fabric of 2.0%, and a moisture absorption ratio of the hygroscopic polymer of 23.2%.

[0103] The fiber structure was cut in a direction perpendicular to the knitting direction, and the cross-section was observed under an electron microscope. Fig. 4 is the electron micrograph (×50). The observation result indicated that the number of cross section fibers contained in the front layer was 319, the number of cross section fibers contained in the back layer was 162, and the ratio of the number of cross section fibers contained in the back layer/the number of cross section fibers contained in the front layer (the ratio of the numbers of cross section fibers) was 0.51. The result also revealed that the hygroscopic polymer was fixed to the ground weave of the knitted fabric.

[0104] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 0.5°C, the coolness during sitting was "poor", the texture was "good", the light fastness was class 4, and the fabric provided a poor comfortable feeling when a person sit.

Comparative Example 2

[0105] A water jet loom-weaving machine was used, and the polyethylene terephthalate false-twisted yarn with 167 dtex-48 f (filament) of Reference Example 2 was supplied as the warp and the weft to weave a twill weave having a weave density of warp of 128/2.54 cm and a weave density of weft of 81/2.54 cm.

[0106] Next, the woven fabric was dyed in the same manner as in Example 1, and a hygroscopic polymer was fixed, giving a fiber structure of Comparative Example 2 having a weight per unit area of 197 g/m^2, a fixing ratio of the hygroscopic polymer of 8.3%, a moisture absorption ratio of the fabric of 1.9%, and a moisture absorption ratio of the hygroscopic polymer of 22.8%.

[0107] The fiber structure was cut in a direction perpendicular to the weaving direction, and the cross-section was observed under an electron microscope. Fig. 5 is the electron micrograph (×150). The observation result indicated that the number of cross section fibers contained in the front layer was 107, the number of cross section fibers contained in the back layer was 133, and the ratio of the numbers of cross section fibers was 1.24. The hygroscopic polymer was fixed to the ground weave of the woven fabric.

[0108] Table 1 shows the result of the performance evaluation. The fabric had a surface temperature drop of 1.3°C, the coolness during sitting was "poor", the texture was "good", the light fastness was class 4, and the fabric provided a poor comfortable feeling when a person sit.

[Table 1]

			Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Comparative Example 1	Comparative Example 2
Fabric			Warp knitting Tricot	Warp knitting Tricot	Warp knitting Raised tricot	Warp knitting Tricot	Warp knitting Raised tricot	Circular knitting	Woven fabric	Circular knitting	Woven fabric Twill
Composition	Weight per unit area (g/m^2)		310	275	330	318	340	232	400	232	197
	Thickness (mm)		0.73	0.67	1.01	0.74	1.05	0.6	3.0	0.60	0.42
	Course (C)		59	50	60	59	60	39	(warp) 150	37	(warp) 140
	Wale (W)		33	33	40	33	40	37	(weft) 150	39	(weft) 96
	Original yarn	L1	84T-48F-drawn yarn	167T-48 F-finished yarn	84T-48F-drawn yarn	84T-48F-drawn yarn	84T-48F-drawn yarn	(back layer side) 84T-72F	167T-72F-drawn yarn	(back layer side) 84T-36F	(warp) 167T-48F
		L2	84T-36F-finished yarn	84T-36F-drawn yarn	84T-48F-drawn yarn	84T-36F-finished yarn	84T-48F-drawn yarn	(front layer side) 84T-36F	-	(back layer side) 84T-72F	(weft) 167T-48F
		L3	84T-48F-drawn yarn	84T-36F-drawn yarn	84T-48F-finished yarn	84T-48F-drawn yarn	84T-48F-finished yarn	-	-	-	-
		L4	84T-48F-drawn yarn	-	-	84T-48F-drawn yarn	-	-	-	-	-
	Weave	L1	1-2/1-0	1-0/3-4	2-3/1-0	1-2/1-0	2-3/1-0	-	-	-	-
		L2	3-4/1-0	2-3/2-1 1-0/1-2	1-0/1-2	3-4/1-0	1-0/1-2	-	-	-	-
		L3	2-3/2-1 1-0/1-2	1-0/1-2 2-3/2-1	1-0/3-4	2-3/2-1 1-0/1-2	1-0/3-4	-	-	-	-
		L4	1-0/1-2 2-3/2-1	-	-	1-0/1-2 2-3/2-1	-	-	-	-	-

	Number of cross section fibers contained in front layer	235	121	220	245	231	161	230	319	107
	Number of cross section fibers contained in back layer	850	485	1380	854	1417	322	980	162	133
	Ratio of numbers of cross section fibers (back layer/front layer)	3.62	4.01	6.27	3.49	6.13	2.00	4.26	0.51	1.24
Performance	Fixing ratio of hygroscopic polymer (%)	7.3	12.3	12.5	7.0	12.6	8.6	10.5	8.6	8.3
	Moisture absorption ratio of fabric (%)	2.4	3.0	3.0	2.3	2.9	2.0	3.5	2.0	1.9
	Moisture absorption ratio of hygroscopic polymer (%)	32.8	24.3	24.0	32.8	23.0	23.2	33.3	23.2	22.8
	Surface temperature drop of fabric (°C)	2.1	1.9	2.3	2.0	2.4	2.6	2.3	0.5	1.3
	Coolness during	Very good	Very good	Very good	Very good	Very good	Very good	Very good	Poor	Poor

	sitting									
	Texture	Very good (26 points)	Very good (25 points)	Very good (29 points)	Good (18 points)	Good (22 points)	Good (18 points)	Very good (26 points)	Good (20 points)	Good (19 points)
	Light fastness	Class 4	Class 4	Class 4	Class 4	Class 4	Class 4	Class 4	Class 4	Class 4

Claims

1. A fiber structure prepared by fixing a hygroscopic polymer to fibers of a fabric, a front layer on a front surface side of the fiber structure and a back layer on a back surface side of the fiber structure having different fiber densities, a boundary between the front layer and the back layer being on a center line of a cross section of the fiber structure.

2. The fiber structure according to claim 1, wherein the fabric is in the form of a woven fabric or a knitted fabric, and the fabric has a ground weave in the back layer side.

3. The fiber structure according to claim 1 or 2, wherein the hygroscopic polymer is a polymer of one or more monomers selected from sodium acrylamido-2-propanesulfonate, sodium styrenesulfonate, sodium isoprenesulfonate, sodium allylsulfonate, and sodium methallylsulfonate or a copolymer of one or more of the monomers and an additional monomer except the monomers.

4. The fiber structure according to any one of claims 1 to 3, wherein the hygroscopic polymer is fixed to the fabric in a fixing ratio of 4 to 20% by mass.

5. The fiber structure according to any one of claims 1 to 4, wherein the number of cross section fibers contained in the back layer divided by the number of cross section fibers contained in the front layer (the ratio of the numbers of cross section fibers) ranges from 2 to 10, where the fiber structure is cut in the direction perpendicular to a weaving or knitting direction of the fiber structure, and the center line of the cross section is the boundary between the front layer on the front surface side and the back layer on the back surface side.

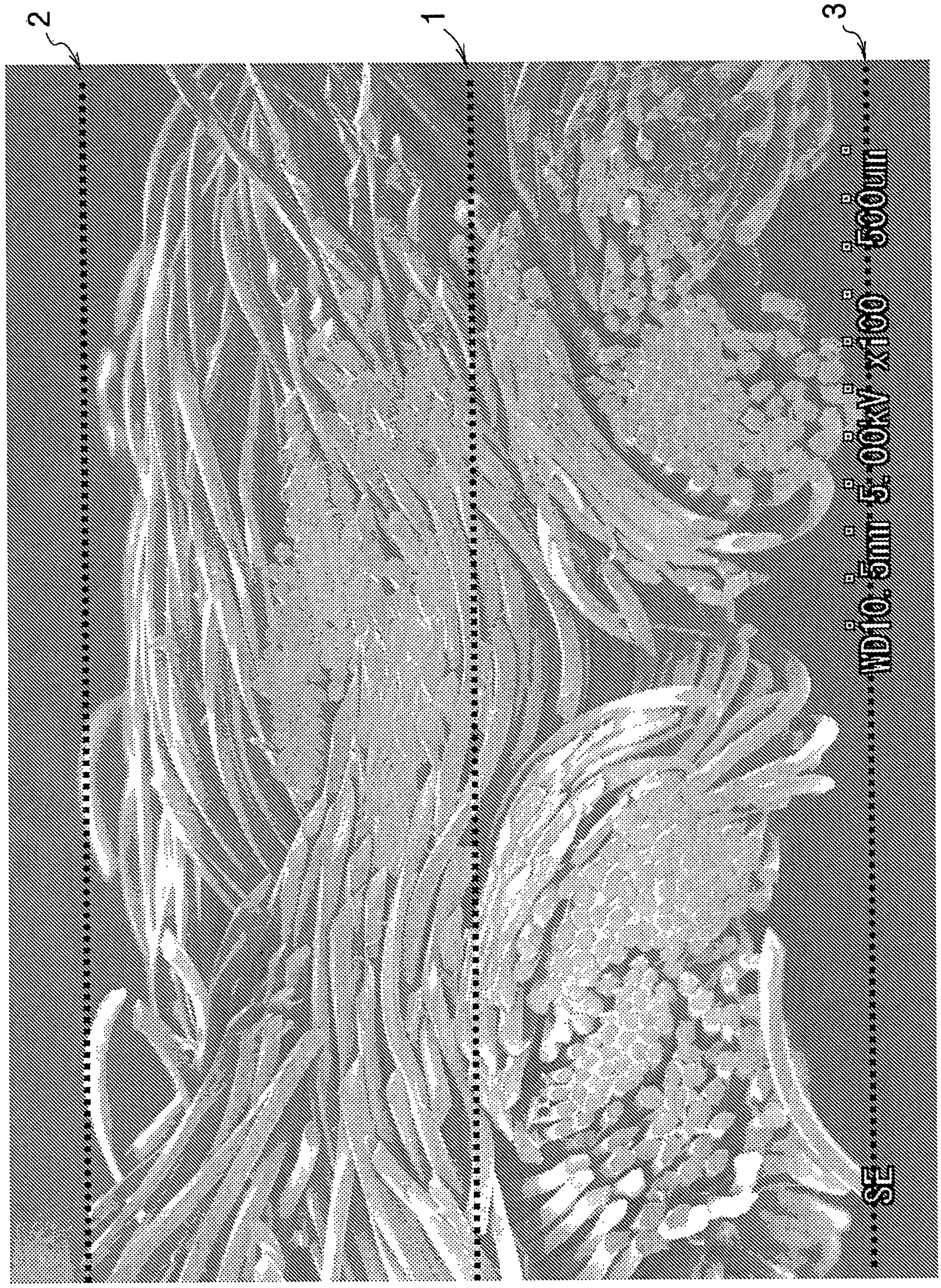
6. The fiber structure according to any one of claims 1 to 5, wherein the fabric has a weave selected from the following groups a to c:

    group a: a warp knit that is produced with a knitting machine equipped with two or more reeds and has a two needle swing weave or a three needle swing weave for the back layer;
    group b: a weft knit that is produced with an interlock knitting machine and has a patterned weave for the front layer; and
    group c: a pile fabric having a ground weave.

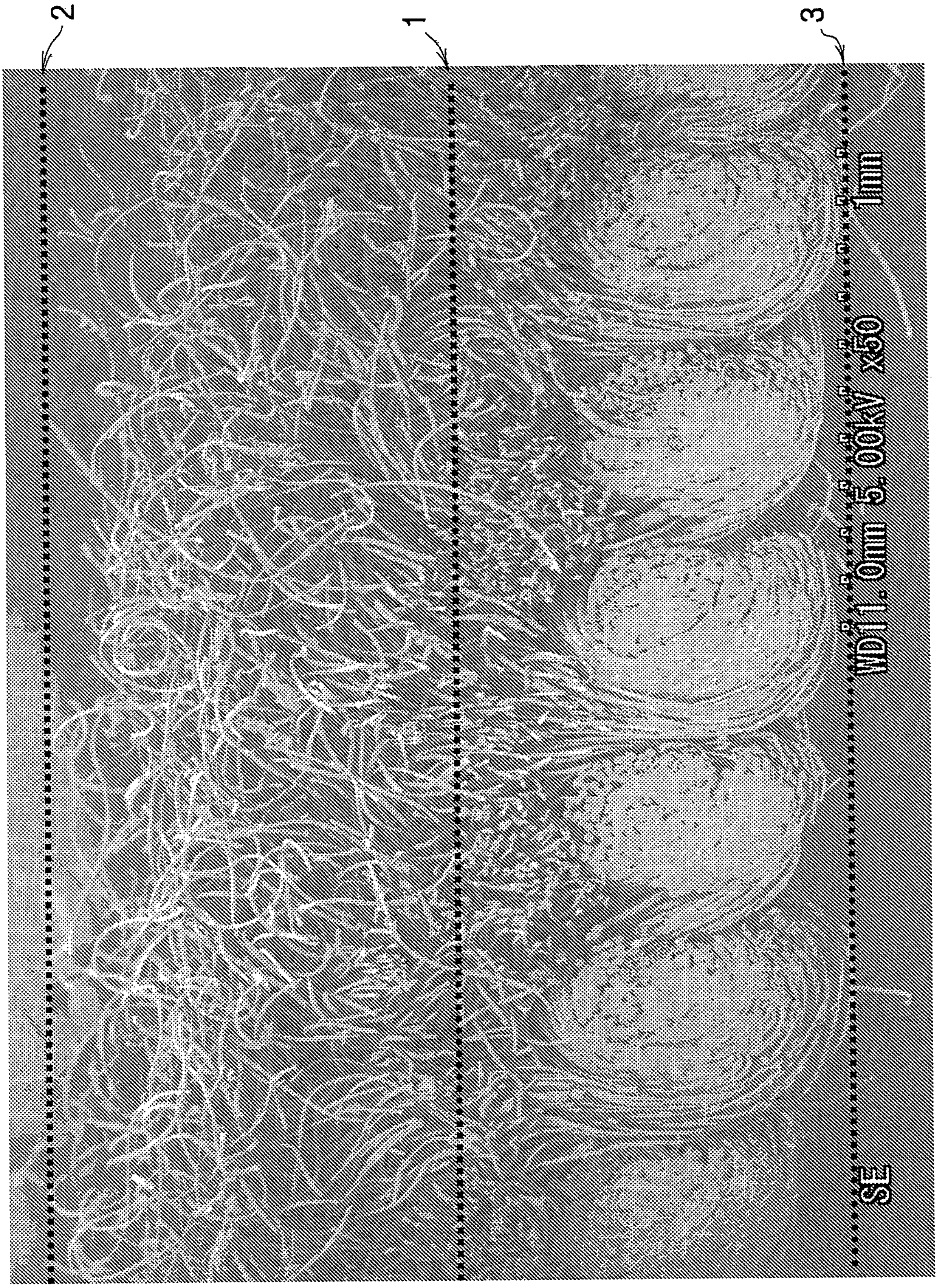
7. A vehicle interior material comprising the fiber structure according to any one of claims 1 to 6.

[Fig. 1]

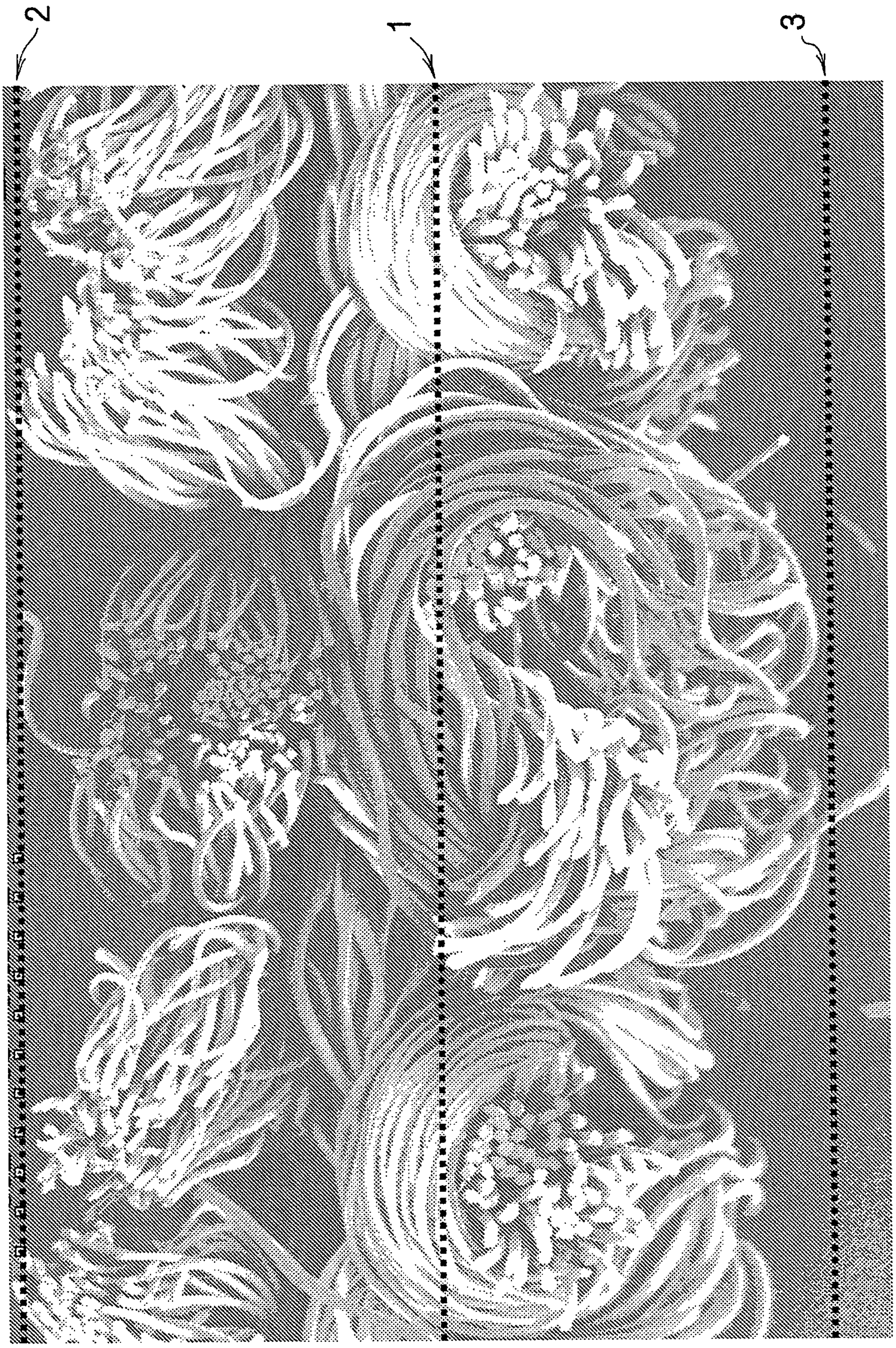
[Fig.2]



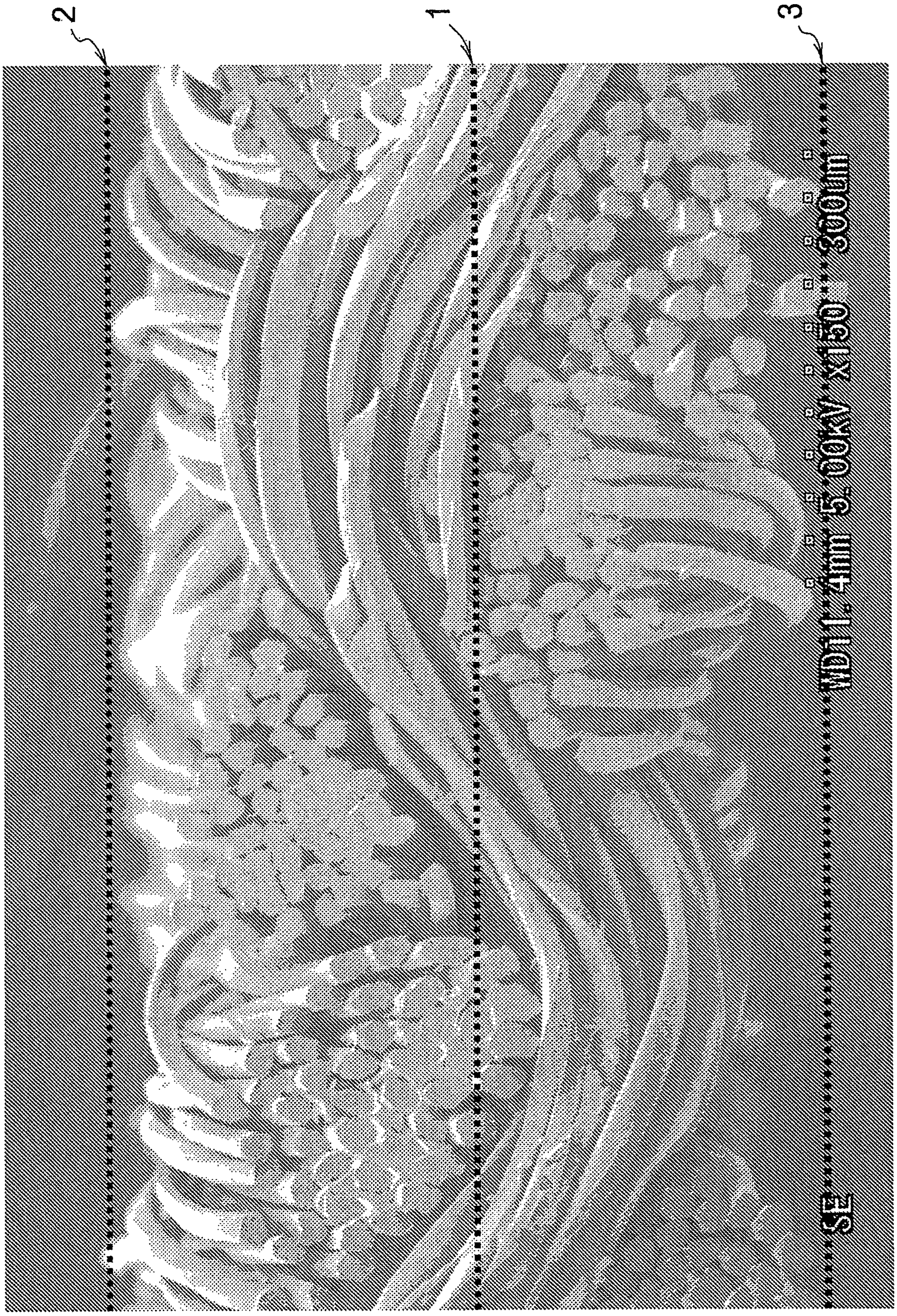
[Fig.3]



[Fig.4]



[Fig. 5]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/054834

A. CLASSIFICATION OF SUBJECT MATTER
D04B21/00(2006.01)i, *D03D1/00*(2006.01)i, *D03D25/00*(2006.01)i, *D03D27/00*(2006.01)i, *D04B1/00*(2006.01)i, *D06M15/227*(2006.01)i, *D06M15/233*(2006.01)i, *D06M15/263*(2006.01)i, *D06M15/285*(2006.01)i
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)
D04B1/00-1/28, 21/00-21/20, D03D1/00-27/18, D06M13/00-15/715, B60N2/00-2/72

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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.
X Y A	JP 2002-180308 A (Toray Industries, Inc.), 26 June 2002 (26.06.2002), claims 1 to 2, 5 to 6; paragraphs [0018], [0025] to [0027], [0053] to [0055] & US 2003/0068949 A1 & EP 1260355 A1 & WO 2002/028633 A1 & CN 1392833 A	1-2 3-4,6 5,7
Y A	JP 2003-278050 A (Ventex Co., Ltd.), 02 October 2003 (02.10.2003), claims 1, 3; paragraph [0010] & US 2003/0181118 A1 & KR 10-2002-0028051 A	1-4,6 5,7
Y A	JP 2002-212880 A (Toray Industries, Inc.), 31 July 2002 (31.07.2002), claim 1; paragraph [0017] & US 2003/0068949 A1 & EP 1260355 A1 & WO 2002/028633 A1 & CN 1392833 A	1-4,6 5,7

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

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Date of the actual completion of the international search	Date of mailing of the international search report
23 May, 2013 (23.05.13)	04 June, 2013 (04.06.13)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/054834

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-088653 A (Komatsu Seiren Co., Ltd.), 27 March 2002 (27.03.2002), claim 1; paragraphs [0018], [0023] to [0024], [0041] (Family: none)	1-7

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REFERENCES CITED IN THE DESCRIPTION

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