US 20170226672A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2017/0226672 A1
(43) Pub. Date: Aug. 10, 2017
KIMURA et al.

(54) NON-WOVEN FABRIC

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(21) Appl. No.: **15/321,780**

(22) PCT Filed: **Jun. 25, 2015**

(86) PCT No.: **PCT/JP2015/068353**

§ 371 (c)(1),
(2) Date: **Apr. 25, 2017**

(30) **Foreign Application Priority Data**

Jun. 26, 2014 (JP) 2014-131732

Publication Classification

(51) **Int. Cl.**
D04H 1/495 (2006.01)
D01G 15/04 (2006.01)
D04H 1/70 (2006.01)

(52) **U.S. Cl.**
CPC ***D04H 1/495*** (2013.01); ***D04H 1/70*** (2013.01); ***D01G 15/04*** (2013.01)

(57) **ABSTRACT**

The present disclosure relates to a non-woven fabric that is formed from a base part that spreads out in a planar shape and from a plurality of projecting parts that protrude in a thickness direction (Th) from the base part. Each of the projecting parts has a projecting surface part. Each of the projecting surface parts is configured such that the fiber density of the projecting surface part increases toward one side in a prescribed direction that is a surface direction of the non-woven fabric.

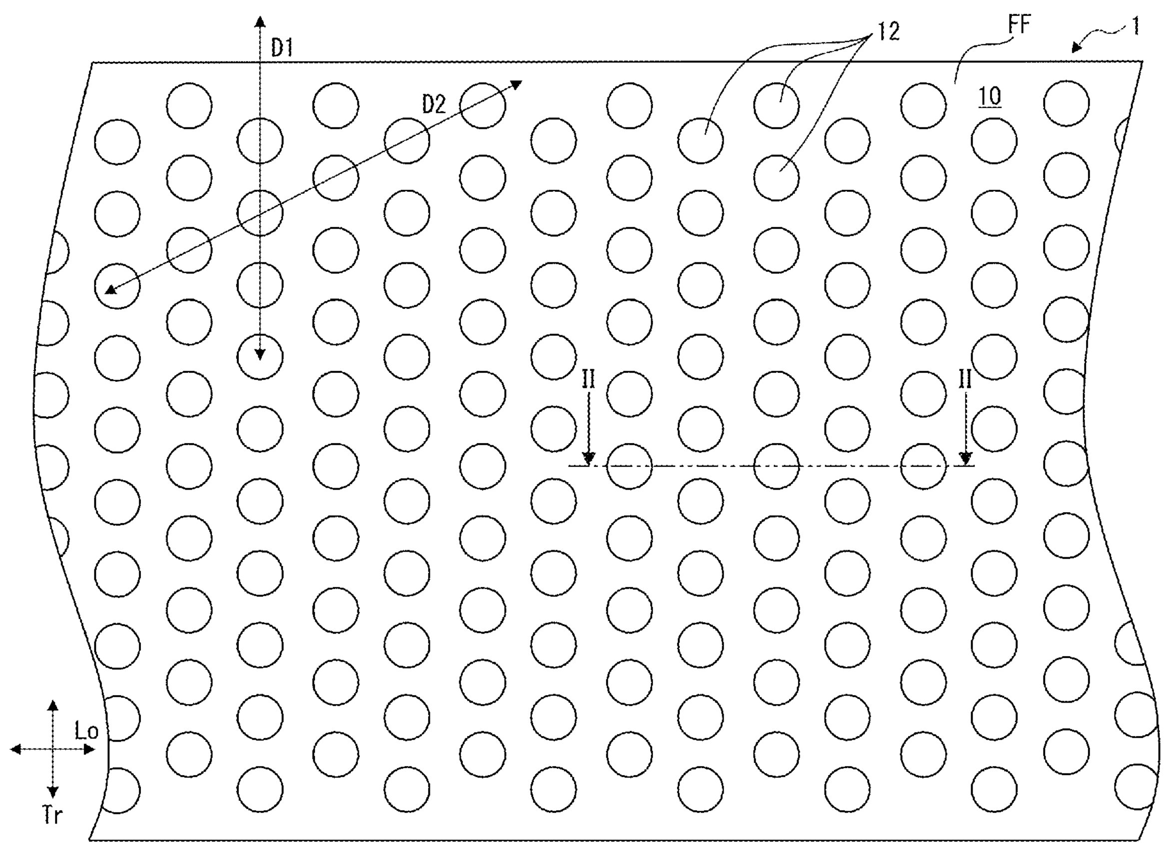


FIG. 1

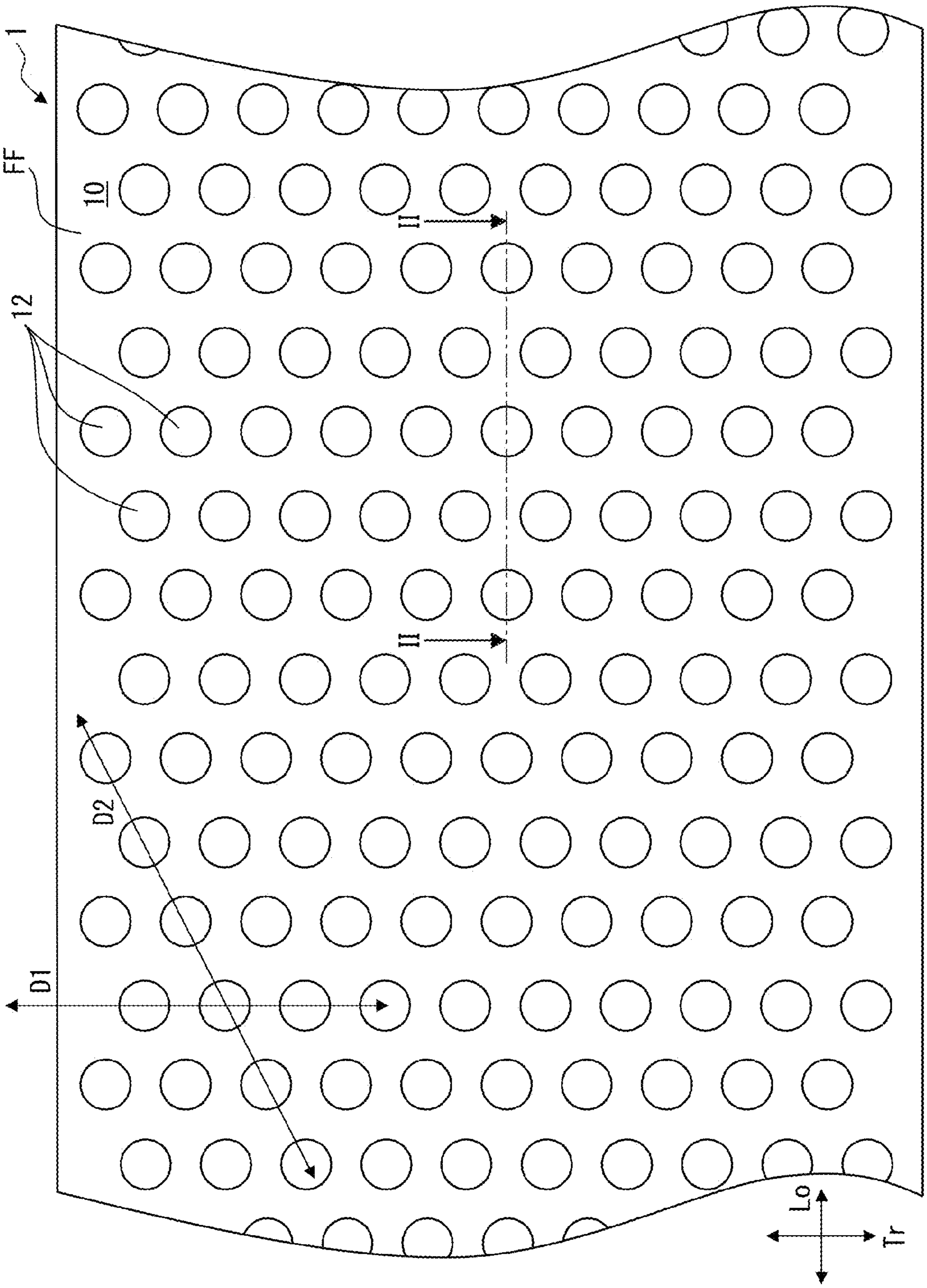


FIG. 2

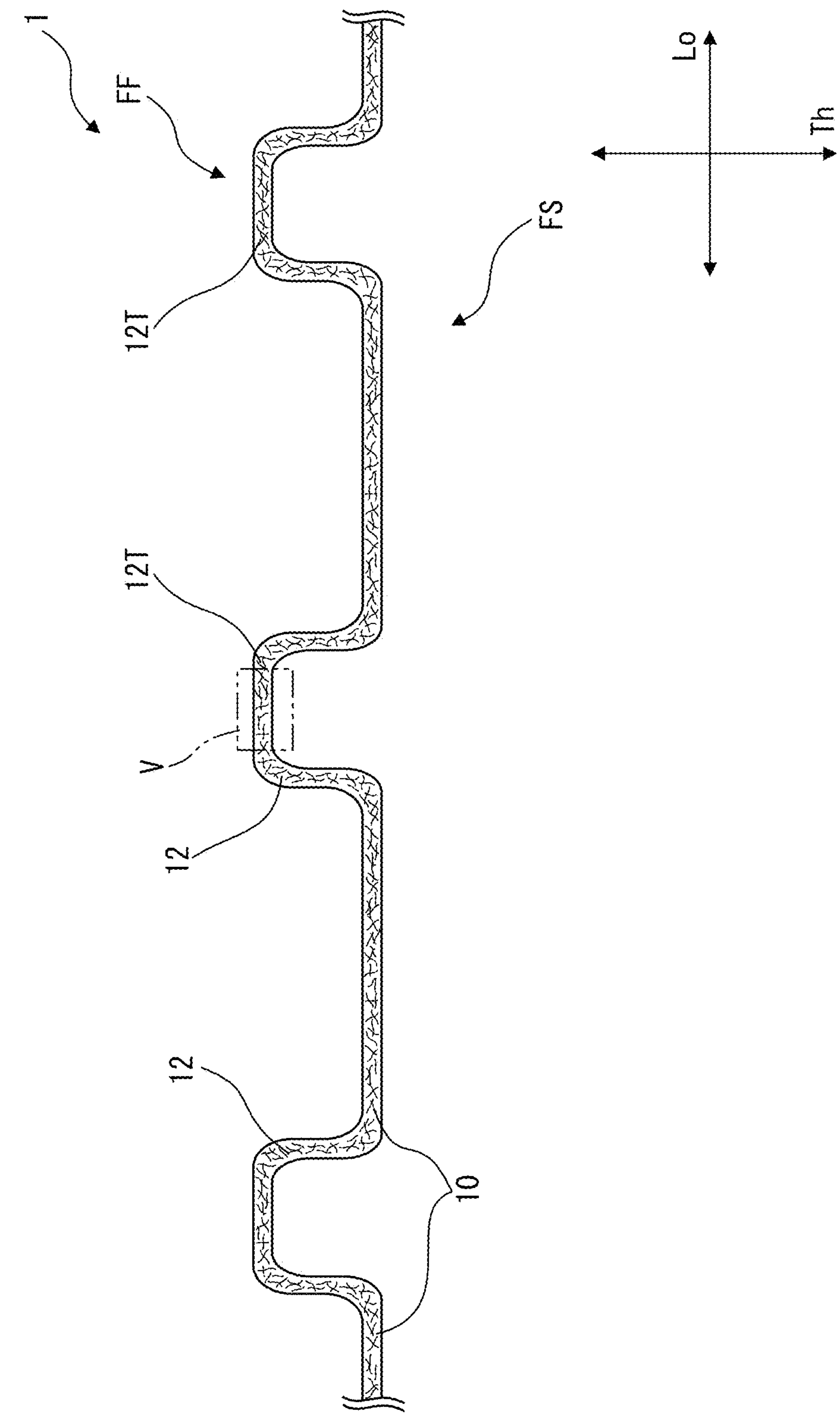


FIG. 3

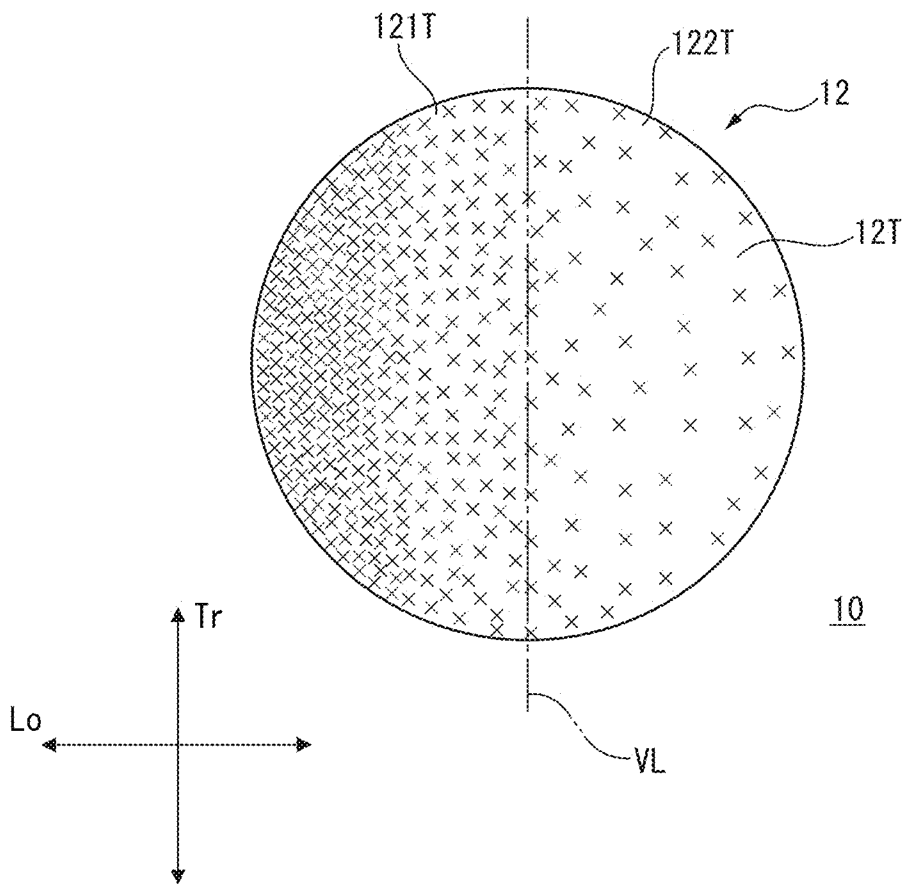


FIG. 4

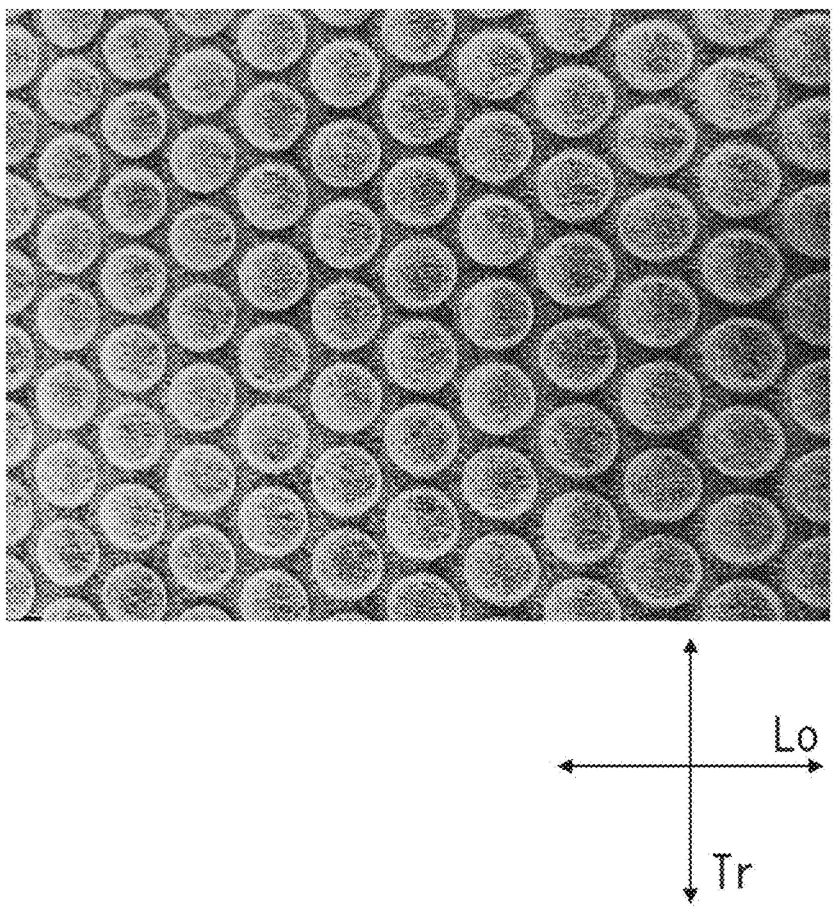


FIG. 5

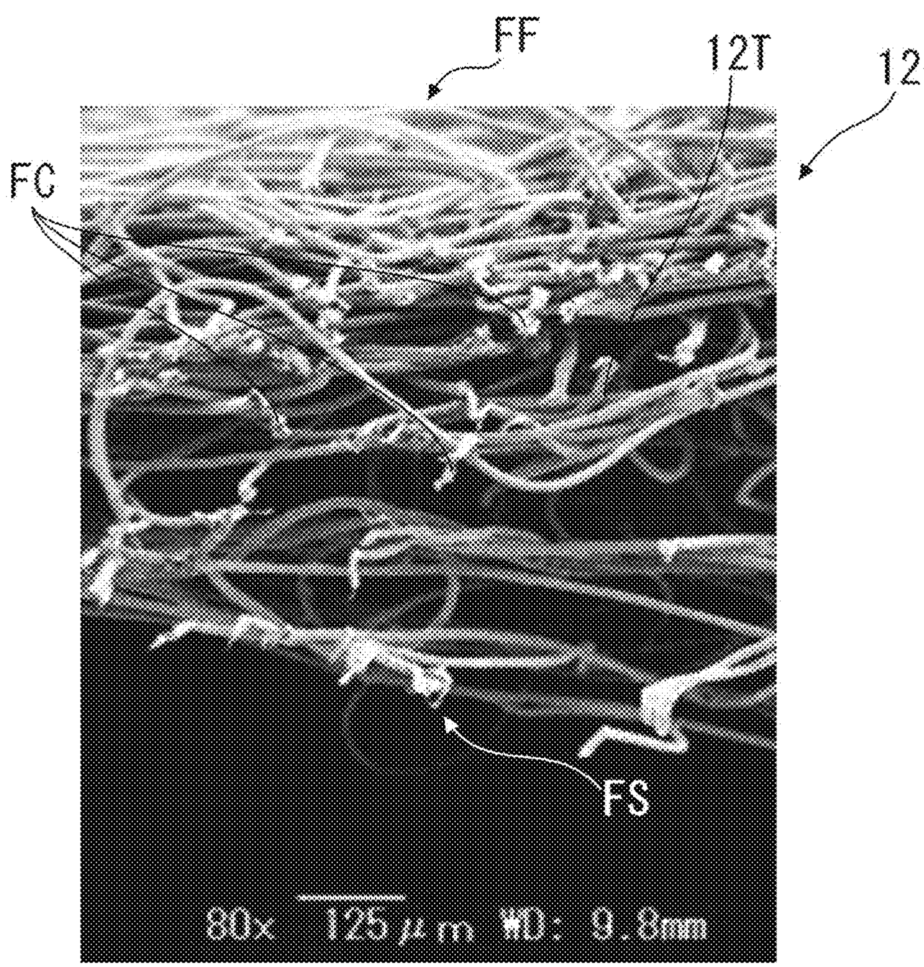


FIG. 6

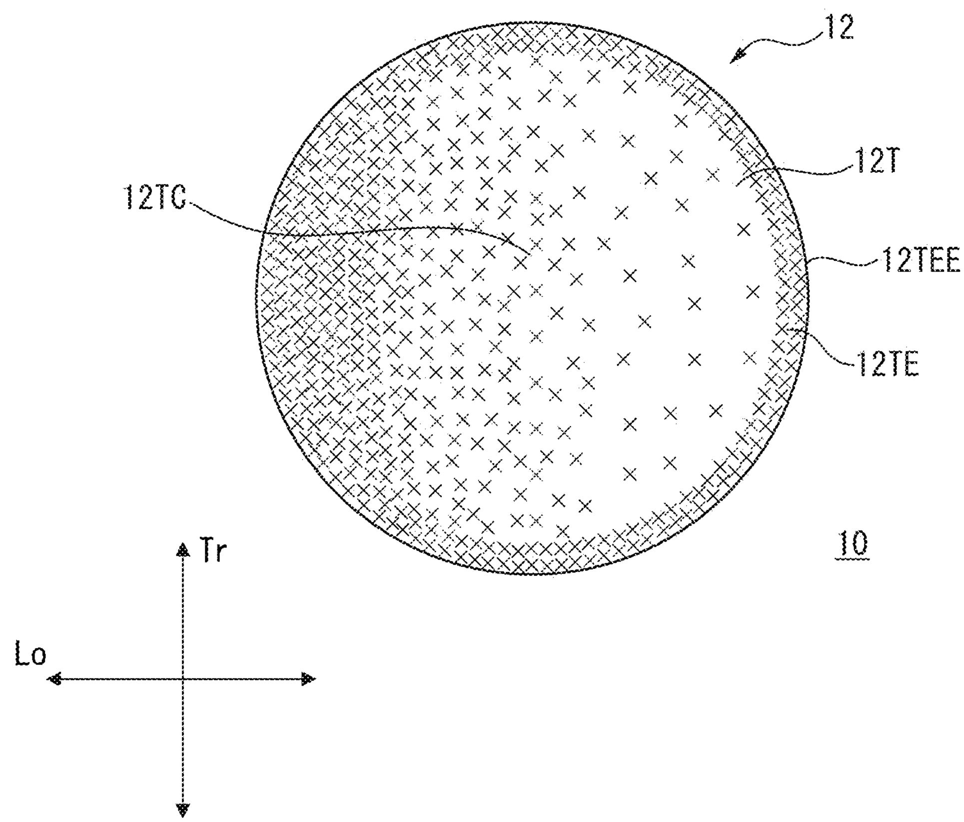


FIG. 7

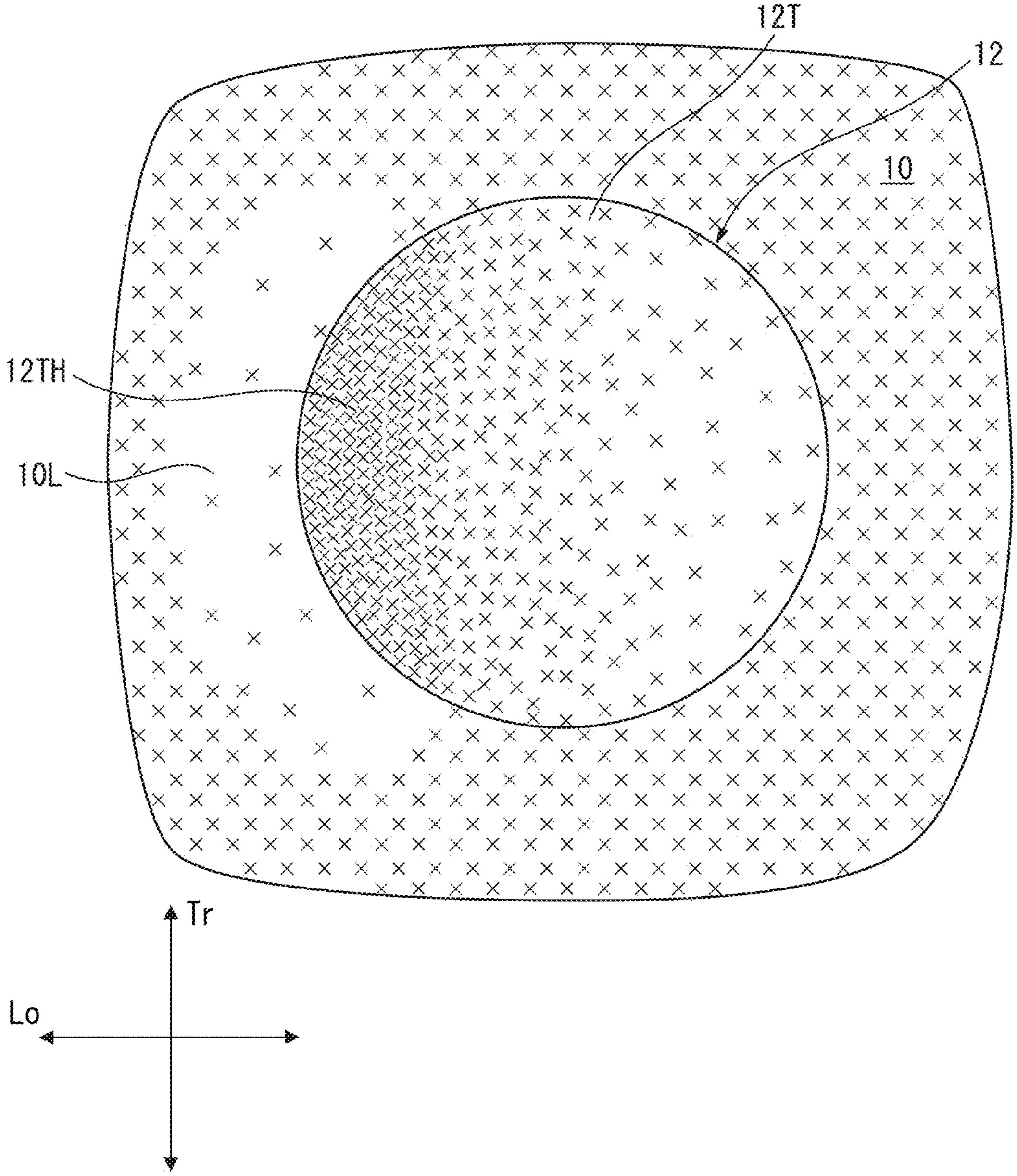


FIG. 8

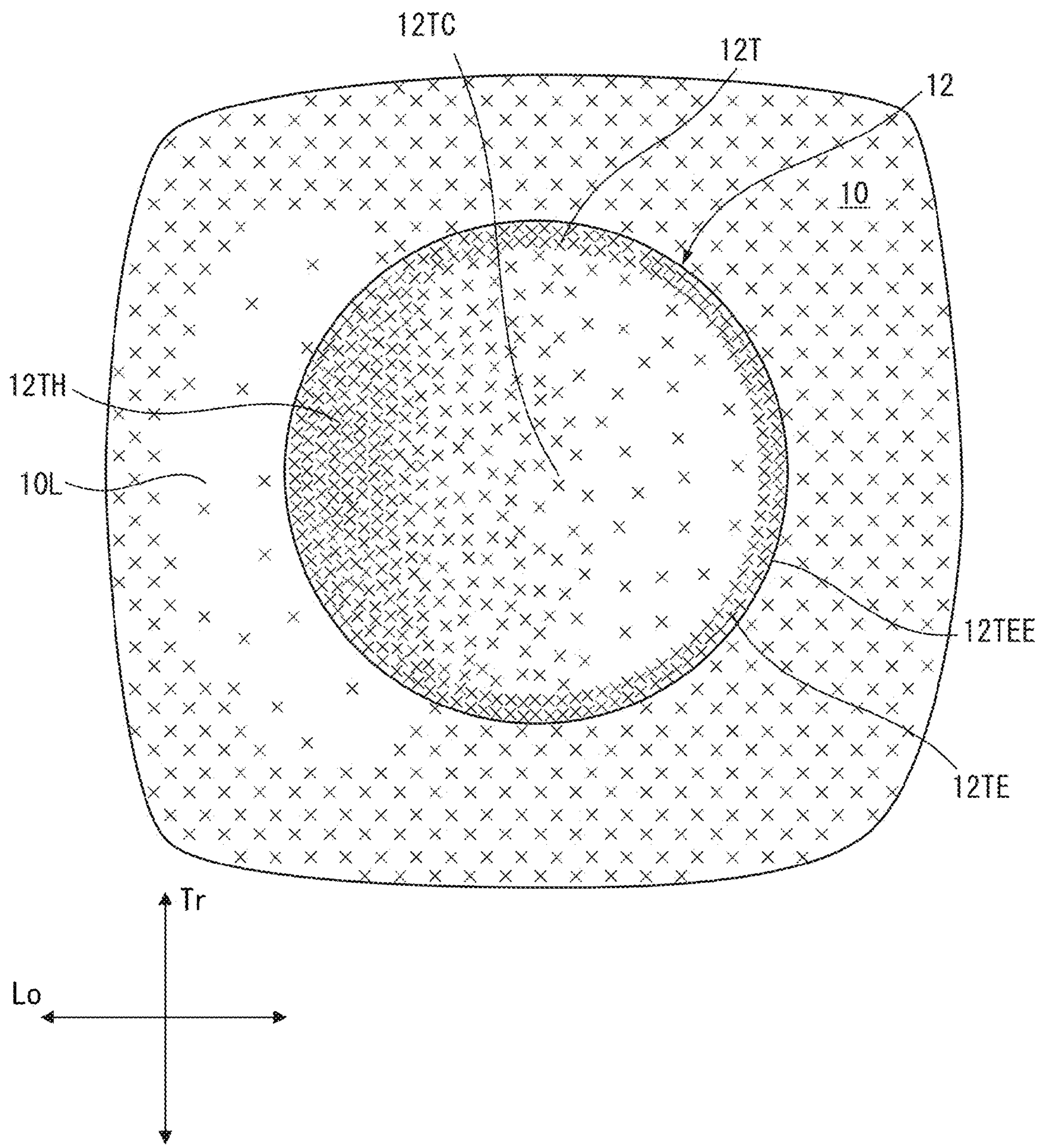


FIG. 9

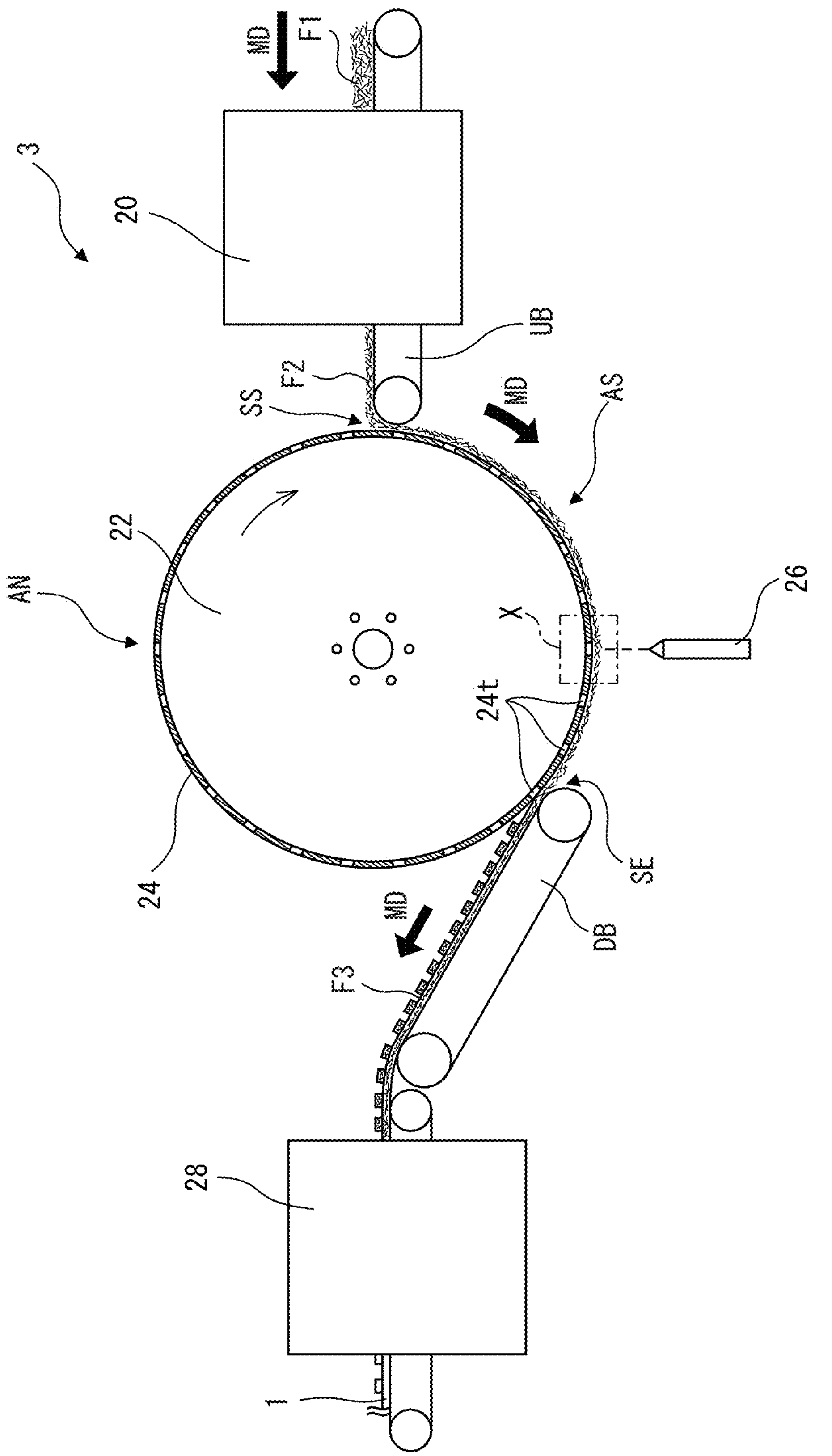


FIG. 10

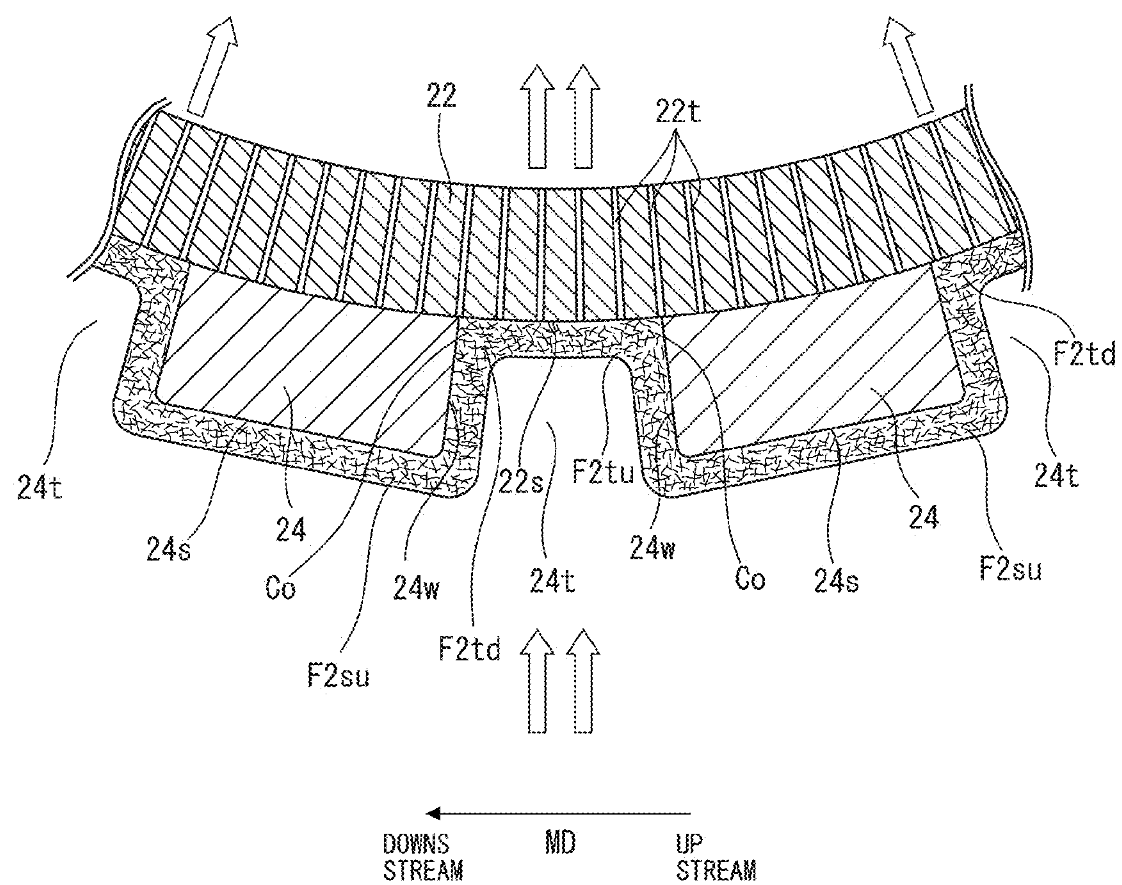
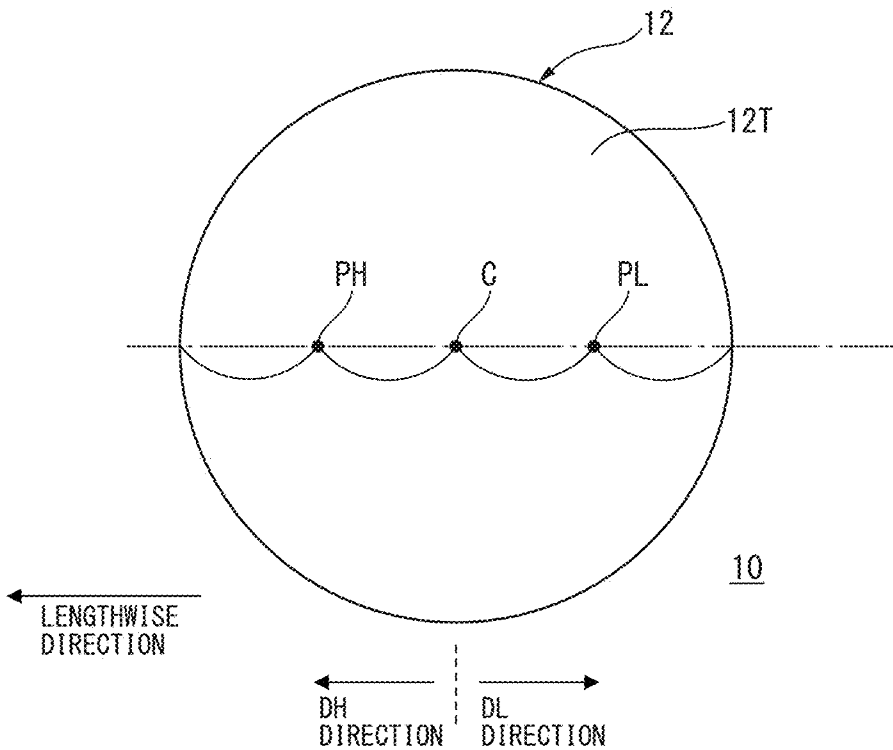

22
22t
F2td
24t
24t
24s
24
Co
24w
24t
22s
F2tu
24w
Co
24s
24
F2su
F2su
F2td
DOWNS STREAM
MD
UP STREAM

FIG. 11


12
12T
PH
C
PL
10
LENGTHWISE DIRECTION
DH DIRECTION
DL DIRECTION

NON-WOVEN FABRIC

TECHNICAL FIELD

[0001] The present invention pertains to a nonwoven fabric and especially to a nonwoven fabric in which a fiber density is gradually distributed in the nonwoven fabric.

BACKGROUND ART

[0002] Patent Literature 1 discloses a nonwoven fabric including first projection portions projecting to the first surface side which is on the side observed in planar view of the sheet-like nonwoven fabric, and second projection portions projecting to the second surface side which is on the opposite side to the first surface, the first projection portions and the second projection portions alternately extending in two directions of the first direction and the second direction in planer view of the nonwoven fabric, and the fiber density in the first surface side at the protruding surface portion of each of the first projection portions being lower than the fiber density in the second surface side thereof.

CITATION LIST

Patent Literature

[0003] PTL 1: Japanese Unexamined Patent Publication No. 2012-144835

SUMMARY OF INVENTION

Technical Problem

[0004] However, in the nonwoven fabric according to the invention disclosed in Patent Literature 1, the fiber density of fibers configuring the nonwoven fabric is not formed so as to be approximately even, when the nonwoven fabric is observed in planar view, and thus the direction in which absorbed liquid permeates the nonwoven fabric cannot be controlled. Accordingly, when such a nonwoven fabric is used for a top sheet of an absorbent article, for example, body fluids such as urine or menstrual blood excreted on the nonwoven fabric may permeate the nonwoven fabric from the position at which the body fluid is excreted to the surroundings by extending without directivity. As a result, the body fluids may permeate outward of the absorbent article, and thus the body fluids may reach the outside of the absorbent article, which causes leakage.

[0005] The object of the present invention is therefore to provide a nonwoven fabric that allows absorbed liquid to permeate therethrough in a desired direction.

Solution to Problem

[0006] To solve the above described problem, the present invention provides a nonwoven fabric comprising a base portion which extends in a planar shape and a plurality of protruding portions which protrude in a thickness direction from the base portion, wherein

[0007] each of the protruding portions has a protruding surface portion, and

[0008] the each protruding surface portion is configured so that a fiber density of the each protruding surface portion is gradually distributed in a predetermined direction in a planar direction of the nonwoven fabric.

Advantageous Effects of Invention

[0009] According to the nonwoven fabric of the present invention, the fiber density of the each protruding surface portion of the protruding portions is gradually distributed in a predetermined direction, whereby the absorbed liquid can permeate the nonwoven fabric in a desired direction.

BRIEF DESCRIPTION OF DRAWING

[0010] FIG. **1** is a planar view of a nonwoven fabric according to a first embodiment of the present invention.

[0011] FIG. **2** is a partial end surface view along a cross-section II-II of FIG. **1**.

[0012] FIG. **3** is an explanatory diagram of a distribution of a fiber density of a protruding surface portion of a protruding portion in a nonwoven fabric **1** shown in FIG. **1**.

[0013] FIG. **4** is a photo which is photographed in a planar view of the nonwoven fabric shown in FIG. **1**.

[0014] FIG. **5** is a photo of a cross-section in which portion V of FIG. **2** is enlarged.

[0015] FIG. **6** is an explanatory diagram of a distribution of a fiber density of a protruding surface portion of a protruding portion in a nonwoven fabric according to a second embodiment.

[0016] FIG. **7** is an explanatory diagram of distributions of a fiber density of a protruding surface portion of a protruding portion, and a fiber density of a base portion positioned in a state of surrounding the protruding portion, in a nonwoven fabric according to a third embodiment.

[0017] FIG. **8** is an explanatory diagram of distributions of a fiber density of a protruding surface portion of a protruding portion, and a fiber density of a base portion positioned in a state of surrounding the protruding portion, in a nonwoven fabric according to a fourth embodiment.

[0018] FIG. **9** is a schematic view showing a general outline of manufacturing equipment to manufacture the nonwoven fabric according to the embodiment of the present invention.

[0019] FIG. **10** is an enlarged view of portion X in FIG. **9**.

[0020] FIG. **11** is an explanatory diagram of measurement points to measure a fiber density of a protruding surface portion of a protruding portion of the nonwoven fabric according to the first to the third examples.

DESCRIPTION OF EMBODIMENTS

First Embodiment

[0021] Hereinbelow, a nonwoven fabric **1** according to a first embodiment of the present invention is described with reference to FIG. **1** to FIG. **5**.

[0022] FIG. **1** is a planar view of a nonwoven fabric according to the first embodiment, and FIG. **2** is a partial end surface view along a cross-section II-II of FIG. **1**. The nonwoven fabric **1** according to the first embodiment extends in a plane of the nonwoven fabric **1** defined by a longitudinal direction Lo and a transverse direction Tr, and has the first surface FF which can be observed in a planar view of FIG. **1** and a second surface FS which is positioned at the opposite side of the first surface FF.

[0023] As shown in FIG. **1** and FIG. **2**, the nonwoven fabric **1** is formed by a base portion **10** which extends in an approximately planar shape, and a plurality of protruding portions **12** which protrude from the base portion **10** in a thickness direction Th, and to the side of the first surface FF in the first embodiment. Each of the protruding portions **12** includes a protruding surface portion **12**T which is distant from the base portion **10** in the thickness direction Th of the nonwoven fabric **1**. Here, the protruding surface portion **12**T is referred to as a portion of the protruding portion **12** positioned on a side where an apex portion of the protruding portion **12** is present, the apex portion being most distant from the base portion **10** in the thickness direction Th, with respect to the middle point in the thickness direction Th between the base portion **10** and the apex portion of the protruding portion **12**, and the portion further forming a certain surface facing the protruding direction of the protruding portion **12** from the base portion **10**.

[0024] In the first embodiment, each of the protruding surface portions **12**T is approximately flat. However, each of the protruding surface portions **12**T need not be made into a completely flat surface, and may include a certain inclined surface or a curved surface.

[0025] Further, in the first embodiment, each of the protruding portions **12** has an approximately cylinder-like shape with a diameter of approximately 10 mm in appearance. In another embodiment, each of the protruding portions **12** may take the shape of, for example a truncated cone, an elliptic or a polygonal cylinder, or an elliptic or a polygonal truncated cone, etc., each having a protruding surface portion with a certain area.

[0026] FIG. **3** is an explanatory diagram of a distribution of a fiber density of the protruding surface portion **12**T of the protruding portion **12** in the nonwoven fabric **1** shown in FIG. **1**. Incidentally, FIG. **3** gives an explanation by focusing on one protruding portion **12**, and describes the distribution of the fiber density of the protruding surface portion **12**T, by the amount of the density of (the number of) the sign "X".

[0027] As shown in FIG. **3**, each of the protruding surface portions **12**T is configured so that the fiber density of each of the protruding surface portions **12**T is gradually distributed in a longitudinal direction Lo of the nonwoven fabric **1**, among the planar direction of the nonwoven fabric **1**. That is to say, the protruding surface portion **12**T has, on a certain segment extending in the longitudinal direction Lo, portions in which the fiber density on one side of the longitudinal direction Lo is higher, and the fiber density on the other side of the longitudinal direction Lo is lower.

[0028] Further, in other words, in the nonwoven fabric **1** according to the first embodiment, when each of the protruding surface portions **12**T is divided into two hemi-protruding surface portions **121**T, **122**T, each having the same areas, by a virtual line VL which extends in a direction perpendicular to the longitudinal direction Lo of the nonwoven fabric **1** in a planar view of the nonwoven fabric **1**, that is to say, in a transverse direction Tr, the fiber density of one hemi-protruding surface portion **121**T is higher than the fiber density of the other hemi-protruding surface portion **122**T. Here, "the fiber density of a hemi-protruding surface portion" is generally referred to as an average of the fiber densities in the entire hemi-protruding surface portions **121**T and **122**T, however, when measuring the fiber densities as described later, it is referred to as an average of the fiber densities obtained by cutting each of the hemi-protruding surface portions **121**T and **122**T in a direction vertical to the direction in which the fibers are gradually distributed, that is to say, in the transverse direction Tr in the case of the first embodiment, then dividing each of the hemi-protruding surface portions **121**T and **122**T into three parts in a direction in which the fibers are gradually distributed, that is to say, in the longitudinal direction Lo of the nonwoven fabric **1** in the case of the first embodiment, and thus the fiber densities are measured in the center portions in the transverse direction Tr at these cutting planes.

[0029] FIG. **4** is a photo which is obtained by photographing the nonwoven fabric shown in FIG. **1** in a planar view of the nonwoven fabric, on a black stand. In the photo shown in FIG. **4**, the shades of colors show how high or low the fiber densities are. That is to say, the darker the black is in the photo shown in FIG. **4**, the color of the photographing stand can be easily observed therethrough, and thus indicating that the fiber density is low, whereas the darker the white is, the color of the photographing stand can be less easily observed therethrough, and thus indicating that the fiber density is high. The photo of FIG. **4** also supports that at a planar view of the nonwoven fabric **1** in the nonwoven fabric **1** according to the first embodiment, the fiber density of the protruding surface portion **12**T of the protruding portion **12** is gradually distributed in the longitudinal direction Lo among the planar direction of the nonwoven fabric **1**. This is because, when the protruding surface portion **12**T in FIG. **4** is observed, it shows a tendency that one side in the longitudinal direction Lo is darker in black, and the other side in the longitudinal direction Lo is darker in white.

[0030] In the present invention, when measuring "the fiber density", an index of the number of portions FC at which fibers are cut per 1 mm^2, in the cutting plane of the nonwoven fabric **1** is used. To be more specific, a cutting plane of a certain area (for example, approximately 2.0 mm^2) is observed by using an electron scanning microscope (for example, "Real Surface View Microscope VE-7800" manufactured by Keyence Corporation), with the magnification being adjusted to approximately 50 to 100 times, and the number of portions FC at which the fibers are cut (as shown in FIG. **5**) is counted. The cutting plane to be observed includes the entirety throughout the thickness direction Th from the first surface FF to the second surface FS. Then, the number of cut portions is converted to the number of portions per 1 mm^2, and thus the converted number is obtained as the index of "the fiber density".

[0031] The fibers used for the nonwoven fabric **1** in the first embodiment are fibers having a sheath-core structure, in which the material of the sheath is high density polyethylene (HDPE), and the material of the core is polyethylene terephthalate (PET).

[0032] The fibers to be used in the nonwoven fabric may be natural fibers, regenerated fibers (rayon, acetate, etc.), thermoplastic resin fibers (polyolefins such as polyethylene, polypropylene, polybutylene, ethylene-vinyl acetate copolymer, ethylene-ethyl acrylate copolymer, ethylene-acrylic acid copolymer, or ionomer resin; polyesters such as polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, or polylactic acid; polyamides such as nylon, etc.) or their surface modified fibers. Among these fibers, the thermoplastic resin fibers or their surface modified fibers are preferable. Further, these fibers may be composite fibers such as sheath-core type fibers, side-by-side type fibers, island-sea type fibers; hollow type fibers; atypical fibers such as flat, Y-type or C-type fibers; solid crimp fibers such as latent crimped or actual crimped fibers; split fibers split by physical load by water flow, heat or embossing; etc. Incidentally, these fibers may be hydrophilic fibers, or may be hydrophobic fibers. However, when using hydrophobic fibers, an application of hydrophilic oil solution to the fibers, etc., are additionally required.

[0033] Further, as shown in FIG. **1**, in the nonwoven fabric **1** according to the first embodiment, the protruding portions **12** are aligned along a first direction D**1** and along a second direction D**2**, respectively in a linear manner. Here, the first direction D**1** is the same as the transverse direction Tr, and the second direction D**2** is tilted from the first direction D**1** by 60°. Further, in the nonwoven fabric **1** according to the first embodiment, by disposing the protruding portions **12** with an equal interval, the base portions **10** and the protruding portions **12** are disposed evenly. Accordingly, when the nonwoven fabric **1** is used as a top sheet of an absorbent article such as a disposable diaper, a sanitary napkin, or the like, for example, with the first surface FF placed as an exterior surface thereof, the base portions **10** which allow the body fluids excreted on the nonwoven fabric **1** to permeate inside where an absorbent body and the like of the absorbent article are positioned, and the protruding portions **12** which allow the body fluids to permeate therethrough in a desired direction, can be disposed with a preferable distribution.

[0034] Further, as shown in FIG. **1**, in the nonwoven fabric **1** according to the first embodiment, the protruding portions **12** which are adjacent to each other in the first direction D**1** and in the second direction D**2** are respectively provided intermittently with the base portion **10** placed in between. As a result, the body fluids excreted on the first surface FF permeates therethrough toward a direction in which the fiber density is gradually distributed, whereby the body fluids can be moved from the protruding surface portion **12**T of the protruding portion **12** to the adjacent base portion **10**. Accordingly, for example, when the nonwoven fabric **1** is used as a top sheet of an absorbent article, liquids can effectively permeate inside the absorbent article from the base portions **10**.

[0035] Hereinbelow, functions of the nonwoven fabric according to the first embodiment are described. In the nonwoven fabric **1** according to the first embodiment, as described above, each of the protruding surface portions **12**T are configured so that the fiber density of the protruding surface portions **12**T is gradually distributed in the longitudinal direction Lo among the planar direction of the nonwoven fabric **1**. Accordingly, the liquids absorbed by the fibers configuring the protruding portions **12** can easily permeate therethrough from a side where the fiber density is lower to a side where the fiber density is higher by the capillary phenomenon, and thus the liquids can be easily moved to the side where the fiber density is higher in the longitudinal direction Lo. Accordingly, by providing the nonwoven fabric so that the side with higher fiber density is disposed in the direction in which liquids preferably permeate therethrough, the absorbed liquids can permeate therethrough in a desired direction. Incidentally, in the present specification, it should be noted that “liquids can permeate therethrough in a desired direction” is referred not to as the liquids permeating therethrough only in the desired direction, but is referred to as the liquids permeating therethrough in the desired direction being increased.

[0036] Incidentally, the fiber density of the protruding surface portions **12**T is gradually distributed in the longitudinal direction Lo in the nonwoven fabric **1** according to the first embodiment, however, the fiber density of the protruding surface portions **12**T may alternately be gradually distributed in any direction among the planar direction of the nonwoven fabric **1**. That is to say, the protruding surface portions **12**T may be configured so that the fiber density of the protruding surface portions **12**T is gradually distributed in a predetermined direction among the planar direction of the nonwoven fabric **1**. Further, the side at which the fiber density is higher is disposed toward the direction to which liquids preferably permeate, whereby the liquids can permeate therethrough in the desired direction.

[0037] Further, in FIG. **3**, the fiber distribution in the protruding surface portion **12**T of one protruding portion **12** has been described, however, in the nonwoven fabric **1** according to the first embodiment, each of the protruding surface portions **12**T of each of the protruding portions **12** has the fiber distribution which is similar to that shown in FIG. **3**. However, the fiber densities of the protruding surface portions **12**T of the entire protruding portions **12** are not necessarily gradually distributed, and the nonwoven fabric **1** in which a fiber density of the protruding surface portion **12**T of the protruding portion **12** for at least a part of the protruding portions **12** is gradually distributed can be regarded as a nonwoven fabric which is within the scope of the present invention. This is because, such nonwoven fabric can still cause advantageous effects of the nonwoven fabric **1** according to the present invention, which is to allow the liquids absorbed by the nonwoven fabric **1** to permeate therethrough in the desired direction.

[0038] Further, the degree of the uneven distribution of the fiber density in the protruding surface portion **12**T may be as uneven as the one that allows the liquids absorbed by the nonwoven fabric **1** to permeate therethrough in the desired direction.

[0039] In the nonwoven fabric **1** according to the first embodiment, as described above, the protruding portions **12** are aligned along the first direction D**1** and along the second direction D**2** which is tilted from the first direction D**1** by 60°, respectively in a linear manner. In another embodiment, the second direction D**2** is tilted from the first direction D**1** by an angle other than 60°. In still another embodiment, the protruding portions **12** are aligned along only one direction in a linear manner. In still another embodiment, the protruding portions **12** are not aligned along a particular direction, and are disposed at arbitrary positions.

[0040] Further, in the nonwoven fabric **1** according to the first embodiment, as described above, by disposing the protruding portions **12** with an equal interval, the base portions **10** and the protruding portions **12** are disposed evenly. In another embodiment, the intervals of the protruding portions **12** are not even.

[0041] In another embodiment, the protruding portions **12** are aligned along either one of the first direction D**1** and the second direction D**2** in a linear manner, and in still another embodiment, the protruding portions **12** are not aligned along a particular direction, and are disposed randomly.

Second Embodiment

[0042] Hereinbelow, a nonwoven fabric **1** according to a second embodiment of the present invention is described with reference to FIG. **6**. As for the second embodiment, aspects that are different from those in the first embodiment are mainly described.

[0043] FIG. **6** is an explanatory diagram of the distribution of the fiber density of the protruding surface portion **12**T of the protruding portion **12** in the nonwoven fabric **1** according to the second embodiment. As shown in FIG. **6**, in each of the protruding portions **12**, the edge portion **12**TE of the protruding surface portion **12**T has a higher fiber density than the center portion **12**TC of the protruding surface portion **12**T. By configuring the fiber density of the edge portion **12**TE of the protruding surface portion **12**T to be high, the rigidity of the edge portion **12**TE increases, whereby when an external force is added to the protruding portions **12**, the protruding portions **12** can maintain the shapes thereof. Accordingly, for example, when the nonwoven fabric **1** is packaged to be sold, the shape of the nonwoven fabric **1** can be suppressed from being collapsed, when being added with an external force to the protruding portions **12**. As a result, such nonwoven fabric is preferable in that the nonwoven fabric **1** can cause functions and advantageous effects of the superiority in reforming or keeping the shapes thereof even after the nonwoven fabric **1** is packaged and thereafter is opened from the package. Further, the nonwoven fabric **1** according to the second embodiment is also preferable in the appearance thereof, since the nonwoven fabric **1** can keep the shapes of the protruding portions **12** at the time of manufacturing even after the nonwoven fabric **1** is packaged and is opened.

[0044] Incidentally, the edge portion **12**TE is in the region of the protruding surface portion **12**T, which is along the edge **12**TEE of the protruding surface portion **12**T and has a certain width in the direction toward the center portion **12**TC, as wide as to confirm the fiber density of the edge portion **12**TE. Further, the center portion **12**TC is a portion which is more distant from the edge **12**TEE than the edge portion **12**TE. Incidentally, when the identification of the edge portion **12**TE and the center portion **12**TC is difficult, a certain range around the center of gravity of the geometric shape of the protruding surface portion **12**T in a planar view of the nonwoven fabric **1** is set as the center portion **12**TC. Further, in the case of the second embodiment, the width of the edge portion **12**TE is approximately 1 mm with respect to the protruding surface portion **12**T having the diameter of approximately 10 mm, that is, the length of approximately 10% of the diameter (or the stretching length of the protruding surface portion **12**T).

[0045] Incidentally, also in the second embodiment, in the same manner as the nonwoven fabric **1** according to the first embodiment, each of the protruding surface portions **12**T is configured so that the fiber density of each of the protruding surface portions **12**T is gradually distributed in a longitudinal direction Lo of the nonwoven fabric **1**, among the planar direction of the nonwoven fabric **1**. That is to say, in the second embodiment, on a certain segment extending in the longitudinal direction Lo at the center portion **12**TC of the protruding surface portion **12**T, portions in which the fiber density on one side of the longitudinal direction Lo is higher, and the fiber density on the other side of the longitudinal direction Lo is lower are present.

Third Embodiment

[0046] Hereinbelow, a nonwoven fabric **1** according to a third embodiment of the present invention is described with reference to FIG. **7**. As for the third embodiment, aspects that are different from those in the first embodiment are mainly described.

[0047] FIG. **7** is an explanatory diagram of distributions of the fiber density of the protruding surface portion **12**T of the protruding portion **12**, and the fiber density of the base portion **10** positioned in a state of surrounding the protruding portion **12**, in the nonwoven fabric **1** according to the third embodiment. Referring to FIG. **7**, in the third embodiment, in the planar view of the nonwoven fabric **1**, in the portion **10**L of the base portion **10** which is positioned close to the portion **12**TH at which the fiber density of the fibers configuring the protruding surface portion **12**T of the protruding portion **12** is high, the fiber density is lower than the other portions in the base portion **10**. That is to say, the fiber density of the base portion **10** surrounding the protruding portion **12** decreases as the portion **12**TH at which the fiber density of the protruding portion **12** is high is located closer therefrom.

[0048] As a result, a portion in which the fiber density is lower than the other portions is formed in the base portion **10**. Accordingly, for example, when the nonwoven fabric **1** according to the third embodiment is used as a top sheet of an absorbent article, the liquids which have moved to the portion **12**TH at which the fiber density of the protruding portion **12** is high can be allowed to permeate therethrough quickly at the portion **10**L at which the fiber density of the base portion **10** is low which is positioned nearby, as described above. As a result, it is preferable because the liquids excreted on the nonwoven fabric **1** can be allowed to permeate inside of the absorbent article in which the absorbent body and the like are provided.

Fourth Embodiment

[0049] Hereinbelow, a nonwoven fabric **1** according to a fourth embodiment of the present invention is described with reference to FIG. **8**. As for the fourth embodiment, aspects that are different from those in the third embodiment are mainly described.

[0050] FIG. **8** is an explanatory diagram of distributions of the fiber density of the protruding surface portion **12**T of the protruding portion **12**, and the fiber density of the base portion **10** positioned in a state of surrounding the protruding portion **12**, in the nonwoven fabric **1** according to the fourth embodiment. In the nonwoven fabric according to the fourth embodiment, in the same manner as the nonwoven fabric according to the second embodiment, in each of the protruding portions **12**, the edge portion **12**TE of the protruding surface portion **12**T has a higher fiber density than the center portion **12**TC of the protruding surface portion **12**T. That is to say, the nonwoven fabric **1** according to the fourth embodiment is a nonwoven fabric having the functions and advantageous effects of both the nonwoven fabrics **1** according to the second and the third embodiments. These effects are the same as the functions and the advantageous effects of the nonwoven fabrics **1** according to the second and the third embodiments, and thus the description thereof is omitted.

(Manufacturing Method of a Nonwoven Fabric)

[0051] Hereinbelow, the manufacturing method of the nonwoven fabric **1** according to the fourth embodiment is described. FIG. **9** is a schematic view showing the general outline of the manufacturing equipment **3** to manufacture the nonwoven fabric **1** according to the embodiment of the present invention. and FIG. **10** is an enlarged view of portion X in FIG. **9**. The manufacturing equipment **3** is provided with a carding machine **20** which opens and adjusts the basis weight of the fibers F**1**, a suction drum **22** and an air jet nozzle **26** which form the fibers F**2** so as to be the shape of the nonwoven fabric **1**, and a heat processing machine **28** which performs heat processing for the fiber F**3** so that the shape formed into the fibers F**3** is fixed. Incidentally, in FIG. **9**, the later described fibers F**1** to F**3** and the nonwoven fabric **1** are conveyed in the direction shown in the arrow MD, and the conveying direction MD matches with the longitudinal direction Lo of the nonwoven fabric **1**.

[0052] The manufacturing method of the nonwoven fabric **1** is briefly described as follows. First, the fibers F**1** is opened and the basis weight thereof is adjusted by the carding machine **20**, and then the opened fibers F**2** are supplied to the suction drum **22**. Next, the fibers F**2** are sucked onto the exterior surface of the suction drum **22** at which a pattern plate **24** is provided, and are blown with warm air by the air jet nozzle **26** while being moved, and thus the fibers F**2** are formed so as to be the shape of the nonwoven fabric **1** according to the above described embodiment. Next, the formed fibers F**3** are subjected to heat processing in the heat processing machine **28**, and the shape of the fibers F**3** which have been formed in the previous step is fixed, whereby the nonwoven fabric **1** is completed.

[0053] Hereinbelow, the manufacturing method of the nonwoven fabric **1** is described in detail. In the manufacturing steps of the nonwoven fabric **1**, the opened fibers F**1** are first supplied to the carding machine **20**. In the carding machine **20**, the fibers F**1** are further opened, and the basis weight (mass per unit area) of the fibers F**1** is adjusted to a desirable value.

[0054] The fibers F**2** having passed through the carding machine **20** are then supplied to the suction drum **22**. The interior of the suction drum **22** is formed to be hollow, and the interior of the suction drum **22** has negative pressure, due to the air being sucked by suction means such as a blower, etc. A plurality of suction holes **22***t* are provided on the exterior surface of the suction drum **22**, whereby the outside air can be sucked. Incidentally, the size of the suction holes of the suction drum **22** is very small, and thus the fibers F**2** are not sucked into the interior of the suction drum **22**.

[0055] The exterior surface of the suction drum **22** is covered by the pattern plate **24** in the entire circumference thereof, and to be more specific, the fibers F**2** are supplied onto the pattern plate **24**. In the present manufacturing method, the pattern plate **24** is a perforated plate in which through holes **24***t* each having a complementary shape to each of the protruding portions **12** of the nonwoven fabric **1** are provided with the distribution of the protruding portions **12**.

[0056] According to such configuration, the suction holes of the suction drum **22** exposed at the through holes **24***t* of the pattern plate **24** suck the fibers F**2** supplied onto the pattern plate **24**. Incidentally, in the nonwoven fabric **1** according to the present embodiment, the positional difference of the height of the first surface FF in the thickness direction Th of the nonwoven fabric **1** between the base portion **10** and the protruding surface portion **12**T of each of the protruding portions **12** is approximately equal to the thickness of the pattern plate **24**.

[0057] Incidentally, in the present manufacturing method, the suction drum **22** is configured so that on the exterior surface thereof, the suction is performed for the fibers F**2** within the area AS from the point SS at which the fibers F**2** are passed from the upstream belt conveyor UB to the point SE at which the fibers F**2** are passed on to the downstream belt conveyor DB, and the suction is not performed in the other areas AN. Such configuration is adopted so as to improve the efficiency of the suction function by the suction drum **22**.

[0058] The fibers F**2** sucked onto the exterior surface of the suction drum **22** are blown with warm air by the air jet nozzle **26**. Here, the air jet nozzle **26** has a mechanism which uniformly jets a predetermined amount of the warm air in a uniform width in the width direction. By adjusting the width of the blowing ports, the distance between the blowing ports and the fibers F**2**, etc., the air jet nozzle **26** is configured so that the warm air is substantially uniformly jetted over the entire width of the laminate formed by the fibers F**2**. The fibers F**2** can be formed so as to be the shape of the nonwoven fabric **1** according to the present embodiment, by the suction function and the jetting function by the suction drum **22** and the air jet nozzle **26**.

[0059] The temperature of the warm air jetted from the air jet nozzle **26** is higher than the melting point of the fibers F**2**, however, the temperature of the warm air is adjusted not to be too high, in order to prevent the nonwoven fabric **1** from being too stiff after the nonwoven fabric **1** is completed. Further, the velocity of the warm air is determined so as to form the fibers F**2** into a desired shape. Generally, the temperature and the velocity of the warm air jetted from the air jet nozzle **26** differ according to the material of the fibers to be used, the basis weight, the shape of the nonwoven fabric **1** after completion, etc. However, the optimal temperature and velocity are preferably determined for example by experiments, etc. For example, the temperature of the warm air jetted from the air jet nozzle **26** ranges preferably from 80 [° C.] to 400 [° C.], and the velocity thereof ranges preferably from 10 to 200 [m/sec]. In the present manufacturing method, the temperature of the warm air jetted from the air jet nozzle **26** is 180 [° C.], and the velocity thereof is 38.9 [m/sec]. Incidentally, at this stage, the fibers F**2** can be formed, and at the same time, the shape thereof can be fixed to a certain degree, by jetting the warm air to the fibers F**2** with a temperature higher than the melting point thereof.

[0060] Incidentally, in the manufacturing equipment **3** according to the present embodiment, the surface of the laminate formed by the fibers F**2** facing the suction drum **22** and the pattern plate **24** is to be the first surface FF of the nonwoven fabric **1**, and the surface of the laminate facing the air jet nozzle **26** is to be the second surface FS of the nonwoven fabric **1**.

[0061] When the fibers F**2** are jetted by the air jet nozzle **26**, the fibers F**2** are blown and are moved to the surroundings. As a result, the amount of fibers at the jetted portion is decreased, and whereby the fiber density at the jetted portion is decreased. On the other hand, since the air jet nozzle **26** is disposed in a fixed state, the fibers F**2** located inside the through holes **24***t* of the pattern plate **24** are eventually jetted with warm air at the portion F**2***tu* which is positioned in the upstream side of the conveying direction MD, whereby the fiber density thereof is lowered. Subsequently, the fibers F**2** moved by the jetting function of the air jet nozzle **26** are fixed to the position after movement by the suction function of the suction drum **22**. To be more specific, first, warm air is jetted to the portion F**2***td* at the downstream side of the conveying direction MD of the fibers F**2** located inside the through holes **24***t*, and the fibers located at the portion F**2***td* are blown and are moved to the downstream side of the conveying direction MD. However, subsequently, warm air is jetted to the portion F**2***tu* at the upstream side of the conveying direction MD of the fibers F**2** located inside the through holes **24***t*, and the fibers are moved to the downstream side of the conveying direction MD. Then, the fibers F**2** located inside the through holes **24***t* of the pattern plate **24** are continuously sucked by the suction drum **22**, whereby the fibers F**2** are conveyed to the subsequent processing with the movement of the fibers being suppressed. As a result, eventually, the fiber density of the portion F**2***td* at the downstream side of the conveying direction MD of the fibers F**2** is made higher, and oppositely, the fiber density of the portion F**2***tu* at the upstream side of the conveying direction MD of the fibers F**2** which are jetted at the final stage is made lower. Accordingly, in the nonwoven fabric **1**, in each of the protruding portions **12**, the protruding surface portion **12**T is configured so that the fiber density of the protruding surface portion **12**T is gradually distributed in a predetermined direction, which is the longitudinal direction Lo of the nonwoven fabric **1** matching with the conveying direction MD in the above described embodiment.

[0062] Further, the same can be said for the portion F**2***su* which is positioned at the upstream side of the conveying direction MD, among the fibers F**2** located on the exterior surface **24***s* which is positioned in between the through holes **24***t* of the pattern plate **24**. That is to say, warm air is jetted to the portion F**2***su*, whereby the fibers F**2** are blown and are moved to the surroundings. At this time, the fibers F**2** also move inside the through holes **24***t*. Subsequently, warm air is jetted to the portion F**2***tu* at the upstream side of the conveying direction of the fibers F**2** located inside the through holes **24***t*, among the fibers F**2**, however, once the fibers F**2** are moved inside the through holes **24***t*, the fibers F**2** do not come back to the exterior surface **24***s* from inside the through holes **24***t*, whereby the fiber density at the portion F**2***su* is lowered. On the other hand, the fiber density at the portion F**2***tu* at the upstream side of the conveying direction of the fibers F**2** inside the through holes **24***t* is made higher. As a result, as in the nonwoven fabric **1** according to the third embodiment, the fiber density of the base portion **10** surrounding the protruding portion **12** decreases as the portion **12**TH at which the fiber density of the protruding portion **12** is high is located closer therefrom.

[0063] Further, it is difficult for a corner portion Co which is formed at the portion where the side walls **24***w* forming the through holes **24***t* of the pattern plate **24** and the exterior surface of the suction drum **22** are connected to each other to receive warm air, and it is difficult for the fibers to move from the corner portion Co. On the other hand, the fibers are blown from the surroundings of the corner portion Co by the warm air jetted from the air jet nozzle **26** and are moved to the corner portion Co. Then, the corner portion Co corresponds to the edge portion **12**TE of the protruding portion **12** in the nonwoven fabric **1**. As described above, in the above manufacturing method, the amount of the fibers at the corner portion Co is increased, and as a result, as in the nonwoven fabric **1** according to the second embodiment, the edge portion **12**TE of the protruding portion **12** has a higher fiber density than the center portion **12**TC of the protruding portion.

[0064] The shape of the protruding portion **12** is eventually determined by the shape of the through holes **24***t* of the pattern plate **24**, the temperature and the velocity of the warm air jetted from the air jet nozzle **26**, and the like.

[0065] As shown in FIG. **9**, the fibers F**3** formed by the above described suction and jetting functions are then transferred to the heat processing machine **28**. Fibers F**3** are subjected to heat processing in the heat processing machine **28**, and the shape formed in the prior stages is fixed. In the heat processing machine **28**, by performing the heat processing for the fibers F**3** at a relatively low temperature with respect to the melting point of the fibers and with the warm air of low velocity for long hours, the shape of the fibers F**3** formed at the prior stages are fixed, and can also provide flexibility to the nonwoven fabric **1**. Generally, the temperature and the velocity of the warm air in the heat processing machine **28**, the processing time, etc., differ according to the material of the fibers to be used, the basis weight, etc. However, the optimal temperature and velocity are preferably determined for example by experiments, etc.

[0066] When the heat processing of the fibers F**3** by the heat processing machine **28** is terminated, the nonwoven fabric **1** is completed. The completed nonwoven fabric **1** is cut to a desired size, and is used.

[0067] The manufacturing method of the nonwoven fabric **1** according to the fourth embodiment has been described, however, by suitably changing shape of the pattern plate **24**, the temperature and the velocity of the warm air jetted from the air jet nozzle **26**, etc., the nonwoven fabrics **1** according to the first to the third embodiment can also be manufactured.

EXAMPLES

[0068] In the present examples, a liquid diffusion length test was performed with respect to the nonwoven fabrics set with various conditions. The liquid diffusion length test is a test to confirm that the liquid absorbed by a nonwoven fabric permeates therethrough with directivity.

[0069] Hereinbelow, the Examples 1 to 3 and the Comparative Example are described.

Examples 1 to 3

[0070] The nonwoven fabrics according to Examples 1 to 3 are the nonwoven fabrics manufactured by the above described manufacturing method. The temperature and the velocity of the warm air jetted from the air jet nozzle 26 when manufacturing these nonwoven fabrics, and the temperature and the velocity of the heat processing performed inside the heat processing machine **28** are shown in the later described Table 1. Further, the uneven distribution of the fiber density of the protruding surface portion in the protruding portion was measured according to the above described measuring method of the fiber density in the surroundings of the two measurement points PH, PL shown in FIG. **11**. One measurement point PH is the midpoint between the center point C of the protruding surface portion **12**T in the planar view of the nonwoven fabric **1** and the edge **12**TEE positioned at the side where the fiber density is higher along the longitudinal direction Lo form the center point C. Further, the other measurement point PL is the midpoint between the center point C of the protruding surface portion **12**T and the edge **12**TEE positioned at the side where the fiber density is lower along the longitudinal direction Lo form the center point C. When the difference of the fiber densities measured at these measurement points are large, the fiber density of the protruding surface portion can be evaluated as being more gradually distributed. Referring to the later described Table 1, the fiber density of the protruding surface portion of the nonwoven fabric according to the second embodiment is more gradually distributed than that according to the first embodiment. Further, the fiber density of the protruding surface portion of the nonwoven fabric according to the third embodiment is more gradually distributed than that according to the second embodiment.

Comparative Example

[0071] The nonwoven fabric according to the Comparative Example was formed in which the fibers opened by the carding machine were not sucked by the suction drum, were not jetted with warm air by the air jet nozzle, and were formed into a planar shape so that the fiber density was even by the heat processing machine. The temperature and the velocity of the heat processing performed inside the heat processing machine at this time are shown in the later described Table 1.

[0072] Next, the testing method of the test performed in the present Examples is described. The liquid diffusion length test was performed by disposing the samples of the nonwoven fabrics according to the Examples and the Comparative Example which were cut into the width of **150** mm and the length of 300 mm, on a stainless plate having a width of 250 mm and a length of 450 mm, and by dropping 20 cc of simulated artificial urine onto one protruding portion by 2.5 seconds. At this time, the lengthwise direction of the samples was the direction in which the fiber density of the fibers configuring the protruding surface portion of the protruding portion was gradually distributed, and the direction in which the fiber density of the protruding surface portion was higher along the lengthwise direction was set as DH direction, and the direction in which the fiber density of the protruding surface portion was lower was set as the DL direction. Further, the lengths dh and dl from the dropping point of the artificial urine at which the artificial urine permeated therethrough and reached in the DH direction and in the DL direction were respectively measured. The amount obtained by subtracting the length dl from the length dh was regarded as the liquid diffusion length. The above described liquid diffusion length test was performed for three times, and the amount obtained as the average of each of the measurement values was calculated as the liquid diffusion length.

[0073] Incidentally, the artificial urine used in the liquid diffusion length test was prepared by dissolving 200 g of urea, 80 g of sodium chloride, 8 g of magnesium sulfate, 3 g of calcium chloride and approximately 1 g of a pigment (Blue No. 1) in 10 L of an ion exchanged water.

[0074] Table 1 is shown below. In Table 1, the basis weight, the thickness, the manufacturing conditions of the nonwoven fabrics according to the Examples 1 to 3 and the Comparative Example, the fiber density in the protruding surface portion at the surroundings of each of the measurement points PH, PL, and the results of the liquid diffusion length test are shown. Incidentally, the "thickness" shown in Table 1 is the average value of the thicknesses measured three times under the pressure of 3 gf/cm^2, and in the nonwoven fabrics according to the Examples 1 to 3, the thickness of the protruding portion was measured.

TABLE 1

			Example 1	Example 2	Example 3	Comparative Example
Basis Weight		(g/m2)	25	25	25	30
Thickness		(mm)	1.9	1.3	1.2	2.3
Air Jet	Temperature	(° C.)	180	180	170	—
Warm Air	Velocity	(m/sec)	38.9	44.4	50.0	—
Heat Processing Machine	Temperature	(° C.)	135	135	135	133
Warm Air	Velocity	(m/sec)	0.9	0.9	0.9	0.9
Fiber Density (PH)		(numbers)	44	40	48	—
Fiber Density (PL)		(numbers)	36	25	28	—
Liquid Diffusion Length		(mm)	11	23	31	-1

[0075] As shown in the results of the liquid diffusion length test of Table 1, the more gradually distributed the fiber density of the protruding surface portion is, the longer the liquid diffusion length is. Accordingly, the more gradually distributed the fiber density is, the liquid absorbed in the nonwoven fabric can be permeated therethrough in the direction toward which the fiber density of the fibers configuring the protruded surface portion is gradually distributed.

[0076] All the features which can be understood by those skilled in the art from the description of the specification, drawings and the claims can be applied independently or can be applied in optional combination with another one or a plurality of features disclosed herein to be bound together, as long as such features are explicitly excluded or its technical aspect becomes an impossible or a meaningless combination, even when such features are described only in combination with another specific feature in this specification.

[0077] For example, in the nonwoven fabric **1** according to another embodiment, the edge portion **12**TE of the protruding surface portion **12**T has a higher fiber density than the center portion **12**TC of the protruding surface portion **12**T as in the second embodiment, and at the same time, the fiber density of the base portion **10** surrounding the protruding portion **12** decreases as the portion **12**TH at which the fiber density of the protruding portion **12** is high is located closer therefrom, as in the third embodiment.

[0078] The present invention is defined as follows.

[0079] (1) A nonwoven fabric comprising a base portion which extends in a planar shape and a plurality of protruding portions which protrude in a thickness direction from the base portion, wherein

[0080] each of the protruding portions has a protruding surface portion, and

[0081] the each protruding surface portion is configured so that a fiber density of the each protruding surface portion is gradually distributed in a predetermined direction in a planar direction of the nonwoven fabric.

[0082] (2) The nonwoven fabric according to (1), wherein

[0083] in each of the protruding portions, an edge portion of the each protruding surface portion has a higher fiber density than a center portion of the each protruding surface portion.

[0084] (3) The nonwoven fabric according to (1) Or (2), wherein

[0085] a fiber density of the base portion surrounding the protruding portions decreases as a fiber density of the protruding portions increases.

[0086] (4) The nonwoven fabric according to any one of (1) to (3), wherein

[0087] when the each protruding surface portion is divided into two hemi-protruding surface portions by a virtual line which extends in a direction perpendicular to the predetermined direction in a planar view of the nonwoven fabric, the two hemi-protruding surface portions having the same areas, a fiber density of one hemi-protruding surface portion is higher than a fiber density of the other hemi-protruding surface portion.

[0088] (5) The nonwoven fabric according to any one of (1) to (4), wherein

[0089] the protruding portions are aligned along a first direction and along a second direction which is different from the first direction.

[0090] (6) The nonwoven fabric according to (5), wherein

[0091] each of the protruding portions is arranged with equal intervals in the first direction and in the second direction, with the base portion disposed in between.

[0092] (7) The nonwoven fabric according to (5) or (6), wherein

[0093] the predetermined direction matches the first direction or the second direction.

[0094] (8) The nonwoven fabric according to any one of (1) to (7), wherein

[0095] the predetermined direction matches a conveyance direction when manufacturing the nonwoven fabric.

REFERENCE SIGNS LIST

[0096] **1** nonwoven fabric

[0097] **10** base portion

[0098] **12** protruding portion

[0099] **12**T protruding surface portion

1-8. (canceled)

9. A nonwoven fabric comprising a base portion which extends in a planar shape and a plurality of protruding portions which protrude in a thickness direction from the base portion, wherein

each of the protruding portions has a protruding surface portion,

the each protruding surface portion is configured so that a fiber density of the each protruding surface portion is gradually distributed in a predetermined direction in a planar direction of the nonwoven fabric, and

a fiber density of the base portion surrounding the protruding portions decreases as a fiber density of the protruding portions increases.

10. The nonwoven fabric according to claim **9**, wherein

in each of the protruding portions, an edge portion of the each protruding surface portion has a higher fiber density than a center portion of the each protruding surface portion.

11. The nonwoven fabric according to claim **9**, wherein when the each protruding surface portion is divided into two hemi-protruding surface portions by a virtual line which extends in a direction perpendicular to the predetermined direction in a planar view of the nonwoven fabric, the two hemi-protruding surface portions having the same areas, a fiber density of one hemi-protruding surface portion is higher than a fiber density of the other hemi-protruding surface portion.

12. The nonwoven fabric according to claim **9**, wherein the protruding portions are aligned along a first direction and along a second direction which is different from the first direction.

13. The nonwoven fabric according to claim **12**, wherein each of the protruding portions is arranged with equal intervals in the first direction and in the second direction, with the base portion disposed in between.

14. The nonwoven fabric according to claim **12**, wherein the predetermined direction matches the first direction or the second direction.

15. The nonwoven fabric according to claim **9**, wherein the predetermined direction matches a conveyance direction when manufacturing the nonwoven fabric.

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