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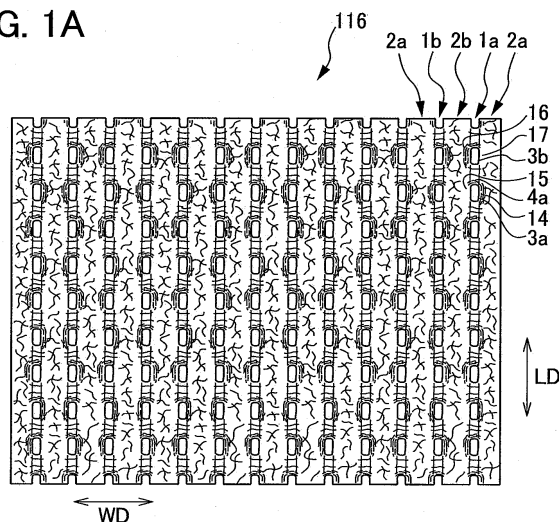
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(54) **NONWOVEN FABRIC**

(57) A nonwoven fabric provided with unevenness and openings, regulated so that without extremely increasing of fiber density at protrudent portions, depressed portions, etc., only part of the periphery of each open area is densified. One side edge portion (14,16) of

each open area (3a,3b) is formed by shifting of fiber web (100) toward the low position of wire (302) with a gradient extending in the direction of width (WD). Nearly none of fiber web (100) is shifted to the side edge portion opposite to the one side edge portion (14,16) of open area (3a, 3b), namely, other side edge portion (15,17).

FIG. 1A



Description

TECHNICAL FIELD

[0001] The present invention relates to a nonwoven fabric and a nonwoven fabric manufacturing method.

BACKGROUND ART

[0002] Conventionally, nonwoven fabrics have been used in a wide variety of fields, for example, sanitary goods such as paper diapers and sanitary napkins, cleaning goods such as wipers, and medical goods such as masks. Thus, the nonwoven fabrics can be used in various different fields, and when they are actually used in the products of the respective fields, it is necessary to be manufactured so as to have suitable characteristics and structure for the applications of the products, respectively.

[0003] The nonwoven fabrics can be manufactured by, for example, forming a fiber layer (a fiber web) by dry method, wet method, or the like, and bonding the fibers in the fiber layer together by chemical bond method, thermal bond method, or the like. In the step of bonding the fibers for forming the fiber layer, there also exists the method including the step of externally exerting physical force on the fiber layer, such as the process of repetitively sticking a large number of needles into the fiber layer, the process of spraying water-jet, or the like.

[0004] However, these methods merely confound the fibers together at the most, and are not intended for adjusting the orientation and arrangement of the fibers in the fiber layer, and the shape of the fiber layer. That is, these methods can manufacture the nonwoven fibers in a mere sheet-shape.

[0005] There has also been proposed a nonwoven fabric provided with openings. For example, Japanese Patent Application Laid-Open No. 6-330443 discloses a method of opening a nonwoven fabric in three dimensions by interposing a nonwoven fabric between a mold having protrusions such as needles protruding outward, and a base material on the receiving side where the protrusions are received, and allowing the protruding portions to penetrate the nonwoven fabric.

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0006] However, in this nonwoven fabric, a fiber aggregate constituting the nonwoven fabric is sandwiched between the protruding portions and the base material on the receiving side, resulting in concave portions, convex portions, and openings. Therefore, the nonwoven fabrics of related art have the problem that, for example, the fibers in the wall portion of the convex portions and in the entire peripheral edge of the openings can be compressed to increase the fiber density, and these fibers may be filmed when heat is further supplied to obtain the nonwoven fabric.

[0007] In the nonwoven fabric so filmed having a high fiber density in the wall portions of the convex portions and in the entire periphery of the openings, the openings are hard to collapse even external pressure is exerted thereon. One reason for this seems that the chips of the standing nonwoven fabric at the locations broken by the needles or the like are hard to tumble. When this nonwoven fabric is used in the top sheet or the like in an absorbent article, there is the tendency that liquid is hard to be penetrated downward. In the event that a large quantity of a predetermined liquid enters the convex portions and the peripheral edges of the openings, there may arise the possibility that the liquid remains in the nonwoven fabric and stains the wearer's skin or the like, resulting in discomfort.

[0008] The present invention aims at providing a nonwoven fabric provided with concave and convex portions, and openings, which can be adjusted to densify only a partial area of the peripheral edges of the openings, without excessively increasing the fiber density in the convex portion and the concave portions.

[0009] The present inventors have completed the present invention based on the discovery that only a part of openings and the peripheral edges of the openings can be densified by blowing gas against a fiber web, from the top surface thereof, supported from the bottom surface by a predetermined net-shaped supporting member so that the fibers constituting the fiber web can be moved. Specifically, the present invention provides the following nonwoven fabrics.

Means for Solving the Problems

[0010] According to a first aspect of the present invention, a nonwoven fabric includes a plurality of openings formed along a first direction; a first side edge portion allocated as one area in the vicinity of a side edge portion of the opening when viewed from a second direction orthogonal to the first direction; and a second side edge portion allocated as the other area in the vicinity of the side edge portion of the opening, separated from the first side edge portion by the opening, the first side edge portion having a higher fiber density than the second side edge portion.

[0011] In a second aspect of the nonwoven fabric as described in the first aspect of the present invention, the first

side edge portion has a higher basis weight than the second side edge portion.

[0012] In a third aspect of the nonwoven fabric as described in the first or second aspect of the present invention, the nonwoven fabric further includes a first opening and a second opening adjacent to each other in an arrangement of the plurality of openings, and a first connecting part of a fiber between the first opening and the second opening, the first connecting part having a higher fiber density than the second side edge portion in the first opening.

[0013] In a fourth aspect of the nonwoven fabric as described in a third aspect of the present invention, at the first side edge portion in the second opening, a content ratio of fibers oriented in the first direction is higher than a content ratio of fibers oriented in the second direction.

[0014] In a fifth aspect of the nonwoven fabric as described in the third or fourth aspects of the present invention, in the first connecting part, a content ratio of fibers oriented in the second direction is higher than a content ratio of fibers oriented in the first direction.

[0015] In a sixth aspect of the nonwoven fabric as described in any one of the third to fifth aspects of the present invention, the first connecting part has a higher basis weight than the second side edge portion in the first opening.

[0016] In a seventh aspect of the nonwoven fabric as set forth in any one of the third to sixth aspects of the present invention, the nonwoven fabric further includes a third opening adjacent to the first opening on the opposite side of the second opening in the arrangement of the plurality of openings, and a second connecting part of fibers between the first opening and the third opening, the second connecting part having a higher fiber density than the second side edge portion in the first opening.

[0017] In an eighth aspect of the nonwoven fabric as described in the seventh aspect of the present invention, the first side edge portion in the second opening and the first side edge portion in the first opening are located on opposite sides in the second direction, the first side edge portion in the third opening and the first side edge portion in the first opening are located on opposite sides in the second direction, and the first side edge portion in the second opening which is an area having a higher fiber density than the second side edge portion, the first connecting part, the first side edge portion in the first opening, the second connecting part, and the first side edge portion in the third opening are continued in a meandering shape.

[0018] In a ninth aspect of the nonwoven fabric as described in the seventh or eighth aspects of the present invention, the first connecting part has a fiber density of at least 0.05 g/cm^3 , and having at least 1.1 times a fiber density of the second side edge portion in at least one of either of the first opening and the second opening, and the second connecting part has a fiber density of at least 0.05 g/cm^3 , and having at least 1.1 times a fiber density of the second side edge portion in at least one of either of the first opening and the second opening.

[0019] In a tenth aspect of the nonwoven fabric as described in any one of the seventh to ninth aspects of the present invention, at the first side edge portion in the third opening, a content ratio of fibers oriented in the first direction is higher than a content ratio of fibers oriented in the second direction.

[0020] In an eleventh aspect of the nonwoven fabric as described in any one of the seventh to tenth aspects of the present invention, at the second connecting part, a content ratio of fibers oriented in the second direction is higher than a content ratio of fibers oriented in the first direction.

[0021] In a twelfth aspect of the nonwoven fabric as described in any one of the seventh to eleventh aspects of the present invention, the second connecting part has a higher basis weight than that of the second side edge portion in the first opening.

[0022] In a thirteenth aspect of the nonwoven fabric as described in any one of the seventh to twelfth aspects of the present invention, a basis weight of the first side edge portion in the first opening, a basis weight of the first side edge portion in the second opening, and a basis weight of the first side edge portion in the third opening are 15 to 250 g/cm^3 , respectively, each being at least 1.1 times a basis weight of the second side edge portion in the first opening, a basis weight of the second side edge portion in the second opening, and a basis weight of the second side edge portion in the third opening, respectively.

[0023] In a fourteenth aspect of the nonwoven fabric as described in any one of the first to thirteenth aspects of the present invention, the nonwoven fabric further includes: a plurality of groove portions formed on one surface of the nonwoven fabric so as to extend in the first direction; and a plurality of raised ridge portions formed so as to extend in the first direction on one surface, the raised ridge portions being adjacent to the plurality of groove portions, respectively, the plurality of openings being formed along the plurality of grooves, respectively.

[0024] In a fifteenth aspect of the nonwoven fabric as described in any one of the first to fourteenth aspects of the present invention, in which the shape of each of the plurality of openings is selected from a substantially circular shape and a substantially elliptical shape.

[0025] In a sixteenth aspect of the present invention, the nonwoven fabric includes an area of density change in which the fiber density continuously or intermittently changes, the area of density change having a plurality of high-density areas extending in a predetermined first direction identical with a process flow direction in a machine when manufacturing the nonwoven fabric.

[0026] In a seventeenth aspect of the nonwoven fabric as described in the sixteenth aspect of the present invention,

the high-density areas have a plurality of C-shaped high-density areas, and one sides of the high-density regions when viewed from a second direction orthogonal to the first direction have a low fiber density, respectively.

[0027] The term "C-shaped" includes the mode of "the reverse C-shaped". That is, the term "C-shaped high-density areas" include the "reverse C-shaped high-density areas".

[0028] In an eighteenth aspect of the nonwoven fabric as described in the sixteenth or seventeenth aspects of the present invention, the high-density area has a meandering shaped high-density area extending in a meandering shape in the first direction.

[0029] In a nineteenth aspect of the nonwoven fabric as described in any one of the first to eighteenth aspects of the present invention, formed by blowing a fluid composed mainly of gas against fibers constituting a fiber aggregate thereby displacing a part of the fibers, the fiber aggregate being supported from one surface thereof by a supporting member having a portion capable of passing through a predetermined fluid, by bringing fibers constituting the fiber aggregate.

Effects of the Invention

[0030] Accordingly, the present invention is capable of providing the nonwoven fabrics provided with the concave/convex portions, and the openings, which can be adjusted to densify only a partial area of the peripheral edges of the openings, without excessively increasing the fiber density in the raised ridge portion as the convex portion and the groove portion as the concave portion. The present invention is also capable of providing the method of manufacturing the nonwoven fabrics.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

Fig. 1A is a plan view of a nonwoven fabric according to a first embodiment of the present invention;
 Fig. 1B is a bottom view of a nonwoven fabric according to a first embodiment of the present invention;
 Fig. 2 is a perspective sectional view of the nonwoven fabric according to the first embodiment;
 Fig. 3A is a plan view of a net-shaped supporting member according to the first embodiment;
 Fig. 3B is a bottom view of a net-shaped supporting member according to the first embodiment;
 Fig. 4 is a perspective view of a fiber web;
 Fig. 5 is a side view for explaining a nonwoven fabric manufacturing apparatus in the first embodiment;
 Fig. 6 is a plan view for explaining the nonwoven fabric manufacturing apparatus of Fig. 5;
 Fig. 7 is an enlarged perspective view of an area Z in Fig. 5;
 Fig. 8 is a bottom view of a blowing unit in Fig. 7;
 Fig. 9A is a plan view of a nonwoven fabric according to a second embodiment of the present invention;
 Fig. 9B is a bottom view of a nonwoven fabric according to a second embodiment of the present invention;
 Fig. 10 is a perspective sectional view of the nonwoven fabric according to the second embodiment;
 Fig. 11A is a plan view of a nonwoven fabric according to a third embodiment of the present invention;
 Fig. 11B is a bottom view of a nonwoven fabric according to a third embodiment of the present invention;
 Fig. 12A is a perspective sectional view showing an example of the applications of the nonwoven fabric according to the present invention;
 Fig. 12B is a partial enlarged view of Fig. 12A;
 Fig. 13A is a perspective view showing another example of the applications of the nonwoven fabric according to the present invention;
 Fig. 13B is a partial enlarged view of Fig. 13A;
 Fig. 14 is a diagram showing an example of the applications of the nonwoven fabric in the present invention;
 Fig. 15A is a perspective view showing a still another example of the applications of the nonwoven fabric according to the present invention; and
 Fig. 15B is a partial enlarged view of Fig. 15A.

PREFERRED MODE FOR CARRYING OUT THE INVENTION

[0032] Figs. 1A and 1B are a plan view and a bottom view of a nonwoven fabric according to a first embodiment of the present invention, respectively. Fig. 2 is a perspective sectional view of the nonwoven fabric according to the first embodiment; Figs. 3A and 3B are a plan view and a bottom view of a net-shaped supporting member according to the first embodiment, respectively. Fig. 4 is a perspective view of a fiber web; Fig. 5 is a side view for explaining a nonwoven fabric manufacturing apparatus in the first embodiment. Fig. 6 is a plan view for explaining the nonwoven fabric manufacturing apparatus of Fig. 5. Fig. 7 is an enlarged perspective view of an area Z in Fig. 5. Fig. 8 is a bottom view of a

blowing unit in Fig. 7. Figs. 9A and 9B are a plan view and a bottom view of a nonwoven fabric according to a second embodiment of the present invention, respectively. Fig. 10 is a perspective sectional view of the nonwoven fabric according to the second embodiment. Figs. 11A and 11B are a plan view and a bottom view of a nonwoven fabric according to a third embodiment of the present invention, respectively. Figs. 12A and 12B are a perspective sectional view and its partial enlarged view showing an example of the applications of the nonwoven fabric according to the present invention, respectively. Figs. 13A and 13B are a perspective view and its partial enlarged view showing another example of the applications of the nonwoven fabric according to the present invention, respectively. Fig. 14 is a diagram showing an example of the applications of the nonwoven fabric in the present invention. Figs. 15A and 15B are a perspective view and its partial enlarged view showing a still another example of the applications of the nonwoven fabric according to the present invention, respectively.

1. Outline of Nonwoven Fabric of the Present Invention

[0033] The nonwoven fabric can be substantially realized as follows. There is prepared a predetermined net-shaped supporting member having a portion capable of passing through a predetermined fluid. A fabric aggregate, with one surface thereof supported by the net-shaped supporting member, can be brought into a substantially sheet shape. When the fibers constituting the substantially sheet shaped fiber aggregate is in the state of having a degree of freedom, a fluid composed mainly of gas is blown against the fiber aggregate from the other surface thereof. Thus, the movement of the fibers can be controlled, and a plurality of openings can be formed along a first direction, for example, a longitudinal direction (LD) being a machine direction. Each of the plurality of openings has the following characteristic feature. One side edge portion, which is allocated as one area in the vicinity of the side edge portion of the opening when viewed from a second direction orthogonal to the first direction, namely a width direction (WD) being a cross direction, has a higher fiber density than the second side edge portion allocated as the other area in the vicinity of the side edge portion of the opening. The nonwoven fabric having the above characteristic features can be configured. The term "machine direction" corresponds to a direction in which a nonwoven fabric or a fiber web is fed through a nonwoven fabric manufacturing machine. The term "cross direction" corresponds to a direction orthogonal to the machine direction.

2. First Embodiment

[0034] A first embodiment in the nonwoven fabric of the present invention will be described with reference to Figs. 1A to 4.

[0035] In the following, groove portions 1a and 1b are examples of a groove portion 1, as shown in Figs. 1A, 1B or 2. Raised ridge portions 2a and 2b are examples of a raised ridge portion 2 as a convex portion. A Second opening 3b adjacent to a predetermined first opening 3a in the longitudinal direction (LD) being the machine direction (hereinafter in some cases, the first openings 3a and 3b are referred to simply as the openings 3a and 3b) are examples of a plurality of openings 3.

2-1. Shape

[0036] As shown in Fig. 1A, 1B, or Fig. 2, a nonwoven fabric 116 in the first embodiment is a nonwoven fabric where the groove portions 1a and 1b are used as a unit, and a plurality of units are arranged side by side. The groove portions 1a and 1b are examples of a groove portion 1 as a concave portion. That is, the nonwoven fabric 116 has on one surface thereof a plurality of groove portions 1a and 1b formed so as to extend in the longitudinal direction (LD) being the machine direction. Between the groove portion 1a and the groove portion 1b, the raised ridge portions 2a and 2b are alternately arranged side by side at substantially equal intervals.

[0037] The nonwoven fabric 116 is also a nonwoven fabric where a plurality of openings 3a and 3b are formed alternately at substantially equal intervals in the longitudinal direction (LD). Although in the present embodiment, the plurality of opening 3a and 3b are so formed, they may not be formed continuously at substantially equal intervals.

[0038] The groove portions 1a and 1b can be formed by passing through the following process on a net support member 100 as a fiber aggregate as shown in Fig. 4. For example, the fiber web 100 is supported from the lower surface thereof by a net-shaped supporting member 300 as shown in Figs. 3A and 3B, and gas is blown against the fiber web 100 from the upper surface thereof in order to move fibers 101 constituting the fiber web 100. This enables the groove portions 1a and 1b to be formed.

[0039] The movement of the fibers 101 constituting the fiber web 100 can be controlled by a fluid composed mainly of gas, which is blown from the upper surface of the fiber web 100.

[0040] The raised ridge portions 2a and 2b are areas in the fiber web 100, against which the fluid composed mainly of gas is not blown. That is, the formation of the groove portions 1a and 1b causes the aforesaid areas to be protruded relatively.

[0041] Here, as shown in Figs. 3A and 3B, wires 301 disposed in the machine direction or the longitudinal direction (LD), and wires 302 disposed in the cross direction or the width direction (WD) are woven to form the net-shaped supporting member 300. The wires 301 and the wires 302 are woven together in a zigzag pattern where the wires 301 cross over the wires 302 in the thickness direction of the net-shaped supporting member 300, and the wires 302 cross over the wires 301 in the thickness direction of the net-shaped supporting member 300. For example, the zigzag pattern of the wires 302 is woven in staggered fashion in the longitudinal direction (LD).

[0042] When the fiber web 100 as the fiber aggregate is supported from the lower surface thereof by the net-shaped supporting member 300 shown in Figs. 3A and 3B, and the fluid composed mainly of gas is blown against the fiber web 100 from the upper surface thereof, the blowing position against the fiber web 100 is preferably nearly the central part between the wires 301 disposed in the machine direction or the longitudinal direction (LD). Thus, the fiber web 100 arranged on the wires 302 in between the wires 301 can be moved to form the openings 3a and 3b. The openings 3a and 3b are hole portions penetrating the nonwoven fabric 116, a plurality of numbers of which are formed at predetermined intervals in the groove portions 1, and which are shaped in a substantially circle or a substantially elliptical. Although in the present embodiment, the openings 3a and 3b are formed at substantially equal intervals, without limiting to this, they may be formed at different intervals.

[0043] The fiber web 100 can be moved to a lower part of the tilted wires 302 arranged in the cross direction or the width direction (WD), thereby to form one side edge portions 14 and 16 in the openings 3a and 3b, respectively. That is, the first side edge portion 14 or 16 is allocated as one area in the vicinity of the side edge portion of the opening 3a or 3b when viewed from the width direction (WD). The second side edge portions 15 and 17 are disposed on the opposite sides of the first side edge portions 14 and 16 in the openings 3a and 3b, respectively. That is, the second side edge portion 15 or 17 is allocated as the other area in the vicinity of the side edge portion of the opening 3a or 3b, separated by the opening 3a or 3b. The fiber web 100 is hardly moved to the second side edge portions 15 and 17 in the openings 3a and 3b, respectively.

[0044] Specifically, as shown in Figs. 1A, 1B and 2, the first side edge portions 14 and 16 in the openings 3a and 3b are formed at the raised ridge portions 2a and 2b, respectively. Here, the first side edge portion 16 in the opening 3b is the side edge portion on the opposite side of the first side edge portion 14 in the width direction (WD).

[0045] On the other hand, the second side edge portions 15 and 17 in the openings 3a and 3b are formed at the raised ridge portions 2a and 2b, respectively. However, the second side edge portions 15 and 17 are areas where the fibers 101 constituting the fiber web 100 is less moved than the first side edge portions 14 and 16.

[0046] Although in the present embodiment, the above-mentioned the first side edge portions 14 and 16 and the second side edge portions 15 and 17 are formed at the raised ridge portions 2a and 2b, without limiting to this, they may be formed at the groove portions 1a and 1b.

[0047] The nonwoven fabric 116 is also a nonwoven fabric where a first connecting part 4a (hereinafter in some cases referred to simply as the connecting part 4a) is formed between the first opening 3a and the second opening 3b. That is, the first connecting part 4a formed so as to connect the adjacent raised ridge portions 2a and 2b is formed between the adjacent openings 3a and 3b in the groove portion 1a or 1b. As will be described later, the first connecting part 4a has a higher fiber density and a higher basis weight than the second side edge portion 15 in the first opening 3a.

[0048] The heights of the raised ridge portions 2a and 2b of the nonwoven fabric 116 in the thickness direction of the nonwoven fabric 116 are 0.3 to 15 mm, preferably 0.5 to 5 mm, respectively. The lengths of the raised ridge portions 2a and 2b in the width direction (WD) of the nonwoven fabric 116 are 0.5 to 30 mm, preferably 1.0 to 10 mm, respectively. The distance between the tops of the adjacent raised ridge portions 2a and 2b is 0.5 to 30 mm, preferably 3 to 10 mm.

[0049] The heights of the groove portions 1a and 1b in the thickness direction of the nonwoven fabric 116 are 90% or less, preferably 0 to 50%, more preferably 1 to 20% of the heights of the raised ridge portions 2a and 2b, respectively. The lengths of the groove portions 1a and 1b in the width direction (WD) of the nonwoven fabric 116 are 0.1 to 30 mm, preferably 0.5 to 10 mm, respectively. The distance between the adjacent groove portions 1a and 1b is 0.5 to 20 mm, preferably 3 to 10 mm. Here, the expression "the height in the thickness direction is 0%" means that this area is the opening 3a or 3b.

[0050] By so designing, for example, when the nonwoven fabric 116 is used as the top sheet of an absorbent article, it is possible to form the groove portions 1a and 1b suitable for avoiding that even if a large amount of a predetermined liquid is discharged, it is hard to widely spread over the surface. Further, even if the raised ridge portions 2a and 2b are brought into such a collapsed state under excessive external pressure, it is easy to maintain the space formed between the groove portions 1a and 1b. As a result, even if a predetermined liquid is discharged under external pressure, the liquid is hard to be widely spread over the surface. Furthermore, even if a predetermined liquid already absorbed by an absorbent core or the like is returned under external pressure, the convex and concave portions formed in the surface of the nonwoven fabric 116 can reduce the contact area to the skin. Hence, the nonwoven fabric 116 has the advantage that it is hard to be widely adhered again to the skin.

[0051] The following is the method of measuring the height, pitch, and width of the groove portions 1a and 1b, or the raised ridge portions 2a and 2b. For example, the nonwoven fabric 116 is placed on a table under no pressure, and

measurements are made by a microscope, from a cross-sectional photograph or a cross-sectional video of the nonwoven fabric 116. The nonwoven fabric 116 used as a sample is cut so that it can pass through the raised ridge portions 2a and 2b and the groove portions 1a and 1b.

[0052] When measuring the height (the length in the thickness direction), the uppermost position of each of the raised ridge portions 2a and 2b and the groove portions 1a and 1b, which are directed upward from the lowermost position of the nonwoven fabric 116 (namely the surface of the table).

[0053] When measuring the pitch of the raised ridge portions 2a and 2b, the distance between the central positions of the raised ridge portions 2a and 2b is measured. Similarly, when measuring the pitch of the groove portions 1a and 1b, the distance between the central positions of the groove portions 1a and 1b is measured.

[0054] When measuring the width of the raised ridge portions 2a and 2b, the maximum width of the bottom surface of the raised ridge portions 2a and 2b, which are directed upward from the lowermost position of the nonwoven fabric 116 (namely the surface of the table). Similarly, the maximum width of the bottom surfaces of the groove portions 1a and 1b is measured.

[0055] No particular limitation is imposed on the cross-sectional shape of the raised ridge portions 2a and 2b. For example, these may be in the shape of a dome, trapezoid, triangle, Q-shape, quadrangle, or the like. In order to improve the touch, the vicinity of the top faces and the side surfaces of the raised ridge portions 2a and 2b are preferably curved surfaces. In order to avoid the collapse of the raised ridge portions 2a and 2b, and maintain the space formed by the groove portions 1, the width is preferably reduced from the bottom surfaces of the raised ridge portions 2a and 2b to the top faces thereof. The cross-sectional shape of the raised ridge portions 2a and 2b is preferably a curve (a curved surface) such as a substantially dome shape.

[0056] The lengths of the openings 3a and 3b in the longitudinal direction (LD) of the nonwoven fabric 116 (or the length in the width direction (WD)) are, for example, 0.1 to 5 mm, preferably 0.5 to 4 mm, respectively. The pitch between the openings 3a and 3b adjacent to each other with the first connecting part 4a interposed therebetween is, for example, 0.5 to 30 mm, preferably 1 to 10 mm.

[0057] The height at the first connecting part 4a in the thickness direction of the nonwoven fabric 116 is equal to or below, preferably 20 to 100%, more preferably 40 to 70% of the height of the raised ridge portions 2a and 2b in the thickness direction of the nonwoven fabric 116.

[0058] The length of the first connecting part 4a in the longitudinal direction (machine direction) and the length in the width direction (cross direction) are, for example, 0.1 to 5 mm, preferably 0.5 to 4 mm, respectively. The pitch between the vertexes of the adjacent first connecting parts 4a is, for example, 0.5 to 30 mm, preferably 1 to 10 mm.

[0059] In the first connecting part 4a, the cross-sectional shape of the nonwoven fabric 116 in the machine direction or longitudinal direction (LD) is a substantially quadrangle. No particular limitation is imposed on the cross-sectional shape of the first connecting part 4a in the machine direction of the nonwoven fabric 116. Besides quadrangle, dome, trapezoid, triangle, Q-shape, or the like may be employed. However, the substantially quadrangle is preferred in order to suppress spread of a predetermine liquid in the groove portions 1a and 1b. In order to avoid that under excessive external pressure, the first connecting part 4a contacts with the skin or the like to give the feeling of a foreign object, the top face of the first connecting part 4a is preferably a flat surface or a curved surface.

2-2. Fiber Orientation and Dense and Nondense of Fiber or Basis weight

2-2-1. Fiber Orientation

[0060] As shown in Figs. 1A, 1B or 2, the nonwoven fabric 116 has areas having different content ratios of longitudinally-oriented fibers. Examples of the different areas are the first side edge portions 14 and 16 in the groove portions 1a and 1b, the openings 3a and 3b, and the raised ridge portions 2a and 2b including the second side edge portions 15 and 17 in the openings 3a and 3b.

[0061] Here, the expression that the fibers 101 are oriented in the longitudinal direction (LD) as the first direction means that the fibers 101 are oriented in the range of -45° to $+45^{\circ}$ in the longitudinal direction (LD). The longitudinal direction (LD) is the machine direction in which the nonwoven fabric or the fiber web is fed through the nonwoven fabric manufacturing machine. The fibers oriented in the longitudinal direction (LD) are referred to as longitudinally-oriented fibers. The expression that the fibers 101 are oriented in the width direction (WD) as the second direction means that the fibers 101 are oriented in the range of -45° to $+45^{\circ}$ in a predetermined width direction (WD) of the nonwoven fabric which is orthogonal to the first direction (longitudinal direction (LD)). The fibers oriented in the width direction (WD) are referred to as laterally-oriented fibers.

[0062] The raised ridge portions 2a and 2b are areas including the first side edge portions 14 and 16 in the openings 3a and 3b, and the second side edge portions 14 and 16 in the openings 3a and 3b. The fibers 101 in the raised ridge portions 2a and 2b, except for the first side edge portions 14 and 16 in the openings 3a and 3b, are as a whole oriented substantially equally in the longitudinal direction (LD) and the width direction (WD) of the nonwoven fabric 116 of the

raised ridge portions 2a and 2b. In other words, in the raised ridge portions 2a and 2b, except for the first side edge portions 14 and 16 in the openings 3a and 3b, the vertical oriented fiber and the laterally-oriented fibers are preferably mixed suitably.

[0063] The fibers 101 constituting the first side edge portions 14 and 16 in the openings 3a and 3b are oriented in the direction along the longitudinal direction (LD) of the nonwoven fabric 116 in the raised ridge portions 2a and 2b. For example, they are oriented in the longitudinal direction (LD) rather than the orientation of the fibers 101 in the raised ridge portions 2a and 2b. That is, the fibers 101 in the first side edge portion 14 in the first opening 3a have a larger number of the longitudinally-oriented fibers than the number of the laterally-oriented fibers. The fibers 101 in the first side edge portion 16 in the second opening 3b have also a larger number of the longitudinally-oriented fibers than the number of the laterally-oriented fibers. For example, the content ratio of the longitudinally-oriented fibers in the first side edge portions 14 and 16 in the openings 3a and 3b is, for example, 55% to 100%, more preferably 60 to 100%. That is, the first side edge portion 14 in the second opening 3b has a higher content ratio of the longitudinally-oriented fibers than the content ratio of the laterally-oriented fibers.

[0064] The groove portions 1a and 1b are areas against which the above-mentioned fluid composed mainly of gas (for example, hot air) is directly blown, so as to form the openings 3a and 3b and the first connecting parts 4a. In the groove portions 1a and 1b, the fibers 101 oriented in the longitudinal direction (LD) (the longitudinally-oriented fibers) are blown toward the first side edge portions 14 and 16 in the openings 3a and 3b. The fibers 101 oriented in the width direction (WD) (the laterally-oriented fibers) are blown toward the connecting part 4a. Thus, the fibers 101 in the first connecting part 4a of the groove portions 1a and 1b can be oriented in the width direction (WD), as a whole.

[0065] Consequently, the content ratio of the longitudinally-oriented fibers in the nonwoven fabric 116 is the lowest in the first connecting parts 4a of the groove portions 1a and 1b. In other words, the first connecting parts 4a have the highest content ratio of the laterally-oriented fiber. That is, the first connecting part 4a has a higher content ratio of the longitudinally-oriented fibers than the content ratio of the laterally-oriented fibers.

[0066] Specifically, the content ratio of the laterally-oriented fibers in the first connecting parts 4a is adjusted to 55 to 100%, preferably 60 to 100%. When the content ratio of the laterally-oriented fiber is lower than 55%, it is difficult to increase the strength of the nonwoven fabric 116 in the width direction (WD) because the groove portions 1a and 1b have a low basis weight, as will be described later. Then, for example, when the nonwoven fabric 116 is used as the top sheet of an absorbent article, there arises the risk of slippage in the width direction or breakage by the friction with the body during the time the absorbent article is used.

[0067] The fiber orientation was measured with a Digital Microscope VHX-100 manufactured by KEYENCE Corporation, in the following measuring procedure. (1) A sample is set so that its longitudinal direction corresponds to a proper direction on an observation table. (2) The lens is focused on the nearest fiber of the sample, except for the fiber irregularly protruded to the near side. (3) The depth of photographing (the depth) is set to create a three dimensional image on a PC screen. (4) The three dimensional image is converted to a two-dimensional image. (5) On the screen, a plurality of parallel lines is drawn to equally divide the longitudinal direction in the measuring range at a proper time. (6) On each of cells subdivided by the drawing parallel lines, it is observed whether the fiber orientation is the longitudinal direction (LD) (the first direction) or the width direction (WD) (the second direction), and the number of the fibers oriented in each direction. (7) To the total fiber numbers in the set range, the rate of the number of the fibers oriented in the longitudinal direction (LD), and the rate of the number of the fibers oriented in the width direction (WD) are calculated to determine the fiber orientation.

2-2-2. Dense and Nondense of Fiber

[0068] The fiber density of the second side edge portions 15 and 17 in the openings 3a and 3b is, for example, 0.005 to 0.2 g/cm³, preferably 0.007 to 0.07 g/cm³. When the fiber density of the raised ridge portions 2a and 2b is lower than 0.005 g/cm³, not only the raised ridge portions 2a and 2b are liable to collapse due to the own basis weight of a predetermined liquid contained in the raised ridge portions 2a and 2b, or the external pressure, but also the absorbed liquid may be liable to return under pressure. When the fiber density of the raised ridge portions 2a and 2b is higher than 0.2 g/cm³, a predetermined liquid entered in the raised ridge portions 2a and 2b is hard to move downward, so that the liquid may remain in the raised ridge portions 2a and 2b, and give a humid feeling to the user.

[0069] The fiber density of the first side edge portions 14 and 16 in the openings 3a and 3b is at least 1.1 times the fiber density in the second side edge portions 15 and 17.

[0070] The fiber density of the first connecting part 4a is 0.05 g/cm³, preferably 0.1 to 0.5 g/cm³. When it is smaller than 0.05 g/cm³, in the event that the raised ridge portions 2a and 2b are collapsed under excessive external pressure, the first connecting parts 4a may also be collapsed. On the other hand, when the fiber density of the first connecting part 4a is larger than 0.5 g/cm³, a predetermined liquid dropped in the groove portions 1a and 1b may remain in the first connecting parts 4a. Then, if excessive external pressure is exerted on the nonwoven fabric 116 and it makes a direct contact with the skin, a humid feeling may be given to the user.

[0071] As described above, it can be said that the first side edge portion 14 in the opening 3a, the first side edge portion 16 in the opening 3b, and the first connecting parts 4a are the high-density areas, each of which has a higher fiber density than at least the second side edge portion 15 in the opening 3a, and the second side edge portion 17 in the opening 3b.

[0072] Especially, the first side edge portion 14 in the opening 3a, and the first side edge portion 16 in the opening 3b can be defined as high-density areas extending in the longitudinal direction (LD). Since the plurality of openings 3a and 3b are formed alternately and intermittently in the groove portions 1a and 1b, the first side edge portion 14 in the opening 3a as the high-density area, and the first side edge portion 16 in the opening 3b are also formed alternately and intermittently along the longitudinal direction (LD). Accordingly, the nonwoven fabric 116 has a plurality of the high-density areas extending in the longitudinal direction (LD).

[0073] The nonwoven fabric 116 is formed so that the spatial area rate measured from one surface in the thickness direction of the nonwoven fabric 116, on which the groove portions 1a and 1b, and the raised ridge portions 2a and 2b are formed, is lower than the spatial area rate measured from the other surface on the opposite side of one surface.

[0074] The fiber web 100 transported over the net-shaped supporting member 300 can be moved by gravity to the opposite surface of the surface where the fluid composed mainly of gas is blown against the fibers 101, and the distance between the fibers near the opposite surface tends to be decreased. On the other hand, the distance between the fibers tends to increase as being closer to the surface against which the fluid composed mainly of gas is blown.

[0075] Under the blowing of the fluid composed mainly of gas, the fibers 101 on the side near the net supporting member 300 can be pressed by the net-shaped supporting member 300, and some of the fibers 101 are oriented in parallel with the flat surface of the net-shaped supporting member 300. As a result, the distance between the fibers can be further reduced to facilitate the crowding of the fibers. Then, by heat treatment such as oven processing in this state, the fibers can be hotmelt, so that the degree of freedom of the fibers 101 is lowered and the spatial area rate in between the fibers is lowered.

[0076] On the other hand, the fibers become less susceptible to excess depression, from the surface on the side of the net-shaped supporting member 300 to the surface against which the fluid composed mainly of gas is blown. Additionally, the fluid composed mainly of gas blown against the raised ridge portions 2a and 2b will strike the net-shaped supporting member 300 and be bounded therefrom, so that some of the fibers 101 can be directed perpendicularly to the net-shaped supporting member 300. The hot melting of the fibers in this state can increase the spatial area rate between the fibers.

[0077] The term "spatial area rate" means the rate of a spatial area where no fiber exists to a gross area. The following is the method of measuring the spatial area rate.

[0078] The used instrument is a Digital Microscope VHX-100 manufactured by KEYENCE Corporation. (1) Firstly, a sample is set to the instrument so that the direction along the groove portions 1a and 1b and the raised ridge portions 2a and 2b is set to a proper direction (here, the machine direction or longitudinal direction (LD)) on an observation table. (2) In the vertexes of the raised ridge portions 2a and 2b, the following measurement is made from one surface from which the raised ridge portions 2a and 2b protrude, and from the other surface on the opposite side of one surface.

(3) The magnification of the lens of the instrument and the magnification on the screen of a personal computer are set suitably, and the lens is focused on the nearest fiber in the sample (except for the fiber irregularly protruded to the near side). (4) Then, the depth of photographing is set to create a three dimensional image of the sample.

(5) The three dimensional image is converted to a two-dimensional image, and the set volume is planarized to specify the space between the fibers in the obtained range. (6) The two-dimensional image is then binarized, and the location where the fibers exist is colored white, and the location where no fiber exists is colored black. (7) The color is inverted so that the location where no fiber exists is changed to white, and the white area and the like are measured.

[0079] In the above measurement, ten samples were measured under the condition where the magnification was set to 300 times, and the depth of photographing was set to 220 μm (the photographing was made per 20 μm , and a total of 11 times of photographing were carried out).

[0080] The spatial area rate can be calculated as follows:

$$\text{Spatial area rate (\%)} = (\text{Spatial gross area} \\ (\text{mm}^2) / \text{Measuring range area (mm}^2)) \times 100$$

[0081] Here, the spatial gross area can be calculated by (spatial gross area on measurement/magnification on meas-

urement), and the measuring range area can be calculated by (measuring range area on measurement/magnification on measurement).

[0082] A high spatial area rate means that the distance between fibers is large and coarse, and therefore the fibers are easy to move and have a high degree of freedom. Further, in such a nonwoven fabric as to have a partially large distance between fibers due to opening treatment, a high spatial area per space can provide a large distance between the fibers over the entire surface of the nonwoven fabric against which a fluid composed mainly of gas is blown. Hence, when the nonwoven fabric 116 is used in, for example, an absorbent article, the resistance when a predetermined liquid such as excrement passes through the nonwoven fabric 116 can be lowered as a whole, thereby facilitating the movement of the liquid into an absorbent core or the like.

[0083] The term "spatial area per space" means the rate of the gross area of the space where no fiber exists to the number of spaces where no fiber exists in a predetermined range. This can be calculated by the following equation:

$$\text{Spatial area (mm}^2\text{/piece)} = \frac{\text{Spatial gross area (mm}^2\text{)}}{\text{Number of spaces (piece)}}$$

[0084] The difference between the spatial area rate measured from a surface where the raised ridge surfaces 2a and 2b protrude, and the spatial area rate measured from the opposite surface is 5% or more, preferably 5 to 80%, more preferably 15 to 40%.

[0085] The spatial area rate measured from the surface where the raised ridge surfaces 2a and 2b protrude is 50% or more, preferably 50 to 90%, more preferably 50 to 80%.

[0086] The spatial area rate per space measured from the surface where the raised ridge portions 2a and 2b protrude are, for example, 3000 μm^2 or more, preferably 3000 to 30000 μm^2 , most preferably 5000 to 20000 μm^2 .

2-2-3. Weight (Basis Weight per Unit Area)

[0087] The total basis weight of the nonwoven fabric 116 is specifically, for example, 10 to 200 g/m^2 , preferably 20 to 100 g/m^2 . In cases where the nonwoven fabric 116 is used in, for example, the top sheet of an absorbent article, it may be broken easily in use when the basis weight is smaller than 10 g/m^2 . On the other hand, when the basis weight is larger than 200 g/m^2 , the entered liquid may be inhibited from being moved downward smoothly.

[0088] The basis weight of the first side edge portions 14 and 16 in the openings 3a and 3b is not less than 1.1 times the basis weight of the second side edge portions 15 and 17. The former basis weight is preferably, for example, 15 to 250 g/m^2 , preferably 20 to 120 g/m^2 . When the former basis weight is smaller than 15 g/m^2 , not only the raised ridge portions 2a and 2b are liable to collapse due to the own basis weight of the liquid contained in the raised ridge portions 2a and 2b, or the external pressure, but also the absorbed liquid may be liable to return under pressure. When the former basis weight is larger than 250 g/m^2 , a predetermined liquid entered in the raised ridge portions 2a and 2b is hard to move downward, and the liquid may remain in the raised ridge portions 2a and 2b, and give a humid feeling to the user.

[0089] The basis weight of the second side edge portions 15 and 17 in the openings 3a and 3b is, for example, 10 to 200 g/m^2 , preferably 20 to 100 g/m^2 . When it is smaller than 10 g/m^2 , not only the raised ridge portions 2a and 2b are liable to collapse due to the own basis weight of the liquid contained in the raised ridge portions 2a and 2b, or the external pressure, but also the absorbed liquid may be liable to return under pressure. On the other hand, when it is larger than 200 g/m^2 , a predetermined liquid entered in the raised ridge portions 2a and 2b is hard to move downward, and the liquid may remain in the raised ridge portions 2a and 2b, and give a humid feeling to the user.

[0090] The basis weight of the first connecting part 4a is 15 to 250 g/m^2 , preferably 20 to 120 g/m^2 . When it is smaller than 15 g/m^2 , in cases where the raised ridge portions 2a and 2b are collapsed under excessive external pressure, the first connecting part 4a may also be collapsed. On the other hand, when it is larger than 250 g/m^2 , a predetermined liquid dropped in the groove portions 1a and 1b may remain in the first connecting part 4a. Then, if excessive external pressure is exerted on the nonwoven fabric 116 so as to make a direct contact with the skin, a humid feeling may be given to the user.

[0091] From the foregoing, it can be said that the first side edge portion 14 in the first opening 3a has a higher basis weight than the second side edge portion 15 in the first opening 3a. Similarly, it can be said that the second side edge portion 16 in the second opening 3b has a higher basis weight than the second side edge portion 17 in the second opening 3b. Further, it can be said that the first connecting part 4a has a higher basis weight than the second side edge portion 15 in the first opening 3a.

2-3. Others

[0092] For example, when the nonwoven fabric of the present embodiment is used for the purpose of absorbing or passing through a predetermined liquid, the groove portions 1a and 1b can pass through the liquid, and the raised ridge portions 2a and 2b are porous so as to be hard to retain the liquid. Alternatively, the openings 3a and 3b formed in the groove portions 1a and 1b can also pass through solid in addition to liquid.

[0093] The groove portions 1a and 1b are provided with the plurality of the openings 3a and 3b, and therefore suitable for passing through liquid and solid. Since the fibers 101 in the bottoms of the groove portions 1a and 1b are oriented in the cross direction (CD), namely the width direction (WD), it is avoidable that too much liquid flows and spreads in the machine direction (MD), namely the longitudinal direction (LD) of the nonwoven fabric 116 of the groove portions 1a and 1b. Although the groove portions 1a and 1b have a low basis weight, the strength in the cross direction (CD) (i.e. the width direction (WD)) of the nonwoven fabric 116 can be increased because the fibers 101 are oriented in the cross direction (CD) (CD orientation) of the groove portions 1a and 1b.

2-4. Manufacturing Method

[0094] A method of manufacturing a nonwoven fabric of the present invention includes the step of blowing a fluid composed mainly of gas against a fiber aggregate formed in a substantially sheet shape, the fibers constituting the fiber aggregate being in the state of having a degree of freedom, so that a plurality of openings can be formed in a machine direction or a longitudinal direction LD. One side edge portion in a cross direction, namely a width direction (WD) in each of the plurality of openings has a higher fiber density than the second side edge portion in the cross direction in each of the plurality of openings.

[0095] The method of manufacturing the nonwoven fabric 116 in the present embodiment will be described below with reference to Figs. 3 to 8. Firstly, the fiber web 100 is placed on the upper surface of the net-shaped supporting member 300. In other words, the fiber web 100 is supported from below by the net-shaped supporting member 300.

[0096] The nonwoven fabric 116 can be manufactured by moving the net-shaped supporting member 300 supporting the fiber web 100, in the machine direction or longitudinal direction (LD), and continuously blowing gas against the fiber web 100 being so moved, from the upper surface thereof.

[0097] As shown in Figs. 5 to 8, a nonwoven fabric manufacturing apparatus 90 for manufacturing the nonwoven fabric 116 of the present embodiment has (i) the net-shaped supporting member 300 that supports the fiber web 100 as a fiber aggregate, from one surface thereof, (ii) a blowing unit 910 and a gas feeding part (not shown) as means for blowing a fluid composed mainly of gas against the fiber web 100, which is the fiber aggregate to be supported from one surface by the net-shaped supporting member 300, from the other side of the fiber web 100, and (iii) a conveyer 930 as moving means for moving the fiber web 100 as the fiber aggregate, in a predetermined direction F.

[0098] As shown in Fig. 3, the net-shaped supporting member 300 is a supporting member having a gas permeable part and a gas impermeable part. The gas permeable part permits a fluid composed mainly of gas, which is blown from the upper surface as the other surface of the fiber web 100, to pass through to the lower side opposite the side in the net-shaped supporting member 300 on which the fiber web 100 is disposed. The air impermeable part does not permit a fluid composed mainly of gas, which is blown from the upper surface of the fiber web 100, to move to the lower side in the net-shaped supporting member 300, and does not permit the fibers 101 constituting the fiber web 100 to pass through to the opposite side in the net-shaped supporting member 300.

[0099] That is, the areas of the wires 301 and the wires 302 and the intersection portion 304 in the net-shaped supporting member 300 correspond to the gas impermeable part. On the other hand, hole parts 303 each being surrounded by the wire 301 and the wire 302 in the net-shaped supporting member 300 correspond to the gas permeable part. The hole parts 303 in the net-shaped supporting member 300 can be moved to the opposite side of the side on which the fiber web 100 is placed in the net-shaped supporting member 300. This enables the formation of protruding portions protruding in the thickness direction. The protruding portions will be described in detail in a third embodiment (refer to Fig. 11).

[0100] In the net-shaped supporting member 300, as described above, the wires 301 disposed in the longitudinal direction (LD) and the wires 302 disposed in the width direction (WD) are woven together, and the wires 302 are woven in the zigzag pattern so as to cross over the wires 301 in the thickness direction. The zigzag patterns of the wires 302 are woven alternately in the longitudinal direction (LD).

[0101] More specifically, the gas impermeable part is woven so that the upper vertex portion of one wire 301 and the lower vertex portion of one wire 302 are connected to each other, and that the lower vertex portion of the other wire 301 adjacent to the 301 and the upper vertex portion of the other wire 302 adjacent to the 302 are connected to each other.

[0102] When the fiber web 100 is supported from the lower surface thereof as one surface, by the net-shaped supporting member 300 shown in Fig. 3, and the fluid composed mainly of gas is blown from the upper surface thereof, as described above, the positional relationship between blowout holes 913 and the wires 301 arranged in the longitudinal direction

(LD) is preferably so that the fluid composed mainly of gas blown through the blowout holes 913 can be blown against substantially the center in between the wires 301.

[0103] Thus, by blowing the fluid composed mainly of gas against the fiber web 100 arranged on the wires 302, the fiber web 100 can be moved to form the openings 3a and 3b, and the fiber web 100 can be moved to an area where the tilting of the wires 302 is low, thereby forming the first side edge portions 14 and 16 in the openings 3a and 3b. The fiber web 100 can be hardly moved to the opposite side edges of the first side edges 14 and 16, namely the second side edge portions 15 and 17.

[0104] The difference of elevation in the tilting of the wires 302 disposed in the longitudinal direction (LD) is 0.5 mm or more, preferably 0.5 to 10 mm, more preferably 1.0 to 5.0 mm.

[0105] For the above-mentioned supporting member, the degree of ventilation can be partially changed by changing in part the weave method, the thread thickness, and the thread shape.

[0106] As the net-shaped member 300, it is possible to use any one of the following members, for example, threads made of resins such as polyester, polyphenylene sulfide, nylon, or conductive monofilament, and threads made of metals such as stainless steel, copper, or aluminum.

[0107] Some of the fluid composed mainly of gas to be blown from the upper surface side of the fiber web 100 is blocked by the wires 301, the wires 302, and the intersections 304 of these in the net-shaped supporting member 300, and the rest can pass through downward without being blocked by the net-shaped supporting member 300.

[0108] The degree of ventilation in the wires 301 and the wires 302 (especially the intersection parts 304 of these wires) which function as the gas permeable part in this case is, for example, not more than 90%, preferably 0 to 50%, more preferably 0 to 20% of the degree of ventilation in the hole portions 303. The term "0%" means that the fluid composed mainly of gas is substantially unable to pass through.

[0109] The degree of ventilation in the area of the hole portions 303 functioning as the gas permeable part is, for example, 10000 to 60000 cc/cm²·min, preferably 20000 to 50000 cc/cm²·min.

[0110] In the net-shaped supporting member to be used, the area functioning as the gas impermeable part has a higher slip properties than the area forming the gas permeable part. High slip properties facilitates the movement of the fibers 101 in the area where the area against which the fluid composed mainly of gas is blown, and the impermeable part cross over. This enhances the forming properties of the openings 3a and 3b and the first connecting parts 4a.

[0111] Referring to Figs. 5 and 6, a nonwoven fabric 115 (corresponding to the nonwoven fabric 116 in the present embodiment) can be formed by sequentially moving the fiber web 100 in a predetermined direction in the nonwoven fabric manufacturing apparatus 90. Moving means moves in the predetermined direction the fiber web 100, which is the fiber aggregate in the state of being supported from one surface by the net-shaped supporting member 300 as described above. Specifically, the fiber web 100, against which the fluid composed mainly of gas has been blown, is moved in a predetermined direction F or machine direction. As the moving means, for example, a conveyer 930 may be used. The conveyer 930 has a gas permeable belt part 939 being gas permeable and formed in a laterally elongated ring shape, on which the net-shaped supporting member 300 is placed, and rotating parts 931 and 933 for rotating the ring-shaped permeable belt part 939, which are arranged inside the permeable belt part 939 and on predetermined both ends in the predetermined direction F.

[0112] The conveyor 930 moves the net-shaped supporting member 300 supporting the fiber web 100 from the lower surface thereof, in the predetermined direction F as described above. Specifically, as shown in Fig. 7, the conveyor 930 moves the fiber web 100 so as to pass through under the blowing unit 910. More specifically, it moves the fiber web 100 so as to pass through inside a heater part 950 as heating means, opening into both side surfaces.

[0113] The blowing means has an air feeding part (not shown) and a blowing unit 910. The air feeding part is connected via an air feeding pipe 920 to the blowing unit 910. The air feeding pipe 920 is connected gas-permeably to the upper side of the blowing unit 910. As shown in Fig. 8, a plurality of the blowout holes 913 are formed at predetermined intervals in the blowing unit 910.

[0114] As shown in Fig. 7, the gas fed from the air feeding part via the air feeding pipe 920 to the blowing unit 910 is blown through the plurality of blowout holes 913 formed in the blowing unit 910. The gas blown through the blowout holes 913 is then continuously blown against the upper surface of the fiber web 100 supported from the lower surface thereof by the net-shaped supporting member 300. Specifically, the gas blown through the plurality of the blowout holes 913 is continuously blown against the upper surface of the fiber web 100 in the state where it is moved in the predetermined direction F on the conveyer 930.

[0115] A suction part 915, disposed under the blowing unit 910 and on the lower side of the net-shaped supporting member 300, sucks the gas and the like which is blown through the blowing unit 910 and passes through the net-shaped supporting member 300. Here, the suction by the suction part 915 can be used to position the fiber web 100 so as to be fixed to the net-shaped supporting member 300. Further, the suction enables the groove portions (the concave/convex portions) etc formed by the air flow to be transported into the heater part 950 in a state where their respective shapes are held more suitably. In this case, it is preferable to transport them to the heater part 950, while suctioning them, at the same time of the formation by the air flow.

[0116] The temperature of the fluid composed mainly of gas to be blown through each of the blowout holes 913 may be the ordinary temperature as in the first embodiment. In order to obtain, for example, superior forming properties of the groove portions (the concave/convex portions) and the openings, the aforesaid temperature can be adjusted to not less than the softening point of at least a thermoplastic fiber constituting the fiber aggregate, preferably in the temperature range of +50°C to -50°C of the melting point thereof. If the fiber is softened, the repulsion of the fiber itself is lowered, and it is therefore easy to hold the shapes of the fibers rearranged by air flow, or the like. When the temperature is further increased, the hot melt between the fibers is initiated, and it is therefore easier to retain the shape of the groove portions (the concave/convex portions) and the like. This facilitates the transportation into the heater part 950 in the state where the shapes of these portions are retained.

[0117] The heater part 950 as heating means is opened into both ends in the predetermined direction F. Thus, the fiber web 100 placed on the net-shaped supporting member 300 moved by the conveyer 930 can be continuously moved through a heating space formed inside the heater part 950 with a predetermined time of stay. For example, when a thermoplastic fiber is contained in the fibers 101 constituting the fiber web 100, it is possible to obtain a nonwoven fabric 115 where the fibers 101 are connected to each other by heating in the heater part 950.

[0118] In order to form the nonwoven fiber 116 having the openings 3a and 3b, a supporting member different from the net-shaped supporting member 300 may be used. Depending on the used supporting member, the dimensions and arrangements of the groove portions 1a and 1b, the raised ridge portions 2a and 2b, the openings 3a and 3b, and the first connecting part 4a can be changed. For example, a sleeve made of metal such as stainless steel, copper, or aluminum may be used. The sleeve may be formed by partially punching a plate of the above-mentioned metal in a predetermined pattern. The location from which the metal is punched functions as a gas permeable part, and the location from which the metal is not punched functions as a gas impermeable part. As described above, the surface of the gas impermeable part is preferably smooth in order to increase the slip properties of the surface.

[0119] In this case, it is preferable to have a suction part 915 for sucking a fluid composed mainly of gas, which is blown against the nonwoven fabric 116 from below the net-shaped supporting member 300 or the supporting member of the above-mentioned sleeve. The suction of this fluid by the suction part 915 can avoid that this fluid blown against the net-shaped supporting member 300 is excessively bounded to disturb the shape of the fiber web 100.

[0120] The strength by which the fluid composed mainly of gas is sucked may be strength by which the fibers 101 in the area where this fluid is blown can be pushed against the supporting member. In order to hold the state of being pushed by the supporting member, the temperature of this fluid is preferably not less than the softening point of at least a part of the fibers of the fibers 101 constituting the nonwoven fabric 116, particularly not less than the softening point nor more than the melting point.

[0121] The shapes of the raised ridge portions 2a and 2b, the openings 3a and 3b, and the first connecting parts 4a can be changed by the adjustments of the gas volume and the temperature of the blown fluid composed mainly of gas, the amount of suction, the permeability of the supporting member, and the basis weight of the fiber web 100. For example, when the amount of the blown fluid composed mainly of gas and the amount of the sucked fluid composed mainly of gas are approximately equal, or when the latter is larger than the former, the bottom surfaces of the raised ridge portions 2a and 2b can be formed so as to follow the shape of the net-shaped supporting member 300.

[0122] Further, by sucking the fluid composed mainly of gas from below the net-shaped supporting member 300, the fibers of the area against which this fluid is blown can be moved while being pushed against the net-shaped supporting member 300, enabling the fibers to be gathered toward the net-shaped supporting member 300. In the raised ridge portions 2a and 2b, the blown fluid strikes the net-shaped supporting member 300 and is bounded suitably, resulting in the state where the fibers are partially oriented in the thickness direction.

3. Other Embodiments

[0123] Other embodiments in the nonwoven fabric of the present invention will be described below. The following embodiments, unless otherwise noted, are similar to the foregoing embodiment, and the same reference numerals have been retained for similar parts.

[0124] Second and third embodiments in the nonwoven fabric of the present invention will be described with reference to Fig. 9A to 11B. The second and third embodiments are different from the first embodiment in the shape of the nonwoven fabric.

3-1. Second Embodiment

[0125] The second embodiment in the nonwoven fabric of the present invention will be described with reference to Figs. 9A and 9B and Fig. 10.

3-1-1. Nonwoven Fabric

[0126] As shown in Figs. 9A, 9B, and 10, a nonwoven fabric 140 in the second embodiment is different from the first embodiment in having a second connecting part 4b formed between a third opening 3c adjacent to a first opening 3a on the opposite side of a second opening 3b adjacent to a first opening 3a. The nonwoven fabric 140 is also different from the first embodiment in that one side edge portion 16 in the second opening 3b, a first connecting part 4a, one side edge portion 14 in the opening 3a, the second connecting part 4b, the third opening 3c, and one side edge portion 18 in the third opening 3c are continued in a zigzag pattern. The nonwoven fabric 140 is identical with the first embodiment in groove portions 1a and 1b, the raised ridge portions 2a and 2b, the openings 3a and 3b, one side edge portions 14 and 16 in the openings 3a and 3b, the second side edge portions 15 and 17 in the openings 3a and 3b, and the first connecting part 4a, as well as the fiber orientation, the fiber dense and nondense, and the basis weight of these.

[0127] The different points of the nonwoven fabric 140 from the first embodiment will be described by taking, as an example of a plurality of openings 3, the third opening 3c (hereinafter the third opening 3c is referred to simply as the opening 3c in some cases,) which is adjacent to the opposite side of the second opening 3b in the first opening 3a, in addition to the first opening 3a and the second opening 3b.

3-1-2. Outline of Nonwoven Fabric

[0128] As shown in Figs. 9A, 9B, and 10, the nonwoven fabric 140 of the present embodiment is a nonwoven fabric having the opening 3c in addition to the openings 3a and 3b, as described above. In other words, the nonwoven fabric 140 is a nonwoven fabric where the openings 3a, 3b, and 3c are formed in the order of the opening 3c, the opening 3a, and the opening 3b from the near side in the drawing, along the longitudinal direction (LD) of the nonwoven fabric 140.

[0129] Like the first side edge portions 14 and 16 in the openings 3a and 3b, the first side edge portion 18 in the width direction (WD) of the nonwoven fabric 140 in the opening 3c is formed in the nonwoven fabric 140. Here, the first side edge portion 18 of the third opening 3c is disposed on the opposite side of the first side edge portion 14 of the first opening 3a in the width direction (WD). On the other hand, the second side edge portion 19 of the opening 3c in the width direction (WD) is formed in the raised ridge portions 2a and 2b.

[0130] The nonwoven fabric 140 is also a nonwoven fabric having the second connecting part 4b formed between the first opening 3a and the third opening 3c. That is, between the first and third openings 3a and 3c adjacent to each other in the groove portion 1a or 1b, the second connecting part 4b is formed so that the raised ridge portions 2a and 2b adjacent to each other can be contacted with the groove portion 1a or 1b interposed therebetween. In other words, a plurality of the second connecting parts 4b formed at predetermined intervals can connect the raised ridge portion 2a and the raised ridge portion 2b adjacent thereto. As will be described later, the second connecting part 4b is an area having a higher fiber density than the second side edge portion 15 in the first opening 3a.

[0131] The above-mentioned third opening 3c can be formed in the same manner as the openings 3a and 3b. The first side edge portion 18 can be formed in the same manner as the first side edge portions 14 and 16. The second side edge portion 19 can be formed in the same manner as the second side edge portions 15 and 17. The second connecting part 4b can be formed in the same manner as the first connecting part 4a. Since the dimension, the thickness, the fiber orientation, the basis weight, and the spatial area rate of these are the same as above, the description thereof is omitted here.

3-1-3. Dense and Nondense of Fiber

[0132] As shown in Figs. 9A, 9B, and 10, like the first connecting part 4a, the second connecting part 4b is an area having a higher fiber density than the second side edge portion 15 in the opening 3a. As described above, the first connecting part 4a and the first side edge portion 14 in the opening 3a are also areas having a higher fiber density than the second side edge portion 15 in the opening 3a.

[0133] That is, the first connecting part 4a, the first side edge portion 14 in the opening 3a, and the second connecting part 4b are the areas of high density. Therefore, since the first connecting part 4a, the first side edge portion 14 in the opening 3a, and the second connecting part 4b are shaped in a C-shape opening into the opposite side (one side) of the first side edge portion 14 in the opening 3a in the width direction (WD) of the nonwoven fabric 140, they can be defined as a whole, as a C-shaped high-density area.

[0134] A plurality of the openings 3a, 3b, and 3c are alternately formed continuously in the groove portions 1a and 1b, and therefore, the first connecting part 4a, the first side edge portion 14 in the opening 3a, and the second connecting part 4b, which are the C-shaped high-density area, are also continuously formed along the longitudinal direction (LD) of the nonwoven fabric 140.

[0135] Accordingly, the nonwoven fabric 140 of the present embodiment can be said to be a nonwoven fabric provided with a plurality of the C-shaped high-density areas extending in the longitudinal direction (LD). The term "C-shaped high-

density area" includes the "reverse C-shaped" high-density area that has the reverse shape of the "C-shaped", namely the reverse C-shaped high-density area. Like the "C-shaped" high-density area formed in the groove portion 1a, and the "reverse-shaped" high-density area formed in the groove portion 1b as in the present embodiment, a pair of "C-shaped" high-density areas may be formed in the groove areas 1a and 1b. Alternatively, a "C-shaped" high-density area of the same shape may be formed in the groove portions 1a and 1b, respectively, so that the "C-shaped" high-density area can be formed in the groove portion 1a, and the "C-shaped" high-density area can be formed in the groove portion 1b.

[0136] As described above, in addition to the first side edge portion 14 in the first opening 3a, the first side edge portion 16 in the second opening 3b, and the first connecting part 4a, the first side edge portion 18 in the third opening 3c is a high-density area having a higher fiber density than the second side edge portion 15 in the first opening 3a.

[0137] As shown in Figs. 9A, 9B, and 10, the nonwoven fabric 140 of the present embodiment is a nonwoven fabric where a high-density area is formed so that the first side edge portion 16 in the second opening 3b, the first connecting part 4a, the first side edge portion 14 in the first opening 3a, the second connecting part 4b, the first side edge portion 18 in the third opening 3c are continued in a zigzag pattern as a whole. The first side edge portion 16 in the second opening 3b, the first connecting part 4a, the first side edge portion 14 in the first opening 3a, the second connecting part 4b, and the first side edge portion 18 in the third opening 3c can be defined as a whole, as a meandering shaped high-density area.

[0138] Since the plurality of the openings 3a, 3b, and 3c are formed in the groove portion 1a and 1b, the first side edge portion 16 in the second opening 3b, the first connecting part 4a, the first side edge portion 14 in the first opening 3a, the second connecting part 4b, and the first side edge portion 18 in the third opening 3c, which are the meandering shaped high-density area, can also be formed in the longitudinal direction (LD) of the nonwoven fabric 140. Therefore, the nonwoven fabric of the present invention can be said to be a nonwoven fabric having a plurality of the meandering shaped high-density areas extending in the longitudinal direction (LD) of the groove portions 1a and 1b.

[0139] The nonwoven fabric 140 of the present embodiment can be manufactured by using the above-mentioned nonwoven fabric manufacturing apparatus 90. The method of manufacturing the nonwoven fabric in the nonwoven fabric manufacturing apparatus 90 can be referred to the descriptions in the manufacturing method of the aforesaid nonwoven fabric 116 and the nonwoven fabric manufacturing apparatus 90. For example, when in the second embodiment, a fluid composed mainly of gas (e.g. hot air) is blown more strongly or the amount of the blown fluid composed mainly of gas is larger than in the first embodiment, the nonwoven fabric 140 can be manufactured by the nonwoven fabric manufacturing apparatus 90 if little line tension is exerted on a fiber web 100, or if a rather overfeed is employed immediately before blowing a fluid composed mainly of gas (e.g. hot air).

3-2. Third Embodiment

[0140] The third embodiment in the nonwoven fabric of the present invention will be described below with reference to Figs. 11A and 11B.

3-2-1. Nonwoven Fabric

[0141] As shown in Figs. 11A and 11B, a nonwoven fabric 150 of the third embodiment is different from the first embodiment in that in the other side, the areas corresponding to raised ridge portions 2a and 2b protrude in the same direction as the direction in which the raised ridge portions 2a and 2b protrude. The nonwoven fabric 150 is also different in that a plurality of protruding portions 10 are formed in the other side. The nonwoven fabric 150 is identical to the foregoing embodiment in groove portions 1a and 1b, the raised ridge portions 2a and 2b, openings 3a, 3b, and 3c, one side edge portions 14, 16, and 18 in the openings 3a, 3b, and 3c, the second side edge portions 15, 17, and 19 in the openings 3a, 3b, and 3c, first connecting parts 4a, second connecting parts 4b, as well as the fiber orientation, the dense and nondense of fiber, and the basis weight of these. The different points will be described below.

3-2-2. Outline of Nonwoven Fabric

[0142] Referring to Figs. 11A and 11B, in the nonwoven fabric 150 of the present embodiment, groove portions 1a and 1b are alternately formed side by side at substantially equal intervals, and the raised ridge portions 2a and 2b are alternately formed at substantially equal intervals between the groove portions 1a and 1b. On the other surface of the nonwoven fabric 150, the areas corresponding to the raised ridge portions 2a and 2b are formed along the longitudinal direction (LD) so as to protrude in the same direction as the raised ridge portions 2a and 2b in one surface thereof. In other words, the areas corresponding to the bottoms of the raised ridge portions 2a and 2b in one surface are depressed to form concave portions in the other surface of the nonwoven fabric 150, and the areas corresponding to the bottom surfaces of the raised ridge portions 2a and 2b on one surface are of a convex shape.

[0143] Referring again to Figs. 11A and 11B, the nonwoven fabric 150 is a nonwoven fabric having on the other side

thereof a plurality of the protruding portions 10 of a predetermined length. The protruding portions 10 are areas corresponding to the first side edge portion 14 in the first opening 3a, the first side edge portion 16 in the second opening 3b, the first connecting part 4a, the second connecting part 4b, and the first side edge portion 18 in the third opening 3c. These areas are of a raised ridge shape protruding in the thickness direction.

[0144] The protruding portions 10 can be formed as follows. A fibers 101 constituting a fiber web 100 in the first side edge portion 14 in the first opening 3a, the first side edge portion 16 in the second opening 3b, the first connecting part 4a, the second connecting part 4b, and the first side edge portion 18 in the third opening 3c, which are high-density areas, is separated from a net-shaped supporting member 300 and then protruded in the thickness direction, resulting in the protruding portions 10. That is, the fibers 101 constituting the fiber web 100, against which a fluid composed mainly of gas has been blown, are subjected to the actions of wires 301 and wires 302 of the net-shaped supporting member 300, so that the plurality of the protruding portions 10 can be formed so as to protrude in the thickness direction of the fiber web 100.

[0145] As shown in Fig. 11B, the cross-sectional shape in the longitudinal direction (LD) of the protruding portions 10 is a substantially quadrangle. No particular limitation is imposed on the cross-sectional shapes of the protruding portions 10. Without limiting to the substantially quadrangle, these may be in the shape of a dome, trapezoid, triangle, Q-shape, or the like. In order to suppress the spread of a predetermined liquid in the groove portions 1a and 1b, the substantially quadrangle is preferred. In order to avoid that under excessive external pressure, the protruding portions 10 contact with, for example, the skin and give the feeling of a foreign object, the top faces of the protruding portions 10 are preferably flat surfaces or curved surfaces.

[0146] Although in the present embodiment the cross-sectional shape of the protruding portions 10 in the longitudinal direction (LD) is the substantially quadrangle, it may be, for example, a protruding portion of triangle pole, a protruding portion of triangle pole whose vertex portion in the thickness direction is a curved surface, a protruding portion of quadrangle, or these protruding portions obliquely tilted to the thickness direction.

[0147] When the nonwoven fiber 150 is viewed from one surface, the plurality of the protruding portions 10, a plurality of flat portions of substantially quadrangle formed between the protruding portions 10, and a plurality of the openings 3a, 3b, and 3c formed in a pair of sides in each of the plurality of the flat portions are formed regularly.

3-2-3. Manufacturing Method and Net-Shaped Supporting Member

[0148] The manufacturing method of the nonwoven fabric 150 of the third embodiment is identical to the foregoing description. When the amount of a fluid composed mainly of gas is larger than that in the second embodiment, as will be described later, the nonwoven fabric 150 can be manufactured by using the nonwoven fabric manufacturing apparatus 90. A net-shaped supporting member 300 used for manufacturing the nonwoven fabric 150 is the same as the net-shaped supporting member 300 used in the first embodiment.

[0149] Specifically, the fluid composed mainly of gas is blown against the fiber web 100 as a fiber aggregate, in the state where it is supported from the lower surface side thereof by the net-supporting member 300. At this time, the blown fluid composed mainly of gas is sucked from below the net-shaped supporting member 300. In cases where the amount of the fluid so sucked is smaller than the amount of the fluid so blown, namely the latter fluid is larger than the former fluid, by allowing the latter fluid to be slightly bounded, the bottom surface of the raised ridge portions 2a and 2b can be formed so as to protrude in the same direction as the raised ridge portions 2a and 2b in the upper surface of the raised ridge portions 2a and 2b. Thus, the areas of the other surface corresponding to the bottom surfaces of the groove portions 1a and 1b can be relatively protruded to form raised ridge portions protruding from the lower surface.

4. Examples of Application

[0150] The nonwoven fabrics of the present invention can be applied to, for example, the top sheets and the like in absorbent articles such as sanitary napkins, liners, and diapers. In this case, the raised ridge portions may be disposed either of the skin surface side or the back surface side. Disposing on the skin surface side reduces the area contacting with the skin, and in some cases, it is less likely to give a humid feeling due to a body fluid. The nonwoven fabrics can also be used as an intermediate sheet between the top sheet and the absorbent core in the absorbent article. This reduces the area contacting with the top sheet or the absorbent core, and in some cases, it is less likely to return from the absorbent core. Further, the nonwoven fabrics can also be used in the side sheets of the absorbent article, the outer surface (an outer back) of the diaper or the like, the female material of a surface fastener, because of a reduction in the area contacting with the skin, and cushion feeling. Furthermore, the nonwoven fabrics can also be used in a wide variety of applications such as wipers for removing the dust or scale adhered to the floor or human body, masks, milk pads, and the like.

4-1. Top Sheet of Absorbent Article

[0151] For example, the nonwoven fabric in the present invention can be used as top sheets 401 and 402 in an absorbent article having concave/convex portions as shown in Figs. 12A to 13B. Specifically, raised ridge portions 2a and 2b are disposed on the skin side. The concave portions (groove portions 1a and 1b) have a plurality of openings parts 3a and 3b, and first connecting parts 4a. The fiber density of one side edge portions 14 in the openings 3a and 3b is higher than the fiber density of other location, for example, the second side edges 15 in the openings 3a and 3b. In this example, the nonwoven fabric is preferably disposed so that the surface provided with the raised ridge portions can be located on the skin side.

[0152] The first side edge portions 14 in the openings 3a and 3b have a relatively high fiber density, namely a high rigidity. It is therefore avoidable that the openings 3a and 3b may easily be collapsed when load is exerted on the first side edges 14. On the other hand, the second side edge portions 15 in the openings 3a and 3b have a relatively low fiber density, and it is therefore avoidable that a predetermined liquid stays around the openings 3a and 3b.

[0153] In cases where this nonwoven fabric is used as the top sheets 401 and 402 of the absorbent article, when a predetermined liquid is discharged, the liquid drops mainly in the groove portions. Since the openings are provided, even for a predetermined liquid having such viscosity as to contain solid, the openings facilitate the movement of the liquid to the absorbent core. It is therefore possible to suppress the liquid from widely spreading over the surface.

[0154] Additionally, since most part of the fibers in the first connecting parts 4a are oriented in the width direction (WD), the tension strength in the cross direction is high. This avoids that the top sheets are broken when friction or the like is exerted in the width direction (WD) during the time the absorbent article is used.

[0155] Thus, if the load exerted on the top sheets is changed by variations of body attitudes, the area contacting with the skin can be held small thereby to maintain a good contact feeling. Furthermore, if the liquid already absorbed by the absorbent core is returned, it is hard to be adhered again to the skin.

4-2. Intermediate Sheet of Absorbent Article

[0156] For example, the nonwoven fabric in the present invention can be used as an intermediate sheet 311 in an absorbent article having concave/convex portions as shown in Fig. 14. Specifically, raised ridge portions 2a and 2b are disposed on the skin side. The concave portions (groove portions 1a and 1b) have a plurality of openings parts 3a and 3b, and first connecting parts 4a. The fiber density of one side edge portions 14 in the openings 3a and 3b is higher than the fiber density of other location, for example, the second side edges 15 in the openings 3a and 3b. In this example, the nonwoven fabric is preferably disposed so that the surface provided with the raised ridge portions can be located on the top sheet side.

[0157] The first side edge portions 14 in the openings 3a and 3b have a relatively high fiber density, namely a high rigidity. It is therefore avoidable that the openings 3a and 3b may easily be collapsed when load is exerted on the first side edges 14. On the other hand, the second side edge portions 15 in the openings 3a and 3b have a relatively low fiber density, and it is therefore avoidable that a predetermined liquid stays around the openings 3a and 3b.

[0158] By arranging the nonwoven fabric as the intermediate sheet so that the surface provided with the raised ridge portions 2a and 2b can be located on a top sheet 310, it is possible to form a plurality of spaces between the top sheet 310 and the intermediate sheet 311. By virtue of the openings 3a and 3b disposed in the intermediate sheet 311, even if a large amount of a predetermined liquid is discharged in a short time, because of less obstruction to the passage of a predetermined liquid, the liquid can be moved quickly to the absorbent core. This prevents the liquid from being returned to the top sheet and widely spread there.

[0159] If the liquid already passed through the intermediate sheet 311 and absorbed by the absorbent core is returned, the liquid is hard to be returned to the top sheet and widely adhered again to the skin, because the rate of contact between the intermediate sheet 311 and the top sheet 310 is low.

[0160] The central parts of the raised ridge portions 2a and 2b contain more fibers oriented in the thickness direction (TD) than the groove portions 1a and 1b, and the vertexes of the raised ridge portions 2a and 2b contact with the top sheet 310. This facilitates the suction of the liquid staying in the top sheet 310 toward the thickness direction (TD). As a result, the liquid is hard to stay in the top sheet.

[0161] Thus, the spot property and residual property on the top sheet can be attained to prevent the liquid from being adhered widely to the skin for a long time. Further, since the first side edge portions 14 in the raised ridge portions 2a and 2b has a high content ratio of longitudinally-oriented fibers oriented in the longitudinal direction (LD), the liquid moved from the top sheet 310 to the first side edge portions 14 can be guided in the longitudinal direction (LD). Hence, if the liquid diffuses in the width direction (WD), it is possible to prevent the induction of the leakage from the absorbent article, thereby increasing the absorption efficiency of the absorbent core.

4-3. External Surface Covering Material of Absorbent Article

[0162] For example, the nonwoven fabric in the present invention can be used as an external surface covering material 320 in an absorbent article having concave and convex portions as shown in Fig. 15. The concave portions (groove portions 1a and 1b) have a plurality of openings parts 3a and 3b, and first connecting parts 4a. The fiber density of one side edge portions 14 in the openings 3a and 3b is higher than the fiber density of other location, for example, the second side edges 15 in the openings 3a and 3b. In this example, the nonwoven fabric is preferably disposed so that the surface provided with the raised ridge portions 2a and 2b can be located outside the absorbent article.

[0163] Since the surface provided with the convex portions or the raised ridge portions 2a and 2b is located outside the absorbent article, it is possible to improve contact feeling when the absorbent article is contacted mainly with the hand when it is used. Additionally, the openings 3a and 3b in the groove portions 1a and 1b provide superior permeability.

5. Individual Components

[0164] Individual components will be described below in detail.

5-1. Components Related to Nonwoven Fabric

5-1-1. Fiber Aggregate

[0165] It can be said that a fiber aggregate is a fiber aggregate formed in a substantially sheet shape, and the fibers constituting the fiber aggregate is in the state of having a degree of freedom. In other words, it is a fiber aggregate having a degree of freedom between the fibers. The term "degree of freedom between the fibers" means the degree to which the fibers of a fiber web being fiber aggregate can be moved freely by a fluid composed mainly of gas. The fiber aggregate can be formed by, for example, blowing a mixed fiber as a mixture of a plurality of fibers so as to form a fiber layer having a predetermined thickness, or alternatively by blowing a plurality of different fibers, respectively, so that they can be stacked a plurality of times to form a fiber layer.

[0166] As the fiber aggregate in the present invention, for example, it is possible to employ a fiber web formed by card method, or a fiber web after having been subjected to hot melting and before solidification of the hot melting between fibers. Other examples of the fiber aggregate are a web formed by air laid method, or a fiber web after having been subjected to hot melting and before solidification of the hot melting between fibers; a fiber web before solidification of the hot melting after having been subjected to embossing by point bond method; a fiber aggregate after spinning by spun bond method and before being embossed, or a fiber aggregate before solidification of the embossed hot melting; a fiber web formed by needle punch method and then half-confounded; a fiber aggregate after spinning by melt blown method and before solidification of the hot melting between fibers; and a fiber aggregate formed by solvent bonding and before solidification between fibers by the solvent.

[0167] Among others, the fiber web formed by card method using relatively long fibers, and the web having a high degree of freedom between fibers formed only by confounding and being before hot melting are preferred because the fibers are susceptible to reorientation by air (gas) flow. In order that after groove portions (concave and convex portions) and the like are formed by using a plurality of air (gas) flows to be described later, they are made into a nonwoven fabric with the shape retained, it is preferable to employ through air method in which thermoplastic fibers contained in the fiber aggregate can be subjected to hot melting by oven processing (heat treatment) by using a predetermine heating device or the like.

5-1-2. Fibers

[0168] As the fiber constituting a fiber aggregate (for example, the fibers 101 constituting the fiber web 100 as shown in Figs. 1A and 1B), fibers which can be obtained by singly using thermoplastic resin, such as low-density polyethylene, high-density polyethylene, straight chain polyethylene, polypropylene, polyethylene terephthalate, modified polypropylene, modified polyethylene terephthalate, nylon, or polyamide, or alternatively by combining these.

[0169] Examples of the composite shape are sheath-core type where a core component has a higher melting point than a sheath component; eccentric sheath-core type; and side-by-side type where right and left components have different melting points from each other. Alternatively, a hollow type, a different type such as flat, Y-type, or C-type, a solid crimp fiber such as latent crimp or explicit crimp, a split fiber to be split by physical load such as water flow, heat, or embossing may be mixed together.

[0170] In order to form a three-dimensional crimp shape, a predetermined explicit crimp fiber or a latent crimp fiber may be added. The term "three-dimensional crimp shape" includes spiral shape, zigzag shape, and Q-shape. Although the fiber orientation is mainly directed in a plane direction, the fiber orientation can be partially directed in the thickness

direction. Since the buckling strength of the fibers themselves acts in the thickness direction, the bulk is hard to be collapsed even if external pressure is exerted. Among others, the spiral shape tends to return to the original shape when the external pressure is released. Even if the bulk is slightly collapsed under excessive external pressure, it is easy to return to the original thickness after the external pressure is released.

[0171] The explicit crimp fiber is the generic name of fibers crimped in advance, such as fibers after having been subjected to a shape supply by mechanical crimping, and fibers whose sheath-core structure is eccentric core type, side-by-side, or the like. The latent crimp fiber exhibits the crimp by heating.

[0172] In the mechanical crimp, after-spinning continuous and linear fibers can be controlled by peripheral speed different of line speed, heat, or pressurization. A larger number of crimps per unit length permit a higher buckling strength under external pressure. For example, the number of crimps is preferably in the range of 10 to 35 pieces/inch, more preferably 15 to 30 pieces/inch.

[0173] The fibers after having been subjected to a shape supply by heat contraction are made up of two or more resins having different melting points, and when they are heated, the heat contraction rate is changed due to the differences in melting point, thereby exhibiting a three-dimensional crimping. The resin configuration of the cross section of the fibers is, for example, sheath-core structure of eccentric sheath-core type or side-by-side type where right and left components have different melting points from each other. The heat contraction rate of these fibers is preferably, for example, in the range of 5 to 90%, more preferably 10 to 80%.

[0174] The method of measuring the heat contraction rate is as follows. (1) A measured web having a 100% of fibers and 200 gsm (g/m^2) is formed; (2) The web is cut to obtain a sample of a size of 250 x 250 mm; (3) The sample is left for five minutes in an oven of 145°C (418.15K); (4) The length after contraction is measured; and (5) The heat contraction rate is calculated from a difference in length before and after contraction.

[0175] When the aforesaid nonwoven fabric is used as a top sheet, the fineness is preferably in the range of 1.1 to 8.8 dtex, in consideration of the penetration of a predetermined liquid, touch, and the like.

[0176] When the aforesaid nonwoven fabric is used as a top sheet, a liquid hydrophilic fiber of cellulose type such as pulp, chemical pulp, rayon, acetate, or natural cotton may be contained in order to absorb, for example, a little amount of menstrual blood or sweat remaining on the skin. It should be noted that because the cellulose fibers are hard to discharge the absorbed liquid, it is preferable to mix, for example, in the range of 0.1 to 5 % by mass to the entire amount.

[0177] When the aforesaid nonwoven fabric is used as a top sheet, hydrophilic agent or water repellent agent may be mixed in or coated on the hydrophobic synthetic fiber described previously, in consideration of the penetration of a predetermined liquid, rewet back. Alternatively, hydrophilic properties may be supplied by corona treatment or plasma treatment.

[0178] In order to increase whitening properties, inorganic filler such as titanium oxide, barium sulfate, or calcium carbonate may be contained. For composite fibers of sheath-core type, inorganic filler may be contained only in the core or both the core and the sheath.

[0179] As previously described, it is easy for the fiber web formed by card method using relatively long fibers to reorient the fibers by air flow. In order that after groove portions (concave and convex portions) are formed by a plurality of air flows, the fibers are made into a nonwoven fabric with its shape retained, it is preferable to employ throw air method where thermoplastic fibers are subjected to hot melting by oven processing (heat treatment). As suitable fibers for this manufacturing method, fibers having sheath-core structure or side-by-side structure are preferably used in order to attain hot melting of the intersections between the fibers. It is more preferable to be composed of fibers of sheath-core structure where the sheaths are surely susceptible to hot melting. Particularly, a sheath-core composite fiber composed of polyethylene terephthalate and polyethylene, or a sheath-core composite fiber composed of polypropylene and polyethylene can be used suitably. These fibers can be used singly or in combination of two or more types. The fiber length is preferably 20 to 100 mm, especially 35 to 65 mm.

5-2. Nonwoven Fabric Manufacturing Apparatus Related Matters 5-2-1. Fluid Composed Mainly of Gas

[0180] The fluid composed mainly of gas in the present invention is, for example, gas adjusted to an ordinary temperature or a predetermined temperature, or aerosol obtained by adding solid or liquid fine grains in this gas.

[0181] Examples of the gas are air and nitrogen. The gas contains liquid steam such as water vapor.

[0182] The aerosol is one where liquid or solid is dispersed in gas. For example, it is possible to disperse any one of the followings: ink for coloring, softening agent for increasing flexibility such as silicon, hydrophilic or water repellent active agent for antistatic or wettability control, titanium oxide for increasing fluid energy, inorganic filler such as barium sulfate, powder bond such as polyethylene in order to increase fluid energy and increase maintaining properties for forming concave and convex portions during heat treatment, antihistaminic agent for antipruritic such as diphenhydramine hydrochloride or isopropylmethylphenol, wetting agent, and bactericide. Here, the solid includes gel matters.

[0183] The temperature of the fluid composed mainly of gas can be adjusted suitably. It may be adjusted suitably according to the characteristics of fibers constituting the fiber aggregate, and the shape of the nonwoven fabric to be manufactured.

[0184] In order to suitably move the fibers constituting the fiber aggregate, the temperature of the fluid composed

mainly of gas is preferably somewhat high so as to be able to increase the degree of freedom of the fibers constituting the fiber aggregate. In cases where a thermoplastic resin is contained in the fiber aggregate, by setting the temperature of the fluid composed mainly of gas to a temperature at which the thermoplastic resin can be softened, the thermoplastic resin located at the area against which this fluid has been blown can be softened or melted, and also cured again.

[0185] Thus, the shape of the nonwoven fabric can be maintained by blowing of, for example, the fluid composed mainly of gas. For example, when a fiber aggregate is moved by predetermined moving means, it is possible to supply such a strength as not to scatter the fiber aggregate (nonwoven fabric).

[0186] The flow rate of the fluid composed mainly of gas can be adjusted suitably. For example, a fiber web 100 can be exemplified as a specific example of the fiber aggregate where individual fibers have a degree of freedom. In the fiber web 100, high-density polyethylene is used in the sheath thereof, and polyethylene terephthalate is used in the core thereof, and the main body thereof is a sheath-core fiber having a fiber length of 20 to 100 mm, preferably 35 to 65 mm, and a fineness of 1.1 to 8.8 dtex, preferably 2.2 to 5.6 dtex. When the opening is made by air laid method, the fibers used should be adjusted so as to have a fiber length of 1 to 50 mm, preferably 3 to 20 mm, and 10 to 1000 g/m², preferably 15 to 100 g/m². For example, the fluid composed mainly of gas may be blown against the fiber web 100 by the blowing unit 910 provided with a plurality of the blowout holes 913 having a diameter of 0.1 to 30 mm, preferably 0.5 to 5 mm, a pitch of 0.5 to 30 mm, preferably 0.1 to 10 mm, and a shape of complete round, ellipse, or rectangle, as shown in Figs. 5 and 6, under the conditions that hot air having a temperature of 15 to 300°C (288.15K to 573.15K), preferably 100 to 200°C (373.15K to 473.15K) is blown at a gas volume of 3 to 50 L/min (L/hole), preferably 5 to 20 L/min (L/hole). A suitable fiber aggregate in the present invention is the fiber aggregate whose fibers can be changed in position and orientation when the fluid composed mainly of gas is blown under the above-mentioned conditions. For example, the nonwoven fabric as shown in Figs. 9A and 9B can be formed by employing aforesaid fibers and manufacturing conditions. The groove portions 1a and 1b and the raised ridge portions 2a and 2b can have the following ranges of dimension and basis weight. That is, the groove portions 1 may have a thickness in the range of 0.05 to 10 mm, preferably 0.1 to 5 mm, a width in the range of 0.1 to 30 mm, preferably 0.5 to 5 mm, and a basis weight in the range of 2 to 900 g/m², preferably 10 to 90 g/m². The groove portions 1a and 1b and the raised ridge portions 2a and 2b can have the following ranges of dimension and basis weight. The raised ridge portions 2a and 2b may have a thickness in the range of 0.1 to 15 mm, preferably 0.5 to 10 mm, a width in the range of 0.5 to 30 mm, preferably 1.0 to 10 mm, and a basis weight in the range of 5 to 1000 g/m², preferably 10 to 100 g/m². Although the nonwoven fabric can be formed in the aforesaid range of numerical values, these are for purposes of illustration only and are not to be construed as limiting values.

5-2-2. Blowing Means

[0187] By adapting the blowing unit 910 so that it can change the direction of the fluid composed mainly of gas, for example, the intervals of the concave portions (groove portions) to be formed and the height of the convex portions (raised ridge portions) to be formed can be adjusted suitably. By adapting the blowing unit 910 so that it can automatically change the direction of the aforesaid fluid, for example, the groove portions or the like can be adjusted suitably so as to have a meandering shape (a corrugation shape, or a zigzag shape), or other shape. By adjusting the amount and the time of blowing of the aforesaid fluid, the shape and the formation pattern of the groove portions and the openings can be adjusted suitably. The angle at which the aforesaid fluid is blown against the fiber web may be perpendicular. Alternatively, in the moving direction F of the fiber web 100, it may be tilted a predetermined angle in the line flow direction as the moving direction F, or directed oppositely a predetermined angle to the line flow direction.

5-2-3. Heating Means

[0188] As the method of bonding the fibers 101 in the nonwoven fabric 116 provided with the openings, there are, for example, bonding by needle punch method, spun lace method, solvent bonding method, and hot bonding by point bond method or air through method. Among others, air through method is preferred in order to maintain the adjusted the fiber orientation, the fiber dense and nondense, or the fiber basis weight, and the shapes of the formed predetermined groove portions, the openings and the raised ridge portions. Preferred is heat treatment by air through method in the heater part 95.

5-2-4. Others

[0189] The nonwoven fabric 115 manufactured by the heat treatment in the heater part 950 is then moved to, for example, the step of cutting the nonwoven fabric 115 in a predetermined shape, the step of winding, or the like, by a conveyor 940 that is continued to the conveyor 930 in a predetermined direction F. Like the conveyor 930, the conveyor 940 has a belt part 949, a rotating part 941, and the like.

Claims

1. A nonwoven fabric comprising:

5 a plurality of openings formed along a first direction;
 a first side edge portion allocated as one area in the vicinity of a side edge portion of the opening when viewed from a second direction orthogonal to the first direction; and
 a second side edge portion allocated as the other area in the vicinity of the side edge portion of the opening, separated from a net-shaped side edge portion by the opening,
 10 the first side edge portion having a higher fiber density than the second side edge portion.

2. The nonwoven fabric according to claim 1, wherein the first side edge portion has a higher basis weight than the second side edge portion.

15 3. The nonwoven fabric according to claim 1 or 2, further comprising:

a first opening and a second opening adjacent to each other in an arrangement of the plurality of openings; and
 a first connecting part of a fiber between the first opening and the second opening,
 20 the first connecting part having a higher fiber density than the second side edge portion in the first openings.

4. The nonwoven fabric according to claim 3, wherein at the first side edge portion in the second opening, a content ratio of fibers oriented in the first direction is higher than a content ratio of fibers oriented in the second direction.

5. The nonwoven fabric according to claim 3 or 4, wherein at the first connecting part, the content ratio of fibers oriented in the second direction is higher than the content ratio of fibers oriented in the first direction.

6. The nonwoven fabric according to any one of claims 3 to 5, wherein the first connecting part has a higher basis weight than the second side edge portion in the first opening.

7. The nonwoven fabric according to any one of claims 3 to 6, further comprising:

a third opening adjacent to the first opening on the opposite side of the second opening in the arrangement of the plurality of openings; and
 a second connecting part of fibers between the first opening and the third opening,
 35 the second connecting part having a higher fiber density than the second side edge portion in the first opening.

8. The nonwoven fabric according to claim 7, wherein the first side edge portion in the second opening and the first side edge portion in the first opening are located on opposite sides in the second direction,
 40 the first side edge portion in the third opening and the first side edge portion in the first opening are located on opposite sides in the second direction, and
 the first side edge portion in the second opening, which is an area having a higher fiber density than the second side edge portion, the first connecting part, the first side edge portion in the first opening, the second connecting part, and the first side edge portion in the third opening are continued in a meandering shape.

9. The nonwoven fabric according to claim 7 or 8, wherein the first connecting part has a fiber density of at least 0.05 g/cm³, having at least 1.1 times a fiber density of the second side edge portion in at least one of either of the first opening and the second opening, and
 45 the second connecting part has a fiber density of at least 0.05 g/cm³, having at least 1.1 times a fiber density of the second side edge portion in at least one of either of the first opening and the second opening.

10. The nonwoven fabric according to any one of claims 7 to 9, wherein at the first side edge portion in the third opening, a content ratio of fibers oriented in the first direction is higher than a content ratio of fibers oriented in the second direction.

11. The nonwoven fabric according to any one of claims 7 to 10, wherein at the second connecting part, a content ratio of fibers oriented in the second direction is higher than a content ratio of fibers oriented in the first direction.

12. The nonwoven fabric according to any one of claims 7 to 11, wherein the second connecting part has a higher basis

weight than the second side edge portion in the first opening.

5 13. The nonwoven fabric according to any one of claims 7 to 12, wherein a basis weight of the first side edge portion in the first opening, a basis weight of the first side edge portion in the second opening, and a basis weight of the first side edge portion in the third opening are 15 to 250 g/cm³, respectively, each being at least 1.1 times a basis weight of the second side edge portion in the first opening, a basis weight of the second side edge portion in the second opening, and a basis weight of the second side edge portion in the third opening, respectively.

10 14. The nonwoven fabric according to any one of claims 1 to 13, further comprising:

a plurality of groove portions formed on one surface of the nonwoven fabric, so as to extend in the first direction; and

15 a plurality of raised ridge portions formed so as to extend in the first direction on one surface, the raised ridge portions being adjacent to the plurality of groove portions, respectively, the plurality of openings being formed along the plurality of grooves, respectively.

20 15. The nonwoven fabric according to any one of claims 1 to 14, wherein the shape of each of the plurality of openings is selected from a substantially circular shape and a substantially elliptical shape.

16. A nonwoven fabric including an area of density change in which the fiber density continuously or intermittently changes, the area of density change having a plurality of high-density areas extending in a predetermined first direction identical with a process flow direction in a machine when manufacturing the nonwoven fabric.

25 17. The nonwoven fabric according to claim 16, wherein the high-density areas include a plurality of C-shaped high-density areas, and one side of the area of high-density has a low fiber density, when viewed from a second direction orthogonal to the first direction, respectively.

30 18. The nonwoven fabric according to claim 16 or 17, wherein the high-density areas include a meandering shaped area of high-density extending in a meandering shape in the first direction.

FIG. 1A

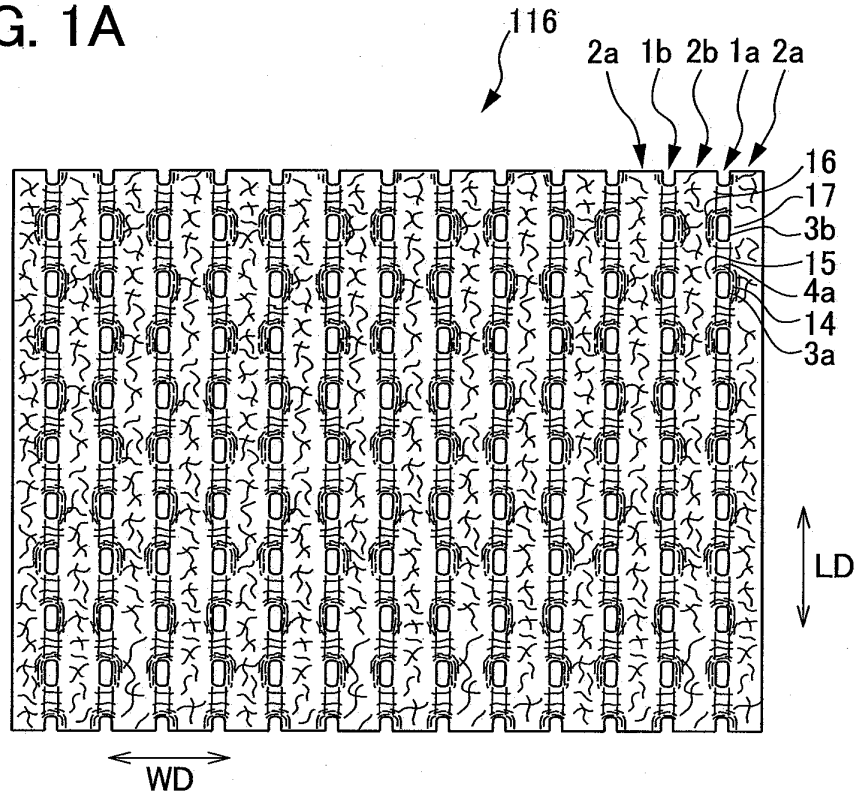


FIG. 1B

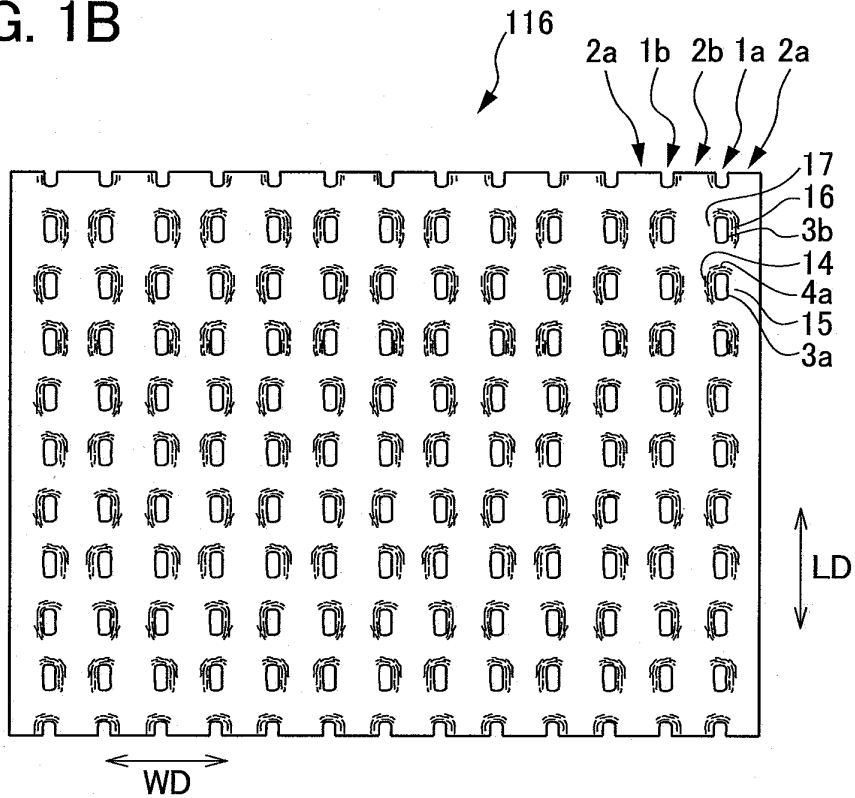


FIG. 2

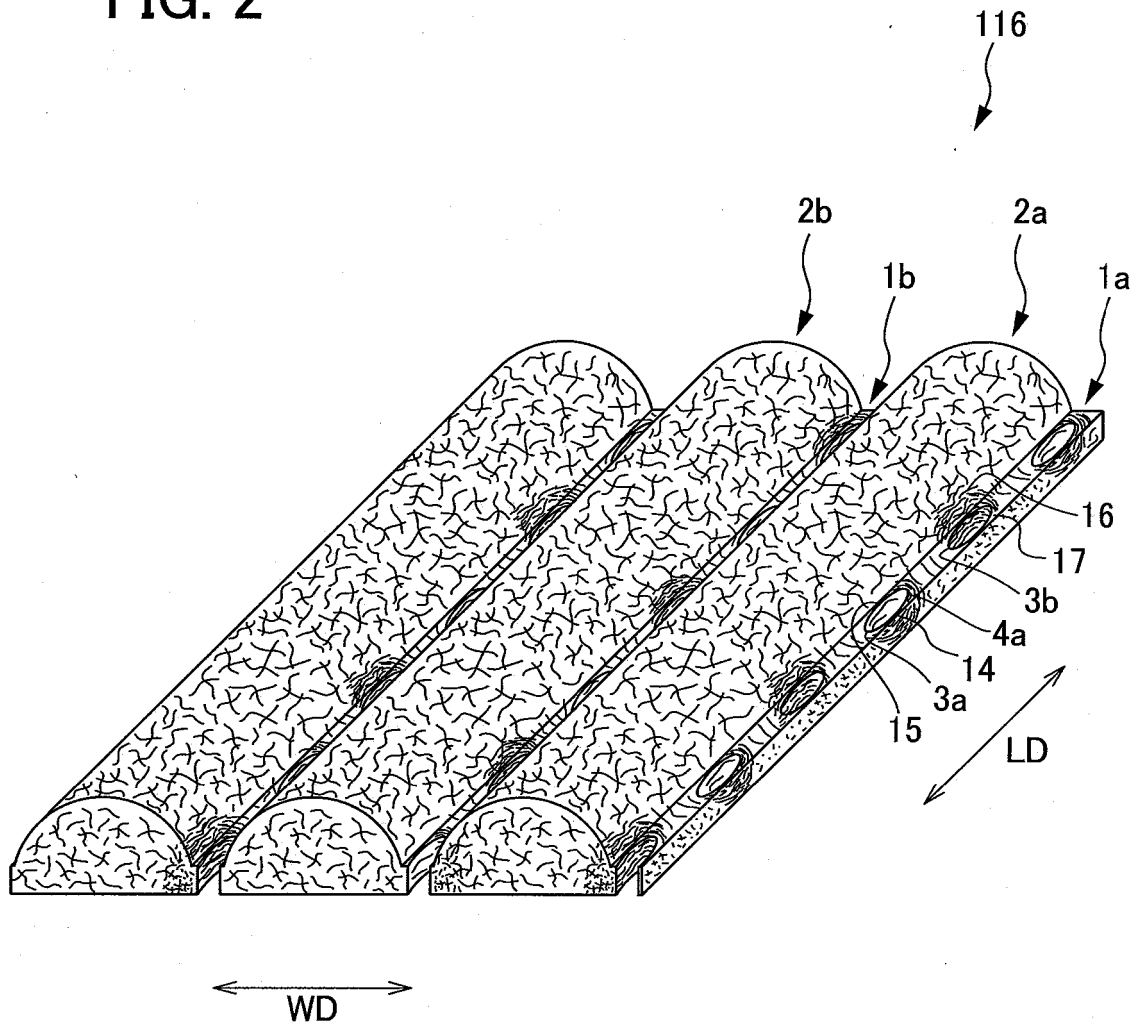


FIG. 3A

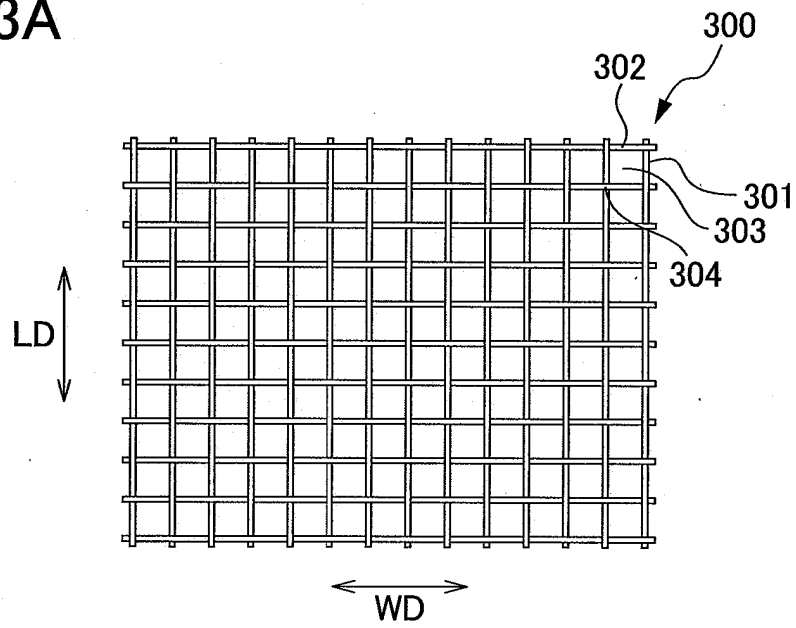


FIG. 3B

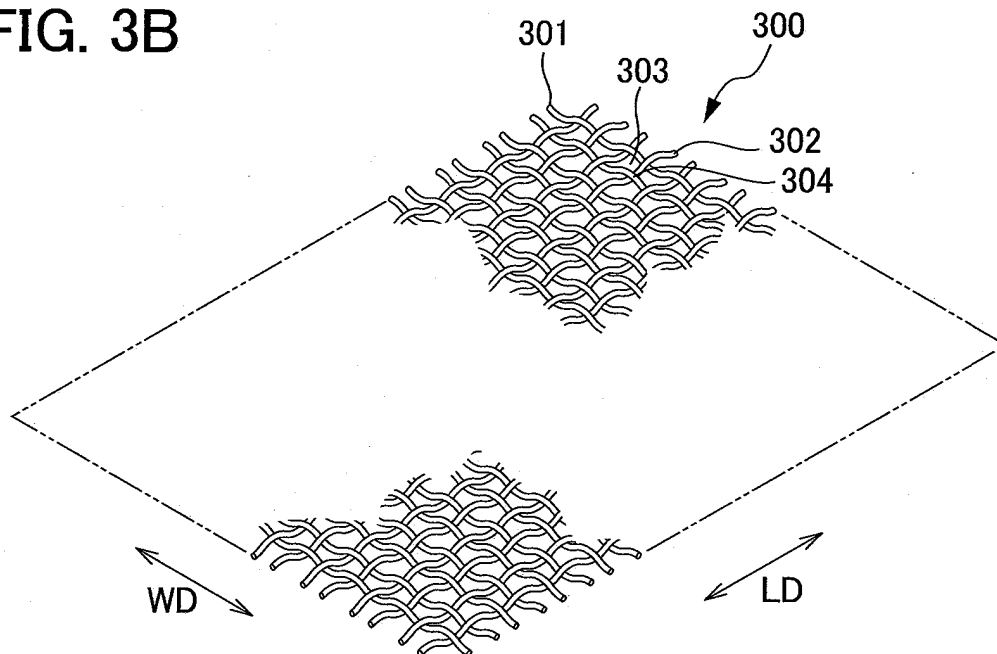


FIG. 4

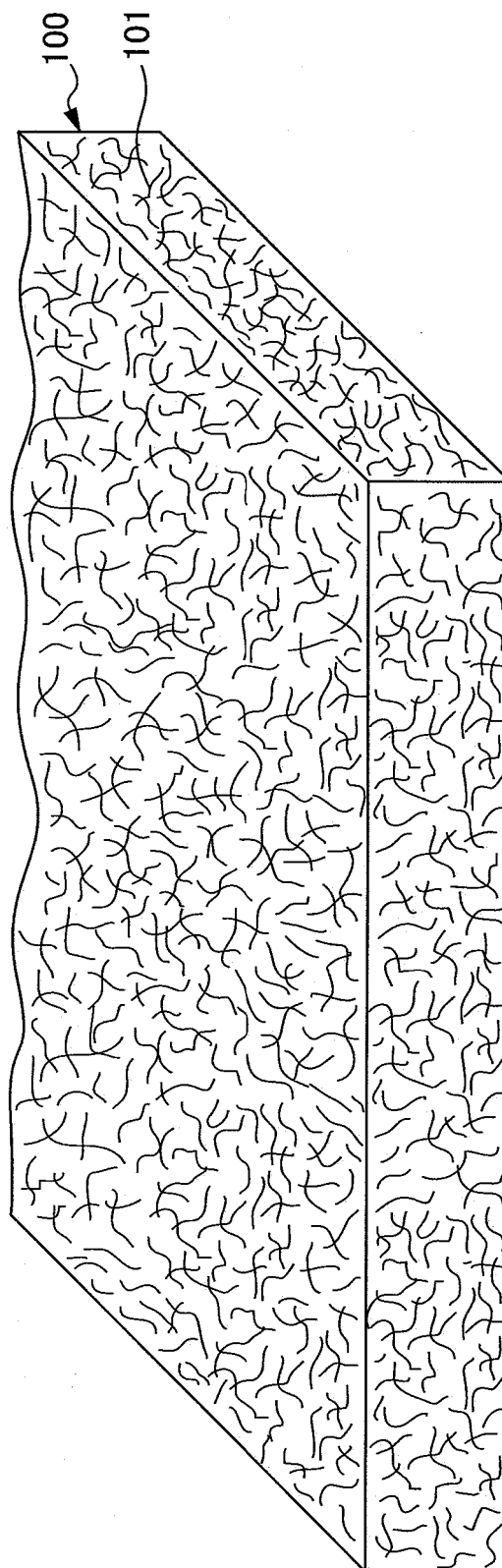


FIG. 5

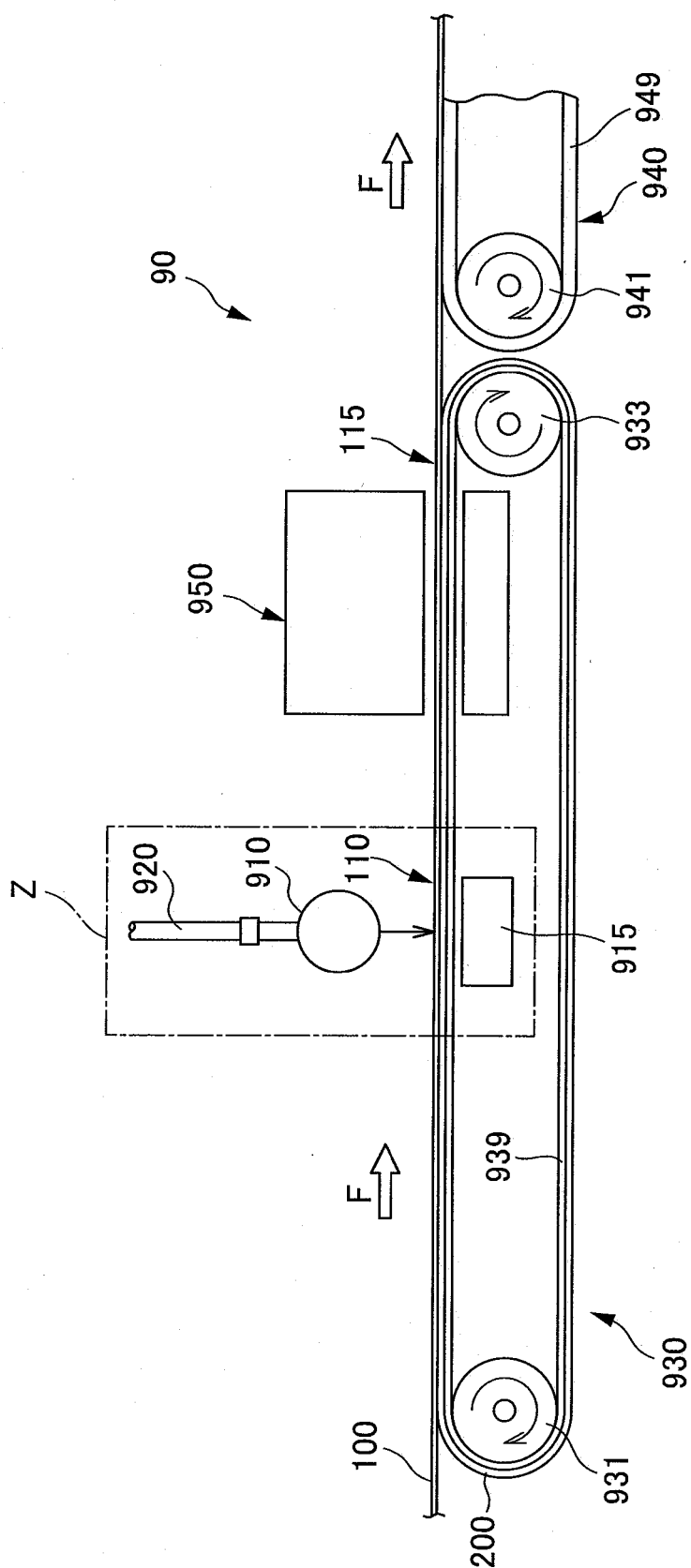


FIG. 6

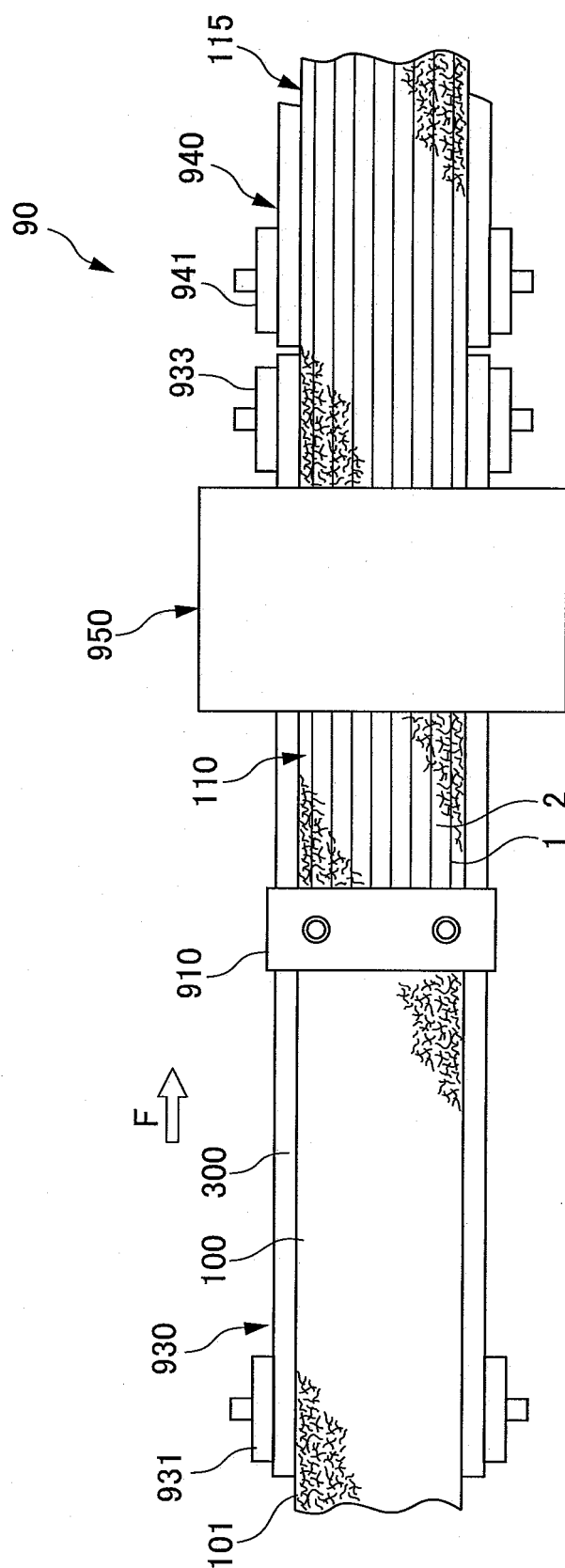


FIG. 7

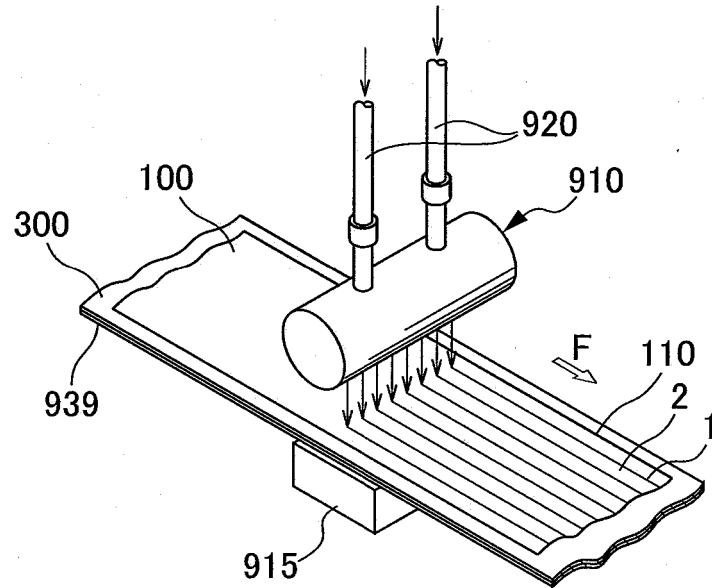


FIG. 8

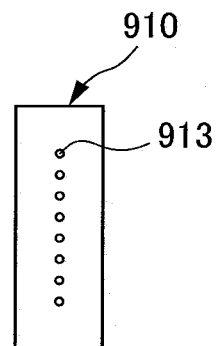


FIG. 9A

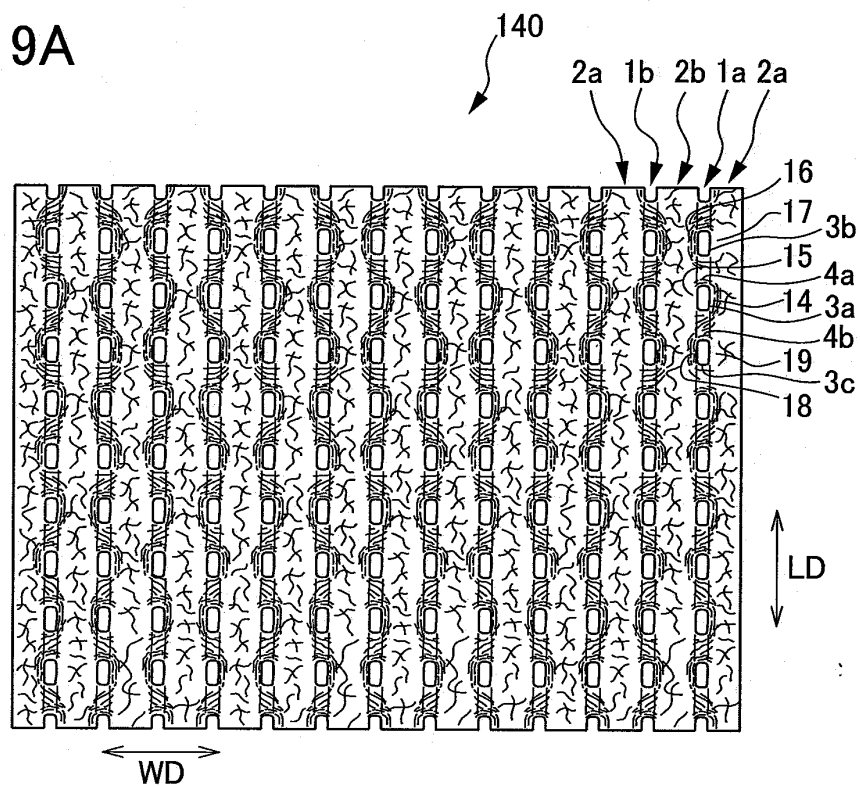


FIG. 9B

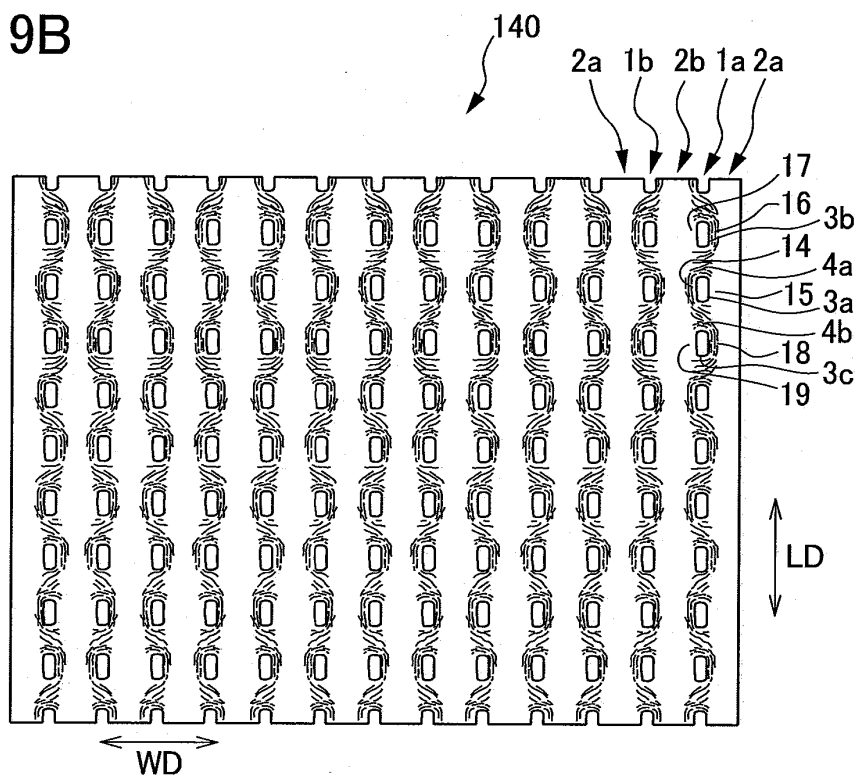


FIG. 10

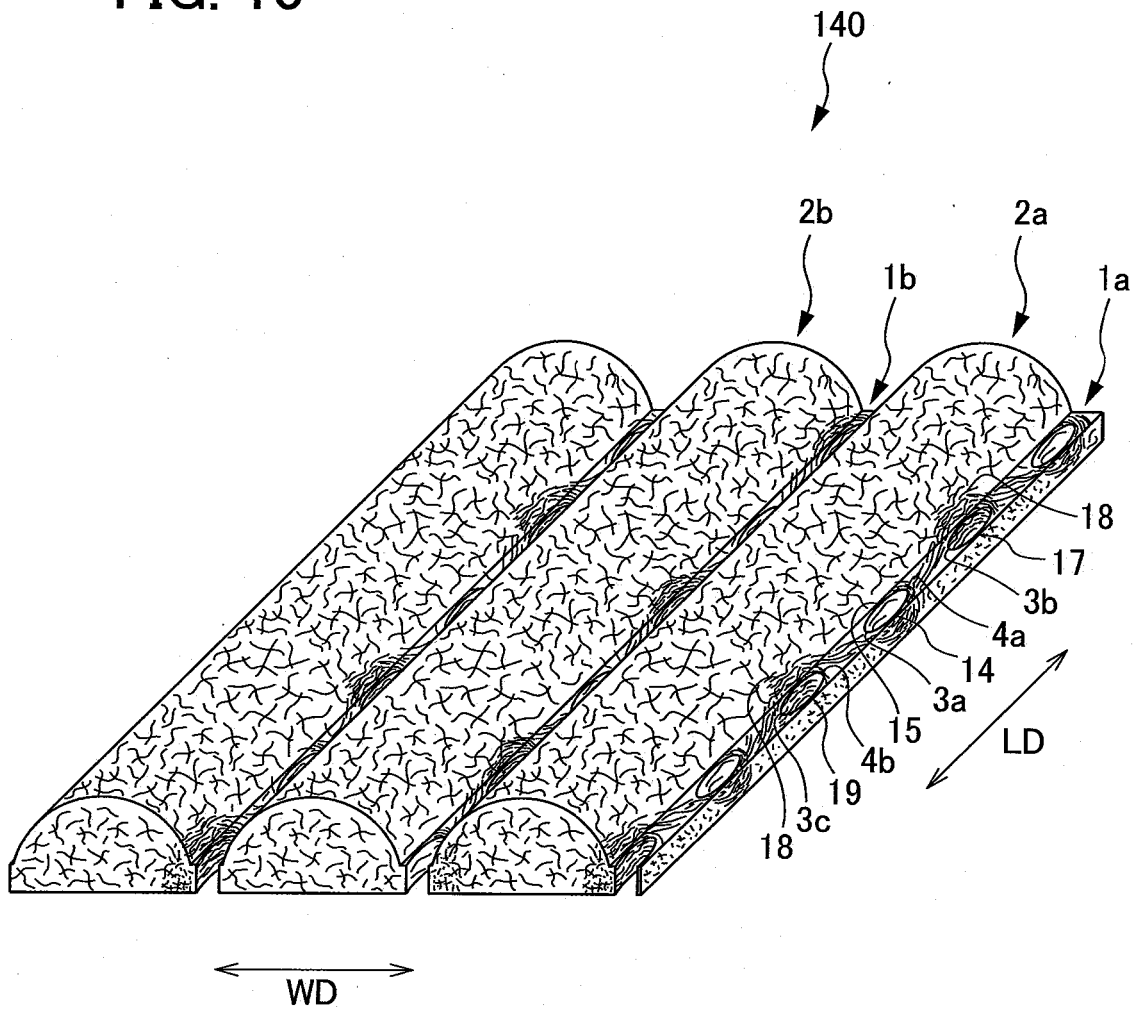


FIG. 11A

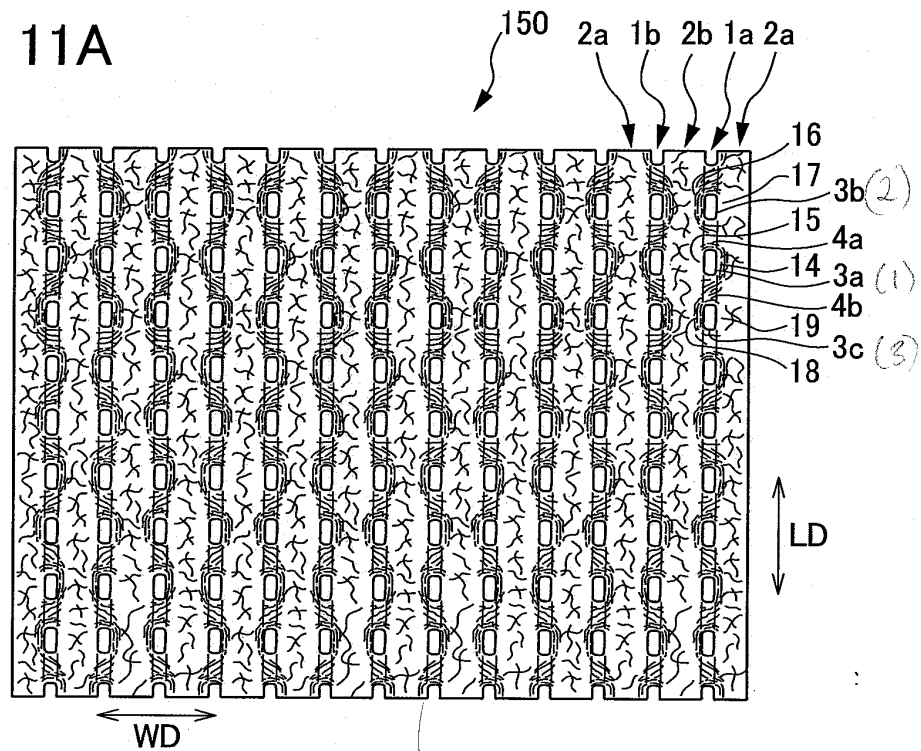


FIG. 11B

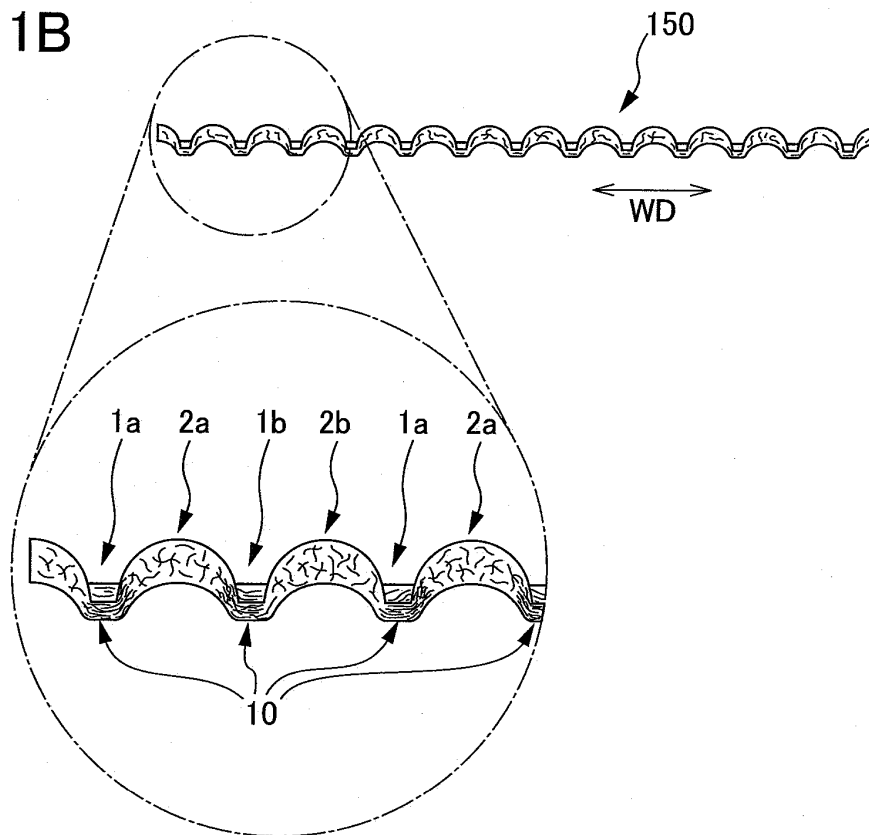


FIG. 12A

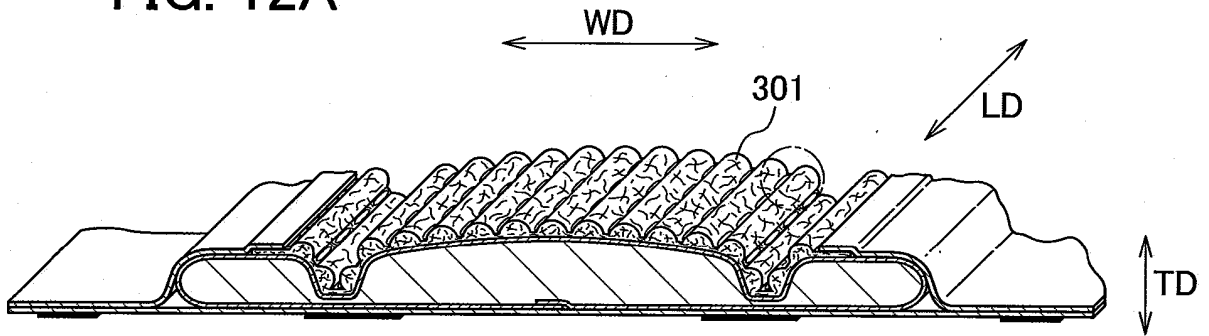


FIG. 12B

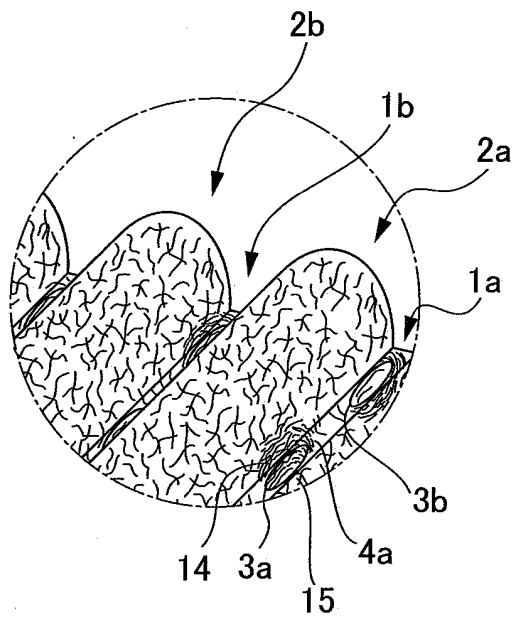


FIG. 13A

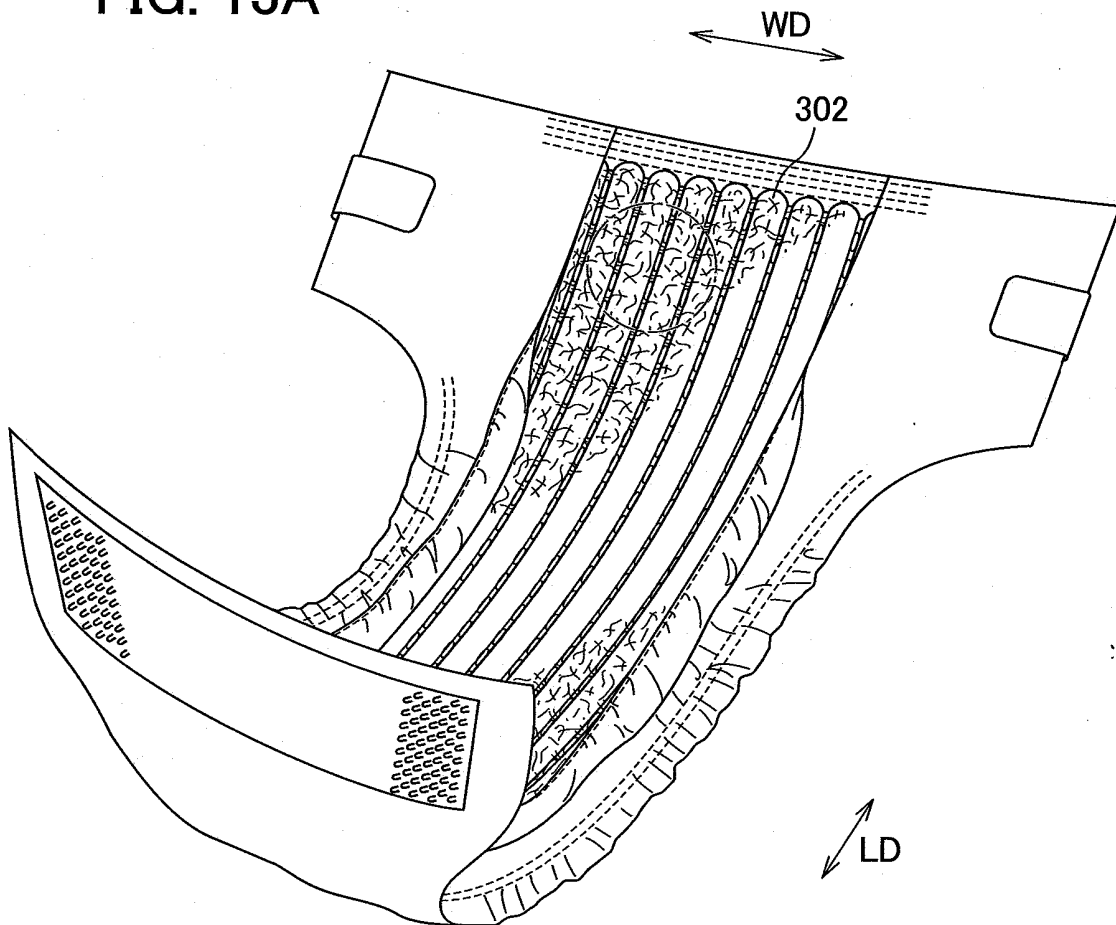


FIG. 13B

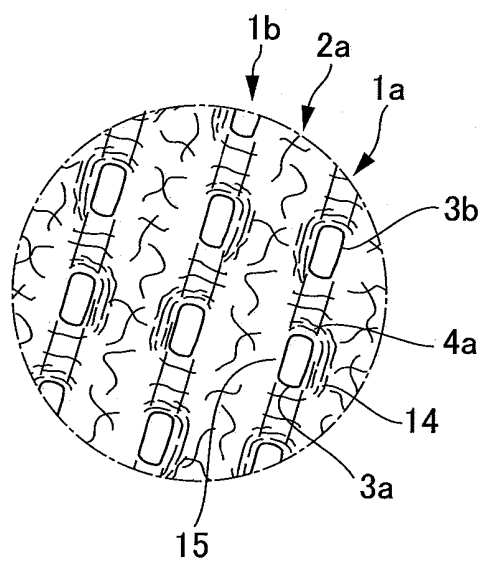


FIG. 14

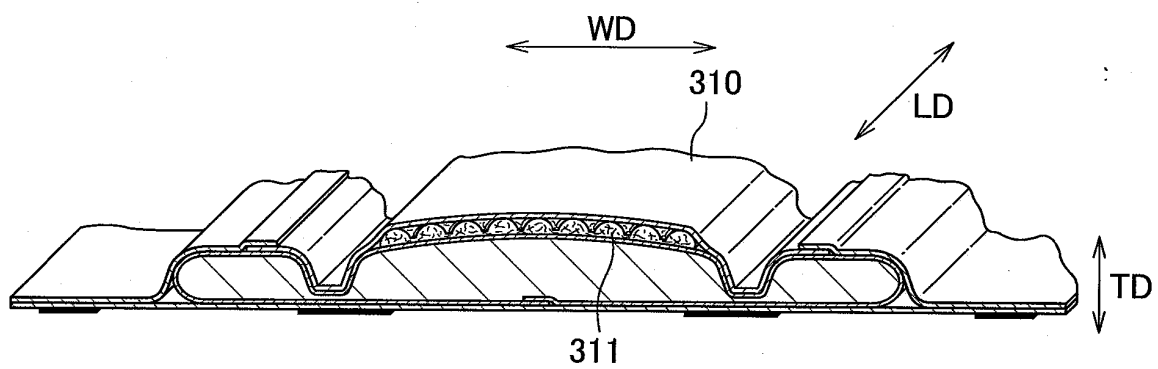


FIG. 15A

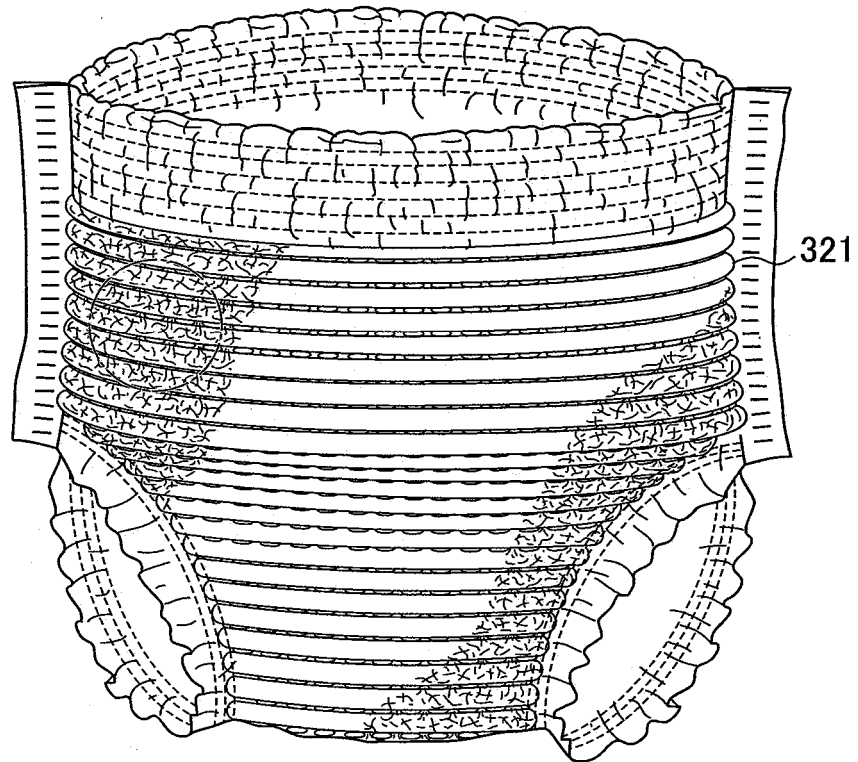
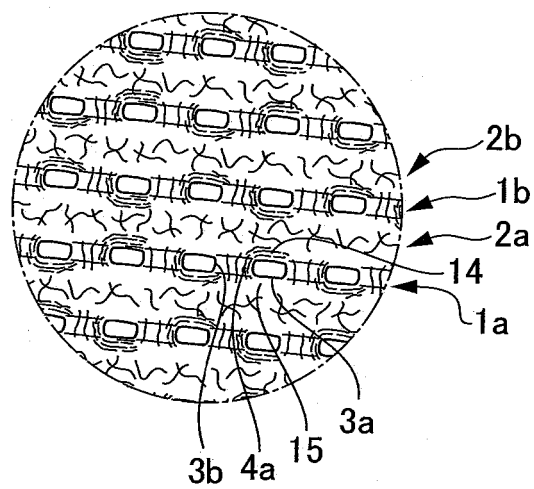


FIG. 15B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/061601

A. CLASSIFICATION OF SUBJECT MATTER D04H1/46(2006.01) i, D04H1/54(2006.01) i, D04H1/72(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) D04H1/00-18/00		
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 1996-2007 Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007		
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	JP 2002-136547 A (Uni-Charm Corp.), 14 May, 2002 (14.05.02), Claims; Par. Nos. [0010] to [0012], [0016]; Figs. 2, 3 & EP 1201213 A2 & US 2002/0052582 A1	1-7, 9-13, 15-17 14 8, 18
Y	JP 2002-30557 A (Daiwabo Co., Ltd.), 31 January, 2002 (31.01.02), Claims; Par. Nos. [0001], [0019], [0050]; Fig. 2 (Family: none)	14
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 24 July, 2007 (24.07.07)		Date of mailing of the international search report 07 August, 2007 (07.08.07)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

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Patent documents cited in the description

- JP 6330443 A [0005]