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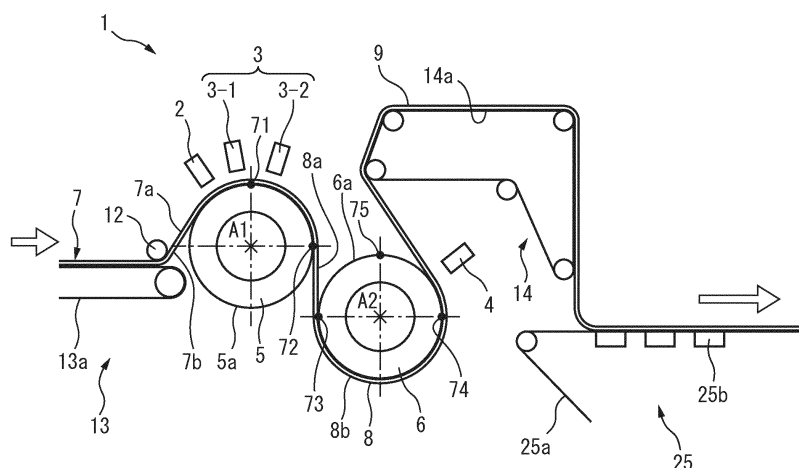
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(54) **METHOD FOR MANUFACTURING NONWOVEN FABRIC WITH UNEVEN PATTERN**

(57) Provided is a method for manufacturing a nonwoven fabric with an uneven pattern that processes a web while delivering the same, wherein the method comprises: a step for preparing a web with a fiber density of $4.8 \times 10^{-2} \text{ g/cm}^3$; a step for disposing the web so as to follow a surface of a first support body having an uneven pattern on the surface and forming a semifinished product with an uneven pattern having an uneven pattern re-

gion wherein the uneven pattern is transcribed while the fibers included in the web are interlaced with one another by spraying a first water flow on the web; and a step for forming a nonwoven fabric by interlacing the fibers included in the semifinished product with an uneven pattern by spraying a second water flow in a region outside of the uneven pattern region in the semifinished product with an uneven pattern.

FIG. 1



Description

FIELD

- 5 **[0001]** The present invention relates to a nonwoven fabric, and particularly relates to a method of manufacturing a nonwoven fabric with protruded and recessed patterns.

BACKGROUND

- 10 **[0002]** A nonwoven fabric is known which is used for absorbent articles such as a sanitary article and a disposable diaper, cleaning articles such as a wiper, medical supplies such as a mask and so on. In such a nonwoven fabric, there are cases in which patterns by protruded and recessed patterns are added in order to add design and functionality thereto. For example, Patent Literature 1 discloses a manufacturing method of a nonwoven fabric in which stripe patterns are added by protruded and recessed patterns.
- 15 **[0003]** The manufacturing method in Patent Literature 1 includes a step of forming stripe patterns by entangling configurational fibers of a fiber web (a first entangling), and then entangling a portion of the configurational fibers of the fiber web on a predetermined supporting body with regular patterns by using a water flow (a second entangling), whereby rearranging the portion of the configurational fibers, so that a plurality of stripes which have regular patterns are expressed, wherein a width of each of the stripes is 4 mm to 50 mm.
- 20 **[0004]** In the above mentioned manufacturing method, first, the first entangling is performed so as to form a sheet in which the fibers are entangled with each other, and then the sheet is placed on the supporting body which has protruded and recessed patterns, and the protruded and recessed patterns are transferred onto the sheet by the second entangling. However, in the sheet which has been formed by the first entangling, since the fibers are strongly entangled with each other, it is conceived that it is difficult for the rearrangement of the fibers to occur. Accordingly, when the second entangling
- 25 is performed by a water flow with low pressure, the rearrangement of the fibers which are strongly entangled with each other does not sufficiently proceed, and there may be cases in which the protruded and recessed patterns cannot be formed, or the visibility of the protruded and recessed patterns is lowered. Accordingly, in order to transfer the protruded and recessed patterns onto the sheet which has been formed by the first entangling, an energy enough to rearrange the fibers which are strongly entangled with each other is required, and thus, the water flow in the second entangling
- 30 needs to be performed with high pressure. Consequently, in the manufacturing method of Patent Literature 1, the energy required to manufacture the nonwoven fabric with protruded and recessed patterns is increased, and there may be cases in which the production efficiency is lowered.

CITATION LIST

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PATENT LITERATURE

[0005] PTL 1: Japanese Unexamined Patent Publication No. 2013-64226

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SUMMARY

TECHNICAL PROBLEM

- 45 **[0006]** The object of the present invention is to provide a method of manufacturing a nonwoven fabric with protruded and recessed patterns which is capable of increasing the production efficiency while maintaining the visibility of the protruded and recessed patterns, when manufacturing the nonwoven fabric with protruded and recessed patterns from a web.

SOLUTION TO PROBLEM

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- [0007]** The present invention provides a method of manufacturing a nonwoven fabric with protruded and recessed patterns by processing a web while conveying the web, including: a step of preparing a web which has a fiber density of $4 \text{ to } 8 \times 10^{-2} \text{ g / cm}^3$; a step of forming a semi-finished product with protruded and recessed patterns by disposing the web so as to be along a surface of a first supporting body which has protruded and recessed patterns on the surface,
- 55 and jetting a first water flow to the web so as to entangle fibers with each other included in the web, the semi-finished product with protruded and recessed patterns including a protruded and recessed pattern present region to which the protruded and recessed patterns are transferred; and a step of forming a nonwoven fabric with protruded and recessed patterns by jetting a second water flow to a region other than the protruded and recessed pattern present region in the

semi-finished product with protruded and recessed patterns so as to entangle the fibers with each other included in the semi-finished product with protruded and recessed patterns.

[0008] The flexibility of movement of the fibers included in the web before the web is entangled is higher than that after the web is entangled. Accordingly, rather than by transferring the protruded and recessed patterns (the patterns) to the web after entangling the web, but by transferring the protruded and recessed patterns to the web while entangling the web, it is easier for the fibers in the web to move according to the protruded and recessed patterns and it is easier for the transfer of the protruded and recessed patterns to be performed. Thus the visibility of the transferred protruded and recessed patterns can be increased, and also the energy of the first water flow can be decreased, whereby the production efficiency can be improved. Further, by making the fiber density of the web to be higher within the predetermined range ($4 \text{ to } 8 \times 10^{-2} \text{ g / cm}^3$) at this time, the fibers can be moderately in close contact with each other, whereby when the protruded and recessed patterns are transferred to the web, the fibers in the web can be prevented from scattering and the texture can be prevented from being disordered, by the impact of the first water flow even when the web is not entangled in advance, that is, the visibility can be prevented from being lowered. Further, since, while the protruded and recessed pattern present region in the semi-finished product is avoided from being entangled by the second water flow, the other regions in the semi-finished product is entangled by the second water flow, a nonwoven fabric which has a suitable strength can be manufactured without lowering the visibility of the transferred protruded and recessed patterns.

[0009] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the step of preparing the web may include: a step of moisturizing a web, which is formed by laminating the fibers, by a water flow and dehydrating the web. In this manufacturing method, after the web includes water, the web is dehydrated, whereby the thickness of the web can be easily thinned, and the web with the fiber density within the predetermined range can be easily obtained. Further, by decreasing the water in the web by dehydration, the energy of the first water flow can be efficiently transmitted to the web.

[0010] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the step of moisturizing and dehydrating the web may dehydrate the web by disposing the web so as to be along the surface of the first supporting body and sucking the web through the first supporting body while moisturizing the web with water. In this manufacturing method, after the web contains water on the first supporting body, the web is dehydrated by suction through the first supporting body, whereby the web can be made to be in a state of being fixed on the protruded and recessed patterns, and the first water flow can be jetted to the web at this state. Accordingly, the energy of the water flow when transferring the protruded and recessed patterns to the web can be decreased, and the production efficiency can be improved.

[0011] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the step of forming the nonwoven fabric may dispose the semi-finished product with protruded and recessed patterns on a second supporting body which is different from the first supporting body and does not include the protruded and recessed patterns on a surface, and jet the second water flow to the semi-finished product with protruded and recessed patterns. In this manufacturing method, the first supporting body shared for adding the protruded and recessed patterns and for entangling the web, and the second supporting body dedicated for entangling the web, are separated from each other, whereby the compatibility of the visibility of the protruded and recessed patterns in the nonwoven fabric and the strength thereof can be achieved.

[0012] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the step of forming the semi-finished product with protruded and recessed patterns may jet the first water flow from a plurality of first water flow nozzles which are aligned along a machine direction in which the web is conveyed, and jetting pressures of the plurality of first water flow nozzles may increase as proceeded in the machine direction. In this manufacturing method, the force of the first water flow is gradually increased, whereby in the jetting by the initial first water flow nozzles, the formation of the protruded and recessed patterns can be proceeded while suppressing the degree of entanglement, and in the jetting by the subsequent first water flow nozzles, the formation of the protruded and recessed patterns can be proceeded while increasing the degree of entanglement. Accordingly, the compatibility of forming the protruded and recessed patterns and entangling the fibers in the web with each other can be achieved.

[0013] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the step of forming the semi-finished product with protruded and recessed patterns may jet the first water flow to one surface of the web, and the step of forming the nonwoven fabric may jet the second water flow to a surface of the semi-finished product with protruded and recessed patterns which corresponds to the other surface of the web. In this manufacturing method, the water flow can be jetted to both surfaces of the web and of the semi-finished product, whereby fibers in the web and in the semi-finished product can be efficiently entangled with each other.

[0014] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, a jetting pressure of the first water flow may be lower than a jetting pressure of the second water flow. In this manufacturing method, since the jetting of the first water flow is of low pressure, the movement of the fibers in the web is smaller. Accordingly, although the entanglement of the fibers in the web with each other is less, the fibers in the web can move delicately so as to be

rearranged according to the protruded and recessed patterns. That is, the formation of the protruded and recessed patterns can be proceeded while suppressing the degree of entanglement. Further, since the subsequent jetting of the second water flow is of high pressure, the movement of the fibers in the semi-finished product is larger. Accordingly, the entanglement of the fibers in the semi-finished product with each other is increased, that is, the entanglement can be further proceeded. Consequently, a nonwoven fabric which has a suitable strength can be obtained without lowering the visibility of the protruded and recessed patterns.

[0015] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the first supporting body may be disposed on an outer circumferential surface of a cylindrical first suction drum which rotates around a horizontal shaft line, and the step of forming the semi-finished product with protruded and recessed patterns may jet the first water flow from a position above the shaft line. In this manufacturing method, the first water flow has only to be jetted downward or diagonally downward with respect to the first supporting body, and the first water flow need not be jetted upward or diagonally upward, whereby the energy of the first water flow can be efficiently transmitted to the web, and the jetting pressure of the first water flow can be lowered. Accordingly, the production efficiency can be improved.

[0016] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the first supporting body may be disposed on an outer circumferential surface of a cylindrical first suction drum which rotates around a shaft line, the second supporting body may be disposed on an outer circumferential surface of a cylindrical second suction drum which is arranged on a downstream side in a machine direction than the first suction drum and rotates around a shaft line, the first suction drum and the second suction drum may be arranged so as not to be in contact with each other and the respective shaft lines are parallel to each other, the step of forming the semi-finished product with protruded and recessed patterns may jet the first water flow to a first surface of the web while making the web be sucked by the first suction drum and retaining the web on the surface of the first supporting body so that the first surface of the web faces outward, the step of forming the nonwoven fabric may jet the second water flow to a surface of the semi-finished product with protruded and recessed patterns, the surface corresponding to a second surface of the web, the second surface being positioned on an opposite side of the first surface, while making the semi-finished product with protruded and recessed patterns which has left the first suction drum be sucked by the second suction drum and retaining the semi-finished product with protruded and recessed patterns on a surface of the second supporting body so that the second surface of the semi-finished product with protruded and recessed patterns faces outward, and in a vertical direction, the shaft line of the first suction drum may be positioned above the shaft line of the second suction drum. In this manufacturing method, when the semi-finished product with protruded and recessed patterns which has been formed in the first suction drum is conveyed to the second suction drum, the chance of the sheet of the semi-finished product with protruded and recessed patterns being decreased in the width thereof by the conveyance can be lowered. Accordingly, the patterns on the semi-finished product with protruded and recessed patterns (the nonwoven fabric) can be prevented from being disordered.

[0017] In the method of manufacturing the nonwoven fabric with protruded and recessed patterns, the step of moisturizing and dehydrating the web may dehydrate the web by sucking the web through the first supporting body while moisturizing the web by jetting a third water flow to the web through a mesh. In this manufacturing method, when the water flow is jetted to the web through a mesh, the water flow hits the mesh, whereby the water pressure of the water flow is lowered, and also the water flow is widely spread so as to reach the web. Since the water pressure is lowered, the water flow is widely spread without the configurational fibers of the web being entangled by the water flow. Therefore, the web is efficiently moisturized, and the web can be made to be in a state of being fixed on the protruded and recessed patterns.

ADVANTAGEOUS EFFECTS OF INVENTION

[0018] The present invention is capable of increasing the production efficiency while maintaining the visibility of the protruded and recessed patterns, when manufacturing the nonwoven fabric with protruded and recessed patterns from a web.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

FIG. 1 is a view schematically showing a portion of a configurational example of a manufacturing apparatus to be used in a method of manufacturing a nonwoven fabric with protruded and recessed patterns according to a first embodiment of the present invention.

FIG. 2 is a view schematically showing a cross section of a configurational example of a first suction drum of the manufacturing apparatus.

FIG. 3 is a view schematically showing a portion of a cross section of a configurational example of a supporting

body of the first suction drum.

FIG. 4 is a view schematically showing a configurational example of a water supplying device of the manufacturing apparatus.

FIG. 5 is a view schematically showing a configurational example of a first jetting nozzle of the manufacturing apparatus.

FIG. 6 is a view schematically showing a configurational example of nozzle holes of the first jetting nozzle.

FIG. 7 is a view schematically showing a configurational example of a semi-finished product with protruded and recessed patterns.

FIG. 8 is a view schematically showing a cross section of a configurational example of a second suction drum of the manufacturing apparatus.

FIG. 9 is a view schematically showing a configurational example of a second jetting nozzle of the manufacturing apparatus.

FIG. 10 is a view schematically showing a configurational example of nozzle holes of the second jetting nozzle.

FIG. 11 is view schematically showing a configurational example of the entire manufacturing apparatus to be used in the method of manufacturing the nonwoven fabric with protruded and recessed patterns according to the embodiment of the present invention.

FIG. 12 is a cross sectional view schematically showing the state of the web being moisturized by a water supplying device and being dehydrated by the first suction drum.

FIG. 13 is a cross sectional view schematically showing the state of the web on protruded and recessed patterns when being moisturized and being dehydrated.

FIG. 14 is a view which schematically showing a portion of a cross section of a configurational example of the semi-finished product on the supporting body.

FIG. 15 is a view schematically showing a portion of a configurational example of a manufacturing apparatus to be used in a method of manufacturing a nonwoven fabric with protruded and recessed patterns according to a second embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

(First embodiment)

[0020] First, a manufacturing apparatus to be used in a method of manufacturing a nonwoven fabric with protruded and recessed patterns will be explained.

[0021] FIG. 1 schematically shows a portion of a configurational example of a manufacturing apparatus to be used in a method of manufacturing a nonwoven fabric with protruded and recessed patterns. A manufacturing apparatus 1 is a manufacturing apparatus which processes a web 7 while conveying the web 7, whereby forms a semi-finished product with protruded and recessed patterns 8 from the web 7, and finally manufactures a nonwoven fabric with protruded and recessed patterns 9 from the semi-finished product with protruded and recessed patterns 8. As the protruded and recessed patterns, patterns which have protruded portions protruded from, recessed portions recessed from, or opening holes penetrating to the other surface from, at least one surface of the web 7, the semi-finished product 8 and the nonwoven fabric 9, or the combination thereof, and which add design and functionality thereto. The manufacturing apparatus 1 includes an upstream side conveying device 13, a first suction drum 5, a water supplying device 2, a first jetting nozzle 3, a second suction drum 6, a second jetting nozzle 4, a downstream side conveying device 14 and a dehydrating device 25.

[0022] The upstream side conveying device 13 includes an upstream side conveying belt 13a and a direction changing roll 12, and changes the conveying direction of the web 7 placed on the upstream side conveying belt 13a upward by the direction changing roll 12 so as to convey the web 7 to the first suction drum 5. At this time, the web 7 is conveyed so that a first surface 7a of the web 7 faces the outer side of the upstream side conveying device 13, and a second surface 7b on the opposite side of the first surface 7a is in contact with the upstream side conveying belt 13a.

[0023] The first suction drum 5 includes, on an outer circumferential surface 5a, a first supporting body which has protruded and recessed patterns on the surface thereof, and while rotating the first supporting body around a shaft line A1, sucks the web 7 conveyed from the upstream side conveying device 13 through the first supporting body, and further, while retaining the web 7 on the outer circumferential surface 5a, conveys the web 7 to the second suction drum 6. At this time, the web 7 is conveyed along the surface of the first supporting body so that the first surface 7a faces the outer side of the first suction drum 5, and the second surface 7b faces the inner side of the first suction drum 5 and is in contact with the outer circumferential surface 5a.

[0024] The water supplying device 2 supplies water from the first surface 7a side to the web 7 which is retained on the outer circumferential surface 5a of the first suction drum 5, and moisturizes the web 7. The first suction drum 5 sucks the water from the second surface 7b side for the moisturized web 7, and dehydrates the web 7.

[0025] The first jetting nozzle 3 jets water (the first water flow) from the first surface 7a side to the web 7 which is retained on the outer circumferential surface 5a of the first suction drum 5, and while entangling the fibers of the web 7 with each other, presses the web 7 to the protruded and recessed patterns of the first supporting body, whereby transfers the protruded and recessed patterns to the web 7, so as to form the semi-finished product with protruded and recessed patterns 8. In the present embodiment, as the first jetting nozzle 3, two nozzles of the first jetting nozzles 3-1 and 3-2 are provided in order from the upstream side along the machine direction of the web 7. The first suction drum 5 sucks water from the second surface 7b side for the web 7 which is being entangled and transferred. In the semi-finished product 8, a protruded and recessed pattern present region in which the protruded and recessed patterns are present, and a protruded and recessed pattern non-present region in which the protruded and recessed patterns are not present, are formed.

[0026] The second suction drum 6 includes, on an outer circumferential surface 6a, a second supporting body which does not have protruded and recessed patterns on the surface thereof, and while rotating the second supporting body around a shaft line A2, sucks the semi-finished product 8 conveyed from the first suction drum 5 through the second supporting body, and further, while retaining the semi-finished product 8 on the outer circumferential surface 6a, conveys the semi-finished product 8 to the downstream side conveying device 14. At this time, the semi-finished product 8 is conveyed along the surface of the second supporting body so that a first surface 8a faces the inner side of the second suction drum 6 and is in contact with the outer circumferential surface 6a, and a second surface 8b on the opposite side of the first surface 8a faces the outer side of the second suction drum 6. Note that the first surface 8a of the semi-finished product 8 corresponds to the first surface 7a of the web 7, and the second surface 8b of the semi-finished product 8 corresponds to the second surface 7b of the web 7.

[0027] The second jetting nozzle 4 does not jet water (the second water flow) to the protruded and recessed pattern present region in the semi-finished product 8 which is retained on the outer circumferential surface 6a of the second suction drum 6, but jets water (the second water flow) from the second surface 8b side to the protruded and recessed pattern non-present region, and while maintaining the visibility of the transferred protruded and recessed patterns, makes the fibers of the semi-finished product 8 further entangle with each other, so as to form the nonwoven fabric with protruded and recessed patterns 9. In the present embodiment, as the second jetting nozzle 4, one nozzle of the second jetting nozzle 4 is provided.

[0028] The downstream side conveying device 14 includes the downstream side conveying belt 14a, and receives the nonwoven fabric 9 which has been conveyed by the second suction drum 6 at a position on the substantially upper side of the second suction drum 6 close to the first suction drum 5, so as to convey the nonwoven fabric 9 by the downstream side conveying belt 14a to the dehydrating device 25.

[0029] The dehydrating device 25 includes a conveying belt 25a and a plurality of suction boxes 25b, and while conveying the nonwoven fabric 9 which has been conveyed by the downstream side conveying device 14 to the equipment of the next step by the conveying belt 25a, sucks moisture from the nonwoven fabric 9 on the conveying belt 25a by the plurality of suction boxes 25b.

[0030] Hereinbelow, the manufacturing apparatus 1 will be explained in detail.

[0031] FIG. 2 is a view schematically showing the cross section of a configurational example of the first suction drum 5 of the manufacturing apparatus 1. The first suction drum 5 includes a hollow shaft portion 50 and a cell portion 52 which is formed on the outer side of the hollow shaft portion 50. The hollow shaft portion 50 and the cell portion 52 are coaxially and cylindrically formed with the shaft line A1 as the central axis. The hollow shaft portion 50 is fixed to a base (which is not shown) of the manufacturing apparatus 1, and the cell portion 52 is joined to the hollow shaft portion 50 so as to be rotatable around the shaft line A1. Accordingly, the first suction drum 5 is configured so that the cell portion 52 is rotatable around the fixed hollow shaft portion 50.

[0032] A plurality of penetration holes 53 through which liquid and gas can pass are formed on the outer circumferential surface of the cell portion 52, and further, a supporting body 54 (a first supporting body) is provided on the outer circumferential surface of the cell portion 52. The supporting body 54 is a cylindrical member which has a shaft line of A1, is fixed to the cell portion 52, and rotates around the shaft line A1 integrally with the cell portion 52. The first suction drum 5 can be regarded as rotating around the shaft line A1.

[0033] FIG. 3 is a view schematically showing a portion of the cross section of a configurational example of the supporting body 54. As shown in FIG. 3, the supporting body 54 includes a base material 56 and protruded and recessed patterns 55 which are formed on the surface of the base material 56. The base material 56 is in contact with the outer circumferential surface of the cell portion 52 and includes a plurality of mesh-like opening holes through which liquid and gas can pass. The protruded and recessed patterns 55 are protruded portions and recessed portions which have a patterned shape, and in the present embodiment, are protruded portions which have a predetermined patterned shape. The height "h" of each of the protruded portions can be arbitrarily selected according to the usage, the shape of the pattern, etc., of the nonwoven fabric to be manufactured, and for example, 0.1 to 10 mm may be mentioned.

[0034] At this time, the outer circumferential surface of the supporting body 54 can be regarded as configuring the outer circumferential surface 5a of the first suction drum 5. That is, it can be said that the first suction drum 5 includes,

on the outer circumferential surface 5a, the supporting body 54 which has protruded and recessed patterns 55.

[0035] A pump (which is not shown) capable of sucking liquid and gas is connected to the hollow shaft portion 50, and further, as shown in FIG. 2, suction tubes 51-1 to 51-3 are provided on the outer circumferential surface 50a of the hollow shaft portion 50. Each of the suction tubes 51-1 to 51-3 has one end communicating with an internal space 50b of the hollow shaft portion 50 and the other end opening to the cell portion 52 side, whereby is capable of sucking liquid and gas from the opening portion on the other end side toward the hollow shaft portion 50 on the one end side through the cell portion 52 and the supporting body 54. The suction tube 51-1 is arranged so that the opening portion on the other end side faces the position on a slightly upstream side from a top portion 71 on the upper side in the vertical direction on the outer circumferential surface 5a of the first suction drum 5. The suction tube 51-2 is arranged so that the opening portion on the other end side faces the position on a slightly downstream side from the top portion 71 on the upper side in the vertical direction on the outer circumferential surface 5a of the first suction drum 5. The suction tube 51-3 is arranged so that the opening portion on the other end side faces the position on an upstream side from the opening portion on the other end side of the suction tube 51-1 on the outer circumferential surface 5a of the first suction drum 5. In other words, the opening portions on the other end of the suction tubes 51-1, 51-2, and 51-3 are provided at facing positions of the outer circumferential surface 5a which face the first jetting nozzles 3-1, 3-2 and the water supplying device 2, respectively. Each of the opening portions on the other end of the suction tubes 51-1, 51-2, and 51-3 has a rectangular shape. The length of one side parallel to the circumferential direction of the hollow shaft portion 50 in such rectangular shape is, for example, a length enough for the distance of which the water supplied to the web 7 can move in the circumferential direction, and the length of one side parallel to the shaft line direction of the hollow shaft portion 50 is slightly shorter than the length of the first suction drum 5.

[0036] Accordingly, the suction tubes 51-1 to 51-3 are configured so as to suck, from the second surface 7b side of the web 7 toward the hollow shaft portion 50, the water which is supplied from the first jetting nozzles 3-1, 3-2 and the water supplying device 2 to the first surface 7a of the web 7, while sucking, from the second surface 7b side toward the hollow shaft portion 50, the web 7 which is being conveyed, and reliably retaining the web 7 on the supporting body 54.

[0037] FIG. 4 is a view schematically showing a configurational example of the water supplying device 2 of the manufacturing apparatus 1. Note that in the manufacturing apparatus 1, the machine direction of the web 7 is MD, and the direction perpendicular to the machine direction MD of the web 7, that is, the width direction of the web 7 is CD (also in the present description). The water supplying device 2 sprinkles water 30 to the first surface 7a side of the web 7 which is retained on the outer circumferential surface 5a of the first suction drum 5 so as to moisturize the web 7, and fills the space which is present between the fibers in the web 7 with water. The water supplying device 2 includes for example, an opening 2a which is provided linearly in a direction parallel to the width direction CD, and releases water with low pressure which has been sent from a fluid source which is not shown, without pressurizing the water, from the opening 2a as it is, as the water 30. The water 30 is sprinkled to the web 7 by free fall as it is. The water supplying device 2 is arranged so that the water 30 is supplied to the position of the opening portion of the suction tube 51-3 or the slightly upstream side thereof on the outer circumferential surface 5a of the first suction drum 5.

[0038] Since the purpose of the water supplying device 2 is not entangling the fibers in the web 7 with each other by water but is including water in the web 7, the water supplying device 2 does not jet water with high pressure, and sprinkles water to the web 7. Accordingly, as shown in FIG. 4, the water may be made to freely fall from the position in the vicinity of the web 7 to the web 7 or the water which is sprayed may be sprinkled to the web 7.

[0039] The first jetting nozzle 3-1 is arranged so that water is jetted to the position on a slightly upstream side from the top portion 71 on the upper side in the vertical direction on the outer circumferential surface 5a of the first suction drum 5, that is, the position of the opening portion of the suction tube 51-1. The first jetting nozzle 3-2 is arranged so that water is jetted to the position on a slightly downstream side from the top portion 71 on the upper side in the vertical direction on the outer circumferential surface 5a of the first suction drum 5, that is, the position of the opening portion of the suction tube 51-2.

[0040] Conversely, the first suction drum 5 is capable of reliably sucking the web 7 and stably retaining the web 7 while sucking the water from the first jetting nozzles 3-1 to 3-2 and the water supplying device 2, for the predetermined range of, from the position on the upstream side of the point at which the water that is jetted and supplied from each of the first jetting nozzles 3-1 to 3-2 and the water supplying device 2 hits the web 7, to the position on the downstream side thereof.

[0041] FIG. 5 is a view schematically showing a configurational example of the first jetting nozzle 3 of the manufacturing apparatus 1. In the present embodiment, as the first jetting nozzle 3, two nozzles of the first jetting nozzles 3-1 and 3-2 are provided in order from the upstream side along the machine direction MD. However, in FIG. 5, only the first jetting nozzle 3-1 on the most upstream side is shown and the illustration of the other is omitted. Each of the first jetting nozzles 3-1 and 3-2 jets water with high pressure from the first surface 7a side of the web 7 to the web 7 which is retained on the outer circumferential surface 5a of the first suction drum 5, so as to form the protruded and recessed patterns 40 to which the protruded and recessed patterns 55 are transferred on the web 7, and also entangles the fibers in the web 7 with each other. Accordingly, the web 7 is to be the semi-finished product with protruded and recessed patterns 8 which

includes the protruded and recessed pattern present region and the protruded and recessed pattern non-present region.

[0042] FIG. 6 is a view schematically showing a configurational example of nozzle holes of the first jetting nozzle 3. A member 42 of the first jetting nozzle 3 which faces the outer circumferential surface 5a of the first suction drum 5 includes one row of a plurality of nozzle holes 43 which are arranged linearly with a constant pitch in a direction CD1 parallel to the width direction CD. The width d1 in which the nozzle holes 43 are present in the direction CD1 in the member 42 is longer than the width d2 of the web 7. The first jetting nozzle 3 is configured so as to jet the water with high pressure which has been sent from the fluid source which is not shown from the plurality of nozzle holes 43 to the entirety in the width direction CD of the web 7.

[0043] As the hole diameter of each of the nozzle holes 43, a general specification of jetting nozzles for manufacturing a spun lace may be used, and for example, a hole diameter of 50 to 200 μm may be mentioned, and of 70 to 150 μm may preferably be mentioned. When the hole diameter of each of the nozzle holes 43 is too small, there may be cases in which the nozzle holes are clogged. When the hole diameter of each of the nozzle holes 43 is too large, it is difficult for the pressure of the water flow to be increased, whereby the energy efficiency is decreased.

[0044] As the pitch of the nozzle holes 43 (which is the distance between the centers of the nozzle holes 43 adjacent in the direction CD1), a general specification of jetting nozzles for manufacturing a spun lace may be used, and for example, a pitch of 0.2 to 2.0 mm may be mentioned, and of 0.4 to 1.0 mm may preferably be mentioned. When the pitch of the nozzle holes 43 is too small, there may be cases in which the withstand pressure of the nozzles is decreased and the nozzles are to be broken. When the pitch of the nozzle holes 43 is too large, the entanglement of the fibers with each other is to be insufficient.

[0045] In the present embodiment, each of the first jetting nozzles 3-1 to 3-2 jets, with regard to the vertical direction, the water flow from the position above the shaft line A1 of the first suction drum 5 to the web 7. Accordingly, each of the first jetting nozzles 3-1 to 3-2 has only to jet the water flow to the web 7 downward or diagonally downward and need not jet the water flow to the web 7 upward or diagonally upward, whereby the energy of the water flow can be efficiently transmitted to the web 7, and the jetting pressure of the water flow of each of the first jetting nozzles 3-1 to 3-2 can be lowered. Accordingly, the production efficiency can be further improved.

[0046] Further, in the present embodiment, the water supplying device 2 is disposed, with regard to the vertical direction, on the lower side than the adjacent first jetting nozzle 3-1. Accordingly, the water of the water supplying device 2 can be suppressed from reaching the web 7 below the first jetting nozzle 3-1 by running down the surface of the web 7 after being sprinkled to the web 7. As a result, the water jetted by the first jetting nozzle 3-1 can be suppressed from colliding with the water which has run down the surface of the web 7 and from not being able to efficiently transmit the energy of the jetted water to the web 7.

[0047] FIG. 7 is a view schematically showing a configurational example of the semi-finished product with protruded and recessed patterns 8. The semi-finished product 8 includes a protruded and recessed pattern present region 8g which has the protruded and recessed patterns 40 extending along a direction MD2 parallel to the machine direction MD, and a protruded and recessed pattern non-present region 8h which does not have the protruded and recessed patterns 40 extending along the direction MD2. In the example of this drawing, the protruded and recessed pattern non-present region 8h is formed at each of both ends and at the center in the direction CD2 parallel to the width direction CD, and the protruded and recessed pattern present region 8g is formed between the protruded and recessed pattern non-present region 8h at each of the both ends and the protruded and recessed pattern non-present region 8h in the center. Incidentally, the patterns of the protruded and recessed patterns 40 and the protruded and recessed patterns 55 of the supporting body 54 according to the present invention are not particularly limited to the patterns of FIG. 7.

[0048] FIG. 8 is a view schematically showing a cross section of a configurational example of the second suction drum 6 of the manufacturing apparatus 1. The second suction drum 6 includes a hollow shaft portion 60 and a cell portion 62 which is formed on the outer side of the hollow shaft portion 60. The hollow shaft portion 60 and the cell portion 62 are coaxially and cylindrically formed with the shaft line A2 as the central axis. The hollow shaft portion 60 is fixed to a base (which is not shown) of the manufacturing apparatus 1, and the cell portion 62 is joined to the hollow shaft portion 60 so as to be rotatable around the shaft line A2. Accordingly, the second suction drum 6 is configured so that the cell portion 62 is rotatable around the fixed hollow shaft portion 60.

[0049] A plurality of penetration holes 63 through which liquid and gas can pass are formed on the outer circumferential surface of the cell portion 62, and further, a supporting body 64 (a second supporting body) is provided on the outer circumferential surface of the cell portion 62. The supporting body 64 is a cylindrical member which has a shaft line of A2, is fixed to the cell portion 62, and rotates around the shaft line A2 integrally with the cell portion 62. The second suction drum 6 as a whole can be regarded as rotating around the shaft line A2.

[0050] At this time, the outer circumferential surface of the supporting body 64 can be regarded as configuring the outer circumferential surface 6a of the second suction drum 6. That is, it can be said that the second suction drum 6 includes, on the outer circumferential surface 6a, the supporting body 64 which does not have protruded and recessed patterns.

[0051] A pump (which is not shown) capable of sucking liquid and gas is connected to the hollow shaft portion 60, and

further, as shown in FIG. 8, suction tubes 61-1 and 61-2 are provided on the outer circumferential surface 60a of the hollow shaft portion 60. Each of the suction tubes 61-1 and 61-2 has one end communicating with an internal space 60b of the hollow shaft portion 60 and the other end opening to the cell portion 62 side, whereby is capable of sucking liquid and gas from the opening portion on the other end side toward the hollow shaft portion 60 on the one end side through the cell portion 62 and the supporting body 64. The suction tube 61-1 is arranged so that the opening portion on the other end side faces the position on a slightly downstream side from the top portion 74 on the downstream side in the horizontal direction on the outer circumferential surface 6a of the second suction drum 6. The suction tube 61-2 is arranged so that the opening portion on the other end side faces the position at which the semi-finished product 8 which is conveyed from the first suction drum 5 comes in contact with the outer circumferential surface 6a of the second suction drum 6. In other words, the opening portions on the other end of the suction tubes 61-1 and 61-2 are provided at facing positions of the outer circumferential surface 6a which face the semi-finished product 8 that comes in first contact with the second jetting nozzle 4 and the second suction drum 6. Each of the opening portions on the other end of the suction tubes 61-1 and 61-2 has a rectangular shape. The length of one side parallel to the circumferential direction of the hollow shaft portion 60 in such rectangular shape is, for example, a length enough for the distance of which the water supplied to the web 7 can move in the circumferential direction, and the length of one side parallel to the shaft line direction of the hollow shaft portion 60 is slightly shorter than the length of the second suction drum 6.

[0052] Accordingly, the suction tube 61-1 is configured so as to suck, from the first surface 8a side of the semi-finished product 8 toward the hollow shaft portion 60, the water which is jetted from the second jetting nozzle 4 to the second surface 8b of the semi-finished product 8, while sucking, from the first surface 8a side toward the hollow shaft portion 60, the semi-finished product 8 which is being conveyed, and reliably retaining the semi-finished product 8 on the supporting body 64.

[0053] The second jetting nozzle 4 is arranged so that water is jetted to the position on a slightly downstream side from the top portion 74 on the downstream side in the horizontal direction on the outer circumferential surface 6a of the second suction drum 6, that is, the position of the opening portion of the suction tube 61-1.

[0054] Conversely, the second suction drum 6 is capable of reliably sucking the semi-finished product 8 and stably retaining the semi-finished product 8 while sucking the water from the second jetting nozzle 4, for the predetermined range of, from the position on the upstream side of the point at which the water that is jetted from the second jetting nozzle 4 hits the semi-finished product 8, to the position on the downstream side thereof.

[0055] FIG. 9 is a view schematically showing a configurational example of the second jetting nozzle 4 of the manufacturing apparatus 1. In the present embodiment, as the second jetting nozzle 4, one nozzle of the second jetting nozzle 4 is provided. The second jetting nozzle 4 jets water with high pressure from the second surface 8b side of the semi-finished product 8 to the protruded and recessed pattern non-present region of the semi-finished product 8 which is retained on the outer circumferential surface 6a of the second suction drum 6, so as to further entangle the fibers in the semi-finished product 8 with each other. Accordingly, the strength of the semi-finished product 8 is increased, and the semi-finished product 8 is to be the nonwoven fabric with protruded and recessed patterns 9.

[0056] FIG. 10 is a view schematically showing a configurational example of nozzle holes of the second jetting nozzle 4. A member 45 of the second jetting nozzle 4 which faces the outer circumferential surface 6a of the second suction drum 6 includes one row of a plurality of nozzle holes 46 which are arranged linearly with a constant pitch in a direction CD3 parallel to the width direction CD. The width d3 in which the nozzle holes 46 are present in the direction CD3 in the member 45 is longer than the width d4 of the semi-finished product 8. Note that the member 45 does not include the nozzle holes 46 in a region 45a which faces the protruded and recessed pattern present region 8g of the semi-finished product 8. The second jetting nozzle 4 is configured so as to jet the water with high pressure which has been sent from the fluid source which is not shown from the plurality of nozzle holes 46 toward the protruded and recessed pattern non-present region 8h of the semi-finished product 8 (FIG. 9), and so as not to jet the water toward the protruded and recessed pattern present region 8g of the semi-finished product 8 (FIG. 9) since the corresponding plurality of nozzle holes 46 are not present.

[0057] The hole diameter of each of the nozzle holes 46, the pitch thereof (which is the distance between the centers of the nozzle holes 46 adjacent in the direction CD3), and the distance between rows (which is the distance between the centers of the nozzle holes 46 adjacent in the direction MD3), are the same as those in the case of the nozzle holes 43.

[0058] In the present embodiment, the second jetting nozzle 4 jets the water flow from the position above, in the vertical direction, the shaft line A2 of the second suction drum 6 to the semi-finished product 8. Accordingly, the second jetting nozzle 4 has only to jet the water flow to the semi-finished product 8 downward or diagonally downward and need not jet the water flow to the semi-finished product 8 upward or diagonally upward, whereby the energy of the water flow can be efficiently transmitted to the semi-finished product 8, and the jetting pressure of the water flow of the second jetting nozzle 4 can be lowered. Accordingly, the production efficiency can be further improved.

[0059] Further, the first suction drum 5 and the second suction drum 6 are arranged in a state of not being in contact with each other, that is, in a state in which the semi-finished product 8 is freely conveyed without being compressed by being sandwiched between the outer circumferential surface 5a of the first suction drum 5 and the outer circumferential

surface 6a of the second suction drum 6, so that a certain amount of space is provided in between, and are further arranged so that the respective shaft lines A1, A2 are parallel to each other. Accordingly, the first suction drum 5 and the second suction drum 6 are rotated around the respective shaft lines A1, A2 in opposite directions, whereby the semi-finished product 8 which has been held by the first suction drum 5 can be delivered to the second suction drum 6, in a state of being applied with a moderate amount of tension in the longitudinal direction (the machine direction), so as to convey the semi-finished product 8 from the upstream side to the downstream side in the machine direction.

[0060] Further, in the present embodiment, the first suction drum 5 and the second suction drum 6 are formed to have the same shape and the same size, and accordingly, the outer circumferential diameter of the first suction drum 5 and the outer circumferential diameter of the second suction drum 6 mutually are of the same diameter. Note that each of the outer circumferential diameter of the first suction drum 5 and the second suction drum 6 can be an arbitrary size according to the usage or the required size of the nonwoven fabric to be manufactured, and for example, the ones with approximately 200 to 1700 mm may be used. Further, the relationship between the respective rotation speeds of the first suction drum 5 and the second suction drum 6 may be arbitrarily set, according to the conveying speed of the web 7, the types of the configurational fibers, the positional relationship between the first suction drum 5 and the second suction drum 6, etc., and for example, the rotation speed of the second suction drum 6 may be a rotation speed of approximately 1 to 1.1 times the rotation speed of the first suction drum 5.

[0061] Further, in the present embodiment, the second suction drum 6 is disposed so that the shaft line A2 of the second suction drum 6 is positioned on the lower side than the shaft line A1 of the first suction drum 5 in the vertical direction. The reason is as follows. That is, for the purpose of delivering the semi-finished product 8 to the second suction drum 6 without applying tensile force more than necessary to the semi-finished product 8 and in a state of making the semi-finished product 8 be applied with a moderate amount of tension, by using the phenomenon that the semi-finished product 8 which includes moisture and is heavier by the jetting of water from the first jetting nozzle 3 moves from the first suction drum 5 in a vertically downward direction by its own weight. In other words, when the semi-finished product 8 is pulled in the machine direction more than necessary between the first suction drum 5 and the second suction drum 6 for the sake of stable conveyance of the semi-finished product 8, the semi-finished product 8 tends to extend in the longitudinal direction and shrink in the width direction by the tensile force, that is, it is easy for a phenomenon in which the width is decreased to occur, and accordingly, for such phenomenon is to be prevented.

[0062] FIG. 11 is view schematically showing a configurational example of the entire manufacturing apparatus to be used in the manufacturing method of the nonwoven fabric with protruded and recessed patterns. The manufacturing apparatus 1 further includes, in the present embodiment, a web manufacturing device 20 which manufactures the web 7 on the upstream side than the upstream side conveying device 13. The web manufacturing device 20 includes a first carding machine 21, an air laid machine 22, and a second carding machine 23. The first carding machine 21 feeds the fibers which configure a first fiber laminated body 7-1 from a feeder so as to form the first fiber laminated body 7-1. The air laid machine 22 feeds the fibers which configure a second fiber laminated body 7-2 from a feeder so as to form the second fiber laminated body 7-2. The second carding machine 23 feeds the fibers which configure a third fiber laminated body 7-3 from a feeder so as to form the third fiber laminated body 7-3. Subsequently, these first to the third fiber laminated bodies 7-1 to 7-3 are laminated, whereby the web 7 can be formed. The web 7 in which these first to the third fiber laminated bodies 7-1 to 7-3 are laminated is delivered from a web conveying belt 11a of a web conveying device 11 to the upstream side conveying belt 13a of the upstream side conveying device 13.

[0063] Further, the manufacturing apparatus 1 further includes, on the downstream side than the dehydrating device 25, a drying device 26 which dries the nonwoven fabric 9 from which moisture is sucked by the dehydrating device 25 so as to heat fuse the fibers in the nonwoven fabric 9, and a winding device 28 which winds up the nonwoven fabric 9 conveyed out from the drying device 26. Incidentally, the nonwoven fabric 9 which is wound up by the nonwoven fabric 9 is, for example, subjected to a predetermined treatment after being wound up and being cut, and may be used for absorbent articles, cleaning articles, and medical supplies, etc.

[0064] Next, the method of manufacturing the nonwoven fabric with protruded and recessed patterns will be explained.

[0065] The method of manufacturing the nonwoven fabric with protruded and recessed patterns includes, a step of forming the web which manufactures the web 7 by the web manufacturing device 20, a step of moisturizing and dehydrating the web which moisturizes the web 7 and dehydrates the web 7, a step of pre-entangling and transferring which transfers the protruded and recessed patterns to the web 7 while entangling the web 7 so as to form the semi-finished product 8, and a step of post-entangling which further entangles the semi-finished product 8 so as to form the nonwoven fabric.

[0066] First, in the step of forming the web, the web 7 is manufactured by the web manufacturing device 20. The web 7 which is manufactured by the web manufacturing device 20 is a plurality of fiber laminated bodies being laminated, and not being subjected to an entangling treatment so as to entangle the fibers with each other. In the present embodiment, a fiber laminated body which is formed by a carding method, a fiber laminated body which is formed by an air laid method, and a fiber laminated body which is formed by a carding method are laminated in order, so as to be used for the web 7. Note that each of the fiber laminated bodies which configures the web 7 can be arbitrarily selected according to the usage, etc., of the nonwoven fabric to be manufactured. For example, a fiber laminated body which is formed by a

carding method, a fiber laminated body which is formed by an air laid method, a fiber laminated body which is formed by a wet method, a fiber laminated body which is formed by a spunbond method, a fiber laminated body which is formed by a melt blown method, or a fiber laminated body which is formed by other methods may be used.

[0067] The fibers of the web 7 can be arbitrarily selected according the usage, etc., of the nonwoven fabric to be manufactured. The fiber density of the web 7 is, for example, approximately 2.8 to $3.5 \times 10^{-3} \text{ g / cm}^3$. The basis weight of the web 7 is, for example, approximately 20 to 70 g / m^2 . The thickness of the web 7 is, for example, approximately 7 to 20 mm . Further, the fiber length of the fibers of the web 7 is, for example, approximately 1 to 100 mm , and is preferably 2 to 70 mm . The fineness of the fibers of the web 7 is, for example, approximately 0.1 to 6 dtex , and is preferably 0.5 to 4 dtex .

[0068] As the fibers of the web 7, thermoplastic resin fibers can be used. As the thermoplastic resin which configures the thermoplastic resin fibers, for example, polyolefins, polyesters, polyamides, acryls, etc., may be mentioned. As the polyolefins, for example, polyethylene (PE), polypropylene (PP), polybutylene (PB), and copolymers which are mainly composed of these polyolefins, etc., may be mentioned. As the polyesters, for example, polyethylene terephthalate (PET), polytrimethylene terephthalate (PTT), polybutylene terephthalate (PBT), and copolymers which are mainly composed of these polyesters, etc., may be mentioned. As the polyamides, for example, nylon 6, and nylon 6, 6, etc., may be mentioned. As the acryls, polyacrylonitrile (PAN), etc., may be mentioned. When the thermoplastic resin fibers are used, a hydrophilic treatment may be performed, and as the hydrophilic treatment, for example, treatments which use a surfactant, and hydrophilic agent, etc., may be mentioned.

[0069] As the fibers of the web 7, in addition to the thermoplastic resin fibers, or instead of the thermoplastic resin fibers, other fibers may be used. As other configurational fibers, for example, natural fibers (such as pulp, wool, cotton, etc.), regenerated fibers (such as rayon, acetate, etc.), inorganic fibers (such as glass fibers, carbon fibers, etc.), may be mentioned. Further, in the nonwoven fabric, composite fibers such as core - sheath type fibers, side - by - side type fibers, island / ocean type fibers, etc., hollow type fibers, heterotypic fibers such as flat type, Y type, C type, etc., three dimensional crimped fibers such as latently crimped or apparently crimped fibers, split fibers which are split by physical

load such as water flow, heat, embossing, etc., may be mixed.

[0070] Next, in the step of moisturizing and dehydrating the web, the web 7 which has been manufactured by the web manufacturing device 20 is conveyed to the first suction drum 5 by the upstream side conveying belt 13a of the upstream side conveying device 13, and is further conveyed to the second suction drum 6 while being sucked and retained by the first suction drum 5.

[0071] At this time, the web 7 on the first suction drum 5 is sprinkled with water by the water supplying device 2 so as to be moisturized. Further, the moisturized web 7 is sucked with water and is dehydrated by the first suction drum 5. That is, the water which fills the space between the fibers in the web 7 is sucked by the suction tube 51-3 of the first suction drum 5, so as to be mostly removed.

[0072] The pressure of the water sprinkled by the water supplying device 2 (which is the water pressure at the time when the water is released from the opening 2a of the water supplying device 2) is determined by the thickness of the web 7 and the type of the configurational fibers, however, the water supplying device 2 has only to moisture the web, and in order not to substantially entangle the web 7, the pressure of more than 0.1 MPa (atmospheric pressure) and 0.8 MPa or less may be mentioned, and the pressure is preferably more than 0.1 MPa (atmospheric pressure) and 0.6 MPa , and more preferably more than 0.1 MPa (atmospheric pressure) and 0.5 MPa . The amount of the water to be supplied to the web 7 is determined by the thickness of the web 7 and the type of the configurational fibers, however, the water supplying device 2 has only to moisture the web, and the amount of 100 to 150 L / min may be mentioned.

[0073] In this manner, the pressure of the water sprinkled from the water supplying device 2 is suppressed to a low level, whereby the fibers can be prevented from being scattered, by the water of the water supplying device 2, from the web 7 which has not been subjected to a treatment of entangling the fibers with each other, and the texture can be prevented from being disordered.

[0074] FIG. 12 is a cross sectional view schematically showing the state of the web 7 being moisturized by the water supplying device 2 and being dehydrated by the first suction drum 5. First, in FIG. 12(a), the web 7 is disposed on the outer circumferential surface 5a of the first suction drum 5. At this time, the web 7 includes a large amount of space between the fibers, and is in a bulky state, that is, a thick state. Next, in FIG. 12(b), water is sprinkled to the web 7 by the water supplying device 2. At this time, the space between the fibers in the web 7 is filled with water, however, the bulky state (the thick state) does not change. Further, in FIG. 12(c), the water included in the web 7 is sucked by the first suction drum 5, whereby the web 7 is dehydrated. At this time, the water included in the web 7 and the fibers in the web 7 are chemically bonded (by hydrogen bonding), whereby the fibers in the web 7 is pulled by the water sucked to the inside of the first suction drum 5 so as to move toward the first suction drum 5 side. Or, the fibers in the web 7 is physically pushed by the water sucked to the inside of the first suction drum 5 so as to move toward the first suction drum 5 side. In this manner, the fibers in the web 7 is drawn to the first suction drum 5 side in accordance with the movement of the water, and the space between the fibers in the web 7 is rapidly decreased so that the bulk (the thickness) of the web 7 as a whole is decreased, whereby the fiber density of the web 7 is increased.

[0075] The fiber density of the web 7 immediately after being moisturized by the water supplying device 2 and being dehydrated by the first suction drum 5 is approximately $4 \text{ to } 8 \times 10^{-2} \text{ g / cm}^3$. However, the upper limit thereof is preferably $7.5 \times 10^{-2} \text{ g / cm}^3$, and is more preferably $7 \times 10^{-2} \text{ g / cm}^3$. On the other hand, the lower limit thereof is preferably $4.5 \times 10^{-2} \text{ g / cm}^3$, and is more preferably $5.0 \times 10^{-2} \text{ g / cm}^3$. When the fiber density is too high, the movement of the fibers in the web 7 by the water flow of the first jetting nozzle 3 in the later step is to be difficult and the energy of the water flow of the first jetting nozzle 3 has to be increased, whereby the production efficiency is lowered. When the fiber density is too low, there may be adverse effects such as the fibers in the web 7 being scattered by the impact of the water flow of the first jetting nozzle 3 and the texture being disordered. The fiber density is higher than the fiber density before the web 7 is processed by the water supplying device 2. Further, for example, the basis weight of the web 7 is approximately 20 to 70 g / m², and the thickness of the web 7 is approximately 0.5 to 0.9 mm.

[0076] In this manner, the water is supplied to the web 7 from the water supplying device 2 and the web 7 is dehydrated by the first suction drum 5, whereby it is possible to thin the web 7 and to increase the fiber density of the web 7 to the above mentioned predetermined range. Further, the web 7 is dehydrated and the water included in the web 7 is decreased to a very little amount, whereby the energy of the water jetted from the first jetting nozzle 3 in the later step can be efficiently transmitted to the web 7.

[0077] In this manner, when the fiber density of the web 7 is arranged to the above mentioned predetermined range, the fibers come in close contact with each other, whereby the joining of the fibers with each other is made to be stronger compared to that immediately after the web 7 is formed (however, the joining is weaker compared to that when the web 7 is entangled). Accordingly, when the protruded and recessed patterns are transferred to the web 7 while entangling the fibers in the web 7 with each other in the later step, the fiber density of the web 7 can be suppressed from being uneven by the fibers being scattered by the impact of the water flow jetted from the first jetting nozzle 3, and the texture can be suppressed from being disordered.

[0078] Especially, in a case in which the web 7 is moisturized by the water of the water supplying device 2 and is dehydrated by the first suction drum 5, the web 7 has not been subjected to any sort of drying treatment, whereby a little amount of water remains between the fibers in the web 7. Accordingly, when compared to the case in which the web 7 is dry, the joining force of the fibers with each other by hydrogen bonding through the water between the fibers in the web 7 is stronger (however, the joining is weaker compared to that when the web 7 is entangled). In addition, the fibers on the surface of the web 7 are hardly fluffy, and are in a state of being laid along the surface. Consequently, when the web 7 is entangled by the water flow of the first jetting nozzle 3, the fibers in the web 7 can be more reliably suppressed from being scattered by the impact of the water flow.

[0079] FIG. 13 is a cross sectional view schematically showing the state of the web 7 on protruded and recessed patterns 55 in the step of moisturizing and dehydrating of FIG. 12. When the web 7 is disposed on the protruded and recessed patterns 55 of the supporting body 54, the web 7 is moisturized by the water supplying device 2 and is sucked and dehydrated by the first suction drum 5, whereby the web 7 is deformed so as to substantially correspond to the shape of the protruded and recessed patterns 55, and accordingly, provisional patterns 41 are formed in the web 7. In the provisional patterns 41, a gap S between the protruded and recessed patterns 55 and the web 7, etc., is present, and the protruded and recessed patterns 55 cannot be regarded as being transferred to the web 7. However, since the provisional patterns 41 and the protruded and recessed patterns 55 have shapes which mostly engaged with each other, the web 7 can be made to a state of being fixed on the protruded and recessed patterns 55.

[0080] In this manner, the provisional patterns 41 are formed on the web 7, whereby when the water flow is jetted to the web 7 by the first jetting nozzle 3 in the later step, the protruded and recessed patterns 55 can be transferred to the web 7 with the jetting of further decreased energy, and the production efficiency can be further improved. Further, the web 7 is fixed on the protruded and recessed patterns 55 by using the provisional patterns 41, whereby when the water flow is jetted to the web 7 by the first jetting nozzle 3 in the later step, the web 7 can be prevented from moving by the jet flow.

[0081] Incidentally, when the web 7 which has the fiber density of the above mentioned predetermined range (of 4 to $8 \times 10^{-2} \text{ g / cm}^3$) can be separately prepared, the water supplying device 2 may not be used. In that case, for example, the web 7 which has the fiber density of the determined range is supplied to the first suction drum 5 by the upstream side conveying device 13, and the supplied web 7 is immediately jetted with water by the first jetting nozzle 3. Accordingly, the water supplying device 2 can be omitted, whereby the production cost can be reduced. Further, in that case, the step of forming the web and the step of moisturizing and dehydrating the web prepare the web 7 which has the fiber density of the predetermined range, whereby can be referred to as the step of preparing the web.

[0082] Next, in the step of pre-entangling and transferring, the web 7 on the first suction drum 5 is jetted with water by the first jetting nozzles 3-1 to 3-2, and the protruded and recessed patterns are transferred onto the web 7 while the fibers in the web 7 are entangled with each other. Accordingly, the semi-finished product with protruded and recessed patterns 8 is formed.

[0083] The jetting pressures of the water flows of the first jetting nozzles 3-1 to 3-2 are increased as proceeded in the machine direction MD of the web 7. To be more specific, the jetting pressure P11 of the water flow of the first jetting nozzle 3-1 (which is the water pressure at the time when the water is released from the nozzle holes 43 of the first jetting

nozzle 3-1) satisfies, in order to start transferring the protruded and recessed patterns 55 to the web 7 while starting the entanglement of the web 7 on the supporting body 54 which includes the protruded and recessed patterns 55, preferably $1.0 \text{ MPa} \leq P11 \leq 6.0 \text{ MPa}$. Further, the jetting pressure P12 of the water flow of the first jetting nozzle 3-2 (which is the water pressure at the time when the water is released from the nozzle holes 43 of the first jetting nozzle 3-2) satisfies, in order to proceed with transferring the protruded and recessed patterns 55 to the web 7 while proceeding with the entanglement of the web 7 on the supporting body 54 which includes the protruded and recessed patterns 55, preferably $3.0 \text{ MPa} \leq P12 \leq 7.0 \text{ MPa}$. Note that P11 and P12 satisfy $P11 < P12$.

[0084] In this manner, the jetting pressures of the water flows of the first jetting nozzles 3-1 to 3-2 are gradually increased from the upstream side to the downstream side along the machine direction MD, whereby the transfer of the protruded and recessed patterns can be proceeded while the degree of the entanglement is suppressed to a low level for the initial web 7 which has not been subjected to the entanglement treatment of the fibers with each other and has weak strength, and the transfer of the protruded and recessed patterns can be further proceeded while the degree of the entanglement is increased for the web 7 in which the entanglement is proceeded and which is increased with strength. Accordingly, the transfer (the formation) of the protruded and recessed patterns and the entanglement of the fibers with each other are compatible. In other words, the jetting pressures of the water flows are gradually increased from low pressure to high pressure, whereby while preventing the web 7 from being damaged by the water flow with high pressure rapidly being jetted to the web 7 and by the fibers in the web 7 being scattered, etc., the transfer of the protruded and recessed patterns can be reasonably proceeded little by little, so that the protruded and recessed patterns with high visibility can be formed.

[0085] FIG. 14 is a view schematically showing a cross section of a portion of a configurational example of the semi-finished product 8 on the supporting body 54. In the semi-finished product 8, the protruded and recessed patterns 40 which is formed by being transferred with the protruded and recessed patterns 55 of the supporting body 54, no longer has the gap S as shown in FIG. 13, between the semi-finished product 8 and the protruded and recessed patterns 55, whereby a shape in accordance with the protruded and recessed patterns 55 is formed, that is, the protruded and recessed patterns with high visibility are formed.

[0086] The fibers included in the web have higher flexibility of the movement before entangling the web than after entangling the web. Accordingly, by transferring the protruded and recessed patterns of the supporting body to the web while entangling the web, it is easier for the fibers in the web to move according to the protruded and recessed patterns, and it is easier for the transfer of the protruded and recessed patterns to be performed, compared to transferring the protruded and recessed patterns (the patterns) of the supporting body to the web after entangling the web. In the present embodiment, since the protruded and recessed patterns of the supporting body are transferred to the web 7 while entangling the web 7, the visibility of the transferred protruded and recessed patterns can be increased, and also, the energy of the water flow of the first jetting nozzle 3 can be decreased, whereby the production efficiency can be improved. Further, at this time, the fiber density of the web 7 is arranged to the predetermined range ($4 \text{ to } 8 \times 10^{-2} \text{ g / cm }^3$), whereby when the protruded and recessed patterns are transferred to the web 7, the fibers in the web 7 can be prevented from being scattered by the impact of the water flow of the first jetting nozzle 3, and the texture can be prevented from being disordered. Further, in the semi-finished product 8, since, while the protruded and recessed pattern present region is avoided from being entangled, the protruded and recessed pattern non-present region which is the other region is entangled by the water flow of the second jetting nozzle 4, a nonwoven fabric which has a suitable strength can be manufactured without lowering the visibility of the transferred protruded and recessed patterns.

[0087] Especially, in a case in which the patterns of the protruded and recessed patterns 40 are formed so that the upper portion of the protruded and recessed patterns 55 of the supporting body 54 does not expose to the outer side as shown in FIG. 14, that is, so as not to provide a penetration hole in the semi-finished product 8 (and in the nonwoven fabric 9), the fibers of the web 7 are required to move particularly delicately. In the present invention, the web 7 which has not been subjected to the entanglement treatment, however, has a higher fiber density to some extent is used, and the jetting pressure of the water is initially lowered, so as to perform the entanglement of the fibers in the web 7 with each other and the transfer of the protruded and recessed patterns are performed. To be more specific, the jetting pressure of the first jetting nozzle 3-1 is set to be lower than the jetting pressures of the subsequent first jetting nozzle 3-2 and the second jetting nozzle 4. Accordingly, the fibers in the web 7 can be delicately moved so as to proceed with the rearrangement of the fibers before the thickness of the upper portion in the protruded and recessed patterns 55 becomes too thin or penetration holes are made. Consequently, the patterns of the protruded and recessed patterns 40 which do not include penetration holes can be formed with preferable visibility.

[0088] Next, in the step of post-entangling, the semi-finished product 8 which has been conveyed from the first suction drum 5 is conveyed to the downstream side conveying device 14 while being sucked and retained by the second suction drum 6.

[0089] At this time, in the semi-finished product 8 on the second suction drum 6, the water is not jetted to the protruded and recessed pattern present region but is jetted to the protruded and recessed pattern non-present region by the second jetting nozzle 4, whereby the fibers are further entangled with each other without the protruded and recessed patterns

being disordered. Accordingly, the nonwoven fabric with protruded and recessed patterns 9 in which the strength is improved is formed.

[0090] The jetting pressure P21 of the water flow of the second jetting nozzle 4 (which is the water pressure at the time when the water is released from the nozzle holes 46 of the second jetting nozzle 4-1) satisfies, in order to proceed with the entanglement of the protruded and recessed pattern non-present region 8h of the semi-finished product 8, preferably $5.0 \text{ MPa} \leq P21 \leq 10.0 \text{ MPa}$. Note that P12 and P21 satisfy $P12 \leq P21$.

[0091] Further, in a case in which the jetting pressure of the water flow of the first jetting nozzle 3 is made lower than the jetting pressure of the water flow of the second jetting nozzle 4, the movement of the entanglement of the fibers in the web 7 with each other by the water flow of the first jetting nozzle 3 is to be smaller compared to that of the water flow of the second jetting nozzle 4. Accordingly, although the entanglement of the fibers with each other is small, the fibers can be delicately moved so as to be rearranged in accordance with the protruded and recessed patterns. That is, the formation of the patterns can be proceeded while suppressing the degree of the entanglement. On the other hand, since the jetting pressure of the water flow of the subsequent second jetting nozzle 4 is high, the movement of the entanglement of the fibers with each other is to be larger. Accordingly, the entanglement of the fibers with each other is increased, that is, the entanglement can be further proceeded. Consequently, the fibers can be entangled so as to have a proper sheet strength without lowering the visibility of the patterns.

[0092] In this manner, the water is not jetted to the protruded and recessed pattern present region of the semi-finished product 8 which is retained on the second suction drum 6, but is jetted to the protruded and recessed pattern non-present region thereof, whereby it is possible to entangle the fibers included in the semi-finished product 8 with each other so as to increase the strength thereof without the protruded and recessed patterns of the protruded and recessed pattern present region being disordered. That is, the nonwoven fabric with protruded and recessed patterns 9 which has a proper sheet strength can be manufactured without lowering the visibility of the transferred protruded and recessed patterns.

[0093] In the above mentioned manner, the nonwoven fabric with protruded and recessed patterns 9 is manufactured.

[0094] Incidentally, the position of the water supplying device 2 is not limited to the position shown in FIG. 1, and the water supplying device 2 can be provided at arbitrary positions, as long as such positions enable supplying water before the web 7 is jetted with water from the first jetting nozzle 3. For example, the water supplying device 2 may be disposed at a position in the vicinity of the first surface 7a of the web 7 on the outer side of the upstream side conveying device 13, so as to be capable of supplying water to the web 7 which is being conveyed on the upstream side conveying belt 13a. In that case, a suction box is disposed so as to suck water which is sprinkled to the web 7 at a position which faces the water supplying device 2 on the inner side of the upstream side conveying device 13. Accordingly, the water supplying device and the first jetting nozzle 3 can be separated, and the water of the water supplying device 2 can be suppressed from reaching the web 7 below the first jetting nozzle 3 by running down the surface of the web 7 after being sprinkled to the web 7.

[0095] Incidentally, in the present embodiment, one device of the water supplying device 2 is arranged above the outer circumferential surface 5a of the first suction drum 5, however, a plurality of water supplying devices may be arranged side by side from the upstream side to the downstream side of the machine direction of the web 7. Accordingly, water can be reliably sucked by the web 7.

[0096] Incidentally, in the present embodiment, each of the first jetting nozzles 3-1 to 3-2 is arranged at the position as shown in FIG. 1, however, these first jetting nozzles 3-1 to 3-2 may be provided at arbitrary positions as long as such positions enable reliably jetting water to the web 7 in the range in which the web 7 is sucked and retained by the first suction drum 5. In that case, the positions of the suction tubes 51-1 to 51-2 of the first suction drum 5 are suitably changed to positions which face the first jetting nozzles 3-1 to 3-2.

[0097] In the same manner, in the present embodiment, the second jetting nozzle 4 is arranged at the positions as shown in FIG. 1, however, the second jetting nozzle 4 may be provided at arbitrary positions as long as such positions enable reliably jetting water to the semi-finished product 8 in the range in which the web 7 is sucked and retained by the second suction drum 6. In that case, the position of the suction tube 61 of the second suction drum 6 is suitably changed to a position which faces the second jetting nozzle 4.

[0098] Incidentally, in the present embodiment, there are two nozzles of the first jetting nozzle 3 and one nozzle of the second jetting nozzle 4, however, the number of each of the jetting nozzles is not limited to the above mentioned example, and may arbitrarily set. For example, the number of the first jetting nozzle 3 may be one, or three or more, and the number of the second jetting nozzle 4 may be two or more.

[0099] In a case in which there are a plurality of the second jetting nozzles 4, the jetting pressures of the water flows of the plurality of second jetting nozzles 4 are preferably increased as proceeded in the machine direction MD of the semi-finished product 8. In a case in which the jetting pressures of the water flows of the plurality of second jetting nozzles 4 are gradually increased from the upstream side to the downstream side along the machine direction MD in the manner, the entanglement can be reasonably proceeded little by little and the strength can be reasonably increased.

[0100] Incidentally, in the present embodiment, the nozzle holes 43 of the member 42 of the first jetting nozzle 3 and the nozzle holes 46 of the member 45 of the second jetting nozzle 4 are arranged in one row, however, the rows of each

of the nozzle holes are not limited to the above example, and a plurality of rows may be provided in the respective directions MD1 and MD2, which are parallel to the machine direction MD. In that case, the plurality of rows of the plurality of nozzle holes 43, 46 are preferably disposed in a staggered fashion. As the distance between the rows (which is the distance between the centers of the nozzle holes 43 in rows adjacent in the directions MD1 and MD2), a general specification of jetting nozzles for manufacturing a spun lace may be used, and for example, a distance of 0.1 to 1.5 mm may be mentioned, and of 0.3 to 1.0 mm may preferably be mentioned. When the distance between the rows is too small, there may be cases in which the withstand pressure of the nozzles is decreased and the nozzles are to be broken. When the distance between the rows is too large, the entanglement of the fibers with each other is to be insufficient.

[0101] Incidentally, in the present embodiment, the web 7 is configured by three layers of the fiber laminated bodies, however, the present invention is not limited to this example. The web 7 may be configured by one or two layers of fiber laminated bodies, or even be configured by four or more layers of fiber laminated bodies.

(Second embodiment)

[0102] FIG. 15 is a view schematically showing a portion of a configurational example of a manufacturing apparatus to be used in a manufacturing method of a nonwoven fabric with protruded and recessed patterns. In the manufacturing apparatus 1, the functions of the upstream side conveying device 13, the first suction drum 5, the water supplying device 2, the first jetting nozzle 3, the second suction drum 6, the second jetting nozzle 4, the downstream side conveying device 14, and the dehydrating device 25 are respectively substantially the same as those in the manufacturing apparatus 1 of the first embodiment, however, as shown in FIG. 15, the arrangement of these devices is mainly different. Hereinbelow, the differences will be mainly explained.

[0103] In the present embodiment, the water supplying device 2 is disposed inside of the upstream side conveying device 13, the first suction drum 5 is disposed above the water supplying device 2 (and the upstream side conveying device 13) in the vertical direction, and the second suction drum 6 is disposed above the first suction drum 5 in the vertical direction.

[0104] The web 7 is conveyed by the upstream side conveying device 13 so that the first surface 7a of the web 7 comes in contact with the mesh-like upstream side conveying belt 13a of the upstream side conveying device 13 and the second surface 7b of the web 7 faces the outer side of the upstream side conveying device 13. The web 7 is supplied with water to the first surface 7a from the water supplying device 2 through the mesh of the upstream side conveying belt 13a.

[0105] In this case, the water supplying device 2 is required to supply the water through the mesh from the position below the web 7 in the vertical direction toward the web 7 which is positioned above in the vertical direction. Accordingly, the water needs to be jetted with a predetermined water pressure. However, when the water flow is jetted to the web 7 through a mesh, the water flow hits the mesh, whereby the water pressure of the water flow is lowered, and also the water flow is widely spread so as to reach the web 7. Since the water pressure is lowered, the fibers of the web 7 are not entangled by the water flow, and the water flow is widely spread, whereby the web 7 can be efficiently moisturized in a wide area.

[0106] Subsequently, the web 7 is delivered to (wound up by) the first suction drum 5 in the vicinity of the top portion on the lower side in the vertical direction of the outer circumferential surface 5a of the first suction drum 5. Further, the web 7 is sucked and retained by the first suction drum 5 so that second surface 7b of the web 7 comes in contact with the outer circumferential surface 5a of the first suction drum 5 and the first surface 7a of the web 7 faces the outer side of the first suction drum 5. At this time, the position at which the water is jetted to the web 7 by the water supplying device 2 and the position at which the web 7 is wound up by the first suction drum 5 are substantially the same position. Incidentally, the position of the center of the suction tube 51-1 which sucks water from the web 7 in the first suction drum 5 may be the same position as the position at which the water is jetted to the web 7 by the water supplying device 2, or may be a position on a slightly downstream side in the machine direction. When the positions are the same, the water is supplied to the web 7 by the water supplying device 2, while placing the web 7 on the protruded and recessed patterns of the supporting body on the first suction drum 5, whereby the web 7 can be made to be in a state of being fixed to the protruded and recessed patterns.

[0107] Two nozzles of the first jetting nozzle 3, that is, the first jetting nozzles 3-1 to 3-2 are provided. The first jetting nozzle 3-1 is arranged so as to jet water to the top portion on the downstream side in the horizontal direction in the outer circumferential surface 5a of the first suction drum 5. The first jetting nozzle 3-2 is arranged so as to jet water to a position which is substantially the center between the top portion on the downstream side in the horizontal direction in the outer circumferential surface 5a of the first suction drum 5 and the top portion on the upper side in the vertical direction. Accordingly, the web 7 is jetted with water by the first jetting nozzles 3-1 to 3-2 while being sucked and conveyed by the first suction drum 5. Consequently, the semi-finished product with protruded and recessed patterns 8 to which the protruded and recessed patterns are transferred is formed while the fibers included in the web 7 are entangled with each other.

[0108] Subsequently, the semi-finished product 8 is separated from the first suction drum 5, in the vicinity of the top portion on the upper side in the vertical direction of the first suction drum 5, and is wound up by the second suction drum 6, in the vicinity of the top portion on the lower side in the vertical direction of the second suction drum 6. Further, the semi-finished product 8 is sucked and retained by the second suction drum 6 so that the first surface 8a of the semi-finished product 8 comes in contact with the outer circumferential surface 6a of the second suction drum 6 and the second surface 8b of the semi-finished product 8 faces the outer side of the second suction drum 6.

[0109] Two nozzles of the second jetting nozzle 4, that is, the second jetting nozzles 4-1 to 4-2 are provided. The second jetting nozzle 4-1 is arranged so as to jet water to a position which is substantially the center between the top portion on the upstream side in the horizontal direction in the outer circumferential surface 6a of the second suction drum 6 and the top portion on the upper side in the vertical direction. The second jetting nozzle 4-2 is arranged so as to jet water to the top portion on the upper side in the vertical direction in the outer circumferential surface 6a of the second suction drum 6. Accordingly, the semi-finished product 8 is jetted with water by the second jetting nozzles 4-1 to 4-2 while being sucked and conveyed by the second suction drum 6. Consequently, the nonwoven fabric with protruded and recessed patterns 9 is formed in which the fibers included in the semi-finished product 8 are further entangled with each other and the strength is improved.

[0110] Also in the present embodiment, the effects similar to those in the first embodiment can be achieved.

[0111] Incidentally, in the above mentioned embodiments, the following examples and comparative examples, the basis weight of a fiber sheet such as web, the thickness thereof and the fiber density thereof are measured or calculated according to the following methods.

(Basis weight of a fiber sheet)

[0112] Each of the web on the upstream side conveying device 13 and the web which has been sprinkled with water by the water supplying device 2 and has been dehydrated by the first suction drum 5 is cut out to a size of 30 cm × 30 cm as a sample, and the mass thereof is measured. Further, the measured mass is divided by the area of the sample so as to calculate the basis weight of the sample. A value obtained by the average of the basis weights of ten samples is the basis weight of an example or a comparative example. Incidentally, before the measurement, a drying treatment at an atmosphere of 100 °C or higher is not particularly performed.

(Thickness of a fiber sheet)

[0113] The thickness of each of the web on the upstream side conveying device 13 and the web which has been sprinkled with water by the water supplying device 2 and has been dehydrated by the first suction drum 5 is measured by using a thickness gauge which is equipped with a probe of 15 cm² (manufactured by Daiei Kagaku Seiki MFG. co., Ltd., model type: FS-60DS), under the measurement condition of a measurement load of 3 g / cm². Thicknesses of three portions are measured for one measurement sample, and an average value of the thicknesses of these three portions is the thickness of an example or a comparative example.

(Density of a fiber sheet)

[0114] The fiber density of each of the web on the upstream side conveying device 13 and the web which has been sprinkled with water by the water supplying device 2 and has been dehydrated by the first suction drum 5 is calculated by dividing the basis weight of a fiber sheet obtained by the above mentioned method by the thickness of a fiber sheet obtained by the above mentioned method.

(Tensile strength and tensile elongation of a fiber sheet)

[0115] A rectangular specimen with 150 mm of length × 25 mm of width in which the longitudinal direction is the machine direction MD of the web, and a rectangular specimen with 150 mm of length × 25 mm of width in which the longitudinal direction is the width direction CD of the web are cut out as measurement samples, from the web which is immediately after being sprinkled with water by the water supplying device 2 and being dehydrated by the first suction drum 5. Further, for three measurement samples of each of the measurement samples of the machine direction MD and the width direction CD, the tensile strength and the tensile elongation are measured under conditions of a chuck distance of 100 mm and a tensile speed of 100 mm / min by using a tensile tester which is equipped with a load cell having a maximum load capacity of 50 N (manufactured by Shimadzu Corporation, Autograph, model type: AGS-1kNG). The average values of the tensile strength and the tensile elongation of these three measurement samples of each of the measurement samples of the machine direction MD and the width direction CD are the tensile strength and the tensile elongation of the machine direction MD and the width direction CD.

EXAMPLES

[0116] In order to confirm the effects of the method of manufacturing the nonwoven fabric with protruded and recessed patterns of the present invention, comparative experiments to compare the production efficiency (energy efficiency) for the manufacturing method according to the present invention and a manufacturing method not dependent on the present invention were performed.

(1) Preparation of samples

(1-1) Sample of Example 1

[0117] A fiber laminated body which was formed by PET / PP / PET with a fiber density of approximately 3.0×10^{-3} g/cm³ (a basis weight of approximately 30 g / m² and a thickness of approximately 10 mm) was prepared as the web 7. Next, the web 7 was supplied with water from the water supplying device 2 with a water pressure of 0.5 MPa on the first suction drum 5 in the manufacturing apparatus 1, and subsequently, the web 7 was supplied with water from the first jetting nozzles 3-1 and 3-2 with jetting pressures of 3.0 MPa and 6.0 MPa, respectively. Accordingly, the protruded and recessed patterns 55 were transferred to the web 7 while the fibers in the web 7 were being entangled with each other, so that the semi-finished product 8 in which the protruded and recessed patterns 40 were added to the protruded and recessed pattern present region was formed. Subsequently, on the second suction drum 6, the jetting of water from the second jetting nozzle 4 which did not influence the formation of the protruded and recessed patterns 40 in the protruded and recessed pattern present region was omitted, and the formed semi-finished product 8 was regarded as the nonwoven fabric 9 of the Example 1 as it was. Note that each of the maximum tensile strength and the maximum tensile elongation immediately after water was supplied to the web 7 from the water supplying device 2 with the water pressure of 0.5 MPa was, 0.091 N / 25 mm and 11.9 % in the machine direction MD, and 0.020 N / 25 mm and 0.0501 % in the width direction CD.

(1-2) Sample of Comparative Example 1

[0118] The web 7 which is the same as that of the Example 1 was prepared, and in the manufacturing apparatus 1, the protruded and recessed patterns 55 were not disposed in the supporting body 54 of the first suction drum 5 but were disposed in the supporting body 64 of the second suction drum 6. In the manufacturing apparatus 1 in such a state, the web 7 was supplied with water from the water supplying device 2 with a water pressure of 0.5 MPa on the first suction drum 5, and the web 7 was supplied with water from the first jetting nozzles 3-1 and 3-2 with jetting pressures of 3.0 MPa and 6.0 MPa, respectively. Accordingly, a semi-finished product in which the fibers in the web 7 were entangled with each other, however, the protruded and recessed patterns were not added was formed. Subsequently, water was jetted to the semi-finished from the second jetting nozzle 4 with a jetting pressure of 9.0 MPa on the second suction drum 6. Accordingly, the protruded and recessed patterns 55 were transferred to the semi-finished product while the fibers in the semi-finished product were entangled with each other, so that a nonwoven fabric of the Comparative Example 1 in which the protruded and recessed patterns were added to the protruded and recessed pattern present region was formed. Consequently, in the Comparative Example 1, the transfer of the protruded and recessed patterns was performed by the second jetting nozzle 4 on the second suction drum 6 for the semi-finished product which had already been performed with the entanglement of the fibers with each other. That is, the Comparative Example 1 can be regarded as the manufacturing method which is not dependent on the present invention. Note that each of the maximum tensile strength and the maximum tensile elongation immediately after water was supplied to the web 7 from the water supplying device 2 with the water pressure of 0.5 MPa was the same as that in the Example 1.

(2) Evaluation of performance of the protruded and recessed patterns

(2-1) Evaluation method

[0119] Evaluation of performance of the protruded and recessed patterns of the nonwoven fabrics was performed in accordance with the following method for the samples of the nonwoven fabric with protruded and recessed patterns (the patterns) which had been formed by using the manufacturing apparatus 1. As the protruded and recessed patterns, patterns configured by opening holes which penetrated the nonwoven fabric were used.

[0120] First, the samples were imaged by a scanner (the scanner: Canon image Runner ADVANCE ire - ADVC 5255F, the binarization software: Scalar Corporation, USB Digital Scale 1, 1J). In this case, the more the opening holes are properly formed, the blacker the image is. Next, the images are subjected to binarization processing for the predetermined area (100 mm × 25 mm = 2500 mm²) of the predetermined region which includes the protruded and recessed patterns (the protruded and recessed pattern present region) among the obtained images. Further, the black portions among the

binarized images are defined as the opening hole portions, that is, the portions in which the protruded and recessed patterns are formed, and the proportion of the area of the black portions with respect to the predetermined area (2500 mm²), that is, the area ratio is obtained. The area ratio of the black portions in the nonwoven fabric is compared to the area ratio of the protruded and recessed patterns in the supporting body, so as to be regarded as the performance of the nonwoven fabric. That is, (the performance of the protruded and recessed patterns in the nonwoven fabric) = (the area ratio of the black portions in the nonwoven fabric) / (the area ratio of the protruded and recessed patterns in the supporting body) x 100 (%). For example, in a case in which (the performance of the protruded and recessed patterns in the nonwoven fabric) is high, the performance is excellent, and the protruded and recessed patterns in the nonwoven fabric is approximated to the protruded and recessed patterns in the supporting body, that is, the visibility is increased.

(2-2) Evaluation results

[0121] The evaluation results of the performance evaluation of the protruded and recessed patterns in the Example 1 and the Comparative Example 1 are shown in the following Table 1. Note that "number of blacks" shows the number of the black portions by the protruded and recessed patterns within the region of the predetermined area. "Total area of blacks" shows the total area of these black portions. "Area of one portion" shows the average area per one portion of these black portions. "Area ratio" shows the proportion of the total area of blacks with respect to the predetermined area. "Performance" shows (the performance of the protruded and recessed patterns in the nonwoven fabric) which is calculated by the above mentioned formula.

[Table 1]

	First suction drum			Second suction drum	Area of black portions				Performance (%)
	Water supplying device 2 (MPa)	First jetting nozzle (MPa)		Second jetting nozzle 4 (MPa)	Number of blacks (number)	Total area of blacks (mm ²)	Area of one portion (mm) ²	Area ratio (%)	
		3-1	3-2						
Patterns	-	-	-	-	232	943	4.07	37.5	
Example 1	0.5	3.0	6.0		872	278	31.8	11.1	29.6
Comparative Example 1	0.5	3.0	3.0	9.0	557	7.07	12.7	2.83	7.54

[0122] As shown in Table 1, it was understood that the "total area" of the black portions was more, the average "area" per one portion was more, and thus the "performance" was better in the sample of the Example 1 than the sample of the Comparative Example 1. In other words, it can be understood that the protruded and recessed patterns were formed with better visibility in the sample of the Example 1 than in the sample of the Comparative Example 1.

(3) Production efficiency (energy efficiency)

[0123] In the Example 1, water is jetted to the web 7 from the first jetting nozzles 3-1 and 3-2 with jetting pressures of 3.0 MPa and 6.0 MPa, respectively. Accordingly, in the Example 1, the first jetting nozzle 3 can be regarded as performing the transfer of the protruded and recessed patterns (and the entanglement) with the energy which corresponds to the jetting pressure of 9.0 MPa. On the other hand, in the Comparative Example 1, water is jetted to the semi-finished product from the second jetting nozzle 4 with a jetting pressure of 9.0 MPa. Accordingly, in the Comparative Example 1, the second jetting nozzle 4 can be regarded as performing the transfer of the protruded and recessed patterns with the energy which corresponds to the jetting pressure of 9.0 MPa. Accordingly, in the Example 1 and in the Comparative Example 1, the energy of the water flows supplied from the jetting nozzles so as to form the protruded and recessed patterns can be regarded as approximately the same. At this time, as shown in Table 1, it was understood that the sample of the Example 1 was transferred with the protruded and recessed patterns with a better performance compared to the sample of the Comparative Example 1. That is, in a case in which the transfer of the protruded and recessed patterns was performed with approximately the same amount of energy, it was understood that the performance of the protruded and recessed patterns was better by performing the transfer of the protruded and recessed patterns without performing the processing of entangling the fibers with each other (Example 1), than by performing the transfer of the

protruded and recessed patterns after performing the processing of entangling the fibers with each other (Comparative Example 1). In other words, when trying to form the protruded and recessed patterns with the same performance, the energy of the water flow can be reduced by performing the transfer of the protruded and recessed patterns without performing the processing of entangling the fibers with each other, than by performing the transfer of the protruded and recessed patterns after performing the processing of entangling the fibers with each other. Accordingly, the method of manufacturing the nonwoven fabric of the present invention in which the transfer of the protruded and recessed patterns was performed without performing the processing of entangling the fibers with each other, could improve the production efficiency (the energy efficiency) compared to the manufacturing method of the nonwoven fabric in which the transfer of the protruded and recessed patterns was performed after performing the processing of entangling the fibers with each other.

REFERENCE SIGNS LIST

[0124]

- 1 manufacturing apparatus
- 2 water supplying device
- 3 first jetting nozzle
- 4 second jetting nozzle
- 5 first suction drum
- 6 second suction drum
- 7 web
- 8 semi-finished product
- 9 nonwoven fabric

Claims

1. A method of manufacturing a nonwoven fabric with protruded and recessed patterns by processing a web while conveying the web, comprising:
 - a step of preparing a web which has a fiber density of $4 \text{ to } 8 \times 10^{-2} \text{ g / 3 cm}$;
 - a step of forming a semi-finished product with protruded and recessed patterns by disposing the web so as to be along a surface of a first supporting body which has protruded and recessed patterns on the surface, and jetting a first water flow to the web so as to entangle fibers with each other included in the web, the semi-finished product with protruded and recessed patterns including a protruded and recessed pattern present region to which the protruded and recessed patterns are transferred; and
 - a step of forming a nonwoven fabric with protruded and recessed patterns by jetting a second water flow to a region other than the protruded and recessed pattern present region in the semi-finished product with protruded and recessed patterns so as to entangle the fibers with each other included in the semi-finished product with protruded and recessed patterns.
2. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to claim 1, wherein the step of preparing the web includes: a step of moisturizing a web, which is formed by laminating the fibers, by a water flow and dehydrating the web.
3. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to claim 2, wherein the step of moisturizing and dehydrating the web dehydrates the web by disposing the web so as to be along the surface of the first supporting body and sucking the web through the first supporting body while moisturizing the web with water.
4. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to any one of claims 1 to 3, wherein the step of forming the nonwoven fabric disposes the semi-finished product with protruded and recessed patterns on a second supporting body which is different from the first supporting body and does not include the protruded and recessed patterns on a surface, and jets the second water flow to the semi-finished product with protruded and recessed patterns.

5. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to any one of claims 1 to 4, wherein
the step of forming the semi-finished product with protruded and recessed patterns jets the first water flow from a plurality of first water flow nozzles which are aligned along a machine direction in which the web is conveyed, and jetting pressures of the plurality of first water flow nozzles increase as proceeded in the machine direction.
6. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to any one of claims 1 to 5, wherein
the step of forming the semi-finished product with protruded and recessed patterns jets the first water flow to one surface of the web, and
the step of forming the nonwoven fabric jets the second water flow to a surface of the semi-finished product with protruded and recessed patterns which corresponds to the other surface of the web.
7. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to any one of claims 1 to 6, wherein a jetting pressure of the first water flow is lower than a jetting pressure of the second water flow.
8. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to any one of claims 1 to 4, wherein
the first supporting body is disposed on an outer circumferential surface of a cylindrical first suction drum which rotates around a horizontal shaft line, and
the step of forming the semi-finished product with protruded and recessed patterns jets the first water flow from a position above the shaft line.
9. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to claim 2, wherein
the first supporting body is disposed on an outer circumferential surface of a cylindrical first suction drum which rotates around a shaft line,
the second supporting body is disposed on an outer circumferential surface of a cylindrical second suction drum which is arranged on a downstream side in a machine direction than the first suction drum and rotates around a shaft line,
the first suction drum and the second suction drum are arranged so as not to be in contact with each other and the respective shaft lines are parallel to each other,
the step of forming the semi-finished product with protruded and recessed patterns jets the first water flow to a first surface of the web while making the web be sucked by the first suction drum and retaining the web on a surface of the first supporting body so that the first surface of the web faces outward,
the step of forming the nonwoven fabric jets the second water flow to a surface of the semi-finished product with protruded and recessed patterns, the surface corresponding to a second surface of the web, the second surface being positioned on an opposite side of the first surface, while making the semi-finished product with protruded and recessed patterns which has left the first suction drum be sucked by the second suction drum and retaining the semi-finished product with protruded and recessed patterns on a surface of the second supporting body so that the second surface of the semi-finished product with protruded and recessed patterns faces outward, and
in a vertical direction, the shaft line of the first suction drum is positioned above the shaft line of the second suction drum.
10. The method of manufacturing the nonwoven fabric with protruded and recessed patterns according to claim 3, wherein
the step of moisturizing and dehydrating the web dehydrates the web by sucking the web through the first supporting body while moisturizing the web by jetting a third water flow to the web through a mesh.

FIG. 1

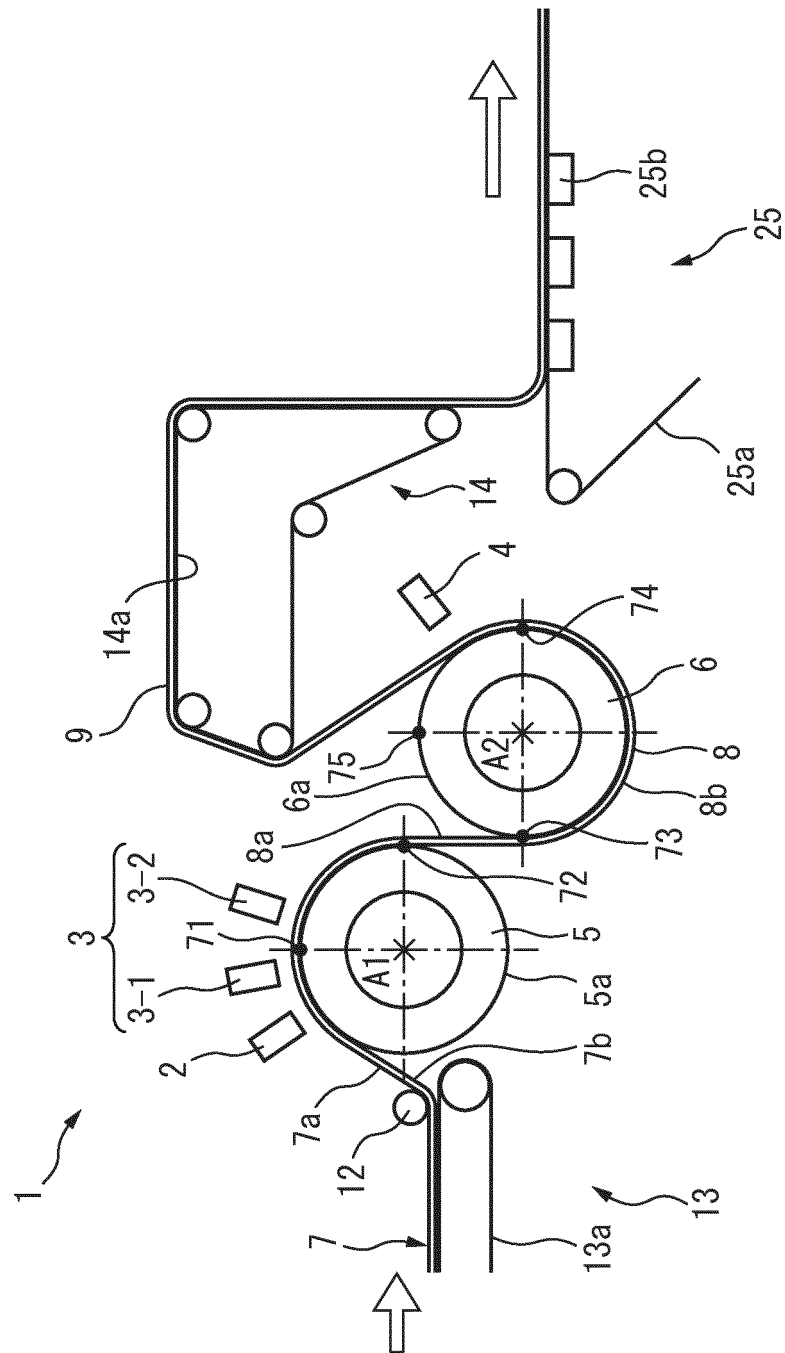


FIG. 2

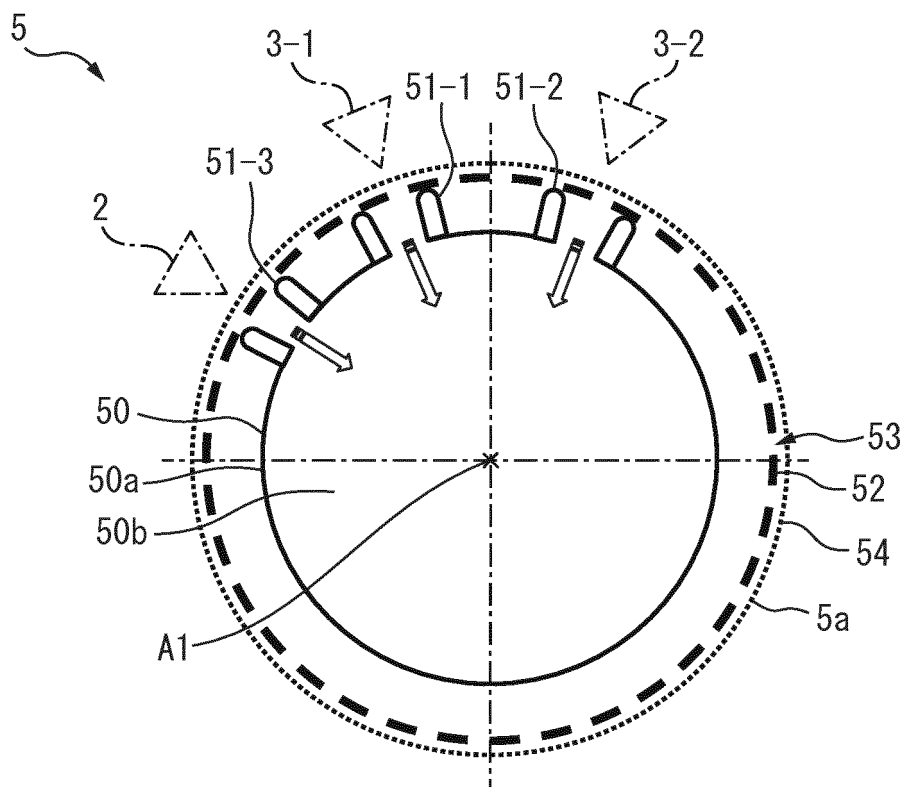


FIG. 3

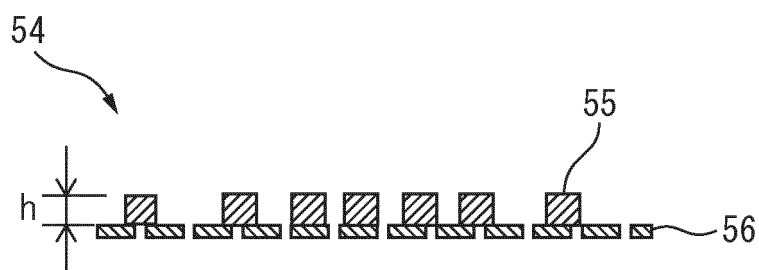


FIG. 4

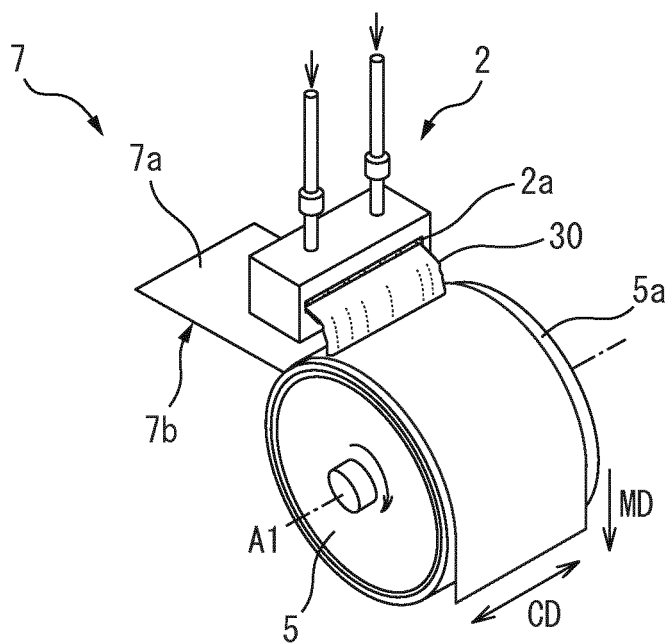


FIG. 5

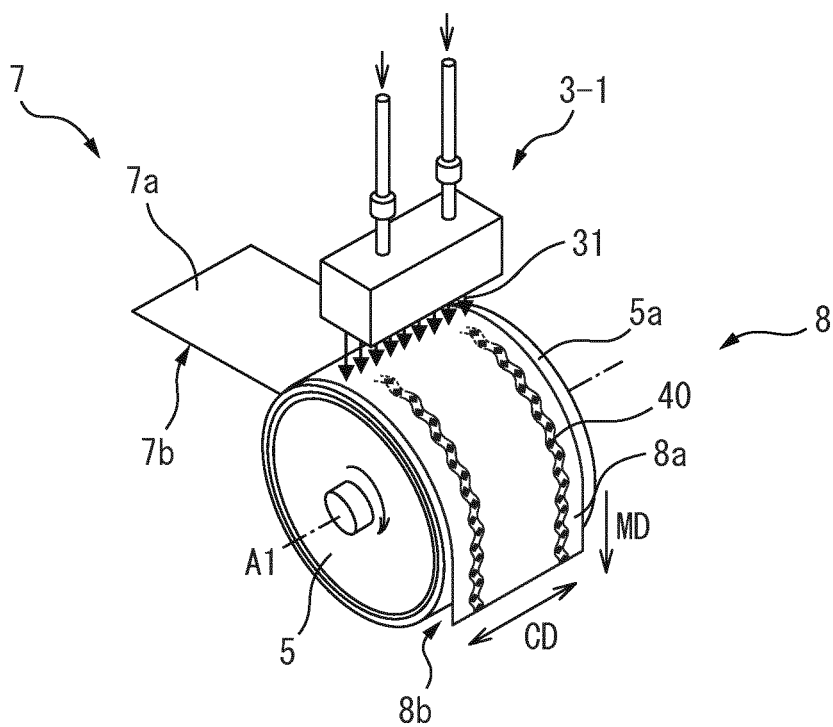


FIG. 6

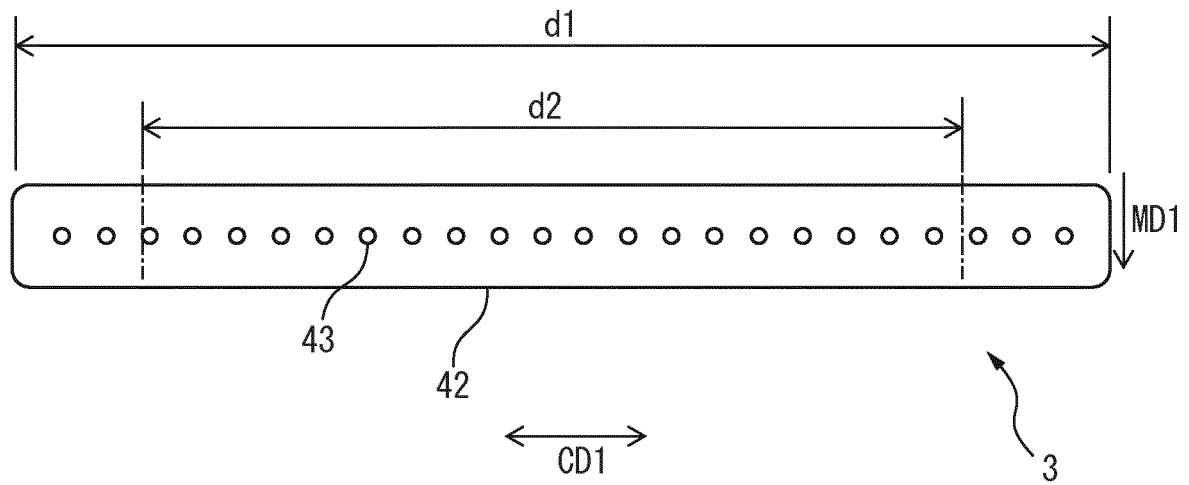


FIG. 7

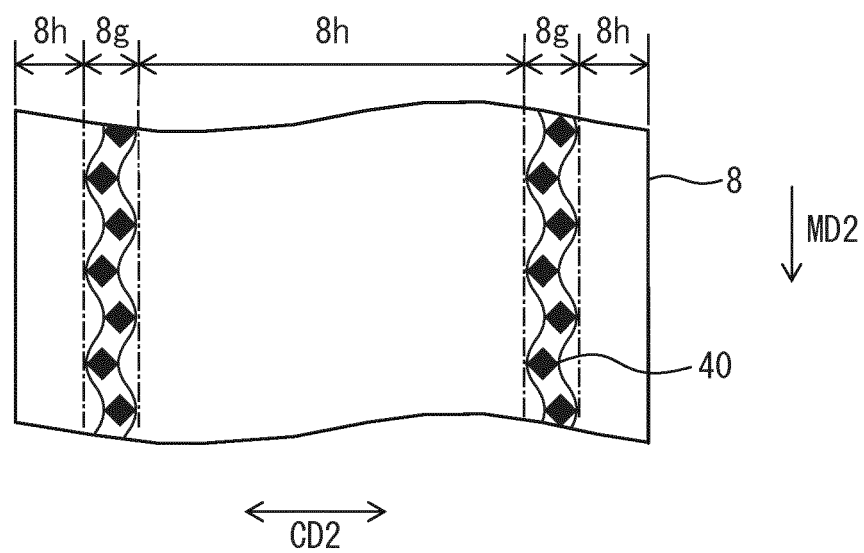


FIG. 8

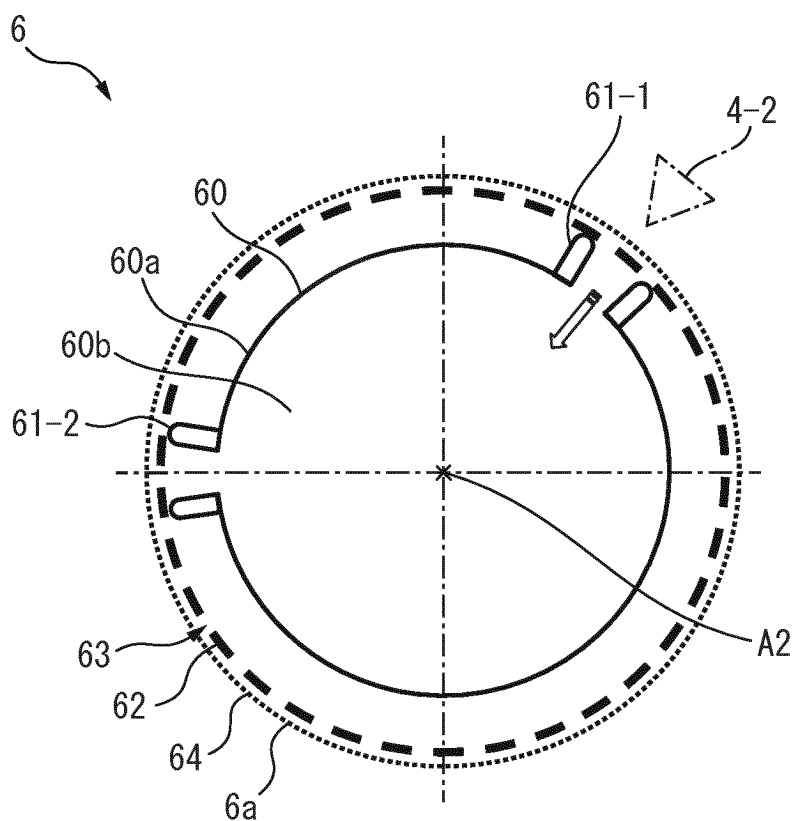


FIG. 9

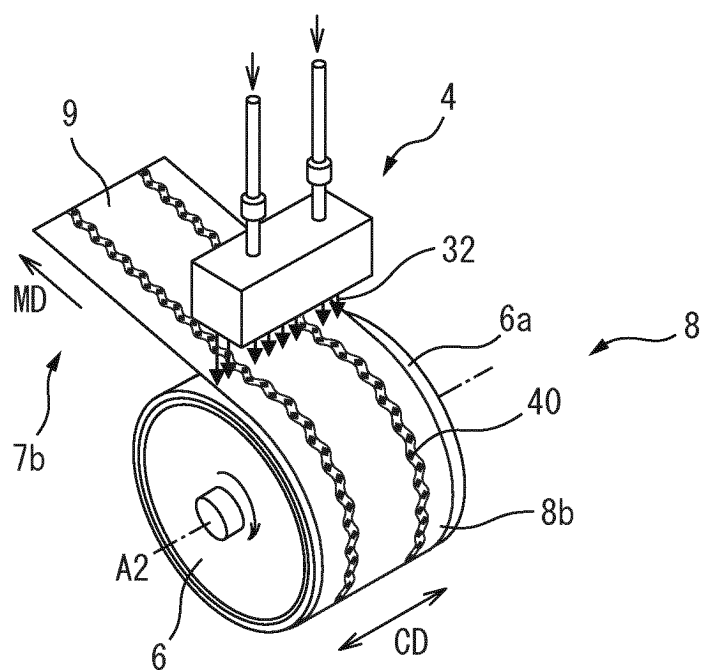


FIG. 10

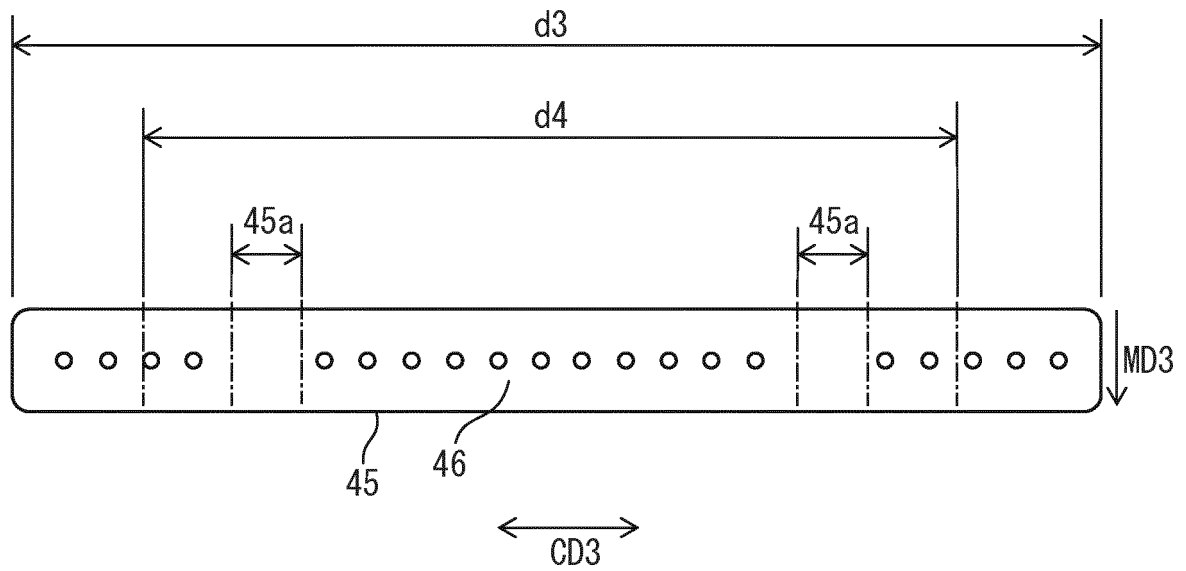


FIG. 11

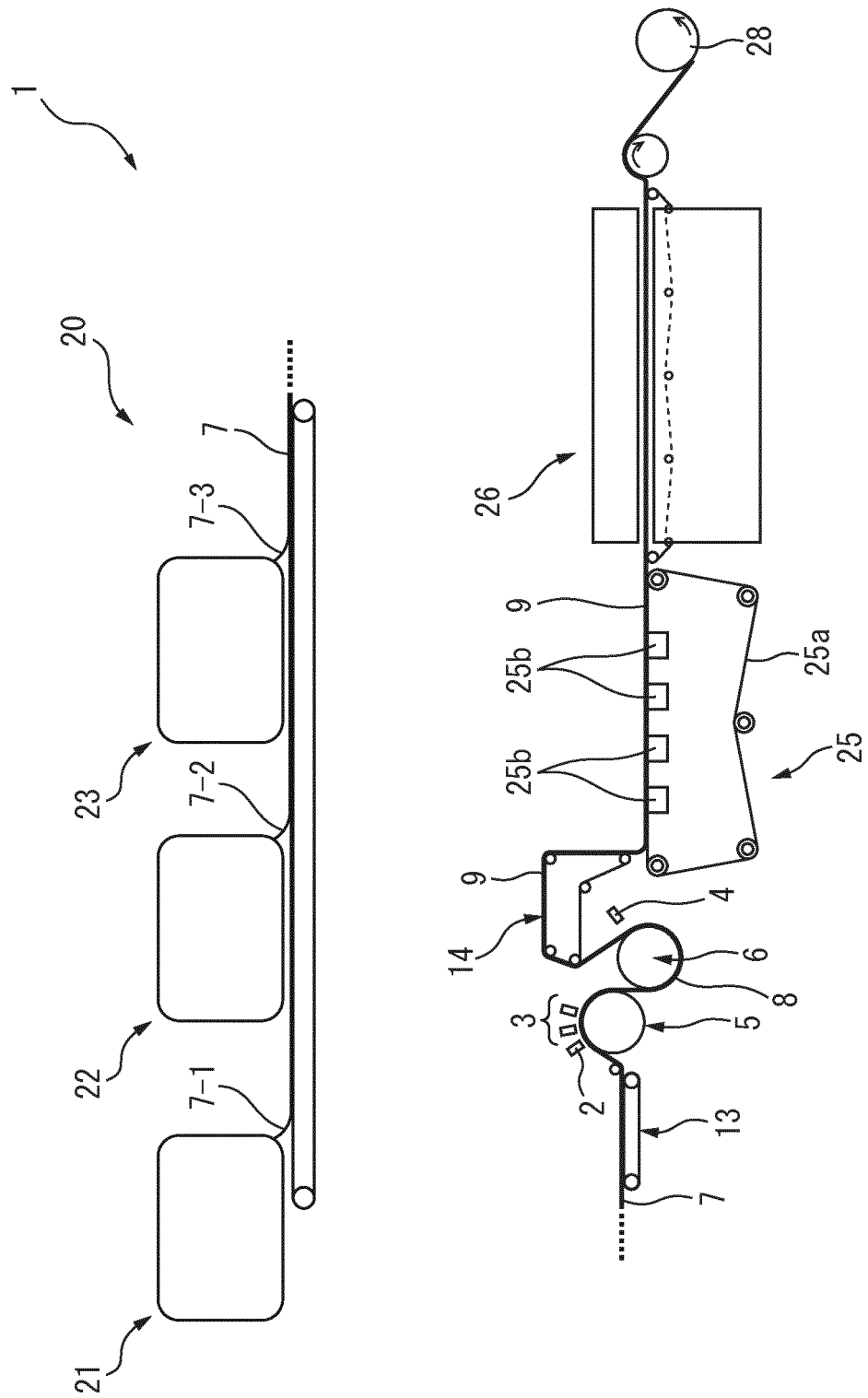


FIG. 12

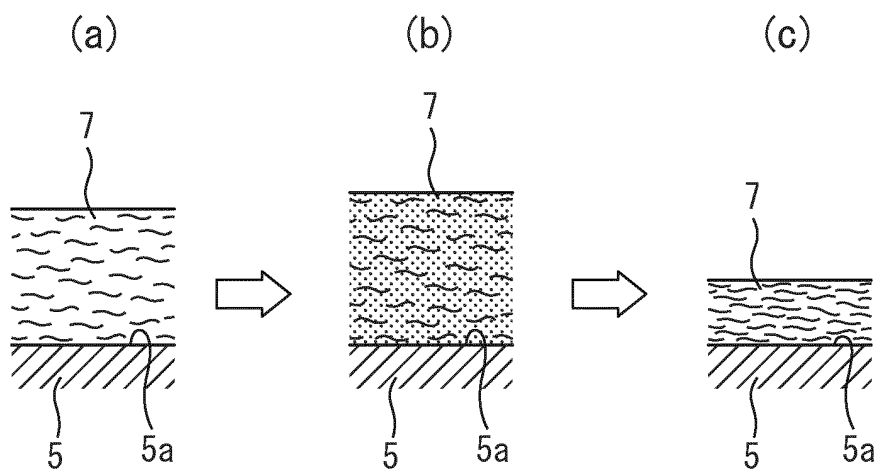


FIG. 13

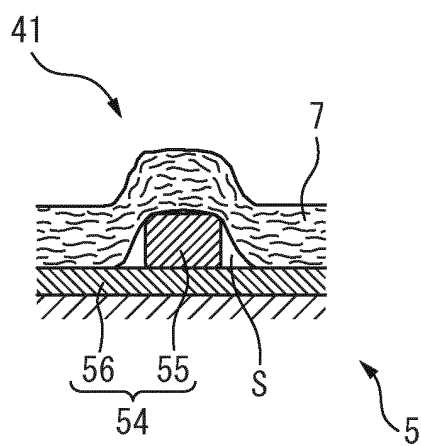


FIG. 14

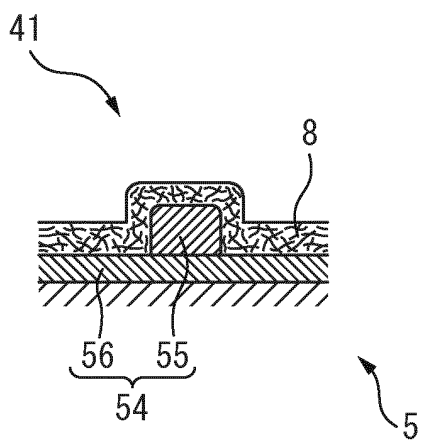
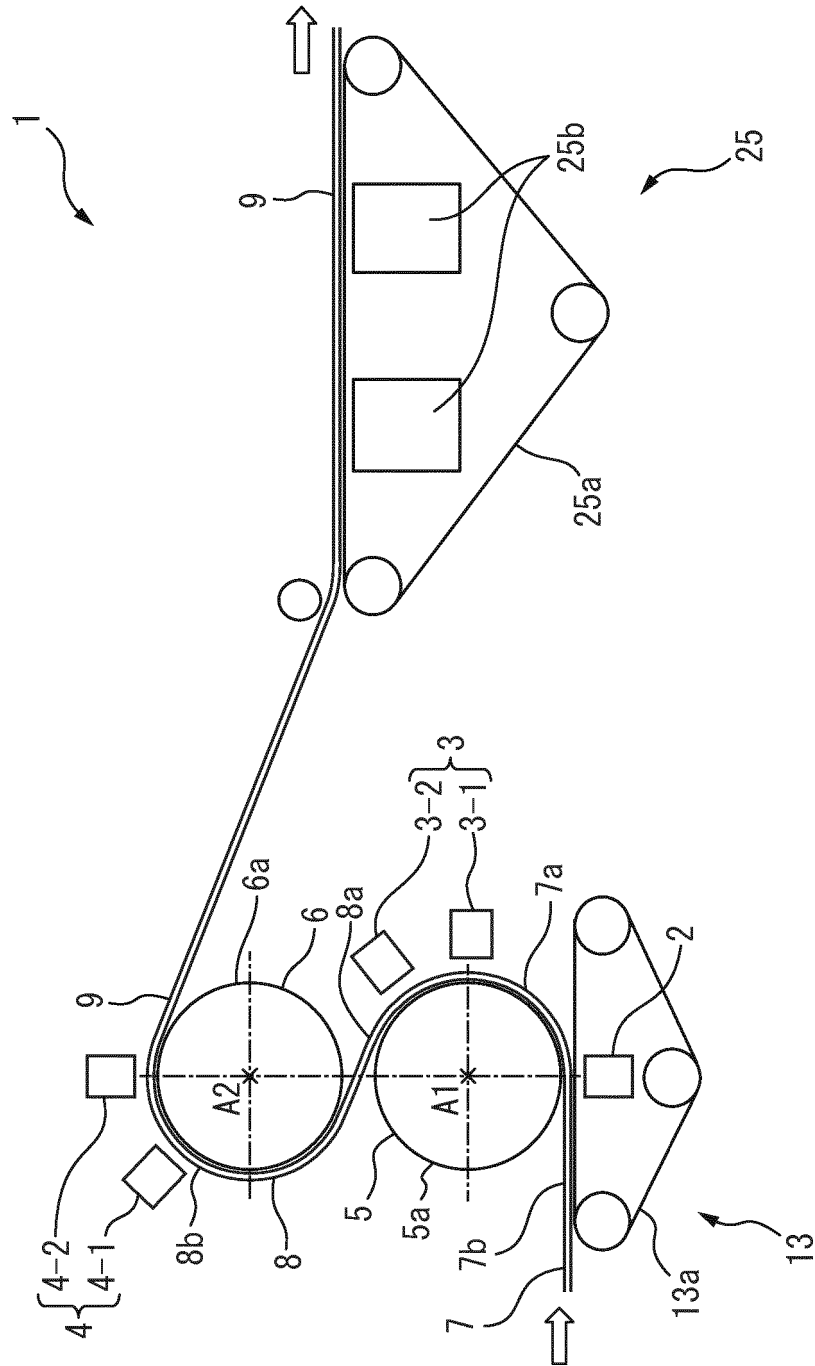


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/071316

A. CLASSIFICATION OF SUBJECT MATTER

D04H1/495(2012.01)i, D04H1/736(2012.01)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)

D04H1/00-18/04, D06B1/00-23/30; D06C3/00-29/00; D06G1/00-5/00;
D06H1/00-7/24; D06J1/00-1/12, A61F13/15-13/84; A61L15/16-15/64

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-106430 A (Kao Corp.), 13 May 2010 (13.05.2010), claims; paragraphs [0044] to [0052]; fig. 5 (Family: none)	1-10
A	JP 2006-187313 A (Kao Corp.), 20 July 2006 (20.07.2006), claims; paragraphs [0024] to [0026], [0036] & EP 1743564 A1 claims; paragraphs [0023] to [0025], [0035] & WO 2006/070513 A1	1-10
A	JP 2002-249965 A (Kuraray Co., Ltd.), 06 September 2002 (06.09.2002), claims; paragraph [0028] (Family: none)	1-10

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 ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
08 September 2016 (08.09.16)Date of mailing of the international search report
20 September 2016 (20.09.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/071316

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 10-025649 A (Fleissner GmbH & Co. Maschinenfabrik), 27 January 1998 (27.01.1998), entire text & US 5761778 A & EP 818568 A3	1-10
A	JP 2012-127045 A (Kao Corp.), 05 July 2012 (05.07.2012), entire text & US 2013/0232712 A1 & WO 2012/070568 A1 & EP 2644761 A1 & CN 103210131 A	1-10
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P, A	US 9169586 B2 (FA-MA JERSEY S.P.A.), 27 October 2015 (27.10.2015), entire text (Family: none)	1-10

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