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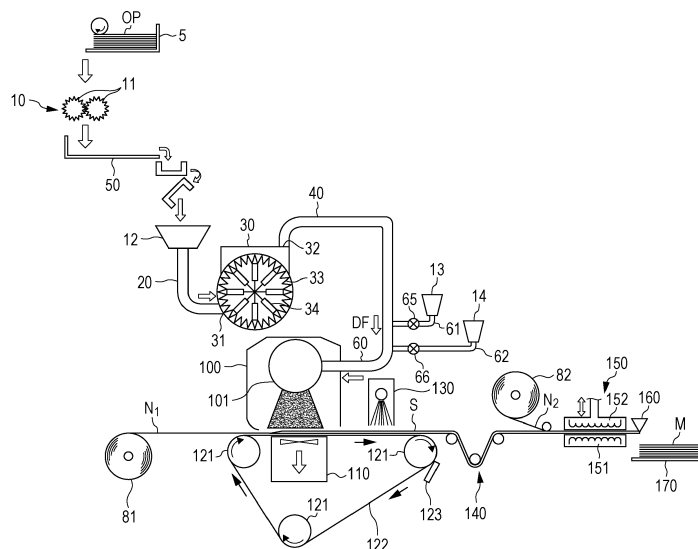
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(54) **EQUIPMENT FOR MANUFACTURING FIBER STRUCTURE, METHOD FOR MANUFACTURING FIBER STRUCTURE, AND FIBER STRUCTURE**

(57) Equipment for manufacturing a fiber structure in the present disclosure includes: a defibrator configured to pulverize and defibrate a fiber material containing fibers; a transport pipe through which a defibrated material defibrated by the defibrator is transported; a melting-material mixing section configured to mix a melting material into the defibrated material transported through the transport pipe; a fibrous-web forming machine configured to accumulate the defibrated material in which the melting

material is mixed and form a fibrous web; a sheet supply section configured to supply a shape-maintaining sheet to the fibrous web; and a heating-and-compression mechanism configured to compress the shape-maintaining sheet and the fibrous web between planar plates and heat the shape-maintaining sheet and the fibrous web to a temperature equal to or higher than a temperature at which the melting material softens.

FIG. 1



Description

[0001] The present application is based on, and claims priority from JP Application Serial Number 2020-012244, filed January 29, 2020 and JP Application Serial Number 2020-087936, filed May 20, 2020, the disclosures of which are hereby incorporated by reference herein in their entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to equipment for manufacturing a fiber structure, a method for manufacturing a fiber structure, and a fiber structure that are based on a dry manufacturing technique in which as little water as possible is used. Such a fiber structure is obtained by accumulating, through an air-laid process, defibrated fibers in air to form a fibrous web. Such a fiber structure is used for, for example, cushioning materials, packing materials, sound-absorbing materials, oil absorbers, tablecloths, construction materials, heat-insulating materials, and recycled paper.

2. Related Art

[0003] In recent years, there have been proposed methods for manufacturing fiber structures whose main components are wastepaper and that are thus reusable as materials after being used and environmentally friendly. In addition, there have been provided methods for stably and easily manufacturing, in a state of almost no environmental deterioration due to dispersion of binders or paper dust, fiber structures in which wastepaper is effectively used and that are, without stiffness caused by using water in the manufacturing processes, excellent in, for example, shock absorbency, heat-insulating properties, strength, and thermoformability.

[0004] JP-A-9-158024 discloses a fiber structure (a liquid absorber). The fiber structure is formed by mixing and defibrating, in air, natural cellulose fibers and/or synthetic fibers, a thermally fusible material, and a thickening material to form a mat, heating the mat to a temperature equal to or higher than a melting point of the thermally fusible material, and then fixing the thickening material in a fibrous web by compressing the mat with press rolls.

[0005] In JP-A-9-158024, fibers shift during formation with the press rolls, and thus the fiber orientations become anisotropic. As a result, when the fiber structure is used, various desired properties (for example, strength, shock absorbency, and absorption properties) may not be achieved.

[0006] In addition, when variations in the distribution of fibers occur during accumulation (air-laid processing) of the fibers, the variations may be increased by press-rolling the fibers, and it is thus difficult to achieve dimensional accuracy in the thickness direction of the fiber

structure.

[0007] FIG. 8 is a schematic diagram illustrating a state in which the thermally fusible material is melted through heating in a heating furnace 15 and compression with press rolls 16 in JP-A-9-158024.

[0008] In JP-A-9-158024, after the heating in the heating furnace 15, the mat is cooled from the surface layers thereof before the density thereof increases. Thus, the concentration of the thermally fusible material in the vicinities of an upper surface sheet 3 and a bottom surface sheet 4 is lower than that at the center in the thickness direction. As a result, the adhesive strength between the mat and the upper surface sheet 3 and between the mat and the bottom surface sheet 4 may be low.

[0009] After the mat is removed from the heating furnace 15, the surface layers of the mat harden during transportation, and the inside of the mat then cools. Thus, the ratio of the melted component on the mat surface adhering to the upper surface sheet 3 and the mat surface adhering to the bottom surface sheet 4 is low, resulting in low adhesive strength. For this reason, the mat and the upper surface sheet 3 and/or the bottom surface sheet 4 do not sufficiently adhere to each other.

[0010] When the adhesive strength between the mat and the upper surface sheet 3 and/or the bottom surface sheet 4 is low, the mat and the upper surface sheet 3 and/or the bottom surface sheet 4 may separate during cutting of pieces from the whole fiber structure. Alternatively, the upper surface sheet 3 or the bottom surface sheet 4 may peel from the mat during handling, and the fiber structure may thus be difficult to orderly store or insert into a container or a case, or post-processing may be difficult to perform.

SUMMARY

[0011] Equipment for manufacturing a fiber structure according to an aspect of the present disclosure includes: a defibrating section configured to pulverize and defibrate a fiber material containing fibers; a transport section through which a defibrated material defibrated by the defibrating section is transported; a melting-material mixing section configured to mix a melting material into the defibrated material transported through the transport section; a fibrous-web forming section configured to accumulate the defibrated material in which the melting material is mixed and form a fibrous web; a sheet supply section configured to supply a shape-maintaining sheet to the fibrous web; and a heating-and-compression mechanism configured to compress the shape-maintaining sheet and the fibrous web between planar plates and heat the shape-maintaining sheet and the fibrous web to a temperature equal to or higher than a temperature at which the melting material softens.

[0012] In the equipment for manufacturing a fiber structure, the sheet supply section supplies the shape-maintaining sheet to a first surface and a second surface opposite to the first surface of the fibrous web.

[0013] In the equipment for manufacturing a fiber structure according to an aspect of the present disclosure, the melting material is melting-resin fibers, and the melting-resin fibers have a fiber fineness of 0.5 dtex or more and 2.0 dtex or less.

[0014] In the equipment for manufacturing a fiber structure according to an aspect of the present disclosure, the melting material is resin particles, and the resin particles have a volume average particle diameter of 4 μm or more and 20 μm or less.

[0015] The equipment for manufacturing a fiber structure according to an aspect of the present disclosure further includes a functional-material mixing section configured to mix a functional material into the defibrated material.

[0016] In the equipment for manufacturing a fiber structure according to an aspect of the present disclosure, the functional material is a fire-retardant material.

[0017] In the equipment for manufacturing a fiber structure according to an aspect of the present disclosure, the fibrous-web forming section includes a dispersion member configured to disperse the defibrated material, a mesh belt on which the dispersed defibrated material is accumulated, the mesh belt being configured to transport the accumulated defibrated material, and a suction member configured to suction the dispersed defibrated material via the mesh belt.

[0018] The equipment for manufacturing a fiber structure according to an aspect of the present disclosure further includes a liquid atomizer configured to atomize a liquid onto the fibrous web transported by a mesh belt.

[0019] A method for manufacturing a fiber structure according to an aspect of the present disclosure includes: pulverizing and defibrating a fiber material containing fibers; transporting a defibrated material through a transport section; mixing a melting material into the defibrated material transported through the transport section; accumulating the defibrated material in which the melting material is mixed and forming a fibrous web; supplying a shape-maintaining sheet to the fibrous web; and compressing and heating the fibrous web to which the shape-maintaining sheet is supplied and melting the melting material.

[0020] In the method for manufacturing a fiber structure, the supplying of the shape-maintaining sheet includes supplying the shape-maintaining sheet to a first surface and a second surface opposite to the first surface of the fibrous web.

[0021] A method for manufacturing a fiber structure according to an aspect of the present disclosure includes: pulverizing and defibrating a fiber material containing fibers; transporting a defibrated material through a transport section; mixing a melting material into the defibrated material transported through the transport section; napping a surface of a first shape-maintaining sheet; accumulating, on the surface of the first shape-maintaining sheet, the defibrated material in which the melting material is mixed and forming a fibrous web; supplying a second shape-maintaining sheet on an opposite side of the fi-

brous web from a side on which the first shape-maintaining sheet is disposed; and compressing and heating the fibrous web disposed between the first shape-maintaining sheet and the second shape-maintaining sheet and melting the melting material.

[0022] In the method for manufacturing a fiber structure, the mixing of the melting material includes mixing, as the melting material, melting-resin fibers having a fiber fineness of 0.5 dtex or more and 2.0 dtex or less into the transported defibrated material.

[0023] A fiber structure according to an aspect of the present disclosure is manufactured by the method for manufacturing a fiber structure.

[0024] As described above, in the equipment and the method for manufacturing a fiber structure in the present disclosure, the fibrous web to which the shape-maintaining sheets are supplied is simultaneously heated and compressed to adhere the shape-maintaining sheets to the fibrous web. Thus, it is possible to manufacture a fiber structure whose strength and rigidity are maintained and that has great ease of handling without, for example, losing the shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a schematic diagram illustrating a schematic configuration of equipment for manufacturing a fiber structure according to an embodiment of the present disclosure.

FIG. 2 is a schematic diagram of a fiber structure yet to be subjected to heating and compression.

FIG. 3 is a schematic diagram of a fiber structure according to the embodiment of the present disclosure.

FIG. 4 is a schematic diagram illustrating heating and compression according to the embodiment of the present disclosure and a state in which a melting material is melted.

FIG. 5 illustrates an outline of a peeling test method. FIG. 6 illustrates peeling test results.

FIG. 7 is a schematic diagram illustrating a schematic configuration of equipment for manufacturing a fiber structure according to another embodiment of the present disclosure.

FIG. 8 is a schematic diagram illustrating a state in which a thermally fusible material is melted through heating in a heating furnace and compression with press rolls in the related art.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0026] Embodiments of the present disclosure will be described below with reference to the drawings. FIG. 1 is a schematic diagram illustrating a schematic configuration of equipment for manufacturing a fiber structure according to an embodiment of the present disclosure.

The equipment for manufacturing a fiber structure according to the embodiment is based on a technique in which a sheet material OP (for example, wastepaper) containing fibers is recycled into a new fiber structure product through a dry process in which as little water as possible is used.

[0027] A manufactured fiber structure is also usable for sound-absorbing materials, which absorb sound, and cushioning materials (packing materials), which absorb external shock. By disposing the fiber structure functioning as a sound-absorbing material inside, for example, various home appliances, the fiber structure can reduce leakage of operating noise to the outside of the appliances. In addition to home appliances, the fiber structure is also usable for various construction materials or sound-absorbing materials to be disposed in, for example, concert halls to control acoustics.

[0028] Corrugated cardboard or newspaper is also usable for the sheet material OP (for example, wastepaper) containing fibers, which is supplied to the equipment for manufacturing a fiber structure according to the embodiment. However, office wastepaper whose recycling routes are yet to be sufficiently established such as confidential document wastepaper or general wastepaper of A4 size, which is currently widespread in most offices, is intended to be used for the sheet material OP. When such a sheet material OP (for example, wastepaper) containing fibers is supplied to a coarse crusher 10 of the equipment for manufacturing a fiber structure, the sheet material OP containing fibers is cut into paper pieces of several centimeters square by coarse crushing blades 11 of the coarse crusher 10. In addition, it is preferable to provide, to such a coarse crusher 10, an automatic feed mechanism 5 for continuously supplying the sheet material OP containing fibers. In consideration of productivity, the supply rate in the automatic feed mechanism 5 is preferably high.

[0029] The coarse crushing blades 11 of the coarse crusher 10 may be a device whose cutting width is wider than the blades of a common shredder. Coarsely crushed pieces (paper pieces) cut into several centimeters square by the coarse crushing blades 11 may be led to a defibrating process, which is a subsequent process, via a metering feeder 50, a hopper 12, and an inlet pipe 20 for coarsely crushed pieces (paper pieces).

[0030] The metering feeder 50 may use any method as long as a fixed amount of coarsely crushed pieces (paper pieces) are supplied to a defibrator, and a vibrating feeder is suitable for the metering feeder 50.

[0031] Such a vibrating feeder tends not to transport a constant amount of light coarsely crushed pieces (paper pieces) due to, for example, static electricity. Thus, light coarsely crushed pieces (paper pieces) are preferably formed into a block-like shape by multi-feeding with the coarse crusher 10 in the previous process. Each block weight is preferably 0.5 g to 2 g.

[0032] Coarsely crushed pieces (paper pieces) may be continuously supplied from the coarse crusher 10 to

the vibrating feeder or may be stored in flexible containers and then supplied to the vibrating feeder. In this case, flexible containers function as buffers, and thus it is possible to reduce the influence, on the manufacturing equipment, of fluctuations in the amount of collected wastepaper to be the sheet material OP. The amount of coarsely crushed pieces (paper pieces) supplied from flexible containers is preferably equal to the amount of coarsely crushed pieces (paper pieces) with which the fiber structure can be continuously produced for about one hour, depending on the production amount of the fiber structure. A large amount of coarsely crushed pieces (paper pieces) supplied from flexible containers to the vibrating feeder at the same time may influence vibration of the vibrating feeder, and thus it is preferable to gradually supply coarsely crushed pieces (paper pieces) from flexible containers. Examples of a method for gradually supplying coarsely crushed pieces (paper pieces) from flexible containers can include a method in which flexible containers are inclined, a method in which flexible containers are shaken by, for example, a motor, and a method in which flexible containers are partly pierced using an air cylinder.

[0033] The inlet pipe 20 for coarsely crushed pieces (paper pieces) is in communication with an inlet 31 of a dry defibrator 30, and the coarsely crushed pieces (paper pieces) led into the dry defibrator 30 from the inlet 31 are defibrated between a rotating rotor 34 and a stator 33 and are formed into defibrated fibers DF. The dry defibrator 30 is a mechanism that generates airflow, and the defibrated fibers DF defibrated in, for example, air are led by such airflow from an outlet 32 to a transport pipe 40.

[0034] Hereinafter, a specific example of the dry defibrator 30 is described. For example, dry wastepaper defibrators including a disc refiner, a turbo mill (produced by FREUND-TURBO CORPORATION), a Ceren Miller (produced by MASUKO SANGYO CO., LTD), or a wind generating mechanism such as that disclosed in JP-A-6-93585 are usable for the dry defibrator 30. The size of the coarsely crushed pieces (paper pieces) supplied to such a dry defibrator 30 may be equal to the size of paper pieces discharged from a common shredder. In consideration of the strength of a manufactured fiber structure, preferably, the coarsely crushed pieces (paper pieces) have a long fiber length. However, excessively large coarsely crushed pieces (paper pieces) are difficult to supply to the dry defibrator 30. Thus, the size of the coarsely crushed pieces (paper pieces) discharged from the coarse crusher 10 is preferably several centimeters square.

[0035] In the dry defibrator 30 including a wind generating mechanism, coarsely crushed pieces (paper pieces) are suctioned, by using the airflow generated by the dry defibrator 30, from the inlet 31 together with the airflow and are defibrated and transported toward the outlet 32. The dry defibrator 30 defibrates supplied coarsely crushed pieces (paper pieces) into a flocculent form.

[0036] For example, an Impeller Mill 250 (produced by Seishin Enterprise Co., Ltd.), which is a type of turbo mill,

can generate an airflow having an airflow volume of about 3 m³/min at 8000 rpm (peripheral speed of about 100 m/s) by using 12 blades installed at a part closer to the outlet thereof. In this case, the airflow velocity at a part closer to the inlet 31 is about 4 m/s, and coarsely crushed pieces (paper pieces) are led into the dry defibrator 30 by the airflow. The coarsely crushed pieces (paper pieces) led into the dry defibrator 30 are defibrated between the blades rotating at high velocity and the stator 33 and are discharged from the outlet 32. The discharge velocity is about 6.5 m/s with a discharge pipe diameter of $\phi 100$.

[0037] When the dry defibrator 30 does not include a wind generating mechanism, it is sufficient to separately provide, for example, a blower configured to generate airflow that leads coarsely crushed pieces (paper pieces) into the inlet 31.

[0038] In the defibrating process in the dry defibrator 30, it is preferable to defibrate pulp into a fibrous form in which the shape of coarsely crushed pieces (paper pieces) is lost because unevenness of the fiber structure to be formed in a subsequent process is eliminated. In this process, for example, printed ink or toner, and coating and additive materials for paper (papermaking chemicals), such as a bleed prevention agent, are also pulverized into grains of several tens of micrometers or less (hereinafter referred to as ink grains and papermaking chemicals). Thus, the output from the dry defibrator 30 is fibers (defibrated fibers DF), ink grains, and papermaking chemicals obtained by defibrating coarsely crushed pieces (paper pieces).

[0039] For example, when a disc refiner is used as the dry defibrator 30, it is preferable to form stationary blades at the circumferential edge thereof in addition to the rotary blades formed on a disc-shaped surface thereof in the radial direction. The gap between the rotary blades on the rotor 34 and the stationary blades on the stator 33 is preferably kept to about the thickness of a paper piece, for example, about 100 to 150 μm . In this case, the defibrated material is moved to the outer circumference by the airflow generated by the rotary blades and is discharged from the outlet 32.

[0040] The defibrated material (defibrated fibers DF) discharged from the dry defibrator 30 ($\phi 100$, sectional area of about 78 cm²) is led into a fibrous-web forming machine 100 through the transport pipe 40 and a transport pipe 60.

[0041] A melting-material transport pipe 61 branches off from the transport pipe 60. The amount of a melting material supplied from a hopper 13 for melting materials (melting-resin fibers) is controlled by a melting-material control valve 65. The melting material is supplied to the transport pipe 60 via the melting-material transport pipe 61 and can be mixed into the defibrated fibers DF transported through the transport pipe 60. The accuracy of the amount of a melting material to be transported can be increased by a method in which the opening degree of the valve is controlled by measuring, with a scale on which a feeder is placed, a reduced amount of the melting

material.

[0042] The pipe diameter of the melting-material transport pipe 61 is preferably smaller than the pipe diameter of the transport pipe 60. This is because melting-resin fibers that are a melting material are likely to disperse in airflow due to increased airflow velocity.

[0043] The melting material maintains the strength and the rigidity of the fiber structure as a formed product formed by the defibrated fibers DF and prevents dispersion of paper dust and fibers. The melting material is melted by being added to the defibrated fibers DF and being heated to bind the fibers. The melting material may be any material, such as fibrous materials or powder (particle or granular) materials, as long as the material is melted by a heating process. However, materials that melt at 200°C or lower are preferable because, for example, paper yellowing does not occur. Materials that melt at 160°C or lower are more preferable in terms of energy.

[0044] The melting material preferably contains a thermoplastic resin, which melts during heat forming. More preferably, fibrous melting materials, which are easily intertwined with defibrated cotton fibers, are used to produce low-density products. It is more preferable to use composite fibers having a core-in-sheath structure. Melting materials having a core-in-sheath structure are preferable because a sheath portion exhibits an adhesive function when melted at a low temperature and because a core portion remains in a fiber form, that is, the shape of the core portion is maintained. It is preferable to use, for example, ETC and INTACK series, which are produced by ES FIBERVISIONS, Inc., or Tetoron (registered trademark), which is a polyester fiber for dry nonwoven fabric and is produced by TEIJIN LIMITED.

[0045] The fineness of each melting-resin fiber is preferably 0.5 dtex or more and 2.0 dtex or less. When the fineness of each melting-resin fiber is more than 2.0 dtex, it is not possible to achieve sufficient adhesive strength between a first shape-maintaining sheet (or a second shape-maintaining sheet) and a defibrated-cotton sheet (fibrous web). When the fineness of each melting-resin fiber is less than 0.5 dtex, for example, there may arise problems in that, in terms of fiber manufacture, the position of a core deviates from the center of a sheath in a core-in-sheath structure and the fibers are difficult to discharge linearly. In addition, there may arise a problem in that, because the fineness of each melting-resin fiber is smaller than that of each of the defibrated fibers DF, the melting-resin fibers and the defibrated fibers DF are mixed unevenly during the manufacturing process due to a large effect of static electricity.

[0046] The length of each melting-resin fiber is preferably about 1 to 10 mm. When the length of each melting-resin fiber is smaller than 1 mm, it is difficult to maintain the shape of the fiber structure due to insufficient adhesive strength. When the length of each melting-resin fiber is larger than 10 mm, fibers are formed into balls in airflow, resulting in a deterioration in the dispersiveness of the fibers.

[0047] Below the melting-material transport pipe 61, which branches off from the transport pipe 60, a functional-material transport pipe 62 branches off from the transport pipe 60. Powder fire retardants are preferably usable in the product. The amount of a fire retardant as a functional material supplied from a hopper 14 for functional materials (fire retardants) is controlled by a functional-material control valve 66. The fire retardant is supplied to the transport pipe 60 via the functional-material transport pipe 62. In the transport pipe 60, the fire retardant can be mixed into the defibrated fibers DF, into which a melting material is mixed, during transportation. The accuracy of the amount of a fire retardant to be transported can be increased by a method in which the opening degree of the valve is controlled by measuring, with a scale on which a feeder is placed, a reduced amount of the fire retardant.

[0048] The pipe diameter of the functional-material transport pipe 62 is preferably smaller than the pipe diameter of the transport pipe 60. This is because a functional material is likely to disperse in airflow due to increased airflow velocity.

[0049] The fire retardant is added to impart incombustibility to the defibrated-cotton sheet (fibrous web) formed by the defibrated fibers DF. For example, hydroxides such as aluminum hydroxide and magnesium hydroxide, boric acid, boric acid compounds such as ammonium borate, phosphorus-based organic materials containing, for example, ammonium polyphosphate or phosphoric esters, or nitrogenous compounds such as melamine and isocyanurate are usable for the fire retardant. In particular, it is preferable to use a composite containing melamine and phosphoric acid.

[0050] Preferably, the fire retardant is a solid fire retardant. The volume average particle diameter of the solid fire retardant is preferably 1 μm or more and 50 μm or less. When the volume average particle diameter is less than 1 μm , it is difficult to transport the solid fire retardant by airflow when the solid fire retardant is accumulated as a defibrated-cotton sheet (fibrous web) (S) in a subsequent suction process. When the volume average particle diameter is more than 50 μm , the adhesive power of the solid fire retardant to fibers is reduced, and thus the solid fire retardant is likely to fall off the fibers. As a result, the solid fire retardant is distributed unevenly and cannot provide sufficient fire retardancy.

[0051] The defibrated fibers DF, into which a melting material and a functional material are mixed through the transport pipe 60, is led into the fibrous-web forming machine 100.

[0052] The first shape-maintaining sheet (N_1) is supplied from a first-shape-maintaining-sheet supply roller 81 to the fibrous-web forming machine 100. The first shape-maintaining sheet (N_1) to be supplied from the first-shape-maintaining-sheet supply roller 81 is a base of a bottom surface (first surface) of the defibrated-cotton sheet (fibrous web) formed by the fibrous-web forming machine 100.

[0053] Both woven fabric and nonwoven fabric are usable for the first shape-maintaining sheet (N_1) in the present disclosure as long as the sheet can maintain the shape of the fibrous web by supporting the fibrous web.

5 The first shape-maintaining sheet (N_1) is required to also have air permeability to properly accumulate the defibrated material, the melting material, and the functional material on which the airflow generated by a suction device 110 acts via the first shape-maintaining sheet (N_1) and that are mixed on the first shape-maintaining sheet (N_1).
10 The additives in wastepaper and the print ink grains pulverized by the dry defibrator 30 are removed from the mixed defibrated material through the suction process. The size of each opening in the first shape-maintaining sheet (N_1) is preferably 100 μm or less. The first shape-maintaining sheet (N_1) is an exterior portion of the product and may thus be colored. In the embodiment, eculle (registered trademark) 3151A, which is a polyester filament nonwoven fabric manufactured through spunbonding by TOYOBO CO., LTD., is used for such a first shape-maintaining sheet (N_1) having air permeability.

[0054] The fibrous-web forming machine 100 is described schematically. The fibrous-web forming machine 100 includes mainly a dispersion mechanism configured to uniformly disperse defibrated fibers in, for example, air, and a mechanism configured to suction the dispersed defibrated fibers onto a mesh belt 122.

[0055] The dispersion mechanism includes a forming drum 101. The mixed defibrated material and a mixed gas (mixed air) are simultaneously supplied to the rotating forming drum 101. A small-hole screen is disposed on a surface of the forming drum 101. The defibrated fibers DF, into which a melting material and a functional material are mixed, are discharged from the small-hole screen. The hole diameter of the drum mesh (hole diameter of the small-hole screen) depends on the size of the mixed defibrated material, and the shape of the hole may be a circular shape. Preferably, each hole is an elongated hole of about 5 mm $\times$ 25 mm to achieve both productivity and uniformity.

[0056] A defibrated material, a melting material, and a functional material are uniformly mixed with a mixed gas (mixed air) and pass through the holes in the forming drum 101.

45 **[0057]** Current plates capable of adjusting the uniformity of materials in the width direction are disposed below the forming drum 101. The mesh belt 122, which is endless and on which the mesh stretched between tension rollers 121 is formed, is disposed below the current plates. A transport gas (transport air) and a mixed gas (mixed air) are suctioned via a suction box. When the amount of a suction gas is larger than the sum of the amount of a transport gas and the amount of a mixed gas, it is possible to prevent materials and paper dust generated during defibration from being blown off. Fine powders (waste powders) passing through the first shape-maintaining sheet (N_1) and the mesh belt 122 are mixed in the suction gas. Thus, to separate the fine pow-

ders (waste powders), it is preferable to dispose, downstream of the process, a cyclone or a filter dust collector.

[0058] Below the fibrous-web forming machine 100 as a fiber-structure forming machine, the mesh belt 122 is moved in the directions of arrows in FIG. 1 by at least one of the tension rollers 121 being driven to rotate. For example, the dirt on a surface of the mesh belt 122 is removed with a cleaning blade 123, which is in contact with the mesh belt 122. The mesh belt 122 may be cleaned by air.

[0059] The mesh belt 122 may be made of any material, such as metal or resin, as long as a sufficient amount of suction air is able to pass through the mesh belt 122 and as long as the mesh belt 122 has sufficient strength to hold materials. When the hole diameter of the mesh is excessively large, a surface of the defibrated-cotton sheet (fibrous web) (S) is formed into an uneven shape. Thus, the hole diameter of the mesh is preferably about 60 μm to 125 μm . When the hole diameter of the mesh is less than 60 μm , it is difficult for the suction device 110 to generate stable airflow.

[0060] The first shape-maintaining sheet (N_1) is supplied onto the mesh belt 122 from the first-shape-maintaining-sheet supply roller 81 at a moving velocity identical to the moving velocity of the mesh belt 122. The suction device 110 can be formed by forming an airtight box having a desirably sized window under the mesh belt 122 and by suctioning gas (for example, air) from a part of the box other than the window to evacuate the box.

[0061] With such a configuration, the defibrated fibers DF transported through the transport pipe 60 are led into the fibrous-web forming machine 100 for forming the fiber structure. The defibrated fibers DF pass through the small-hole screen on the surface of the forming drum 101 and accumulate on the first shape-maintaining sheet (N_1) on the mesh belt 122 due to the suction force generated by the suction device 110. In this case, the fibrous web can be formed by accumulating the defibrated fibers DF having a uniform sheet-like shape on the first shape-maintaining sheet (N_1) while the mesh belt 122 and the first shape-maintaining sheet (N_1) move. The accumulated material (fibrous web) (S) formed by accumulating the defibrated fibers DF is heated and compressed to form the fiber structure having a sheet-like shape.

[0062] The amount of the defibrated fibers DF to be accumulated and the density of the fiber structure to be completed through a subsequent pressing process are determined in the fibrous-web forming machine 100. The defibrated fibers DF are accumulated to a height of about 40 to 60 mm to obtain a fiber structure having, for example, a thickness of 10 mm and a density of about 0.1 to 0.15 g/cm³.

[0063] In the embodiment, to mix melting-resin fibers and a fire retardant into the defibrated fibers DF during transportation through the transport pipe 60, the melting-material transport pipe 61 and the functional-material transport pipe 62, which supply the respective materials, are coupled to the transport pipe 60. However, after mix-

ing a melting material and a functional material, the materials may be supplied through one transport pipe coupled to the transport pipe 60, through which the defibrated fibers DF are transported. In addition, such a transport pipe may be disposed in the fibrous-web forming machine 100. In such a case, for example, fixed amounts of melting-resin fibers and a fire retardant are mixed in the forming drum 101.

[0064] In addition, it is possible to impart incombustibility to the formed defibrated-cotton sheet (fibrous web) (S) by disposing a liquid atomizer 130 and by adding a water-soluble fire retardant functioning as a functional material (for example, APINON-145 (produced by SANWA CHEMICAL CO., LTD.)) to the liquid atomized by the liquid atomizer 130.

[0065] A second shape-maintaining sheet (N_2) is supplied from a second-shape-maintaining-sheet supply roller 82 to a process after through the fibrous-web forming machine 100 and the liquid atomizer 130. The second shape-maintaining sheet (N_2) to be supplied from the second-shape-maintaining-sheet supply roller 82 is a cover of an upper surface (second surface) of the defibrated-cotton sheet (fibrous web) (S) formed by the fibrous-web forming machine 100.

[0066] Both woven fabric and nonwoven fabric are usable for the second shape-maintaining sheet (N_2) in the present disclosure. In the embodiment, similarly to the first shape-maintaining sheet (N_1), eucle (registered trademark) 3151A, which is a polyester filament nonwoven fabric manufactured through spunbonding by TOYOBO CO., LTD., is used for the second shape-maintaining sheet (N_2).

[0067] The embodiment employs the following process. The first shape-maintaining sheet (N_1) is supplied from the first-shape-maintaining-sheet supply roller 81 to the fibrous-web forming machine 100. After the defibrated-cotton sheet (fibrous web) (S) is formed on the first shape-maintaining sheet (N_1), the second shape-maintaining sheet (N_2) is supplied from the second-shape-maintaining-sheet supply roller 82 and then covers the upper surface of the defibrated-cotton sheet (fibrous web) (S).

[0068] Alternatively, it is possible to employ the following process. The first-shape-maintaining-sheet supply roller 81 and the second-shape-maintaining-sheet supply roller 82 are disposed in a section after through (downstream of) the fibrous-web forming machine 100. The defibrated-cotton sheet (fibrous web) (S) formed by the fibrous-web forming machine 100 is then held between the first shape-maintaining sheet (N_1) and the second shape-maintaining sheet (N_2).

[0069] Next, the embodiment employs a configuration in which the defibrated-cotton sheet (fibrous web) (S) reaches a buffer section 140 after the defibrated-cotton sheet (fibrous web) (S) is formed on the first shape-maintaining sheet (N_1) and before the second shape-maintaining sheet (N_2) is supplied to the second surface of the defibrated-cotton sheet (fibrous web) (S).

[0070] The embodiment may employ a configuration in which the buffer section 140 is disposed after the second shape-maintaining sheet (N_2) supplied from the second-shape-maintaining-sheet supply roller 82 is disposed on the second surface of the defibrated-cotton sheet (fibrous web) (S).

[0071] As illustrated in FIG. 2, a fiber structure (M) yet to be subjected to heating and compression is in the state in which the first shape-maintaining sheet (N_1) is disposed on the first surface of the defibrated-cotton sheet (fibrous web) (S) and in which the second shape-maintaining sheet (N_2) is disposed on the second surface of the defibrated-cotton sheet (fibrous web) (S). The thread-like objects in the defibrated-cotton sheet (fibrous web) (S) are the melting-resin fibers that are a melting material. In FIG. 2, the fire retardant that is a functional material is omitted and not illustrated in the defibrated-cotton sheet (fibrous web) (S).

[0072] Next, the defibrated-cotton sheet (fibrous web) (S) illustrated in FIG. 1, whose second surface is covered, is transported to a heating-and-compression mechanism 150. The heating-and-compression mechanism 150 holds the defibrated-cotton sheet (fibrous web) (S), which is a transported object, between a first substrate 151 and a second substrate 152, which is configured to move up and down, and performs hot pressing through which the defibrated-cotton sheet (fibrous web) (S) is simultaneously heated and compressed. The first substrate 151 and the second substrate 152 each include a heater. The heater can heat the sheet held between the first substrate 151 and the second substrate 152.

[0073] FIG. 4 is a schematic diagram illustrating heating and compression according to the embodiment of the present disclosure and a state in which a melting material is melted. As illustrated in FIG. 4, the defibrated-cotton sheet (fibrous web) (S) is pressed while the surfaces thereof are heated by the heating-and-compression mechanism 150 (the first substrate 151 and the second substrate 152). Thus, there can be a large amount of the melting material (high ratio of the melted component) that melts and exudes to the surfaces of the defibrated-cotton sheet (fibrous web) (S), which are in contact with the first shape-maintaining sheet (N_1) and the second shape-maintaining sheet (N_2). As a result, the numbers of the fused points (or the fusion areas) between the defibrated-cotton sheet (fibrous web) (S) and the first shape-maintaining sheet (N_1) and between the defibrated-cotton sheet (fibrous web) (S) and the second shape-maintaining sheet (N_2) increase. Accordingly, the defibrated-cotton sheet (fibrous web) (S) firmly adheres to the first shape-maintaining sheet (N_1) and the second shape-maintaining sheet (N_2).

[0074] The defibrated-cotton sheet (fibrous web) (S) is compressed and heated by the heating-and-compression mechanism 150. As a result, the melting material mixed in the defibrated-cotton sheet (fibrous web) (S) is heated and fuses tightly with the defibrated fibers DF. This contributes to maintenance of the strength and the

shape of the fiber structure and to prevention of dispersion of fibers from the fiber structure.

[0075] By melting and hardening the melting material, the first shape-maintaining sheet (N_1) adheres to the defibrated-cotton sheet (fibrous web) (S) at the first surface of the defibrated-cotton sheet (fibrous web) (S), and the second shape-maintaining sheet (N_2) adheres to the defibrated-cotton sheet (fibrous web) (S) at the second surface of the defibrated-cotton sheet (fibrous web) (S).

[0076] In addition, the strength of the defibrated-cotton sheet (fibrous web) (S) as the fiber structure can be further increased by removing excess moisture through compression and heating in the heating-and-compression mechanism 150.

[0077] The heating process and the compression process may be independently performed. However, it is preferable to simultaneously heat and compress a material. Preferably, the heating time of a material is the time for which the temperature of the material is increased to the temperature at which the melting fibers near the cores of the material can melt. In addition, heating and compression are batch processing, and, to make sufficient heating time, it is thus preferable to dispose the buffer section 140 in a section before the heating-and-compression mechanism 150. The buffer section 140 can be realized by moving up and down a so-called dancer roller (bridge roller). Although the buffer section 140 is disposed in a section before the second shape-maintaining sheet (N_2) is supplied, it is also possible to employ a configuration in which the buffer section 140 is disposed in a section after the second shape-maintaining sheet (N_2) is supplied and before the heating-and-compression mechanism 150.

[0078] After finishing heating and compression, it is required that the heated and compressed fiber structure be rapidly moved and then another defibrated-cotton sheet (fibrous web) (S), which is another material to be heated and compressed, be set. Thus, it is preferable to dispose a mechanism in which a needle is inserted into the exit of the heating-and-compression mechanism 150 to hold and extract the heated and compressed fiber structure. More preferably, the mechanism has a cleaning function because fibers may adhere to the heating and compressing surfaces. For example, it can be proposed to employ a method in which a sheet made of polytetrafluoroethylene (PTFE) or other materials is periodically wound. When the equipment is not in operation, the heating-and-compression mechanism 150 is in a state of being moved and retracted in a direction intersecting the transport direction.

[0079] In the embodiment, the heating-and-compression mechanism 150 is composed of the first substrate 151 and the second substrate 152, which is configured to move up and down. However, the heating-and-compression mechanism 150 may be composed of heating-and-compression rollers. Such heating-and-compression rollers are configured to continuously prepare the fiber structure and thus do not have to be provided with

a buffer.

[0080] A sheet of the fiber structure (M) obtained through the recycling process as described above is cut into a desired size and shape by a cutter 160. The sheets into which the sheet of the fiber structure (M) is cut are each stacked as a whole fiber structure on, for example, a stacker 170 and are cooled. For example, an ultrasonic cutter is preferably used as the cutter 160. The fiber structure may be cut by such an ultrasonic cutter in a width direction of the fiber structure or in the width direction and the direction opposite to the width direction, that is, in the reciprocating directions. For example, a rotary cutter or an octagonal rotary cutter may be used other than an ultrasonic cutter. A whole fiber structure is then cut with, for example, a Thomson die and is formed into a desired size and shape to form the reclaimed fiber structure (M). The reclaimed fiber structure (M) is preferably usable for, for example, sound-absorbing materials, which absorb sound, cushioning materials (packing materials), which absorb shocks (external force), and materials for forming dies.

[0081] The strength and the rigidity of the fiber structure (M) in the present disclosure are maintained by firmly adhering the defibrated-cotton sheet (fibrous web) (S) to the first shape-maintaining sheet (N_1) and to the second shape-maintaining sheet (N_2). Thus, when the fiber structure (M) is cut or cut out as described above, the first shape-maintaining sheet (N_1) and the second shape-maintaining sheet (N_2) are unlikely to be peeled, and thus the fiber structure (M) can be cut with high accuracy. In addition, it is possible to achieve an effect of enabling smooth operations during, for example, handling.

[0082] The adhesive strengths between the defibrated-cotton sheet (fibrous web) (S) and the first shape-maintaining sheet (N_1) and between the defibrated-cotton sheet (fibrous web) (S) and the second shape-maintaining sheet (N_2) were tested to select the proper fiber fineness of a melting-resin fiber as a melting material. Thus, this is described in detail below.

[0083] FIG. 5 illustrates an outline of a peeling test method. The peeling test was performed to quantify the adhesive strength between the defibrated-cotton sheet (fibrous web) (S) and the first shape-maintaining sheet (N_1) (or the second shape-maintaining sheet (N_2)). In FIG. 5, the reclaimed fiber structure (M) used as a sample has a width of about 20 mm and a length of about 120 mm. One end of the reclaimed fiber structure (M) was held between a base and a holding plate. The first shape-maintaining sheet (N_1) was peeled by about 15 mm from the other end of the reclaimed fiber structure (M), and the peeled portion of the first shape-maintaining sheet (N_1) was held with a clamp. A weight was suspended from the clamp to measure the minimum weight under which the first shape-maintaining sheet (N_1) was continuously peeled. The peeling strength (N/m) per unit width was then calculated by using an expression: minimum weight (kg) $\times$ 9.8/width (mm).

[0084] Any sample contains, relative to the weight of

the defibrated-cotton sheet (fibrous web) (S), 20% by weight of the melting-resin fibers as a melting material mixed in the defibrated-cotton sheet (fibrous web) (S). Tetoron (registered trademark), which is a polyester fiber for dry nonwoven fabric and is produced by TEIJIN LIMITED, was used for the melting material. Four kinds of melting-resin fibers having a fiber fineness of 1.1 dtex, a fiber fineness of 1.7 dtex, a fiber fineness of 2.2 dtex, and a fiber fineness of 3.3 dtex were used for the test. FIG. 6 illustrates the peeling strength (N/m) depending on each fiber fineness of the melting-resin fibers.

[0085] As is clear from FIG. 6, the peeling strength (N/m) increases as the fiber fineness (dtex) of the melting-resin fibers decreases. In other words, it is clear that the peeling strength (N/m) increases as the fiber fineness of the melting-resin fibers decreases and thus the adhesive strength between the defibrated-cotton sheet (fibrous web) (S) and the first shape-maintaining sheet (N_1) increases. The fiber fineness of melting-resin fibers is preferably 2.0 dtex or less because the peeling strength (N/m) is preferably about 15 N/m or more to reduce friction and to prevent separation of fibers during handling of the reclaimed fiber structure (M).

[0086] As described above, the adhesive strength between the defibrated-cotton sheet (fibrous web) (S) and the first shape-maintaining sheet (N_1) (or the second shape-maintaining sheet (N_2)) increases as the fiber fineness of melting-resin fibers decreases. It is considered that this is because the number of the melting-resin fibers exposed from both surface (interfaces B_1 and B_2 in FIGS. 2, 3, and 4) of the defibrated-cotton sheet (fibrous web) (S) increases due to small fiber fineness of the melting-resin fibers in the defibrated-cotton sheet (fibrous web) (S), and thus the number of contact points to be adhered to each other increases.

[0087] In the equipment for manufacturing the fiber structure in the present disclosure and a method for manufacturing the fiber structure in the present disclosure, the shape-maintaining sheets (N_1 and N_2) are respectively supplied to the first surface and the second surface opposite to the first surface of the defibrated-cotton sheet (fibrous web) (S) in which melting-resin fibers as a melting material are mixed. The defibrated-cotton sheet (fibrous web) (S) to which the shape-maintaining sheets (N_1 and N_2) are supplied is simultaneously heated and compressed to adhere the shape-maintaining sheets (N_1 and N_2) to the defibrated-cotton sheet (fibrous web) (S). Thus, the equipment and the method for manufacturing a fiber structure in the present disclosure enable a fiber structure to have great ease of handling without, for example, losing the shape and to have the properties required for the fiber structure in various applications.

[0088] Next, another embodiment of the present disclosure will be described. FIG. 7 is a schematic diagram illustrating a schematic configuration of equipment for manufacturing a fiber structure according to another embodiment of the present disclosure. In FIG. 7, components having the same reference signs as those in the

above embodiment are the same components as those in the above embodiment and are not described.

[0089] The embodiment differs from the above embodiment in that, first, the airflow suctioned by the suction device 110 is led into the inlet 31 of the dry defibrator 30 by using a transport pipe 180 in the embodiment. Thus, the coarsely crushed pieces moved from the coarse crusher 10 enter the dry defibrator 30 by being urged by such an airflow. This configuration enables such an airflow to be used efficiently without being wasted and the airflow velocity at the outlet 32 of the dry defibrator 30 to be further higher than that in the above embodiment.

[0090] As described above, in the equipment and the method for manufacturing a fiber structure in the present disclosure, the reclaimed fiber structure (M) is manufactured by mixing melting-resin fibers into defibrated fibers. Thus, with the equipment and the method for manufacturing a fiber structure in the present disclosure, it is possible to manufacture a fiber structure that has great ease of handling without, for example, losing the shape and that has the properties required for the fiber structure in various applications.

[0091] In the equipment and the method for manufacturing a fiber structure in the present disclosure, the first shape-maintaining sheet (N_1) and the second shape-maintaining sheet (N_2) are respectively supplied to the first surface and the second surface opposite to the first surface of the absorber in which melting-resin fibers are mixed. The defibrated-cotton sheet (fibrous web) (S) to which the first shape-maintaining sheet (N_1) and the second shape-maintaining sheet (N_2) are supplied is simultaneously heated and compressed to adhere the first shape-maintaining sheet (N_1) and the second shape-maintaining sheet (N_2) to the defibrated-cotton sheet (fibrous web) (S). Thus, with the equipment and the method for manufacturing a fiber structure in the present disclosure, it is possible to manufacture a fiber structure that has great ease of handling without, for example, losing the shape and that has the properties required for the fiber structure in various applications.

[0092] According to the equipment and the method for manufacturing a fiber structure in the present disclosure, the equipment has a configuration in which as little water as possible is used (water resources are not consumed in large amounts) and thus has a simple configuration in which the amount of water treatment equipment can be reduced. In addition, the equipment does not have to include, for example, a large heater for removing water and thus can achieve high energy efficiency in wastewater recycling.

Claims

1. Equipment for manufacturing a fiber structure, the equipment comprising:

a defibrating section configured to pulverize and

defibrate a fiber material containing fibers;
a transport section through which a defibrated material defibrated by the defibrating section is transported;

a melting-material mixing section configured to mix a melting material into the defibrated material transported through the transport section;
a fibrous-web forming section configured to accumulate the defibrated material in which the melting material is mixed and form a fibrous web;
a sheet supply section configured to supply a shape-maintaining sheet to the fibrous web; and
a heating-and-compression mechanism configured to compress the shape-maintaining sheet and the fibrous web between planar plates and heat the shape-maintaining sheet and the fibrous web to a temperature equal to or higher than a temperature at which the melting material softens.

2. The equipment for manufacturing a fiber structure according to claim 1, wherein the sheet supply section supplies the shape-maintaining sheet to a first surface and a second surface opposite to the first surface of the fibrous web.
3. The equipment for manufacturing a fiber structure according to claim 1, wherein the melting material is melting-resin fibers, and the melting-resin fibers have a fiber fineness of 0.5 dtex or more and 2.0 dtex or less.
4. The equipment for manufacturing a fiber structure according to claim 1, wherein the melting material is resin particles, and the resin particles have a volume average particle diameter of 4 μm or more and 20 μm or less.
5. The equipment for manufacturing a fiber structure according to claim 1, the equipment further comprising a functional-material mixing section configured to mix a functional material into the defibrated material.
6. The equipment for manufacturing a fiber structure according to claim 5, wherein the functional material is a fire-retardant material.
7. The equipment for manufacturing a fiber structure according to claim 1, wherein the fibrous-web forming section includes

a dispersion member configured to disperse the defibrated material,

a mesh belt on which the dispersed defibrated material is accumulated, the mesh belt being configured to transport the accumulated defibrated material, and

- a suction member configured to suction the dispersed defibrated material via the mesh belt.
8. The equipment for manufacturing a fiber structure according to claim 1, the equipment further comprising a liquid atomizer configured to atomize a liquid onto the fibrous web transported by a mesh belt. 5
9. A method for manufacturing a fiber structure, the method comprising: 10
- pulverizing and defibrating a fiber material containing fibers;
- transporting a defibrated material through a transport section; 15
- mixing a melting material into the defibrated material transported through the transport section; accumulating the defibrated material in which the melting material is mixed and forming a fibrous web; 20
- supplying a shape-maintaining sheet to the fibrous web; and
- compressing and heating the fibrous web to which the shape-maintaining sheet is supplied and melting the melting material. 25
10. The method for manufacturing a fiber structure according to claim 9, wherein the supplying of the shape-maintaining sheet includes supplying the shape-maintaining sheet to a first surface and a second surface opposite to the first surface of the fibrous web. 30
11. A method for manufacturing a fiber structure, the method comprising: 35
- pulverizing and defibrating a fiber material containing fibers;
- transporting a defibrated material through a transport section; 40
- mixing a melting material into the defibrated material transported through the transport section; napping a surface of a first shape-maintaining sheet; 45
- accumulating, on the surface of the first shape-maintaining sheet, the defibrated material in which the melting material is mixed and forming a fibrous web;
- supplying a second shape-maintaining sheet on an opposite side of the fibrous web from a side on which the first shape-maintaining sheet is disposed; and 50
- compressing and heating the fibrous web disposed between the first shape-maintaining sheet and the second shape-maintaining sheet and melting the melting material. 55

12. The method for manufacturing a fiber structure according to claim 9, wherein the mixing of the melting material includes mixing, as the melting material, melting-resin fibers having a fiber fineness of 0.5 dtex or more and 2.0 dtex or less into the transported defibrated material.
13. A fiber structure manufactured by the method according to claim 9.

FIG. 1

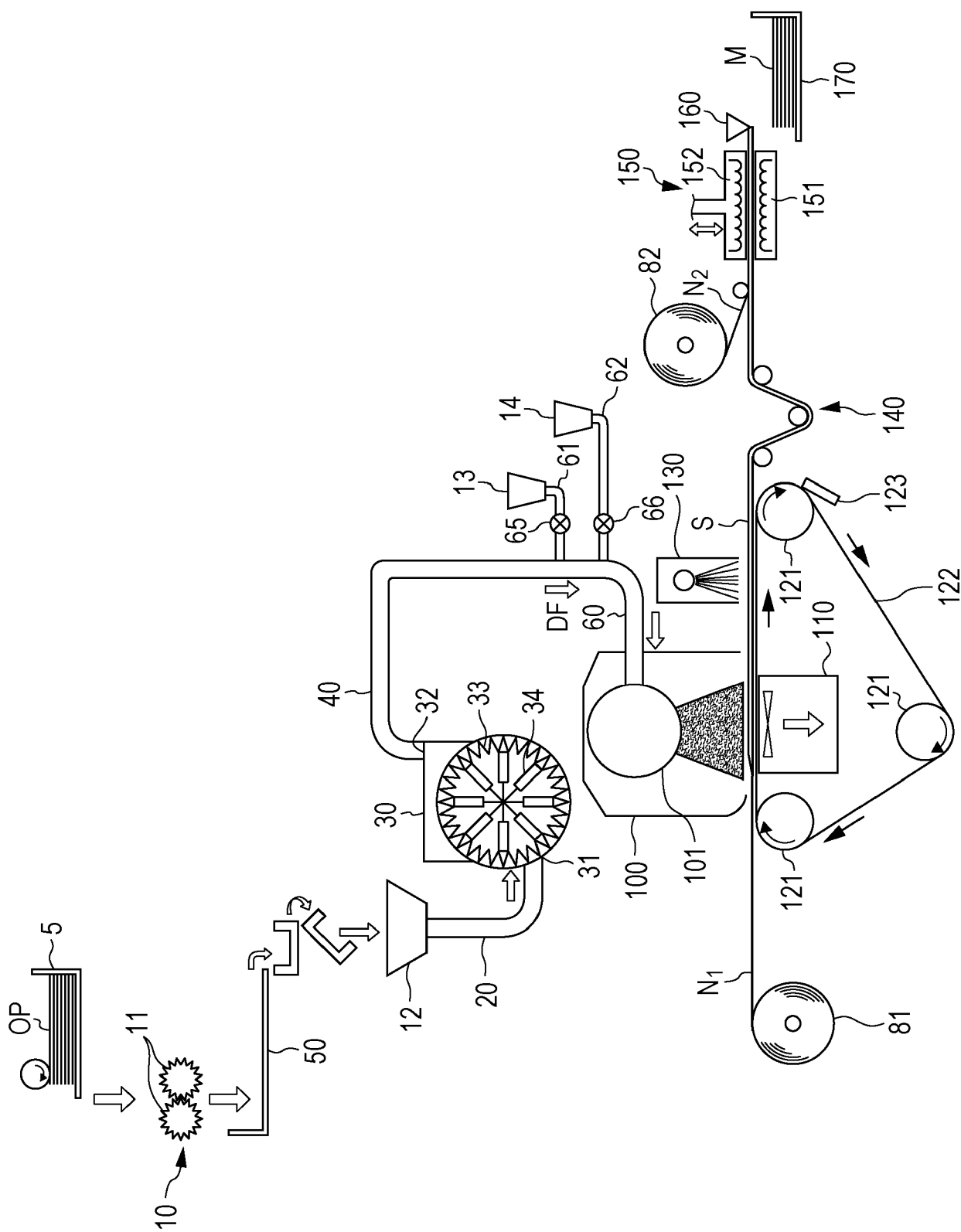


FIG. 2

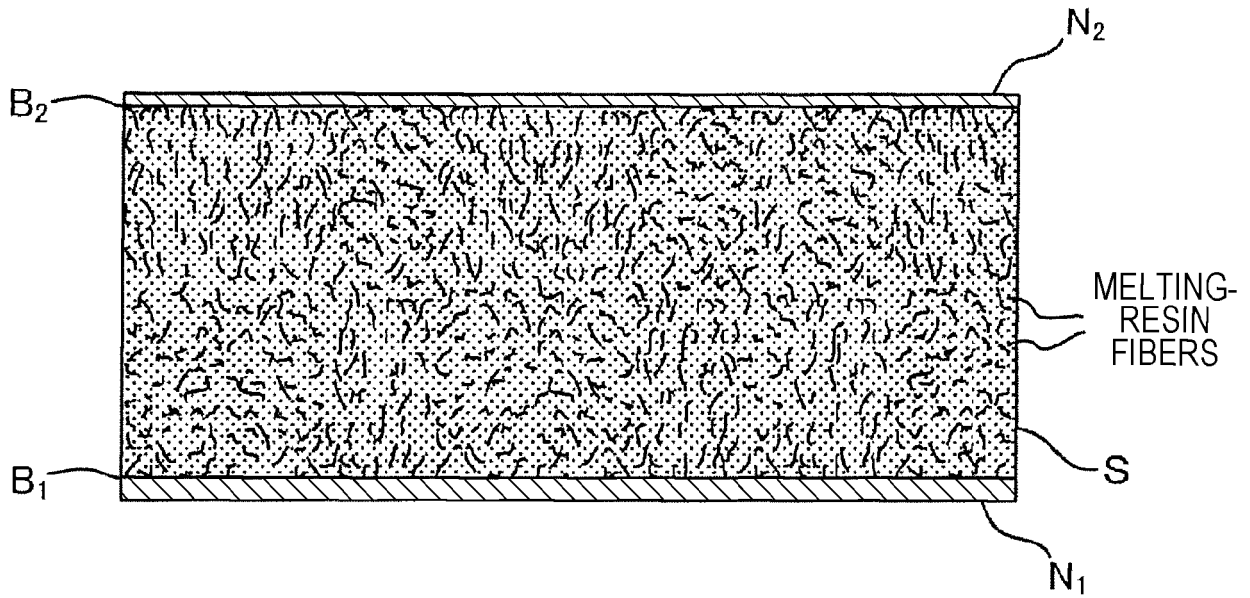


FIG. 3

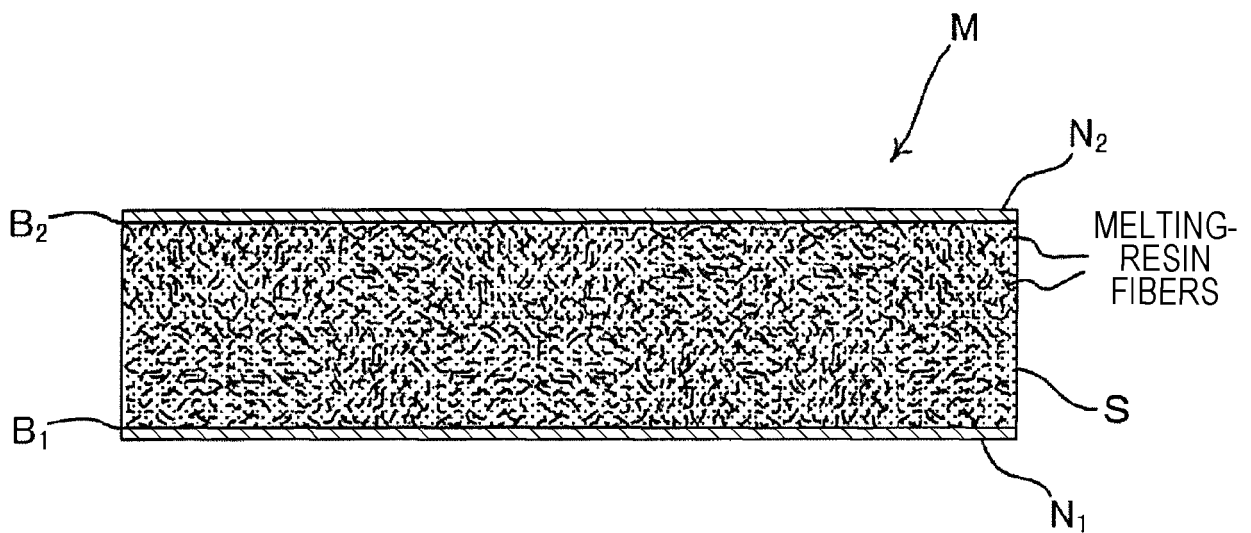


FIG. 4

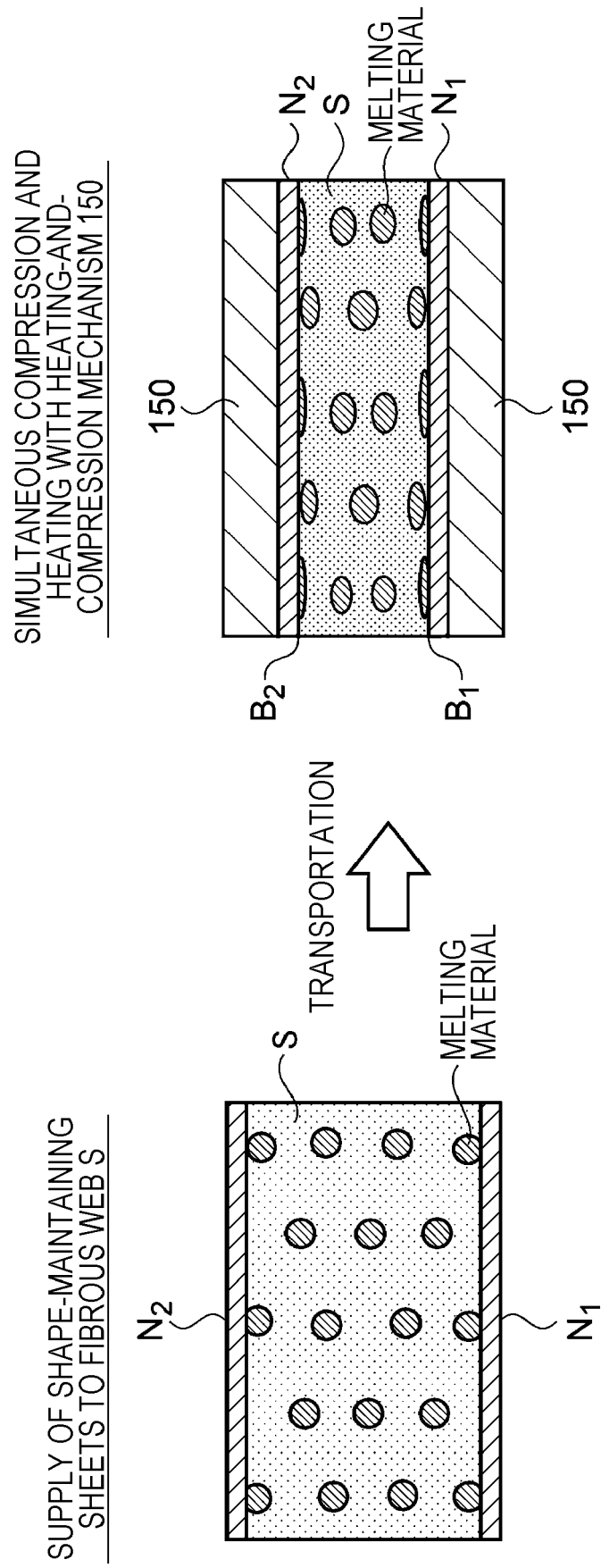


FIG. 5

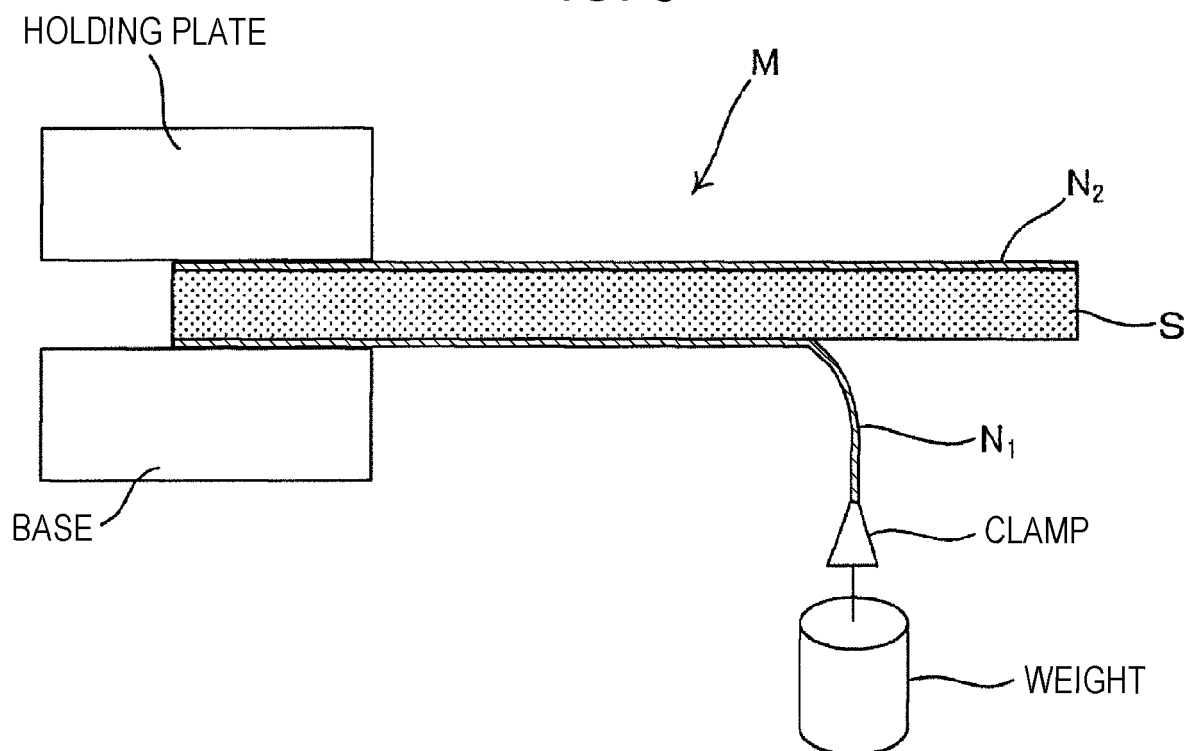


FIG. 6

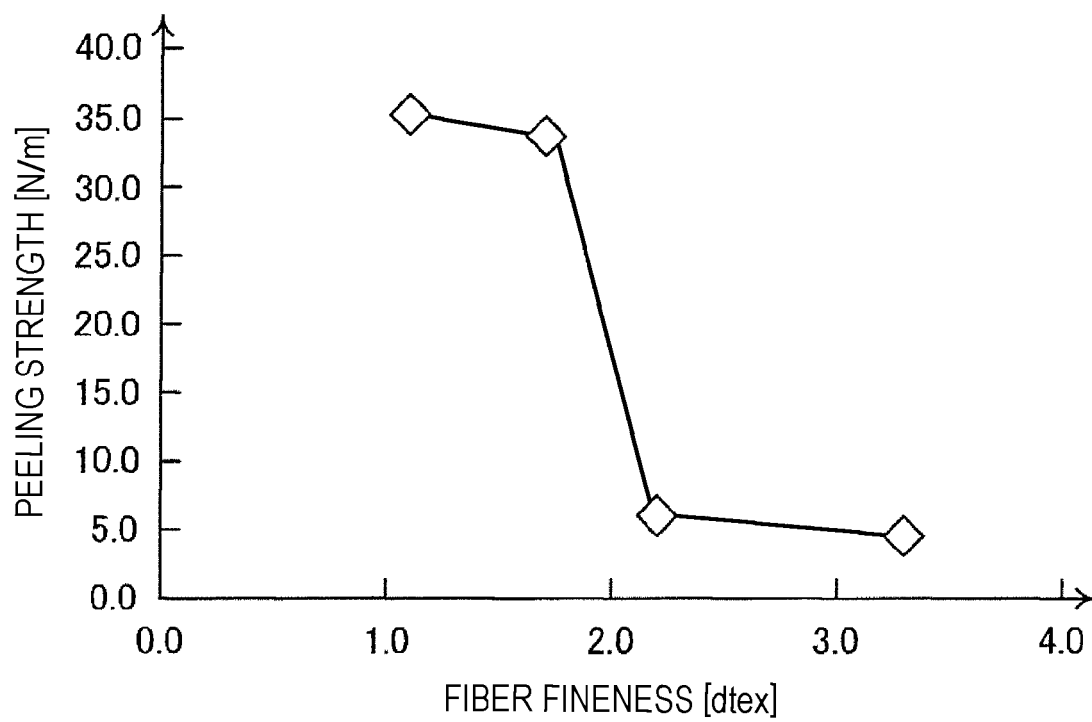


FIG. 7

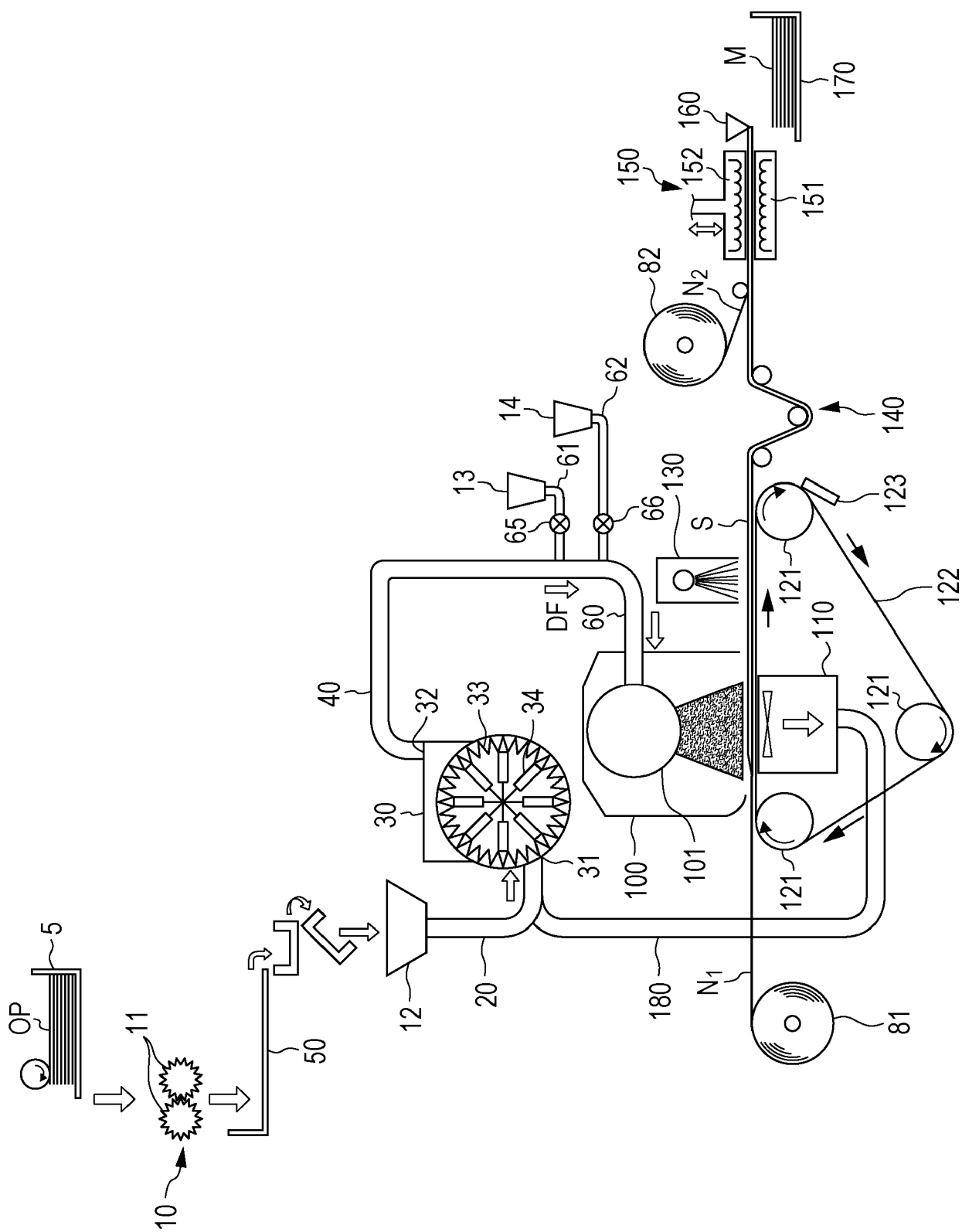
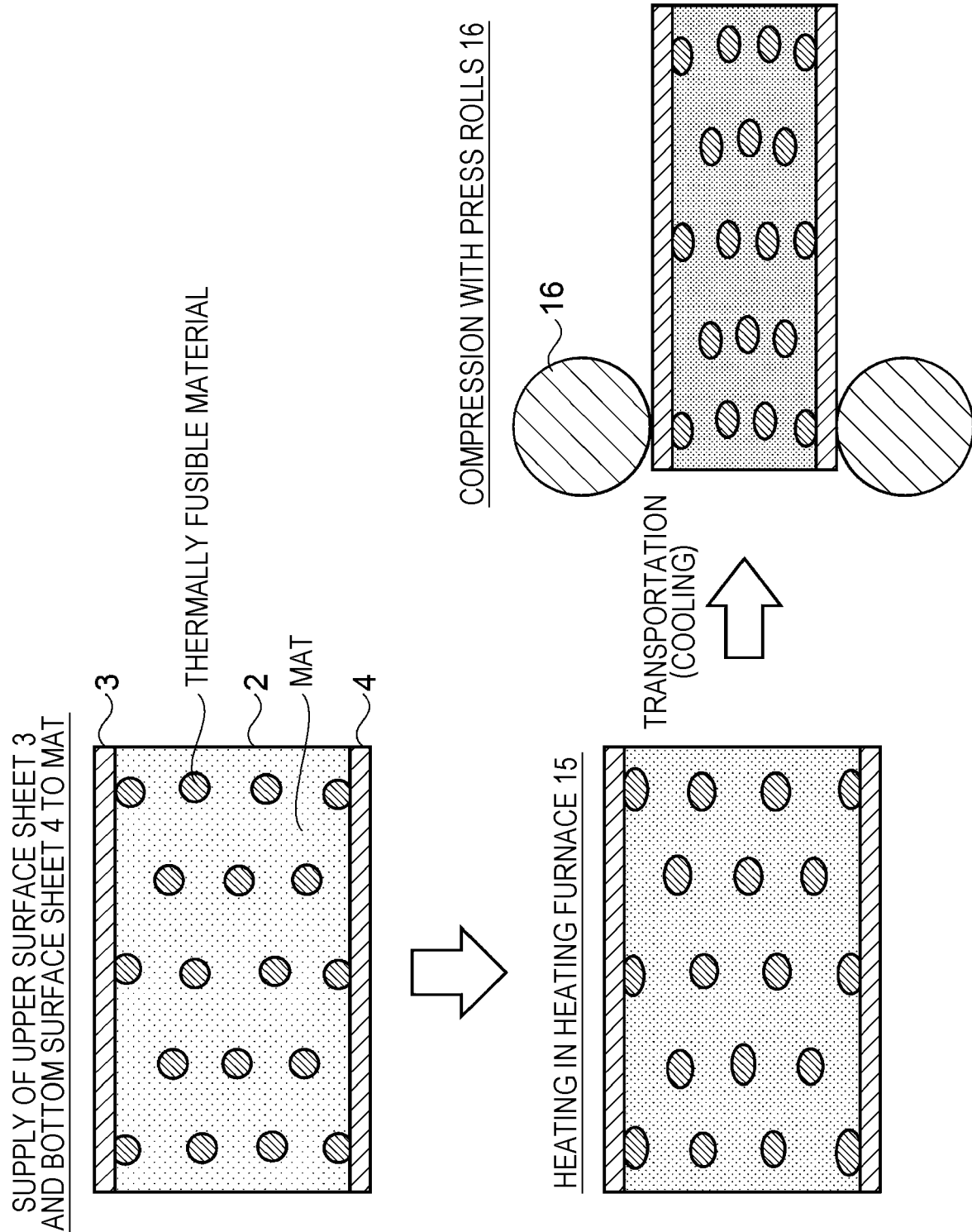


FIG. 8





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Place of search		Date of completion of the search	Examiner
Munich		27 April 2021	Ponsaud, Philippe
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