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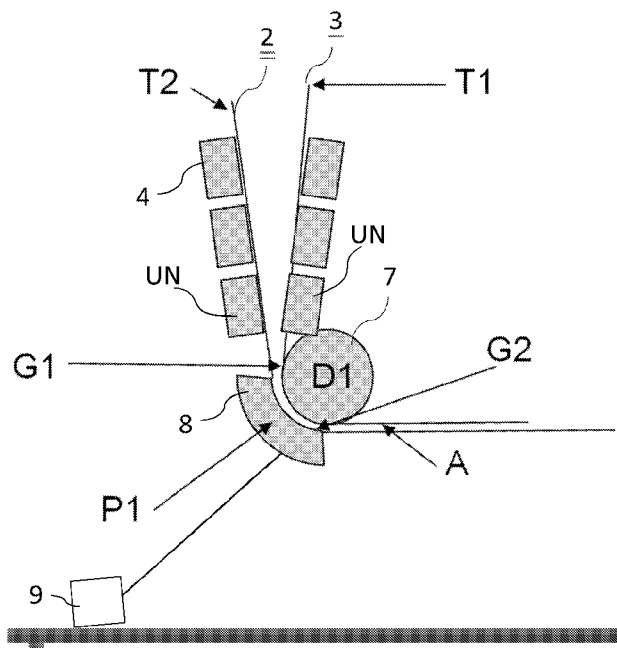


Fig. 2

(57) **Abstract:** According to an example aspect of the present invention, there is provided an apparatus for producing high bulk fibrous web, comprising: a web forming unit (1) for producing a fibrous web, a turning roll (7) and a permeable fabric (2) for transferring the web from the web forming unit (1) supported by the permeable fabric to a turning roll (7) that provides turning of the web to a horizontal direction so that the web is placed between the permeable fabric (1) and the turning roll (7). A suction box (8) providing a partial vacuum is arranged on the opposite side of the web and the fabric in relation to the turning roll (7) for controlling the distance between the fabric (2) and the turning roll (7) and the pressure on the web travelling between the fabric (2) and the turning roll (7).



GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
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METHOD AND APPARATUS FOR PRODUCING A HIGH BULK WEB

FIELD

[0001] The invention concerns method and apparatus for producing elongate fibre
5 products, especially from a furnish comprising cellulosic pulp from plant materials. The
products may be webs, yarns, fabrics or similar.

BACKGROUND

[0002] Producing webs or other products from fibres is basics of paper and board
10 manufacture. Most manufacturing methods include making a mix of fibres, water and
fillers and additives (furnish) and feeding the furnish on a permeable surface to remove
water and form a web of entangled fibres that are held together by chemical bonds and
mechanical forces. The furnish may be foamed to provide specific formation
characteristics. The web is usually rather wet after formation and further water removal is
15 needed. This can be done mechanically in a pressing nip or by heating by various methods.
Different formation and water removal methods are combined in order to obtain desired
end products and designing the manufacturing process defines the product range that can
be manufactured.

[0003] One way to form a web on fabric or similar forming surface is to use feeding
20 funnels. The greatest problem regarding such art (US2010187712 and US2010187171) is
the great amount of funnels, which are difficult to arrange properly in a production scale.
Flow variations occur and bending of structures distorts the feeding process. Processes
described in these publications are not applicable in production scale. There are also
publications US6238518 (B1) and US 6503372. These publications present how to produce
25 multi-layered webs. The drawback of this method is that there is no method or apparatus
describing how to arrange fibres in wished directions in different layers. Fibres are
orientated mostly in machine direction and fibre orientation can't be controlled efficiently.

[0004] Various methods and processes for water removal are described in
publications WO 2009024186, EP 2722437, EP 2063021, EP2722434.

[0005] Known methods for producing webs, fabrics, yarns and such products from fibres have their characteristic strengths and drawbacks. Some methods are suitable for cellulosic material and others better suitable for artificial fibres or mixtures of these fibres. Therefore there is need for novel methods for manufacture of these products. One problem
5 that is constantly addressed is loss of bulk during formation, pressing and drying stages. PCT/FI2017/050696 discloses a method capable for increasing bulk of the web. However, the high bulk of the web is partially lost during subsequent manufacturing stages.

SUMMARY OF THE INVENTION

10 [0006] The invention is defined by the features of the independent claims. Some specific embodiments are defined in the dependent claims.

[0007] According to a first aspect of the present invention, there is provided a web forming unit for producing a fibrous web and the web is transferred from the web forming unit supported by a permeable fabric to a turning roll that provides turning of the web from
15 a vertical direction of the forming section to a horizontal direction so that the web is placed between the permeable fabric and the turning roll. A suction box is providing a partial vacuum and is arranged on the opposite side of the web and the fabric in relation to the turning roll for controlling the distance and pressure on the web travelling between the fabric and the turning roll.

20 [0008] According to a second aspect of the present invention, there is provided a suction box that is concave towards the turning roll.

[0009] According to a third aspect of the invention, there is provided adjustment actuators for controlling at least one of the following: distance of the suction box from the turning roll, distance of the exit edge of the suction box and the turning roll and distance of
25 the incoming edge of the suction box and the turning roll.

[0010] According to a fourth aspect of the invention, there is provided means for controlling the pressure difference between the ambient pressure and the suction box.

[0011] According to a fifth aspect of the invention, the web is formed between two fabrics.

[0012] According to a sixth aspect of the invention, the web is formed on a single fabric.

[0013] According to a seventh aspect of the invention, the web is formed between two fabrics and the fabric travelling on the side of the turning roll is separated from the web when the web exits from the turning roll.

[0014] According to an eighth aspect of the invention, there is provided a suction box having curved suction surface upstream of the turning roll.

BRIEF DESCRIPTION OF THE DRAWINGS

10 [0015] FIGURE 1 illustrates a basic principle of manufacturing fibrous webs.

[0016] FIGURE 2 illustrates schematically the principle of the invention in accordance with at least some embodiments of the present invention;

[0017] FIGURE 3 illustrates an example apparatus capable of supporting at least some embodiments of the present invention.

15

EMBODIMENTS

[0018] DEFINITIONS

20 [0019] In the present context, the term “partial vacuum” depicts a pressure below ambient pressure.

[0020] Ambient pressure is the pressure in the space where the manufacturing takes place, in practice the ambient pressure of the environment.

[0021] In the following, the word “web” is used for products that can be made by utilizing embodiments of the invention. It must be understood that the invention is applicable for manufacturing any kind of elongated fibrous materials.

[0022] When fibrous webs of various kinds are manufactured, the fibres are usually mixed in water or foam and the water content of the mixture is high. This mixture can be formed to a web in various ways and usually the bulk of the web is high at the initial stages of the formation. In order to form a coherent web, water has to be removed from the web.

5 This can be done at first stages by compression and/or vacuum. Especially the compression decreases the bulk of the web. For many products it is desirable to maintain as high bulk as possible since it decreases the amount of fibres needed to make the product and provides some desired properties. However, some compression is needed for various reasons related to the manufacturing process and some loss of the desired bulk is unavoidable. One stage

10 wherein the bulk is lost without providing any beneficial properties to the product is turning of a web that is formed in vertical direction to travel to horizontal direction. This turn is unavoidable as the machinery needed for further processing of the web is quite long and building the whole machinery applying only vertical or horizontal direction would be extremely expensive. For this turn or change of direction a turning roll is used. The turning

15 roll that provides the change of direction is the first turning roll in the downstream travel direction of the web after the web exits from the forming section. As the web travels around the turning roll, the web is unavoidably compressed against the roll and this compression leads to loss of bulk. The various embodiments of the invention address this problem by controlling the distance between the turning roll and the fabric whereon the

20 web travels by suction.

[0023] FIGURE 1 illustrates a basic principle of manufacturing fibre products. More detailed description of this process can be found in PCT/FI2017/050696. The making of the product begins with forming of a web or other elongated product by a former apparatus

1. The former apparatus 1 is arranged first in the upstream direction of the production

25 process at the formation step. At this step furnish comprising fibres water or foam and additives is fed to the nip of fabrics 2, 3 in order to give form to the product that is manufactured. Some of the applicable forms are narrow strips for yarns, wider strips or webs for paper, board, fabric or non-woven products. After the formation step the product is transferred to the pressing and heating stage 6. In this stage pressing and heating is

30 performed in order to provide the final form and consistency for the product that is manufactured.

[0024] FIGURE 2 shows schematically a forming process wherein the web is formed between two fabrics 2, 3. As the invention can be utilized with any forming

technique, the forming process is not described in detail here. In any case a furnish comprising fibres in water or foam suspension is fed on a single fabric that is arranged so that the furnish is sufficiently supported, or the furnish is fed into a gap formed between two fabrics, the first fabric 2 and the second web fabric 3 as in the FIGURE 2. Suction boxes 4 placed on the fabrics may be used to remove water from furnish in order to make the web more coherent. The fabrics 2, 3 are set in a narrowing angle in relation to each other. This provides pressure on furnish and causes water removal through the permeable webs. However, in order to maintain high bulk of the web, the fabrics should be kept apart so that the web is not compressed too much. As the fabrics have to be kept under high tension, the pressure on the web becomes high when the web and the fabrics contact the first turning roll 7 after the forming section and start to turn around the turning roll 7. Normally, this would lead to compression of the web and loss of bulk and consequently thickness of the web.

[0025] In order to avoid pressing of the outer fabric (herein first fabric 2) on the turning roll 7, a concave suction box is placed partially around the turning roll 7. The concave suction box 8 may extend from the contact point of the second fabric 3 that travels against the turning roll 7 to the exit point of the fabrics 2, 3 and the web. The suction box 8 may comprise one single unit or two or more successive units that may even be distanced from each other. In one embodiment, the suction box 8 comprises a concave surface having perforations for providing the suction/vacuum over the first fabric 2. The combined area of the perforations OA may be about min 10% of the surface area to the concave surface. Alternatively any common suction box may be used but they are usually more complex in structure. In order to avoid high stresses, the diameter D1 of the turning roll 7 should be sufficiently large. The diameter can be as small as 200 mm, but it should be preferably at least 400 mm or even more preferably 800 mm or more. The radius R1 of the concave surface of the suction box may be the same or larger as of the turning roll 7

[0026] The incoming gap G1 and the exit gap G2 between the fabrics 2 and 3 may be separately adjustable. For this purpose, adjustment actuators may be provided. In practise, the gap is adjusted by adjusting the distance of the edges of the suction box 8 and the turning roll 7. The adjustment of the exit gap (distance between the fabrics at the exit from the turning roll 7 of the first fabric and the turning roll 7 when only one fabric is used) is of particular interest as this adjustment may be used for controlling the thickness of the web that exits from the turning roll 7. The scale of the thickness of the manufactured

web on which the invention is applicable is quite large, from tissue to thick insulation or sound insulation materials. The curved suction box 8 keeps the fabrics 2, 3 all the time on a distance G1 and G2 from each other so that the fabrics may not be pressed against each other and don't compress the web. The suction box 8 may be used to adjust the distance
5 between the fabrics and the pressure on the web by adjusting the distance of the suction box 8 in relation to the turning roll and the suction force, i.e. the pressure difference provided by the suction box in relation to the ambient pressure. The above arrangement enables a process wherein the web is not allowed to be pressed before the suction box 8, not on its position or even after the suction box. The curved suction box in invention
10 enables adjustment of the distance between fabrics and thereby essentially the bulk.

[0027] The fabrics must be maintained highly tensioned in most manufacturing processes. As an example, the fabrics used with some embodiments of the invention may have an adjustable tension of 2-15 kN/m. This causes high pressure between the webs especially at turning roll 7. As the web is easily compressible at this stage, high pressure
15 leads to high loss of bulk. As some embodiments of the invention provide control of the distance between fabrics 2, 3 or alternatively between the first fabric 2 and the turning roll 7, the thickness of the web exiting from the turning roll 7 and consequently the bulk can be controlled and kept high. The tensions T1 and T2 are usually independently adjustable.

[0028] One feature that has to be taken into account when fibrous webs are made
20 using two opposing fabrics is that one must always control which one of the fabrics the web follows when fabrics are separated. If this is not controlled, the web may split between the fabrics. The concave suction box provides such control automatically. The second fabric may even be lifted from the web immediately or shortly after it exits from the turning roll and the exit angle of the second fabric can be great. The angle between the
25 fabrics on the exit side downstream of the turning roll 7 is depicted with A. This angle should be 0° in minimum. This enables designing shorter route for the second fabric, and consequently a shorter fabric is needed. This is a significant economic advantage. Further, the suction or vacuum provided by the concave suction box 8 enables controlling the distance (gap) between the webs. The pressure difference between the ambient and the
30 partial vacuum provided by the concave suction box 8 may be adjustable. The adjustment is provided by a control unit 9. This provides enhanced process control and more control on water removal. Water removal over the concave surface is efficient as the tension of the fabric keeps the web slightly off from the concave surface and water is removed over the

whole surface, not only at the perforations. The pressure difference or vacuum needed to hold the first fabric towards the concave surface is low as the surface area is large and the vacuum is distributed freely over the whole surface. The pressure P1 inside of the suction box may be between 0 to -70 kPa.

5 **[0029]** In addition to maintaining high bulk, the invention provides better structure of the web as the structure of the web formed at the forming stage is maintained as the web is not overly compressed. The water removal over the turning roll 7 and on the concave vacuum box is efficient, whereby the web exiting the turning roll has high solids content/low moisture content. This decreases need of further drying and subsequent suction
10 boxes after turning roll may be omitted. This leads to decreased stress on fabrics and the lifetime of the fabrics is increased. Further, need of drying power in further stages is reduced, whereby the overall length of the machine is decreased. Financial advantages are evident.

15 **[0030]** One embodiment of the invention comprises a curved suction box UN at the forming section just before the nip of the fabrics and the turning roll. This curved suction box UN is placed on the so called upstream nip area located before the nip of the fabrics and the turning roll 7. Thus, this curved suction box UN may be called upstream suction box UN. The upstream suction box may be placed on one or both sides of the fabrics. This upstream suction box UN may be used on a location before the turning roll 17 and the
20 suction box 7 wherein the fabrics may curve slightly at the curved upstream suction box UN of boxes and where the web travels slightly compressed. The curved surface may be concave or convex. The curved surface causes water to expel by centripetal force. The same effect exists on concave suction box. This enhances water removal even more. A concave suction box UN upstream the turning roll 8 may apply a pressure of 0 – 70 kPa to
25 maximize water removal and minimize loss of bulk caused by the fabric tension at this point of web formation. However, the curved surface placed at the forming section or forming area may not cause pressure differences in cross direction (CD) of the machine in order to avoid disturbances in the formation.

30 **[0031]** It is to be understood that the embodiments of the invention disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for

the purpose of describing particular embodiments only and is not intended to be limiting.

[0032] Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment.

[0033] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present invention may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

[0034] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided, such as examples of lengths, widths, shapes, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

[0035] While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

[0036] The verbs “to comprise” and “to include” are used in this document as open limitations that neither exclude nor require the existence of also un-recited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", i.e. a
5 singular form, throughout this document does not exclude a plurality.

INDUSTRIAL APPLICABILITY

[0037] The invention can be used for manufacturing fibrous webs for various purposes.

ACRONYMS LIST

10 ABC Definition

REFERENCE SIGNS LIST

	1	former apparatus
	2	first fabric
	3	second fabric
15	4	suction box
	5	turning roll
	6	heating stage
	7	turning roll
	8	concave suction box
20	9	control unit

CITATION LIST

Patent Literature

US2010187712 , US2010187171, US6238518, US 6503372, WO 2009024186, EP
2722437, EP 2063021, EP2722434, PCT/FI2017/050696

CLAIMS:

1. An apparatus for producing high bulk fibrous web, comprising:
 - 5 – a web forming unit (1) for producing a fibrous web,
 - a turning roll (7),
 - a permeable fabric (2) for transferring the web from the web forming unit (1) supported by the permeable fabric to a turning roll (7) that provides turning of the web so that the web is placed between the permeable fabric (1) and the turning roll
 - 10 (7), and
 - a suction box (8) providing a partial vacuum arranged on the opposite side of the web and the fabric in relation to the turning roll for controlling the distance between the fabric (2) and the turning roll (7) and pressure on the web travelling between the fabric (2) and the turning roll (7).
- 15 2. An apparatus according to the claim 1, wherein the suction box (8) has a concave surface towards the turning roll (7).
3. An apparatus according to one of the claims 1 or 2 comprising adjustment actuators for controlling at least one of the following: distance of the suction box (8) from the turning
- 20 roll (7), distance (G2) of the exit edge of the suction box (8) and the turning roll (7) and distance (G1) of the incoming edge of the suction box (8) and the turning roll (7).
4. An apparatus according to one of claims 1 – 3, comprising a control unit (9) for controlling the pressure difference between the ambient pressure and the suction box (8).
- 25 5. An apparatus according to any of the preceding claims, comprising two fabrics (2, 3) wherebetween the web is formed.
6. An apparatus according to one of the claims 1 – 4, comprising one fabric (2) whereon
- 30 the web is formed.
7. An apparatus according to the claim 5, wherein the web is formed between two fabrics (2, 3) and the fabric (3) travelling on the side of the turning roll (7) is separated from the web when the web exits from the turning roll (7).

8. An apparatus according to any of the preceding claims, comprising a suction box having curved suction surface upstream of the turning roll.

9. A method for producing high bulk fibrous web, comprising:

- 5 - producing a fibrous web by a web forming unit (1),
- changing the direction of travel by a turning roll (7),
- transferring the web from the web forming unit (1) supported by a permeable fabric (1) to a turning roll (7) that provides turning of the web to a horizontal direction so that the web is placed between the permeable fabric
- 10 (1) and the turning roll (7), and
- providing a partial vacuum by a suction box (8) arranged on the opposite side of the web and the fabric in relation to the turning roll (7) for controlling the distance between the fabric (2) and the turning roll (7) and the pressure on the web travelling between the fabric (2) and the turning roll (7).

15

10. A method according to the claim 9, comprising controlling at least one of the following: distance of the suction box (8) from the turning roll (7), distance (G2) of the exit edge of the suction box (8) and the turning roll (7) and distance (G1) of the incoming edge of the suction box (8) and the turning roll (7).

20

11. A method according to one of claims 9 – 10, comprising controlling the pressure difference between the ambient pressure and the suction box (8).

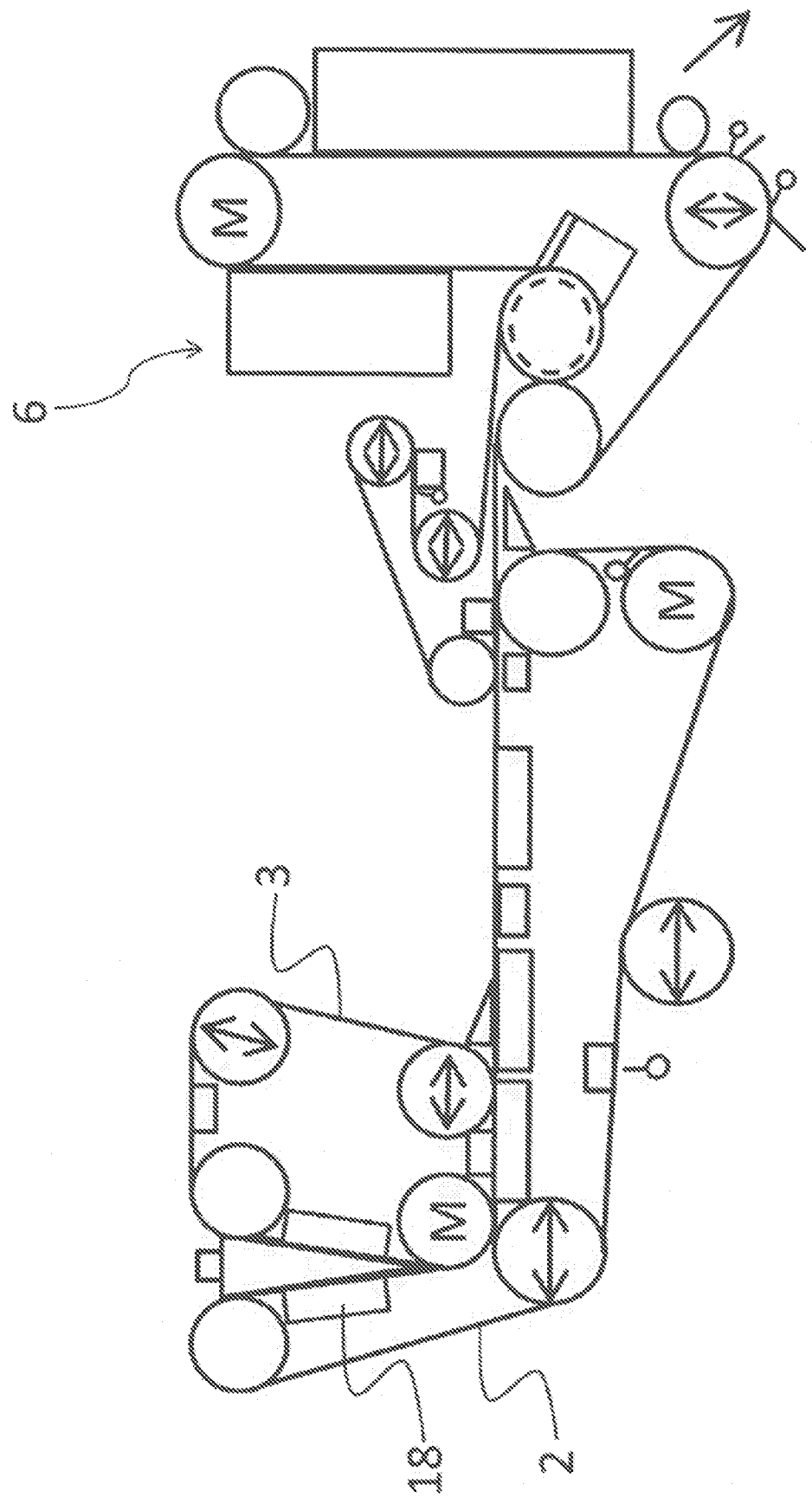


Fig. 1

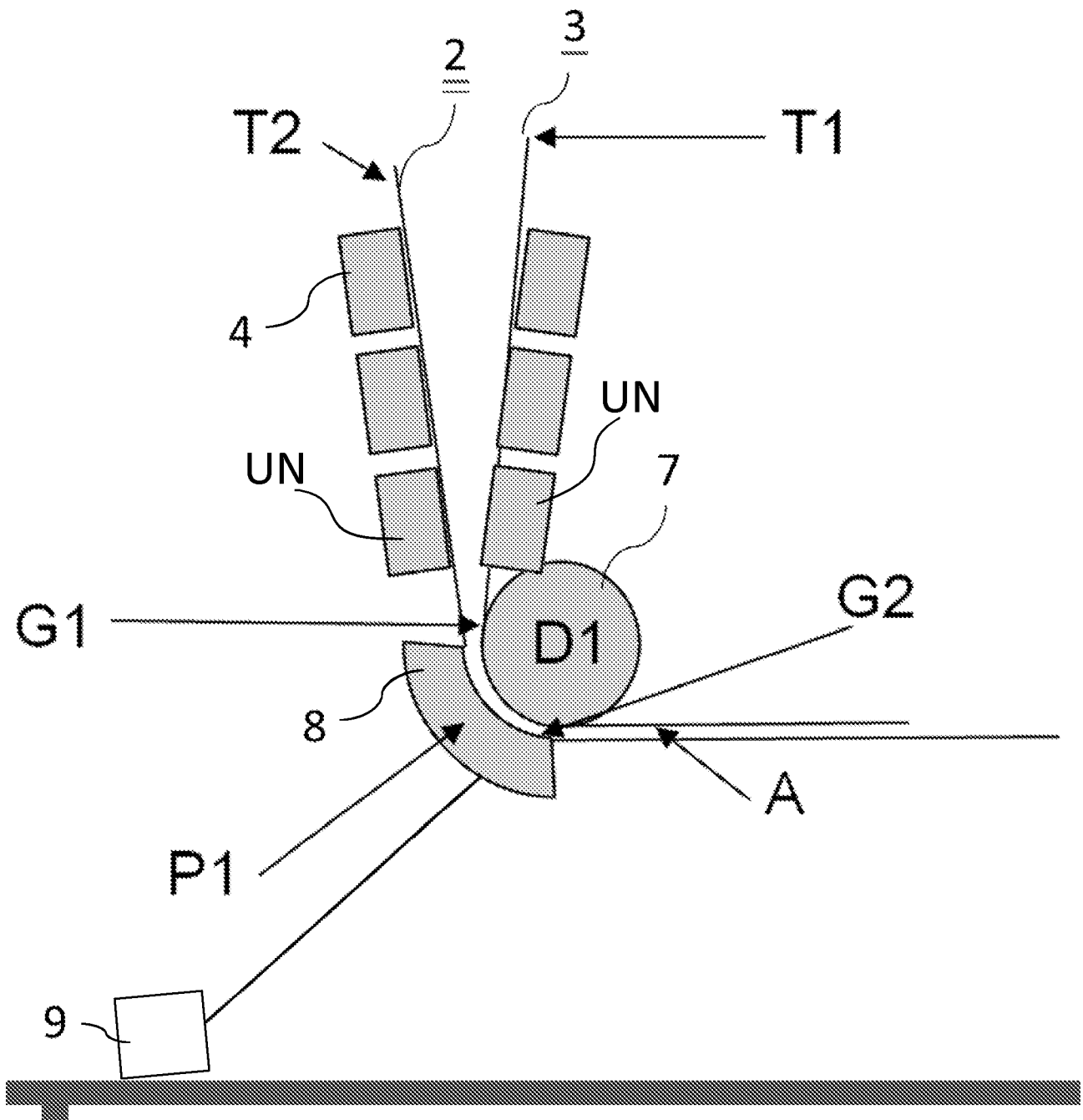


Fig. 2

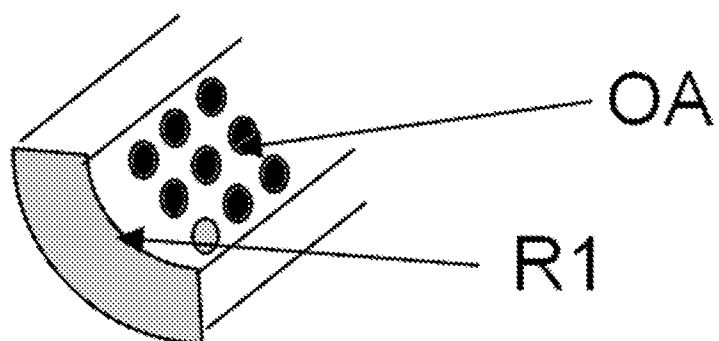


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2019/050455

A. CLASSIFICATION OF SUBJECT MATTER
INV. D21F1/52 D21F9/00 D21F11/14
ADD.

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)
D21F

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/120295 A1 (METSO PAPER INC [FI]; VAELIKANGAS ARTO [FI]; LANKINEN RAUNO [FI]) 16 November 2006 (2006-11-16) page 6, line 27 - page 8, line 26; figure 1 -----	1,2,5, 7-9
X	WO 01/31120 A1 (METSO PAPER INC [FI]; HEIKKILAE PERTTI [FI] ET AL.) 3 May 2001 (2001-05-03) page 6, line 21 - page 7, line 13; figures -----	1,2,5,7, 9
X	DE 23 31 313 A1 (VOITH GMBH J M) 16 January 1975 (1975-01-16) page 4, paragraph 2 - page 6, paragraph 1; figures 1,3,7-10 ----- -/-	1,2,6,8, 9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2019/050455

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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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2019/050455

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