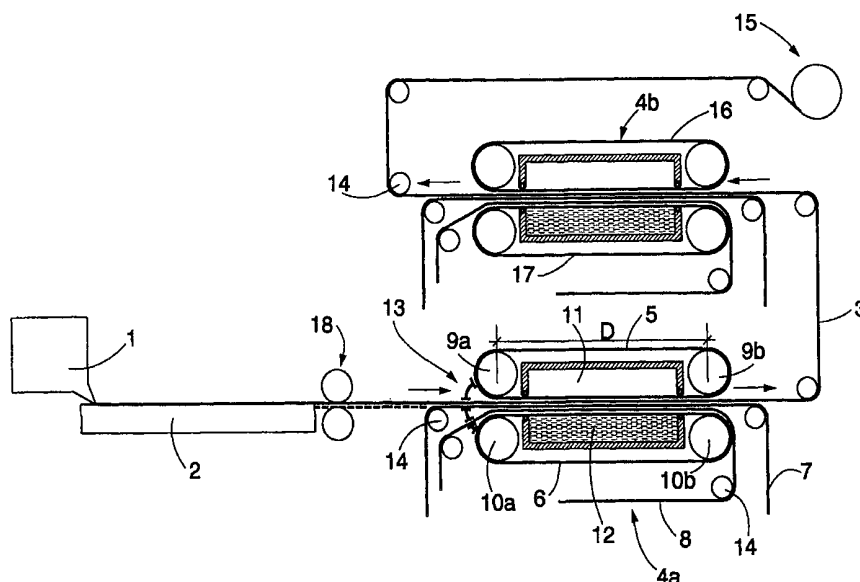




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(54) Title: METHOD OF AND APPARATUS FOR MANUFACTURING PAPER



(57) Abstract

The invention relates to a method and an apparatus for manufacturing paper, and to a press in a paper machine. A fibre web (3) is supplied to a web processing unit (4a) that comprises two endless bands (5, 6) which are impermeable to air and which are arranged to turn around turning rolls (9a, 9b; 10a, 10b) and to run part of the way parallel to each other. The first band (5) is heated and the second band (6) is cooled, and the fibre web (3) is led on a felt or a wire (7, 8) between the bands (5, 6) so that the fibre web (3) touches the heated band (5). A press section is formed between the bands (5, 6), which press section is so long that the fibre web (3) is subjected in the web processing unit (4a) to pressing and at least partly to drying.

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METHOD OF AND APPARATUS FOR MANUFACTURING PAPER

The invention relates to a method of manufacturing paper, the method comprising supplying a pulp to a former that forms a fibre web, pressing moisture from the fibre web, drying the web and reeling it with a reel.

- 5 The invention further relates to an apparatus for manufacturing paper, the apparatus comprising at least a headbox, a former, means for pressing and drying a fibre web, and a reel.

A conventional paper or paperboard machine comprises at least a headbox, a former, a press, a dryer and a reel. A pulp is supplied from the
10 headbox to the former, where a fibre web is formed from the pulp. When the pulp is supplied to the former, it has a dry solids content typically in the range of 0.2 to 1.5%. In the former water is removed from the pulp so that the dry solids content of the formed fibre web is typically about 20%. After the former the fibre web is supplied to the press, where it is further dewatered so that the
15 dry solids content of the fibre web is typically between 35 and 45%. In the dryer the web is dried further to provide a paper or paperboard web having a dry solids content of about 90 to 95%. The finished web is reeled with the reel to wait for further processing, such as calendering or coating.

In the press, the web is led on a felt through a pressing zone or nip
20 formed by the point of contact of two rolls. The press comprises several nips, typically three or four, which are placed one after another. In each nip water is pressed from the web to the felt. The rolls forming the nip are special rolls, such as granite rolls, suction rolls and/or pressure-compensated rolls. Such special rolls are difficult to manufacture and thus expensive. A paper web
25 typically reaches its maximum dry solids content in the nip at a point where the water pressure is equal both in the web and in the felt. When the web and the felt emerge from the nip, they revert back towards their original thickness preceding the pressing, whereafter the web and the felt that is impregnated with water are separated. During these steps some of the water that was
30 already removed from the web starts to return to the web, in other words rewetting occurs. Further, in the press the structure of the web is stressed by rapid press impulses acting on the web in the nip. The web is also subjected to stress during the numerous occasions it is detached from the pressing surfaces. Repeated press impulses and the numerous times the web is
35 detached increase the line tension required by the web transfer. Between the nips the web travels open so that stretching of the web in the machine

direction leads in open draws to narrowing of the web in the cross direction. The line tension thus tends to increase the stretching of the web in the machine direction, local variations in web properties, and roughness of the cross direction profile, and to decrease especially the cross-directional properties of the web.

In so-called wet pressing, a high pressing pressure is applied to remove water which is found mainly on the fibre surfaces and in the pores between them. When the web is detached from the roll in the wet pressing, internal shear forces occur in the web, making the web structure weaker and possibly breaking already existing interfibre bonds. So-called hot pressing employs a high temperature and pressing pressure. Heat is transmitted to the web primarily to obtain a high steam pressure and to achieve a hydraulic pressure gradient inside the fibre network. The hydraulic pressure gradient is produced by means of an occurring steam front. The steam front pushes liquid water ahead to the felt. The amount of heat transmitted in a press impulse during the pressing may be greater than what is required to achieve the aforementioned process. In such a case, the extra energy causes evaporation of water from inside the web and to some extent also from inside the fibres. The problem with this method is how to decrease the steam pressure inside the web to a sufficiently low level before the mechanical pressing ends in order to prevent the web from splitting. Even at best the amount of dry solids in hot-pressing applications remains so low that the risk of web splitting cannot be completely eliminated, wherefore the range of operation available in the hot pressing is rather limited, in other words the temperature of the roll, the pressing pressure, paper basis weight and the density and permeability of the web may only vary within a narrow range.

US Patent 5,071,513 sets forth solutions for producing a lengthened pressing zone and discloses the use of heat to improve the removal of liquid water. These arrangements mainly relate to thermally assisted wet presses with long nips. In the arrangement, a high pressing pressure and a high temperature of the pressing surface are applied to provide a steam front which makes the pressing more effective by pushing water ahead to the felt. The pressing surface is not heated during the pressing but before the nip. The pressing pressure is transmitted in two stages. At the end of the pressing most of the water has already been removed but the thermal energy remaining in the web is still able to evaporate a small amount

of humidity. This arrangement is a very rough dewatering method, which causes variation in the properties of the web in the direction of web thickness and possibly moves the smaller particles, such as filler particles. Further, the pressing zone is so short that even though some water can be removed from the web, the properties of the web cannot be changed significantly.

The purpose of the present invention is to provide an arrangement with which the properties of a fibre web can be improved and the aforementioned drawbacks can be avoided.

The method according to the invention is characterized by pressing moisture from the fibre web with a web processing unit comprising two endless bands that are impermeable to air, first turning rolls, around which the first band is arranged to turn, and second turning rolls, around which the second band is arranged to turn, the first band being heated and the second band being cooled, and the first and the second band being arranged to run part of the way parallel to each other so that a press section is formed between the bands, in which section the fibre web is subjected to pressing and at the end of the press section at least partly to drying, the change from the pressing to the drying taking place gradually, and the fibre web and at least one felt or wire being led between the bands so that the fibre web touches the heated first band.

Further, the apparatus according to the invention is characterized in that the apparatus comprises a web processing unit comprising two endless bands that are impermeable to air, first turning rolls, around which the first band is arranged to turn, and second turning rolls, around which the second band is arranged to turn, heating means for heating the first band and cooling means for cooling the second band, which first and second band are arranged to run part of the way parallel to each other so that a press section is arranged between the bands, which section is so long that in the web processing unit the fibre web is subjected to pressing and at the end of the press section at least partly to drying, the fibre web and at least one felt or wire being arranged to be led between the bands so that the fibre web is arranged to touch the heated first band.

The basic idea of the invention is that moisture is pressed from a fibre web with a web processing unit comprising two endless bands which are impermeable to air and arranged to turn around turning rolls and to run part of the way parallel to each other. The first band is heated and the second band

is cooled, and a fibre web runs between the bands on a felt or a wire so that the web touches the heated band. A long press section is thus formed between the bands. The press section is so long that at the beginning of the press section the fibre web is subjected to wet pressing and at the end thereof at least partly to drying. The pressing and the drying are not clearly separated but the change from one process to the other in the web processing unit takes place gradually. At the beginning of the web processing unit, heat is transferred to the interior of the web by means of steam. The idea of a preferred embodiment is that the press section is so long that at the end thereof the web surface dries and the generation of steam at the interface between the web and the hot band ends, whereupon at the end of the press section the process changes to conductive heat transmission where heat is transferred into the interior of the web through conduction. The idea of a second preferred embodiment is that the length of the press section is adjusted such that the ratio of its length to the distance between the turning rolls of one band is greater than 3:5. The idea of a third preferred embodiment of the invention is that after the web processing unit according to the invention the web is dried with a second, substantially similar web processing unit. The idea of a fourth preferred embodiment is that the first and the second web processing units are placed one on top of the other.

The invention has an advantage that the dewatering is rapid and it is closely connected to solidification of sheet structure and formation of interfibre bonds. The removal of liquid water mainly from between the fibres is also closely related to the removal of water from fibre walls. Transfer from a web structure where cohesion is based on water surface tension to a structure where cohesion is based on interfibre hydrogen bonds takes place continuously without intermediate steps. The internal structure of fibres and the structure of interfibre bonds can be adjusted advantageously. Thus, both the mechanical properties and the geometrical structure of the web remain unchanged. Also, the stretching, narrowing and shrinkage of the web can be prevented entirely. In the arrangement according to the invention, the web is dried in the web processing unit sufficiently in order to eliminate the risk of web splitting, since the strength of the web increases as the structure becomes more cohesive due to the new interfibre bonds. Secondly, the permeability of the web increases as water is removed, and thirdly, the steam pressure inside the web does not differ substantially from the ambient

pressure as the steam emerges from the web processing unit. It is possible to avoid the absorption of water back into the web after the pressing, and the press impulses that stress the structure of the fibre web. Further, the number of times the web must be detached from the pressing surfaces can be reduced, which means that the web structure is stressed to a lesser extent and the line tension does not have to be very high. Further, the number of open draws over the web path can be reduced, which leads to better and more even quality properties and also enables a higher speed of the paper machine. Also, the removal of water in the form of liquid and steam can be controlled in the best possible manner with respect to the paper properties. There are several possible control variables, such as pressing pressure, surface temperature of the heated band, and surface temperature of the cooled band. Furthermore, the arrangement according to the invention provides particularly good gloss and smoothness of the product to be manufactured. Also, the structure of the fibre web in the direction of thickness can be controlled very well or shaped as desired. The process of the invention is gentle and the web can be made to propagate almost linearly. Due to the long press section it is possible to run webs with a different basis weight, dry solids content, density and permeability with the same apparatus. The arrangement is also advantageous with respect to energy consumption. In the web processing unit the heated band can be heated with steam, for example, since it is freely available in paper mills and inexpensive compared to, for instance, electric energy required by induction heating. Some of the water is removed in a liquid form, wherefore no energy is required for its evaporation. The invention provides excellent opportunities to recover the used energy since the temperature of the cooled band is typically about 80°C, which means that when the band is being cooled in cooling water, for example, it is possible to recover at a relatively high temperature substantially the same amount of energy that was transmitted to the heated band. Also the water that was removed in the form of water and steam can be recovered from the wires and from the condensate arriving at the cooled band. By arranging a second web processing unit, which is substantially similar to the first web processing unit, to dry the fibre web after the first unit it is possible to control very well the properties of the fibre web. When the heated bands of the first and the second web processing unit placed one after the other are positioned against opposite web surfaces, both sides of the fibre web can be made glossy and smooth.

Further, positioning the first and the second web processing unit one on top of the other requires considerably less space and thus reduces the costs of construction.

In the present application, 'paper' refers to paperboard in addition
5 to paper.

The invention will be described in greater detail in the accompanying figure, which is a schematic side view, in partial cross-section, of an apparatus according to the invention.

The accompanying figure shows an apparatus for manufacturing
10 paper. The apparatus comprises a headbox 1, from which pulp is supplied to a former 2, where a fibre web 3 is formed from the pulp. After the former 2 the fibre web 3 is led to a web processing unit 4a. Between the former 2 and the web processing unit 4a there may be a baby press 18. From the web processing unit 4a the fibre web 3 can be supplied to a second web
15 processing unit 4b for drying and from there to a reel 15. The paper machine may further comprise, for example, a size press, calender or coating units, which are not shown in the accompanying figure for the sake of clarity.

The web processing unit 4a comprises an endless first band 5 or upper band and an endless second band 6 or a lower band, which are
20 impermeable to air, thermally conductive and preferably made of metal. A fine wire or felt 7, a coarse wire 8 and a fibre web 3 run between the opposite surfaces of the bands. The propagation of the fibre web 3 is illustrated in the accompanying figure by arrows. The first band 5 is arranged to turn around first turning rolls 9a and 9b situated at the ends of the web processing unit 4a.
25 The second band 6 is correspondingly arranged to turn around second turning rolls 10a and 10b also positioned at the ends of the web processing unit 4a below the first turning rolls 9a and 9b. The wires 7 and 8 are supported and guided by guide rolls 14. Since the pressure prevailing in the space between the bands 5 and 6 in the pressing zone usually differs from the pressure
30 outside or laterally on the sides of the bands 5 and 6, both sides of the apparatus between the bands 5 and 6 or near the edges thereof are provided with seals preventing the liquid or vapour escaping laterally from the space between the bands 5 and 6 or vice versa. In order to provide compression between the bands, the web processing unit 4a comprises a pressure
35 chamber 11, which is situated above the first band 5. The first band 5 is sealed with seals to the body of the pressure chamber 11 so that the steam in

the chamber remains at a suitable pressure. Below the second band 6 there is a water chamber 12, which comprises a medium, such as water, that cools the second band 6. The edges of the water chamber 12 are provided with seals with which the second band 6 is sealed to the frame of the water chamber 12.

5 The first band 5 touching the fibre web 3 is heated by means of hot steam provided in the pressure chamber 11. The second band 6, in turn, is cooled continuously by means of water provided below it. Therefore, in the press section between the pressure chamber 11 and the water chamber 12 the fibre web 3 is subjected to compression which presses water from the fibre
10 web 3 to the wires 7 and 8. Further, the steam pressure generated on the surface of the first band 5 removes water from the web in a liquid form, whereupon the evaporation of the water does not consume all the energy. In such a situation, heat is transferred to the fibre web in order to produce on the microlevel a steam front which generates a hydraulic pressure gradient in the
15 water which is provided in the fibre web and should be removed therefrom.

The press section is made very long, in other words the ratio of the length of the press section to the distance D between the turning rolls 9a and 9b is greater than 3:5. Compared to the turning roll 9a or 9b, the length of the press section is more than three times the length of the diameter of the turning
20 roll 9a or 9b. Preferably, the length of the press section is more than four times the length of the diameter of the turning roll 9a or 9b. When a deaeration unit 13 is placed in front of the web processing unit 4a, the amount of air removed from the fibre web 3 and the wires 7 and 8 is so great that the fibre web 3 is subjected to compression substantially all the way between the
25 turning rolls 9a and 9b, in which case the ratio of the press section to the distance between the turning rolls 9a and 9b is about 1:1. The length of the press section is typically about 10 m. Due to the long press section it is possible to implement both wet pressing and drying in the same process device, i.e. the web processing unit 4a. By adjusting the process conditions,
30 for example the pressing pressure and/or the surface temperature of the bands 5 and 6, it is possible to vary the intensity and length of the wet pressing stage and the ratio of the press section and the drying section in the web processing unit 4a. The pressing pressure may vary, for example, from 0.5 to 10 bar, the temperature of the heated band may vary from about 150 to
35 200°C, for instance, and the temperature of the cooled band e.g. from 50 to 90°C.

After the web processing unit 4a the fibre web can be dried, for example, by a cylinder dryer that is known per se. However, the drying is most preferably carried out with a second web processing unit 4b shown in the accompanying figure, which has a substantially similar structure as the web processing unit 4a according to the invention. A first band 16 in the web processing unit 4b is heated and a second band 17 is cooled. A fibre web 3 is led to the second web processing unit 4b such that the web surface that was against the wire 7 in the web processing unit 4a is placed against the heated band 16 of the web processing unit 4b. Both surfaces of the fibre web 3 are then made very smooth and glossy. By placing the units with substantially similar structures shown in the accompanying figure one after the other, it is possible to control and adjust the properties of the fibre web 3 in a very reliable and accurate manner. It is also rather simple to place the web processing units 4a and 4b one on top of the other, thus considerably reducing the space required.

In the former 2 the fibre web 3 can be drained onto the same wire which runs further to the web processing unit 4a and through it, as shown in the accompanying figure by a broken line. In such a situation the fibre web 3 is supported over a long distance, and the first open draw takes place only after the web processing unit 4a at a very high dry solids content.

When supplied to the web processing unit 4a, the fibre web 3 is always so wet that its dry solids content is below 35%. The dry solids content of the fibre web 3 formed with the former 2 is typically about 20%. If a baby press 18 is used, the dry solids content of the fibre web after the baby press 18 and before the web processing unit 4a is typically about 30%, for example. It has been discovered in conducted tests that in the case of thin paper qualities with a basis weight of, for example, about 50 to 60 g/m², the dry solids content of a web can be increased from less than 30% to as high as over 90% with the web processing unit 4a according to the invention. In such a case, for example, there would be no need to use a separate dryer after the web processing unit 4a. Further, since the web processing unit 4a provides very good smoothness and gloss, separate calendering is not necessarily required. Therefore the web processing unit 4a according to the invention may even replace a press, a dryer and a calender in a conventional paper machine. On the other hand, a calender in a paper machine may have a similar structure as the web processing unit 4a according to the invention,

which means that there would then be three units with a substantially similar structure in the paper machine, placed one after the other in the line of production of the fibre web 3.

The figure and the related description are only intended to illustrate
5 the inventive idea. The details of the invention may vary within the scope of the claims. Therefore it is not essential what kind of pressure medium is used in the pressure chamber 11 and in the water chamber 12. The pressure medium in the pressure chamber 11 may be, for example, steam, air, water or hot fuel combustion products. In addition to water, the pressure medium in the
10 water chamber 12 may be air, for example. Besides the heating provided by the pressure chamber 11, the first band 5 can also be heated in other points of the apparatus. Further, the first band 5 may be heated entirely outside the pressure chamber 11, or the fibre web 3 may be pressed even without the pressure chamber 11.

15 Also, the second band 6 can be cooled from outside the water chamber 12 or the cooling can be carried out entirely without the water chamber 12. Similarly, the pressure chamber 11 and the water chamber 12 can be divided into separate chambers, whereupon the pressure in the chambers, and thus the pressing pressure acting on the fibre web 3, can be
20 adjusted separately in a desired manner.

CLAIMS

1. A method of manufacturing paper, the method comprising supplying a pulp to a former (2) that forms a fibre web (3), pressing moisture from the fibre web (3), drying the web and reeling it with a reel (15),
5 **characterized** by pressing moisture from the fibre web (3), whose dry solids content is below 35%, with a web processing unit (4a) comprising two endless bands (5, 6) that are impermeable to air, first turning rolls (9a, 9b), around which the first band (5) is arranged to turn, and second turning rolls (10a, 10b), around which the second band (6) is arranged to turn, the first
10 band (5) being heated and the second band (6) being cooled, and the first and the second band (5, 6) being arranged to run part of the way parallel to each other so that a press section is formed between the bands, in which section the fibre web (3) is subjected to pressing, the web processing unit (4a) thus acting as a press, and at the end of the press section at least partly to drying,
15 the change from the pressing to the drying taking place gradually, and the fibre web (3) and at least one felt or wire being led between the bands (5, 6) so that the fibre web (3) touches the heated first band (5).

2. A method according to claim 1, **characterized** in that the press section is made so long that at the end thereof heat is transmitted to the
20 interior of the web through conduction.

3. A method according to claim 1 or 2, **characterized** in that the ratio of the length of the press section to the distance (D) between the turning rolls (9a, 9b, 10a, 10b) of one band (5, 6) is greater than 3:5.

4. A method according to any one of the preceding claims,
25 **characterized** in that the fibre web (3) is dried substantially entirely with the web processing unit (4a).

5. A method according to any one of claims 1 to 3, **characterized** in that after the web processing unit (4a) the fibre web (3) is dried with a second web processing unit (4b), which has a substantially similar
30 structure as the web processing unit (4a).

6. A method according to claim 5, **characterized** in that the web processing units (4a, 4b) are placed one on top of the other.

7. A method according to any one of the preceding claims, **characterized** in that in the former (2) the fibre web (3) is formed onto
35 the wire, whereafter it is supplied from the former (2) to the pressing and through it on the same wire.

8. A method according to any one of the preceding claims, **characterized** in that after the former (2) and before the web processing unit (4a) the fibre web (3) is pressed with a baby press (18).

9. An apparatus for manufacturing paper, the apparatus comprising
5 at least a headbox (1), a former (2), means for pressing and drying a fibre web (3), and a reel (15), **characterized** in that the apparatus comprises a web processing unit (4a) being arranged to act as a press and comprising two endless bands (5, 6) that are impermeable to air, first turning rolls (9a, 9b),
10 around which the first band (5) is arranged to turn, and second turning rolls (10a, 10b), around which the second band (6) is arranged to turn, heating means for heating the first band (5) and cooling means for cooling the second band (6), which first and second band (5, 6) are arranged to run part of the way parallel to each other so that a press section is arranged between the bands, which section is so long that in the web processing unit (4a) the fibre
15 web (3) is subjected to pressing and at the end of the press section at least partly to drying, the fibre web (3) and at least one felt or wire (7, 8) being arranged to be led between the bands (5, 6) so that the fibre web (3) is arranged to touch the heated first band, the fibre web (3) supplied to the web processing unit (4a) being arranged to be so wet that its dry solids content is
20 below 35%.

10. An apparatus according to claim 9, **characterized** in that the press section is made so long that the ratio of the length thereof to the distance between the turning rolls (9a, 9b, 10a, 10b) of one band (5, 6) is greater than 3:5.

25 11. An apparatus according to claim 9 or 10, **characterized** in that the web processing unit (4a) is arranged to dry the fibre web (3) substantially dry.

12. An apparatus according to claim 9 or 10, **characterized** in that the apparatus comprises a second web processing unit (4b), which has
30 a substantially similar structure as the first web processing unit (4a).

13. An apparatus according to claim 12, **characterized** in that the web processing units (4a, 4b) are placed one on top of the other.

14. An apparatus according to any one of claims 9 to 13, **characterized** in that the fibre web (3) is arranged to be supported by the
35 same wire in the former (2) and in the web processing unit (4a).

15. An apparatus according to any one of claims 9 to 14, **characterized** in that the apparatus comprises a baby press (18), which is arranged to press the fibre web (3) before the web processing unit (4a).

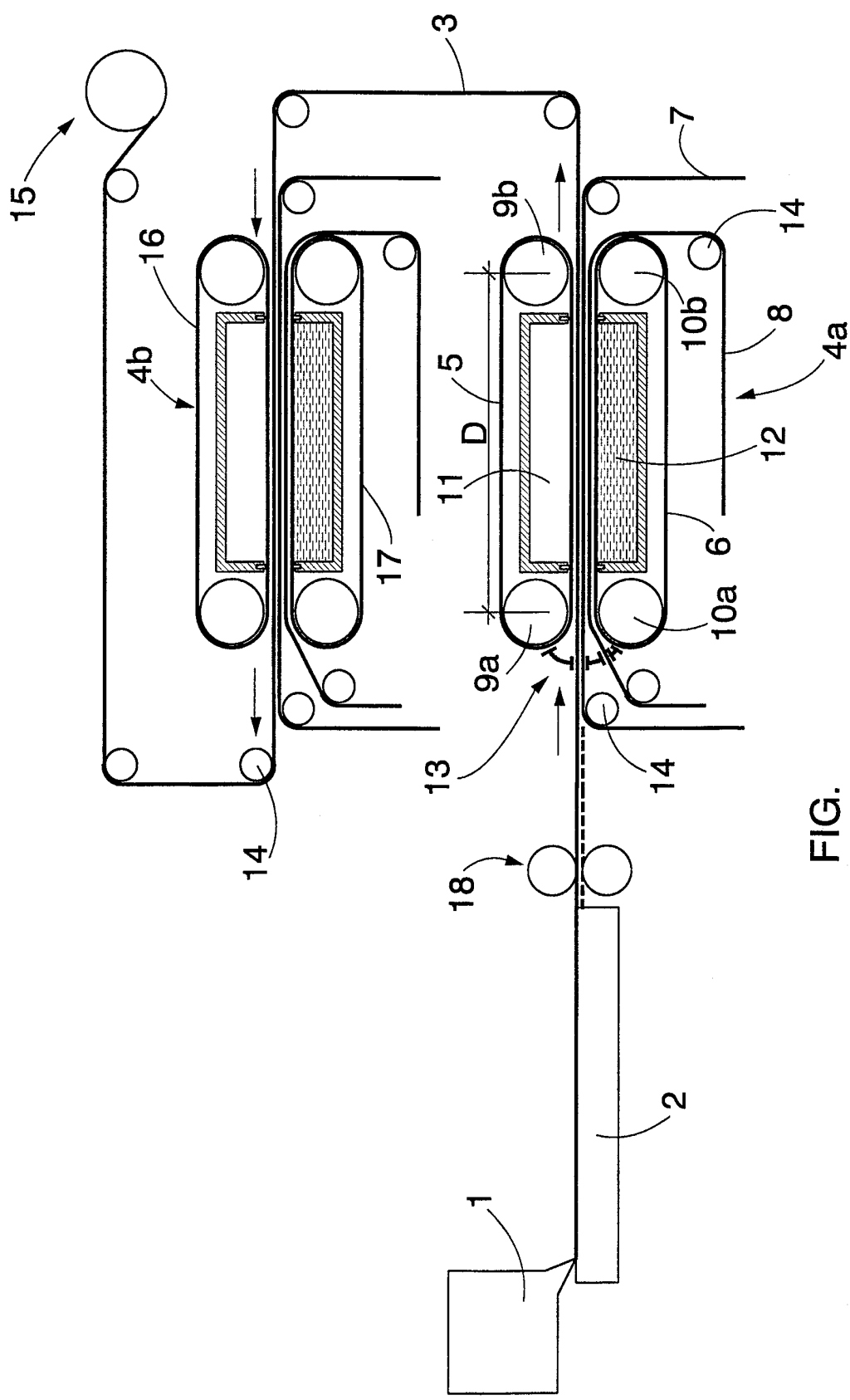


FIG.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 99/00612

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21F 5/00

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)

IPC6: D21F

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

SE,DK,FI,NO classes as above

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

DIALOG: ALLSCIENCE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9819006 A1 (VALMET CORPORATION), 7 May 1998 (07.05.98), page 3, line 4 - line 35, figure 1	1,9
A	----- -----	2-8,10-15

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

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Date of mailing of the international search report

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Information on patent family members

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