



(51) International Patent Classification:
D21F 1/52 (2006.01)

(21) International Application Number:
PCT/FI2009/050349

(22) International Filing Date:
4 May 2009 (04.05.2009)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:
20085408 5 May 2008 (05.05.2008) FI

(71) Applicant (for all designated States except US): **METSO PAPER, INC.** [FI/FI]; Fabianinkatu 9 A, FI-00130 Helsinki (FI).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **AHMANIEMI, Samppa** [FI/FI]; Rivitie 2, FI-40950 Muurame (FI). **POIKOLAINEN, Antti** [FI/FI]; Ritopohjantie 5 As 4, FI-40250 Jyväskylä (FI). **TISSARI, Tomi** [FI/FI]; Haukkalantie 43, FI-40740 Jyväskylä (FI). **MUHONEN, Jukka** [FI/FI]; Hietatie 24, FI-FI40530 Jyväskylä (FI).

(74) Agent: **FORSSÉN & SALOMAA OY**; Lautatarhankatu 8 B, FI-00580 Helsinki (FI).

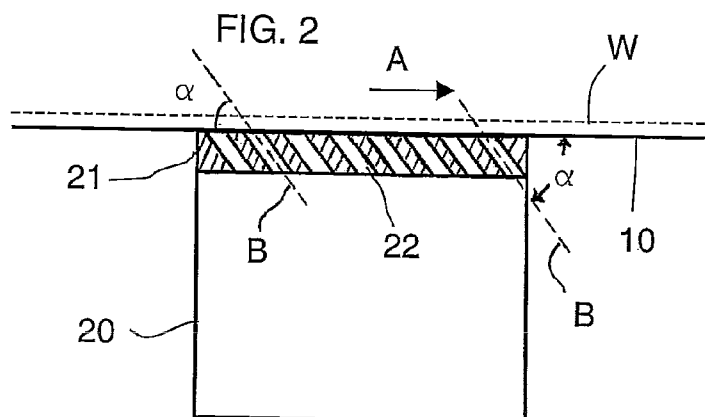
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: FORMING SECTION OF PAPER OR BOARD MACHINE, METHOD FOR THE FORMING OF WEB, AND SUCTION BOX



(57) Abstract: The forming section of a paper or board machine comprises a double-wire part, where water is removed from the web between two wires, and after the double-wire part there is at least one high-vacuum suction box (20) before a point where the web is transferred to the press section. The vacuum in the suction box (20) is 20-80 kPa, the cover (21) of the suction box is equipped with holes (22), the centre axis (B) of which holes (22) forms a sharp angle (α) with the direction of travel (A) of the wire (10) running over the cover (21), and the open area of the cover (21) is 40-90%. The suction box (20) is placed at the end of the forming section at a location where the dry solids content of the web (W) is at least 6%, preferably at least 10%.

Forming section of paper or board machine, method for the forming of web, and suction box

5 The present invention concerns the forming section of a paper or board machine, where the forming section comprises a double-wire part, where water is removed from the web between two wires, and after the double-wire part there is at least one high-vacuum suction box before a point where the web is transferred to the press section. The invention also concerns a method for the forming of a paper or
10 board web on such a forming section, and a high-vacuum suction box.

Prior art solutions include the placing of at least one flat suction box on a short single-wire part following a double-wire web forming and dewatering zone, the purpose of the flat suction box being to increase the dry solids content of the web
15 before the web is transferred to the press section. After the double-wire part, the dry solids content of the web is already so high that it is difficult to extract more water out of the web without a considerable vacuum. The use of a high vacuum involves many problems, one of which is the increase in the porosity of the web as a function of vacuum.

20 Present flat suction boxes generally employ ceramic foil covers, which have dewatering foils in the cross direction to the direction of travel of the web. Such a foil arrangement wears the wire, because the wire bends as a result of vacuum every time the wire runs over a gap between two foils. A high vacuum raises the
25 power required to run the wire and increases the wear of the wire as a result of friction forces. It is often necessary to make compromises in terms of the dry solids content, because the wire wears more at higher vacuum levels and the power required to run the wire increases. The web running over the foil cover of the suction box is subject to a series of very short vacuums created by separate pulses.
30 The porosity of the web increases as a function of vacuum, which is why the prob-

lem involved in the use of high vacuums is that there are more pinholes in the web.

One problem in prior art forming sections is the re-wetting of the web after the suction box. FI patent publication 110702 presents a method for preventing the re-wetting of the web. In the method, the web is led, supported by a wire, past at least two vacuum chambers so that in the direction of travel of the web, the vacuum in the first vacuum chamber pulls water from the web and wire, and the vacuum in the second vacuum chamber prevents the transfer of moisture from the wire back to the web, so that the vacuum in the first vacuum chamber is higher than the vacuum in the second vacuum chamber. The vacuum chambers used in the method are ordinary high-vacuum suction boxes with a foil cover.

US patent 2 487 202 presents a suction box cover where the suction holes are arranged to run through the cover at an inclined angle with respect to the direction of travel of the wire. Due to the inclination of the holes, water removed from the wire side meets the inclined back wall of each suction hole, and the back wall tends to guide the water out of the wire instead of letting the water splash back to the web through the wire. The suction box is used beneath the Fourdrinier forming section, where the web is still relatively wet and it is easy to remove water from it. The suction box as such is not suited for use at the end of the forming section, where a high vacuum is needed. A high vacuum together with suction holes arranged in lines in the machine direction and with a small open area of the cover easily creates streaks in the web produced.

The objective of the present invention is to overcome or at least reduce the disadvantages related to prior art solutions. The specific objective is to intensify dewatering after the double-wire part before the web is transferred to the press section. Another objective is to reduce the power needed to run the wire, and to save the wire from wear.

The characteristics of the forming section according to the invention are presented in the characterizing part of claim 1.

5 The characteristics of the method according to the invention are presented in the characterizing part of claim 6.

The characteristics of the suction box according to the invention are presented in the characterizing part of claim 8.

10 A high-vacuum suction box with a vacuum of 20-80 kPa is placed at the end of the forming section according to the present invention. The cover of the suction box is provided with holes, with the center axis of the holes forming a sharp angle with the direction of travel of the wire running over the cover. The open area of the cover is 40-90%. It has been discovered that by using such a cover with in-
15 clined holes, the power needed to run the wire can be reduced, the dry solids content of the web after the forming section can be improved, and the life time of the wire can be extended as compared to prior art solutions, where the suction box in a corresponding position has a foil cover.

20 The power needed to run the wire decreases as the friction between the suction box cover and the wire sliding over it is reduced. This is so mostly because the wire makes a considerably smaller bend at each individual suction hole than when the wire runs over a uniform slot in the cross direction of the machine. When the power needed to run the wire is decreased, the wire usually also wears less and its
25 life time is extended.

The dry solids content of the web increases mostly because the holes drilled through the cover at an inclined angle remove water from the wire and web more effectively than slots or holes going through the cover at an angle of 90°. The vac-
30 uum of the suction box pulls water from the web to the lower surface of the wire, and the water is guided downwards in the suction hole along the inclined back

wall of the hole. By drilling the holes at an inclined angle through the cover, it is possible to reduce the splashing of water from the back wall of the hole back to the web. The open area of the hole cover can be increased easily from that in a slot cover without compromising the strength of the cover. Friction is also reduced as the regions between the holes are narrow, so they are lubricated well by water. The creation of streaks in the web is prevented by not placing the suction holes in rows in the machine direction.

The suction box cover is preferably manufactured from steel and coated with a ceramic or other coating which enhances durability. The cover can also be completely of a ceramic material or some other suitable material.

The solution according to the invention accomplishes significant benefits over a conventional forming section, where there is a suction box with a foil cover at the end of the forming section. One essential difference is that on the forming section according to the present invention, the amount of pinholes in the web does not increase even though the vacuum in the suction box needs to be raised. When using conventional suction boxes with a foil cover, it is not always possible to use a sufficiently high vacuum, because in this case there would be too many pinholes in the web, and this is not acceptable in all paper grades.

Another essential difference to the use of a conventional suction box with a slot cover is that a high-vacuum suction box with inclined holes gives a high dry solids content after the press section at a relatively low vacuum level (30-40 kPa). So as to achieve a high dry solids content after the press section, it has been necessary to use a very high vacuum level at the end of the forming section in conventional solutions. This has resulted in high energy consumption.

The suction box with inclined holes used on a forming section according to the invention does not remove as much fines from the lower surface of the web as a suction box with a slot cover, because dewatering is not pulsating. In certain paper

grades, a low fines content on the lower surface of the web has been a problem when using a high-vacuum suction box with a foil cover.

5 The forming section according to the invention allows the use of lower wire tensions, because there is no fear of the wire bending at the slot between foils in a high-vacuum suction box. This enables the use of rolls with a lighter structure on the forming section.

10 The benefits of a suction box with a hole cover with inclined holes include smaller friction and easier dewatering, which enables the use of a smaller vacuum level. There is less re-wetting of the web after the suction box when the center axis of the holes is in a sharp angle with respect to the direction of travel of the wire. It has been estimated that by using the new cover design for the suction box, the power needed to run the wire can be reduced by more than 10%, and the life time
15 of the wire can be extended by more than 10%. The new cover design enables an improvement of more than 1% in the dry solids content of the web after the forming section as compared to a conventional foil cover.

20 In what follows, the invention is described by making reference to the enclosed figures, with the invention not being restricted narrowly by the figures.

Figure 1 is a side view of the forming section according to the invention.

25 Figure 2 is a side view of the high-vacuum suction box cover.

Figure 3 is a top view of the suction box cover.

Figure 1 shows a double-wire forming section, which comprises bottom wire 10 and top wire 11, between which there is a double-wire web forming and dewater-
30 ing zone. The pulp suspension is fed from the headbox 12 into the forming gap between the wires 10 and 11. Dewatering from the pulp suspension begins as the

wires 10, 11 turn over the suction sector of the forming roll 13. The forming roll 13 is followed by a two-chamber dewatering box 14, at the first dewatering chamber of which there are loaded dewatering foils 15 on the side of the bottom wire loop 10, and the dewatering foils 15 can be loaded against the cover of the dewatering box 14. The dewatering box 14 is followed by the second forming roll 16 placed on the side of the bottom wire loop 10, where the forming roll 16 turns the inclined upward run of the wires 10, 11 to an inclined downward run. At the end of the double-wire part on the side of the bottom wire loop 10, there is a transfer suction box 17, which ensures that the web follows the bottom wire 10 when the top wire 11 is separated from the bottom wire 10.

The double-wire part is followed by a short single-wire part, where the web W runs suspended by the bottom wire 10 to the pick-up point P, where the web W is detached from the bottom wire 10 by means of the pick-up roll 18 and transferred to be suspended by the fabric 19 on the press section. On this single-wire part, there is a high-vacuum suction box 20, the purpose of which is to remove as much water from the web W before the web W is transferred from the forming section to the press section. The dry solids content of the web before the suction box 20 is more than 6%, preferably more than 10%.

20

Figure 2 shows a magnification of the high-vacuum suction box 20, and Figure 3 shows a part of the suction box cover 21 as a top view. Through the cover 21, there a high number of holes 22, the center axis B of which forms a sharp angle α with the direction of travel A of the wire 10 running over the cover 21. The angle α in this case is approximately 45° . Generally, the angle α should be in a range of $30-85^\circ$, so that the wire 10 running over the suction box cover 21 meets the back edge of the hole 22 at a sharp angle. In this case, the back edge of the hole 22 scrapes water from the lower surface of the wire 10, and the water is removed downwards along the inclined back wall of the hole 22.

30

The holes 22 are placed in a staggered pattern with respect to each other so that in the direction of travel A of the web there is no uniform line formed by consecutive holes 22, which might create streaks in the web. The wire 10 running over the cover 21 cannot bend significantly at the holes 22, because the wire 10 always has lateral support at each hole 22. The open area of the cover 21 can be relatively high, higher than in conventional slot covers. Figure 3 does not disclose the fact that the cross section of the cylindrical holes 22 in the direction of the plane of the cover 21 is actually oval, which contributes to an increase in the open area of the cover 21.

Typically, the length of the suction box cover 21 in the direction of the paper machine is 100-600 mm, and the width of the cover 21 corresponds to the width of the paper machine. The cover 21 can be uniform or it can be assembled from several cover elements installed side by side in the width direction of the paper machine. The cover 21 can be straight or curved. The open area of the cover 21 can be in a range of 40-90%. The diameter of the holes 22 is usually 5-20 mm, and their center axis B forms an angle of 30-85° with respect to the direction of travel of the wire 10. The holes 22 can be cylindrical, or their cross-sectional area may be oval or polygonal. A vacuum of 20-80 kPa is preferably used in the suction box 20.

The many variations of the invention are possible within the scope of protection defined by the below patent claims. A high-vacuum suction box according to the invention can be placed not only on the single-wire part following the double-wire part, but also at the end of the double-wire part or, on a Fourdrinier forming machine, at the end of the web forming section on an area where the dry solids content of the web is more than 6%, preferably more than 10%. Several suction boxes according to the invention can be placed after one another, or the suction box can be placed after a normal flat suction box.

Claims:

1. A forming section of a paper or board machine, where the forming section comprises a double-wire part, where water is removed from the web between two
5 wires (10, 11), and after the double-wire part there is at least one high-vacuum suction box (20) before a point (P) where the web (W) is transferred to the press section, **characterized** in that the vacuum in the suction box (20) is 20-80 kPa, the cover (21) of the suction box (20) is equipped with holes (22), the centre axis
10 (B) of which holes (22) forms a sharp angle (α) with the direction of travel (A) of the wire (10) running over the cover (21), and the open area of the cover (21) of the suction box (20) is 40-90%.
2. A forming section as claimed in claim 1, **characterized** in that the cover (21) of the suction box (20) is a coated steel cover.
- 15 3. A forming section as claimed in claim 1 or 2, **characterized** in that there is a vacuum of over 30 kPa, preferably over 40 kPa, in the suction box (20).
4. A forming section according to any of the above claims, **characterized** in that
20 the centre axes (B) of the suction box cover holes (22) form an angle (α) of 35-85°, preferably 40-60°, with the direction of travel (A) of the wire (10) running over the suction box (20).
5. A forming section according to any of the above claims, **characterized** in that
25 the suction box (20) is placed at a location where the dry solids content of the web (W) is at least 6%, preferably at least 10%.
6. A method for the forming of a paper or board web on a forming section, which comprises a double-wire part, after which double-wire part, before the web (W) is
30 transferred to the press section, water is removed from the web by means of a high-vacuum suction box (20), **characterized** in that a vacuum of 20-80 kPa is

used in the said suction box (20) and that the suction box (20) is equipped with a cover (21), the open area of which is 40-90% and which comprises holes (22), the centre axis (B) of which holes (22) forms a sharp angle (α) with the direction of travel (A) of the wire (10) running over the cover (21).

5

7. A method as claimed in claim 6, **characterized** in that the dry solids content of the web (W) when the web (W) comes to the suction box (20) is over 6%, preferably over 10%.

- 10 8. A high-vacuum suction box (20) intended for the forming section of a paper or board machine, **characterized** in that there is a vacuum of 20-80 kPa in the suction box (20), the cover (21) of the suction box is equipped with holes (22), the centre axis (B) of which holes (22) forms a sharp angle (α) with the direction of travel (A) of the wire (10) running over the cover (21), and the open area of the
- 15 cover (21) of the suction box is 40-90%.

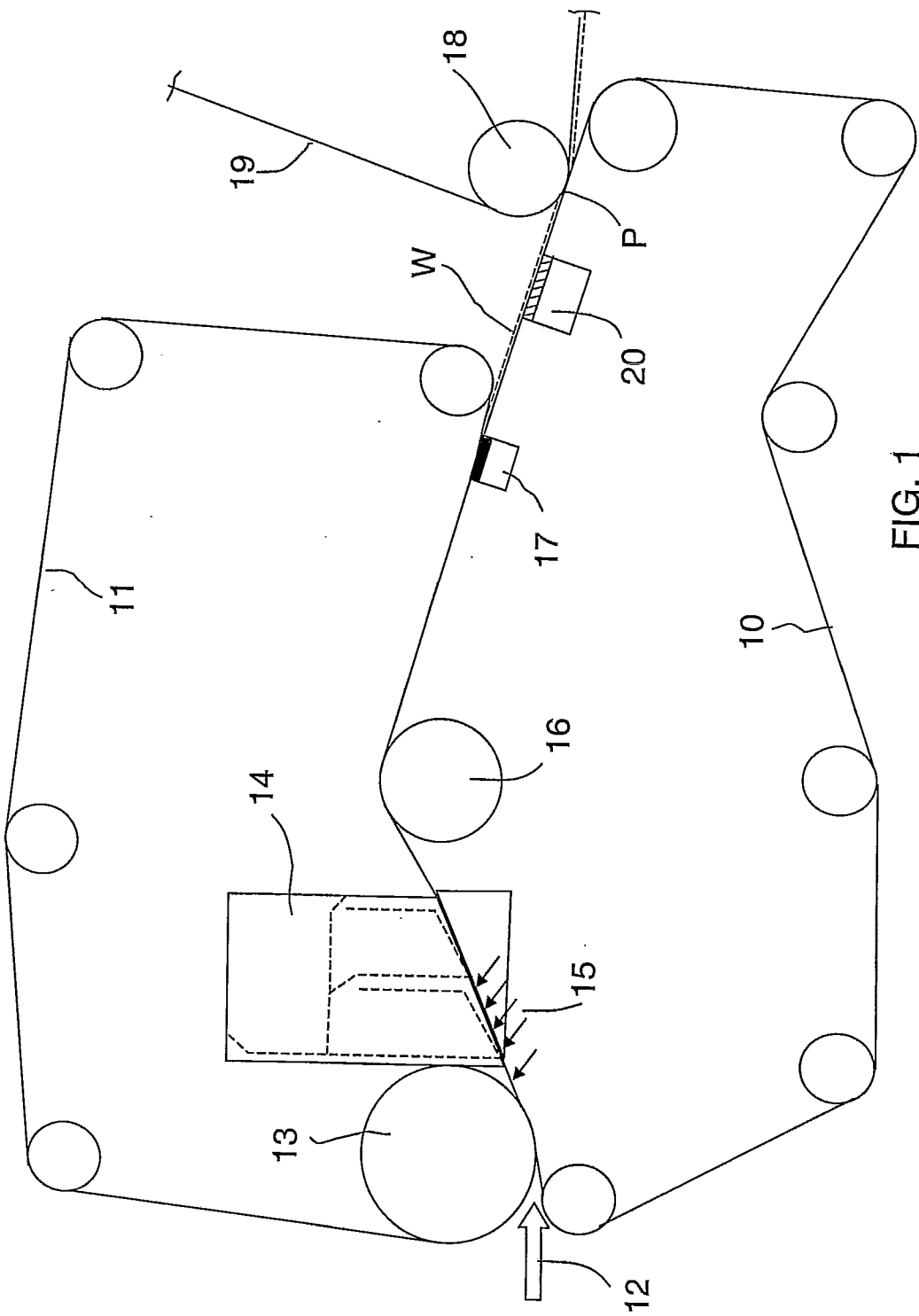
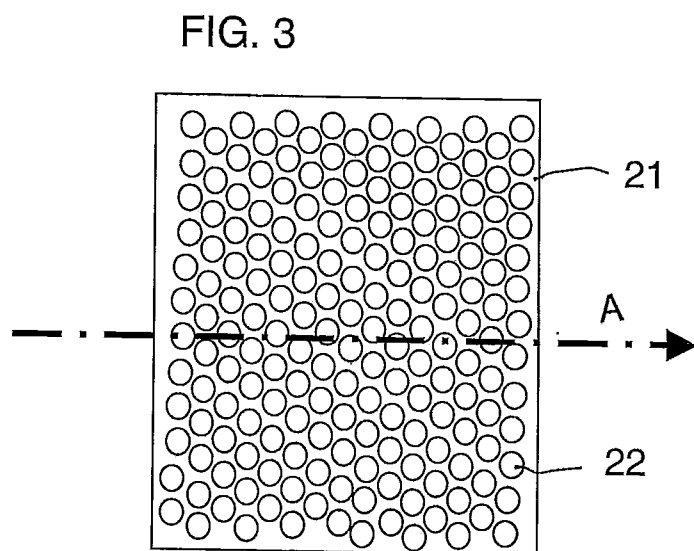
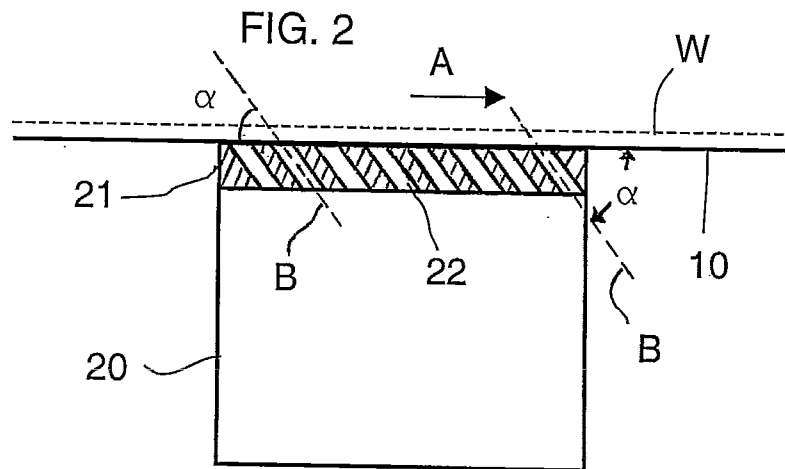


FIG. 1

2/2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2009/050349

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

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

EPO-internal, WPI, COMPDX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007181276 A1 (BAUBOCK JORG et al.) 09 August 2007 (09.08.2007), figures 1 and 4; paragraphs 3-4, 10-12 and 19-23	1-8
Y, D	US 2487202 A (WADLEIGH GEORGE R) 08 November 1949 (08.11.1949), figures 2 and 3; column 1, lines 7-28	1-3, 5-8
Y	US 2934143 A (LLOYD HORNBOSTEL) 26 April 1960 (26.04.1960), figures 3 and 4; column 1, lines 31-67; column 3, lines 20-22	1-8
A	FI 118211 B (METSO PAPER INC) 31 August 2007 (31.08.2007), abstract; page 4, line 20 – page 5, line 25	2



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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

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

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

01 July 2009 (01.07.2009)

Date of mailing of the international search report

22 July 2009 (22.07.2009)

Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland

Facsimile No. +358 9 6939 5328

Authorized officer

Anna Vainio

Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2009/050349

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
US 2007181276 A1	09/08/2007	BR PI0700085 A CA 2572525 A1 EP 1806453 A1 AT 502805 A4	16/10/2007 05/07/2007 11/07/2007 15/06/2007
US 2487202 A	08/11/1949	None	
US 2934143 A	26/04/1960	None	
FI 118211 B	31/08/2007	CN 101454504 A EP 2024561 A1 WO 2007135231 A1	10/06/2009 18/02/2009 29/11/2007

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2009/050349

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

D21F 1/52 (2006.01)