(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 October 2012 (18.10.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/139661 A1

(51) International Patent Classification: *D21F 3/10* (2006.01)

(21) International Application Number: PCT/EP2011/056037

(22) International Filing Date: 15 April 2011 (15.04.2011)

(25) Filing Language: English

(26) Publication Language: English

(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)*: **HYENSJÖ, Marko** [SE/SE]; Kung Eriks väg 4, S-656 38 Karlstad (SE). **HÖGBLAD, Jon** [SE/SE]; Busterudsvägen 21, S-655 94 Karlstad (SE). **ZETTERGREN, Bengt** [SE/SE]; Finns väg 1, S-655 00 Kil (SE). **AXELSSON, Stefan** [SE/SE]; Sommarrovägen 45 B, S-652 30 Karlstad (SE). **SKOGSBERG, Rune** [SE/SE]; Nolgårdsvägen 20, S-663 41 Hammarö (SE). **ARONSON, Joakim** [SE/SE]; Kilslundsgatan 5, S-665 34 Kil (SE).

(74) **Agent**: **JOHANSSON, Lars E.**; P.O. Box 138, S-683 23 Hagfors (SE).

(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, CL, 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, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, 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, RS, SE, SI, SK, SM,

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WO 2012/139661 A1

(54) Title: A SUCTION ROLL AND A METHOD OF OPERATING SUCH A SUCTION ROLL

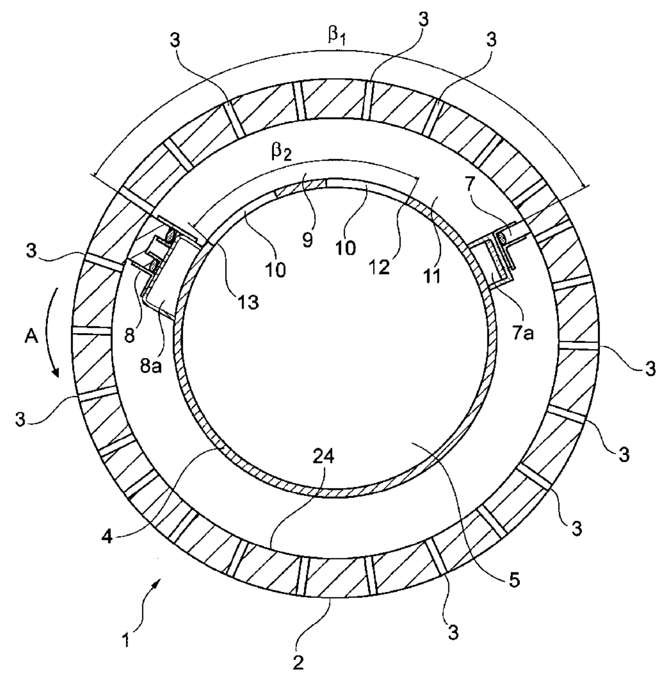

Fig. 2

(57) Abstract: The invention relates to a suction roll (1) having a rotatable roll shell (2) with a plurality of perforations (3); a suction box (4) within the rotatable shell (2) which has a wall that defines an inner space (5) that is connected to or connectable to a source (6) of underpressure. The suction box (4) has a circular cylindrical cross section and it is arranged to remain stationary while the roll shell (2) rotates. A first seal (7) and a second seal (8) arranged on the suction box (4) delimit a suction zone. The wall of the suction box (4) has an air inlet zone (9) formed by at least one through-hole (10), the air inlet zone (9) is located in the area between the first seal (7) and the second seal (8) such that a suction zone (11) is formed in the area between the seals (7, 8) when the suction box (4) is connected to a source (6) of underpressure. With regard to the seals (7, 8), the air inlet zone (9) is asymmetrically placed in the circumferential direction of the roll shell (2) in such a way that it is displaced towards the second seal (8).

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))*

— *with amended claims (Art. 19(1))*

A SUCTION ROLL AND A METHOD OF OPERATING SUCH A SUCTION ROLL

FIELD OF THE INVENTION

The present invention relates to a suction roll for use in a fibre web machine such as a papermaking machine, a tissue machine, a board (paperboard) machine or a machine for making pulp. The invention also relates to a method of operating such a suction roll.

BACKGROUND OF THE INVENTION

In fibre web machines, a commonly used component is the suction roll. Suction rolls are used in many different positions and sometimes for different purposes. For example, a suction roll may be used as a pick-up roll that is used to transfer a fibrous web from one paper machine fabric to another paper machine fabric. This may be the case when a suction roll is placed inside the loop of a permeable felt and exerts suction through the felt to pick up a web from a forming wire or from another felt. In the same way, a suction roll can be used to pick a fibrous web from a felt or from an impervious transfer belt in a press section and transfer the web to a drying wire that runs through the drying section of a paper making machine. Suction rolls can also be used for other purposes, For example, they can be used to form dewatering nips with other rolls. Typically, suction rolls are used in all kinds of fibre web machines such as paper making machines; tissue making machines, machines for paper such as newsprint and in machines for making grades with a higher basis weight such as paperboard as well as pulp making machines.

Typically, a suction roll has a roll mantle (i.e. an outer shell) which has a plurality of perforations. The roll mantle is arranged to be rotatable about a suction box that is located inside the outer shell. The suction box is arranged to be stationary (i.e. it does not rotate). The suction box is connected to a source of vacuum (underpressure) such that a suction effect is achieved. Moreover, the suction box is provided with openings such that the underpressure in the suction box can act to produce suction through the perforations in the rotatable roll mantle. The suction box is provided with a pair of seals arranged in holders on the suction box. The holders and the seals extend in the longitudinal (i.e. axial) direction of the roll. The seal holders and the seals also extend in the radial direction between the suction box and the inner surface of the roll mantle (the rotatable shell) such that a suction zone is achieved between the seals. Suction rolls of this general design have been in use in fiber web machines for many years.

An example of a prior art suction roll is disclosed in US patent No. 2,772,606. That document discloses a suction roll which is provided with a plurality of perforations. An elongated tubular member is placed inside the roll and the tubular member has a slot. Other example of a prior art suction rolls are disclosed in, for example, US patent No. 4,862,648 and US patent No. 3273492.

Prior art suction rolls are also known where the suction box inside the rotatable shell (rotatable mantle) has a substantially rectangular cross section.

Although they are very useful, suction rolls cause noise and they consume much energy. Another problem that has been noted by the inventors of the present invention is that the flow of air in the axial direction of the roll may be disturbed which causes losses. As a consequence, the suction effect varies over the axial length of the suction roll. To achieve a sufficient suction effect over the entire length of the roll, the vacuum (underpressure) must therefore be kept higher than what would have been necessary without such disturbances.

Therefore, it is an object of the invention to provide a suction roll where the energy consumption can be decreased and where the suction effect can be kept more even over the entire length of the suction roll. Reduced energy consumption may also contribute to a reduced noise level.

These and other objects are achieved by means of the present invention.

DISCLOSURE OF THE INVENTION

The invention relates to a suction roll for a fibre web machine, for example a paper making machine. The inventive suction roll has a rotatable roll shell with a plurality of perforations and a suction box located within the rotatable shell. The suction box has a wall that defines an inner space that is connected to or connectable to a source of underpressure. The suction box is arranged to remain stationary while the roll shell rotates. A first seal and a second seal are arranged on the suction box and each seal extends radially between the suction box and the inner surface of the rotatable shell. The seals also extend in the axial (longitudinal) direction of the roll. The first and second seal respectively are spaced from each other in the circumferential direction of the rotatable shell. The wall of the suction box has an air inlet zone formed by at least one through-hole. The air inlet zone is located in the area between the first seal and the second seal such that a suction zone is formed in the area between the seals when the suction box is connected to a source of underpressure (i.e. the seals define the limits of the suction zone). The air inlet zone of the suction box has a first edge in the circumferential direction of the rotatable shell and a second edge in the circumferential direction wherein the second edge is the edge which is closest to the second seal. With regard to the seals, the air inlet zone is asymmetrically placed in the circumferential direction of the roll shell in such a way that it is displaced towards the second seal.

Preferably, the suction roll has a circular cylindrical cross section.

Since the air inlet zone is displaced towards the second seal, the second edge of the air inlet zone is closer to the second seal than the first edge to the first seal, i.e. the distance from the second edge of the air inlet zone to the second seal is smaller than the distance from the first edge of the air inlet zone to the first seal.

The air inlet zone may, in principle, be formed by a single axially extending slot. However, it is preferably formed by a plurality of through-holes in the wall of the suction box that extend in rows in the axial direction of the suction box.

The second seal is the seal on outgoing side in the circumferential direction of rotation of the rotatable shell. In preferred embodiments of the invention, the second seal has a longer extension in the circumferential direction than the first seal.

In many realistic embodiments, the area between the first and the second seal extends over an arc length of 40° - 150° as seen along the inner surface of the roll shell. In preferred embodiments, the first edge of the air inlet zone (the edge that of the air inlet zone which is closest to the first seal) is displaced from the first seal by at an arc length which is 10% - 80 % of the total arc length between the seals while the second edge of the air inlet zone (the edge of the air inlet zone which is closest to the second seal) is displaced from the second seal by no more than 10% of the total arc length between the seals.

Preferably, the area between the first and the second seal extends over an arc length of 60° - 120°.

Preferably, the second edge of the air inlet zone is displaced from the second seal by no more than 5 % of the total arc length between the seals, preferably by no more than 3 % of the total arc length between the seals.

In preferred embodiments, the first edge of the air inlet zone is displaced from the first seal by 20 % - 80 % of the total arc length between the seals, preferably by 30 % - 70 % of the total arc length between the seals.

In preferred embodiments, more than 50 % of the total open area of the air inlet zone is placed closer to the second seal than to the first seal.

The through-holes may have many shapes. For example, they may be round (i.e. circular cylindrical) or rectangular. However, in advantageous embodiments, the through-holes are shaped as elongated slots that extend mainly in the axial direction of the suction roll. Such through-holes in the suction box that are shaped as elongated slots preferably have rounded corners or they may be elliptically shaped.

In embodiments of the invention, the air inlet zone may comprise a first and a second parallel row of through-holes extending in the axial direction of the roll, the first row being parallel with the second row. In such embodiments, the through-holes in the first row may advantageously be offset in the axial direction of the roll in relation to the through-holes of the second row. Embodiments are also conceivable with only one row of through-holes.

In many realistic embodiments, the rotatable roll shell may have a diameter in the range of 500 mm – 1800 mm, preferably a diameter in the range of 800 mm – 1600 mm. For such dimensions, each through-hole may have an extension in the circumferential direction that corresponds to an arc length of 90 mm – 150 mm, preferably 100 mm – 140 mm.

The suction box has an exhaust channel for air at an axial end of the roll. In advantageous embodiments, the exhaust channel may have a conical part that is tapered towards the axial end of the suction roll. The conical part may optionally be followed a circular cylindrical part. Where such a circular cylindrical part is used, it may optionally lead to an expanding part of the exhaust channel. As the air passes through the exhaust channel, it may thus first pass through a narrowing section /the tapered conical part, then pass though a circular cylindrical part of constant or substantially constant cross sectional area whereafter the air may exit into an expanding part of the exhaust channel.

Preferably, the second seal has an extension in the circumferential direction that is more than 2 times as long as the extension of the first seal in the circumferential direction and preferably 2 – 4 times as long.

The inner space of the suction box is connected to a source of underpressure such that the maximum underpressure in the inner space of the suction box will be in the range of 15 MPa – 70 MPa, preferably in the range of 25 MPa – 50 MPa.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic side view of a suction roll with a suction zone.

Figure 2 is a cross-sectional side view of a suction roll according to the invention.

Figure 3 is a perspective view of parts of the inventive suction roll.

Figure 4 is a cross sectional longitudinal view of the inventive suction roll.

Figure 5 is an enlargement of some of the details shown in Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

With reference to Figure 1, it can be seen how a suction roll 1 is used to form a press nip N with a counter roll 20. Through the nip N, a fibrous web W is passed together with a water-absorbing felt F. The web W and the felt F move in the machine direction MD and the suction roll is rotating in the direction of the arrow A. The suction roll 1 has a suction zone 11. When the felt F and the web W pass through the nip, the suction in the suction zone 11 will act on the web W and the felt F. In Figure 1, the suction zone 11 as such is shown as being symmetrically placed in the nip. It should be understood that this need not be the case. For example, in some cases where a suction roll is used as a nip roll, the suction zone could be asymmetrically placed in the nip.

The inventors have found that one cause for disturbances and pressure losses in the suction roll are caused when air that has already been sucked into the suction box bounces back into the area between the suction box and the rotatable shell. When air bounces back, vortexes may be created that disturb the flow of air. If this can be prevented, pressure losses can be reduced. In order for air to be evacuated as smoothly as possible, the inventors have found that it would be preferable if the air can be caused to move out of the suction box in a swirling movement of the air such that the air is not just moving linearly in the axial direction but also rotates such that it performs a spiraling movement out of the suction box, i.e. it moves in a vortex that assists the evacuation of air. Moreover, the air should be prevented from bouncing back. To help achieving a spiraling movement of the air, the suction box should preferably have a cross sectional shape without any corners or at least without any sharp corners. When there are no corners, or when the corners are not so sharp, air passing though the inner space 5 will not be so much disturbed in its flow. Preferably, the cross sectional shape should be circular cylindrical. However, shapes deviating from a circular cylindrical cross section may also be considered. For example, polygonal cross sections such as pentagonal, hexagonal, or octagonal cross sections may be considered. The suction box may be formed by (for example) a sheet of metal that has been bent to a polygonal shape with so many corners that the cross section approaches a circular cylindrical shape, for example 7 – 40 corners or even more corners. A cross section without corners (or with less sharp corners) results is a smoother air flow and thus reduces energy consumption. However, it should be understood that the cross sectional shape of the suction box could also be made in other ways, for example elliptical. Even a cross sectional shape that is rectangular could be considered in the context of the present invention even though this would not be a preferred embodiment of the invention since a cross section without sharp corners s preferred in order to achieve a smooth air flow. However, to reduce the tendency of air to bounce back, further design improvements are required as will be explained in the following.

With reference to Figure 2, it can be seen that the suction roll 1 has a rotatable roll shell 2 with a plurality of perforations 3. In many realistic embodiments, the thickness of the roll shell 2 in the radial direction may be on the order of 40 mm – 100 mm but other dimensions are also possible. Wall thickness may be less than 40 mm or more than 100 mm. The wall thickness of the roll shell 2 depends much on the requirements of the particular application. The dimensions of the perforations 3 also vary from case to case. However, in many realistic embodiments the perforations may have a diameter in the range of 3 mm – 11 mm (both smaller and larger diameters are possible). For example, the perforations 3 may have a diameter of 4 mm. A suction box 4 is placed inside the rotatable shell 2 and the wall of the suction box 4 defines an inner space 5. The suction box 4 is normally placed coaxially with the rotatable shell or substantially coaxially with the rotatable shell 2 but embodiments are conceivable where this is not the case. With reference to Figure 4, the inner space 5 of the suction box 4 is connected to or connectable to a source 6 of underpressure. The suction box 4 according to the invention preferably has a circular cylindrical cross section even though other shapes are possible. The suction box 4 is arranged to remain stationary while the roll shell 2 rotates. In Figure 2, the arrow A indicates the direction of rotation of the rotatable shell 2 during normal operation of the suction roll.

It should be understood that the roll 1 has an axial extension (see Figure 3 and Figure 4). Of course, this applies also to the roll shell 2 and the suction box 4.

The suction box 4 has a first seal 7 and a second seal 8 that are both placed in seal holders 7a, 8a arranged on the suction box 4. Each seal extends radially to the inner surface of the rotatable shell 2 and axially from one axial end of the suction box 4 to the other axial end of the suction box. As can be seen in Figure 2, the seals 7, 8 define between them, in cooperation with the rotatable shell, a suction zone 11. When the suction roll 1 is used as a forming roll in a wire section or as a press roll in a press nip, water is sucked into the perforations 3 and may then be ejected by centrifugal forces when the roll shell moves beyond the area between the seals 7, 8. In case the suction roll is a pickup roll for transferring the web from one supporting fabric to another, the amount of water is normally negligible.

In principle, a suction box 4 is conceivable where the seals 7, 8 are not placed in any special holders but are instead made integrally with the suction box 4 as such. Such a design may have certain disadvantages, for example if the seals 7, 8 become worn out. However, embodiments without seal holders 7a, 8a are conceivable.

The first seal 7 is spaced from the second seal 8 in the circumferential direction of the rotatable shell 2. With reference to Figure 2, it can be seen that the area between the first seal 7 and the second seal 8 extends over an arc with the angle β_1. The wall of the suction box 4 has an air inlet zone 9 formed by at least one through-hole 10 in the wall of the suction box 4. With reference to Figure 2, the air inlet zone extends over an arc length which in Figure 2 is determined by the angle $\beta 2$. As can be seen in Figure 2 and in Figure 5, the air inlet zone 9 is located in the area between the first seal 7 and the second seal 8 such that a suction zone 11 is formed in the area between the seals 7, 8 when the suction box 4 is connected to a source 6 of underpressure. As best seen in Figure 5, the air inlet zone 9 has a first edge 12 in the circumferential direction of the rotatable shell 2. The first edge 12 is the edge closest to the first seal 7. The air inlet zone also has a second edge 13 in the circumferential direction which is the edge that is closest to the second seal 8. In the embodiment of Figure 2 and Figure 5, the air inlet zone has two rows of through-holes 10 (see also Figure 3). The air inlet zone 9 can best be understood as the zone in which there are openings (through-holes) into the inner space 5 of the suction box 4. Where there are two rows of through-holes 10, the first edge 12 of the air inlet zone can be thought of as an axially extending line that connects the edge of each through-hole 10 in the row of through-holes closest to the first seal 7 because that is where, in the circumferential direction of the roll, air begins to enter into the suction box 4. In the same way, the second edge 13 of the air inlet zone can be thought of as a line that connects the edge of each through-hole 10 in the row closest to the second seal 8 (i.e. those edges of the through-holes 10 in that that are closest to the second seal) since this is, in the circumferential direction, the end of the zone where air enters the suction box 4.

Reference will now be made to Figure 2 and Figure 5. With regard to the seals 7, 8, the air inlet zone 9 is asymmetrically placed in the circumferential direction of the roll shell 2 in such a way that it is displaced towards the second seal 8. The distance from the second edge 13 of the air inlet zone 9 to the second seal 8 is thus smaller than the distance from the first edge 12 to the first seal.

As can be seen in Figure 2 and also in Figure 3, the air inlet zone 9 may be formed by a plurality of through-holes 10 in the wall of the suction box 4 that extend in rows in the axial direction of the suction box 4 . However, embodiments are also conceivable with only one row of such through-holes. 10. In such embodiments, the entire air inlet zone 9 will be made up by this single row. The first edge 12 of the air inlet zone will then coincide with those edges of the through-holes 10 that are closest to the first seal 7 while the second edge 13 of the air inlet zone 9 would coincide with those edges of the through-holes 10 closest to the second seal 8.

It should also be understood that instead of a plurality of through-holes 10, the air inlet zone 9 could, in principle, be formed by one single slot that extends in the axial direction of the suction roll 1. In such a case, the first 12 edge would simply be that edge of the single slot which is closest to the first seal 7 while the second edge 13 would simply be the edge of the single slot which is closest to the second seal 8.

It should be understood that the second seal 8 is the seal on outgoing side in the circumferential direction of rotation of the rotatable shell 2. In the same way, the first seal 7 is the seal on the ingoing side in the direction of rotation (i.e. the direction of arrow A in Figure 2).

Normally, the seal on the outgoing side (the second seal 8) has a longer extension in the circumferential direction than the seal on the ingoing side (i.e. the first seal 7). At least that part of the seal 8 that directly meets the inner surface 24 of the rotatable shell 2 has a longer extension in the circumferential direction than the corresponding part of the seal on the ingoing side (i.e. the first seal 7). The reason for this is that the seal on the outgoing side may have a surface facing the inner surface 24 of the rotatable shell which is slightly slanted such that the wedge-shaped gap is created between the seal 8 and the inner surface 24 of the rotatable shell. The distance between the second seal 8 and the inner surface 24 of the roll shell thus increases in the circumferential direction. Such a design may be used on the outgoing side to avoid a very sudden pressure change on the outgoing side which could otherwise generate harmful pressure pulses and irritating noise. For this reason, the second seal 8 (i.e. the seal on the outgoing side is normally made longer in the circumferential direction than the seal on the ingoing side. The second seal 8 may also have further extensions and/or elongated shape in the circumferential direction to reduce noise.

Preferably, the second seal 8 has an extension in the circumferential direction that is more than 2 times as long as the extension of the first seal 7 in the circumferential direction and preferably 2 – 4 times as long. With reference to Figure 5, the distance w_2 is thus longer than the distance w_1, preferably more than 2 times longer. In many realistic embodiments, the distance w_1 may be about 15 mm – 25 mm while the distance w_2 may be, for example 50 mm – 70 mm.

The seals 7, 8 are preferably placed in seal holders 7a, 8a, which are fastened to the wall of the suction box 4 by any suitable fastening means such as by welding, screws or the like. The seals 7, 8 may be loadable or adjustably loadable against the inner face of the shell 2 by means of loading elements such as tubes 22. In a preferred embodiment the seals 7, 8 may be lockable in their holders 7a, 8a in a position to avoid a contact against the inner surface 24 of the roll shell 2 so that a very small gap is formed between the inner surface 24 of the roll shell 2 and the radially outermost surface of the seal 7, 8. The locking means are not disclosed in the drawings but such locking means are well known. For example, suitable locking means are sold by the applicant of the present application under the name LocSeal ™. The seals 7, 8 are typically (but not necessarily) made of a mixture of rubber and graphite. The seals may be formed of a two-part structure comprising a radially inner and radially outer part connected together by a mechanical bond, for example a dove-tail joint. The two-part structure enables replacement of only the outer part when it is worn due to contact with the roll shell 2.

For such embodiments where the seals 7, 8 are placed in seal holders 7a, 8a, the seal holders 7a, 8a may be thought of as being extensions of the seals 7, 8 which extensions are connected (fastened) to the wall of the suction box 4.

Since the air inlet zone 9 is displaced towards the second seal 8 (the seal on the outgoing side), the air that is sucked into the suction box will be sucked into the suction box at a point that is closer to the end of the air inlet zone. This reduces the tendency (the risk) that the air bounces back out of the suction box.

In most realistic embodiments, the area between the first 7 seal and the second seal 8 extends over an arc length of 40° - 150° and the edge 12 of the air inlet zone 9 which is closest to the first seal 7 (i.e. the first edge 12) is displaced from the first seal 7 by at an arc length α_1 which is 10% - 80 % of the total arc length β_1 between the seals 7, 8 while the edge 13 of the air inlet zone 9 which is closest to the second seal 8 (i.e. the second edge 13) is displaced from the second seal 8 by an arc length α_2 which is no more than 10% of the total arc length between the seals 7, 8. When the arc length α_2 is short, this also reduces the amount of air that may bounce back from the second seal 8 itself. In terms of millimeters, the shortest distance from the second edge 13 of the air inlet zone 9 to that lowermost part of the second seal holder 8a may be 0 mm – 15 mm in preferred embodiments of the invention, even more preferred as little as 0 mm – 10 mm. For example, the shortest distance from the second edge 13 to the lowermost part of the second seal holder 8a could be in the range of 0 mm – 8 mm or in the range of 2 mm – 8 mm.

The fact that the air inlet zone 9 is displaced towards the second seal 8 which is the seal on the outgoing side means that air that is sucked in through the through-holes 10 tend to move more tangentially into the suction box 4 (i.e. the air moves not just radially inwards but the movement of the air has a component along the inner wall of the suction box 4). This assists in creating a swirling movement (vortex) in the inner space 5 of the suction box 4 which in turn reduces energy consumption.

Normally, the area between the first 7 and the second seal 8 extends over an arc length β_1 of which is in the range 60° - 130° and the edge of the air inlet zone 9 which is closest to the second seal 8 is displaced from the second seal by no more than 5 % of the total arc length between the seals 7, 8, preferably by no more than 3 % of the total arc length between the seals 7, 8. Embodiments are also conceivable where the edge of the air inlet zone which is closest to the second seal 8 coincides with or substantially coincides with the second seal holder 8a such that the air inlet zone 9 ends precisely where the second seal 8 begins. This substantially reduces the risk that air bounces back.

The entire air inlet zone 9 (i.e. the zone between the first edge 12 and the second edge 13) may, in realistic embodiments, extend over an arc length β_2 which is in the range of 30 – 75 % of the total arc length β_1 between the seals 7, 8. In one embodiment contemplated by the inventors, the total arc length β_1 between the seals may be about 110° - 120° while the arc length $\beta2$ of the air inlet zone for the suction box 4 may be about 70° - 80°.

With reference to Figure 5, that edge of the air inlet zone 9 that is closest to the first seal 7 (i.e the first edge 12) is displaced from the first seal 7. In Figure 5, it can be seen how the first edge 12 is displaced from the first seal 7 by an arc length α_1. This arc length α_1 corresponds to 20 % - 80 % of the total arc length between the seals 7, 8, preferably by 30 % - 70 % of the total arc length between the seals 7, 8. This means that air that is sucked into the suction zone 11 must pass the part of the suction box extending over the arc length α_1 before it can enter the inner space 5 of the suction box 4. This may also tend to give that part of the air stream a direction of movement which is not directed directly radially into the center of the suction box 4. Instead, that part of the air stream gets a more peripheral direction of movement which further reduces the risk that air bounces back.

While arc lengths have been given above in degrees, the skilled person understands that for circular cylindrical objects such as the roll shell 2 and circular cylindrical embodiments of the suction box 4, they can equally well be presented in meters or millimeters since the arc length in millimeters is then determined by the angle and the diameter of such objects.

Since it is advantageous that air should be sucked in close to the outgoing side, it is preferably so that more than 50 % of the total open area of the air inlet zone 9 is placed closer to the second seal 8 than to the first seal 7. For example, 52 % - 100% of the open area could be located closer to the second seal 8 than to the first seal 7. Or 60 % - 100 % of the open area could be located closer the second seal 8 than to the first seal 7.

As previously explained, embodiments are possible where the suction box 4 does not have a circular cylindrical shape. In principle, the wall of the suction box 4 in the area between the holders 7a, 8a, of the seals 7, 8 could even be formed by a substantially flat sheet. Also in such embodiments the air inlet zone 9 would of course be displaced towards the second seal. For such embodiments, the term “arc length” may be understood (when it is applied to the suction box 4) as the length of the wall of the suction box 4 in the area between the seals 7, 8, i.e. the path along which the wall of the suction box 4 extends between the seals 7, 8, regardless of whether this means an arc-shaped path in the case of a circular cylindrical suction box, a polygonal path or a straight path. Of course, when the seals 7, 8 are provided with seal holders 7a, 8a, this would be the path between the seal holders 7a, 8a since the seal holders 7a, 8a would then be the parts of the seals 7, 8 that meet the wall of the suction box 4.

In advantageous embodiments, the through-holes 10 are shaped as elongated slots that extend mainly in the axial direction of the suction roll. Preferably, the through-holes 10 either have rounded corners. Rounded corners increases mechanical strength since sharp corners may result in s concentration of mechanical tensions. A possible design is elliptically shaped through-holes 10.

When the air inlet zone 9 comprises a first and a second parallel row of through-holes 10 extending in the axial direction of the suction roll 1, the first row is preferably parallel with the second row. In such embodiments, the through-holes 10 in the first row may optionally (but not necessarily) be offset in the axial direction of the suction roll 1 in relation to the through-holes 10 of the second row. In this way, air sucked in through the through-holes 10 in one row may be less likely to interfere with air streams sucked in through the through-holes 10 in the other row.

The dimensions of the suction roll 1 will of course vary depending on the requirements of each particular case. However, in many realistic embodiments, the rotatable roll shell 2 may have a diameter in the range of 500 mm – 1800 mm, preferably a diameter in the range of 800 mm – 1600 mm. In such embodiments, each through-hole may suitably have an extension in the circumferential direction that corresponds to an arc length of 90 mm – 150 mm, preferably 100 mm – 140 mm.

With reference to Figure 4, the suction box 4 has an exhaust channel 14 for air at an axial end of the suction roll 1. In advantageous embodiments, the exhaust channel 14 may comprises a conical part 15 that is tapered towards the axial end of the suction roll 1. In this way, the exhaust channel 14 will not abruptly be reduced in diameter. Instead, the diameter will decrease gradually which will result in a smoother air flow. In Figure 4, the perforations 3 in the roll shell 2 are not visible but it should of course be understood that they are present.

The conical part 15 of the exhaust channel 14 may be followed by a circular cylindrical part 16 that leads to an expanding part 17 of the exhaust channel. The gently (e.g. conically) expanding part 17 has the advantageous effect that the air must not suddenly reduce its speed. This makes air evacuation smoother.

The inner space 5 of the suction box 4 is connected to a source 6 of underpressure such that the maximum underpressure in the inner space of the suction box will be in the range of 15 MPa – 70 MPa, preferably in the range of 25 MPa – 50 MPa. The source 6 of underpressure is schematically indicated in Figure 4. Since such devices are known as such no further explanation of this component is necessary.

As can be seen in Figure 4, the rotatable roll shell or mantle 2 can be journalled in bearings 18, for example roller bearings. The bearings 18 may be placed in bearing housings 19. During operation, the rotatable shell 2 may be caused to rotate by a fabric such as a felt F (see for example the felt F in Figure 1). Alternatively, the suction roll may be connected to a separate drive arrangement (not shown) for rotation of the roll shell 2.

Computer simulation of the inventive suction roll has indicated reduced energy consumption. Moreover, computer simulation has showed that the difference in underpressure over the axial length of the roll becomes small. In the simulation, the axial length of the suction roll was 5,5 m and the difference in underpressure from the driver side to the tender side was then only 313 Pa.

The suction box 4 may be made of metal, such as sheet metal of iron, steel (for example stainless steel), aluminum or any other metal or metal alloy. It may also be constructed of other materials than metallic materials. For example, it may consist of or comprise fibre reinforced plastic materials such as glass and/or carbon fibre reinforced epoxy or polyester. The seal holders may comprise (wholly or in part) the same material or materials as the suction box 4 or they may be made of another material than the suction box 4.

CLAIMS

1. A suction roll (1) for a fibre web machine, the suction roll (1) having a rotatable roll shell (2) with a plurality of perforations (3); a suction box (4) within the rotatable shell (2) which suction box (4) has a wall that defines an inner space (5) that is connected to or connectable to a source (6) of underpressure, the suction box (4) being arranged to remain stationary while the roll shell (2) rotates, a first seal (7) and a second seal (8) being arranged on the suction box (4) and extending radially between the suction box (4) and the inner surface (24) of the rotatable shell (2), the first and second seals (7, 8) being spaced from each other in the circumferential direction of the rotatable shell (2), the wall of the suction box (4) having an air inlet zone (9) formed by at least one through-hole (10), the air inlet zone (9) being located in the area between the first seal (7) and the second seal (8) such that a suction zone (11) is formed in the area between the seals (7, 8) when the suction box (4) is connected to a source (6) of underpressure, *characterised in that* , with regard to the seals (7, 8), the air inlet zone (9) is asymmetrically placed in the circumferential direction of the roll shell (2) in such a way that it is displaced towards the second seal (8).

2. A suction roll (1) according to claim 1, wherein the suction box (4) has a circular cylindrical cross section.

3. A suction roll (1) according to claim 1, wherein the air inlet zone (9) is formed by a plurality of through-holes (10) in the wall of the suction box (4) that extend in rows in the axial direction of the suction box (4) .

4. A suction roll (1) according to any of the previous claims, wherein the second seal (8) is the seal (8) on outgoing side in the circumferential direction of rotation of the rotatable shell (2).

5. A suction roll (1) according to claim 1 or claim 4, wherein the second seal (8) has a longer extension in the circumferential direction than the first seal (7).

6. A suction roll (1) according to any of the previous claims, wherein the area between the first (7) and the second seal (8) extends over an arc length (β_1) of 40° - 150° and wherein that edge (12) of the air inlet zone (9) which is closest to the first seal (7) is displaced from the first seal (7) by at an arc length ($\alpha1$) which is 10% - 80 % of the total arc length between the seals (7, 8) while the edge (13) of the air inlet zone (9) which is closest to the second seal (8) is displaced from

the second seal by an arc length (α_2) which is no more than 10% of the total arc length (β_1) between the seals (7, 8).

7. A suction roll (1) according to claim 6, wherein the area between the first (7) and the second seal (8) extends over an arc length of 60° - 130° and wherein the edge of the air inlet zone (9) which is closest to the second seal (8) is displaced from the second seal by no more than 5 % of the total arc length between the seals (7, 8), preferably by no more than 3 % of the total arc length between the seals (7, 8).

8. A suction roll (1) according to claim 6 or claim 7, wherein that edge of the air inlet zone (9) that is closest to the first seal (7) is displaced from the first seal by 20 % - 80 % of the total arc length between the seals (7, 8), preferably by 30 % - 70 % of the total arc length between the seals (7, 8).

9. A suction roll (1) according to claim 1, wherein more than 50 % of the total open area of the air inlet zone (9) is placed closer to the second seal (8) than to the first seal (7).

10. A suction roll (1) according to claim 3, wherein the through-holes (10) are shaped as elongated slots that extend mainly in the axial direction of the suction roll (1) and where the through-holes (10) either have rounded corners or are elliptically shaped.

11. A suction roll (1) according to claim 3 or claim 10, wherein the air inlet zone (9) comprises a first and a second parallel row of through-holes (10) extending in the axial direction of the suction roll (1), the first row being parallel with the second row and wherein the through-holes (10) in the first row are offset in the axial direction of the suction roll (1) in relation to the through-holes (10) of the second row.

12. A suction roll (1) according to claim 11, wherein the rotatable roll shell (2) has a diameter in the range of 500 mm – 1800 mm, preferably a diameter in the range of 800 mm – 1600 mm and wherein each through-hole has an extension in the circumferential direction that corresponds to an arc length of 90 mm – 150 mm, preferably 100 mm – 140 mm.

13. A suction roll (1) according to claim 1, wherein the suction box (4) has an exhaust channel (14) for air at an axial end of the suction roll (1) and wherein

the exhaust channel (14) comprises a conical part (15) that is tapered towards the axial end of the suction roll (1).

14. A suction roll (1) according to claim 1, wherein conical part of the exit is followed by a circular cylindrical part (16) that leads to an expanding part (17) of the exhaust channel.

15. A suction roll (1) according to claim 5, wherein the second seal (8) has an extension in the circumferential direction that is more than 2 times as long as the extension of the first seal (7) in the circumferential direction and preferably 2 – 4 times as long.

16. A method of operating a suction roll (1) according to any of claims 1 – 16, wherein the inner space of the suction box (4) is connected to a source (5) of underpressure such that the maximum underpressure in the inner space (5) of the suction box (4) will be in the range of 15 MPa – 70 MPa, preferably in the range of 25 MPa – 50 MPa.

AMENDED CLAIMS
received by the International Bureau on 22 August 2011 (22.08.2011)

1. A suction roll (1) for a fibre web machine, the suction roll (1) having a rotatable roll shell (2) with a plurality of perforations (3); a suction box (4) within the rotatable shell (2) which suction box (4) has a wall that defines an inner space (5) that is connected to or connectable to a source (6) of underpressure, the suction box (4) being arranged to remain stationary while the roll shell (2) rotates, a first seal (7) and a second seal (8) being arranged on the suction box (4) and extending radially between the suction box (4) and the inner surface (24) of the rotatable shell (2), the first and second seals (7, 8) being spaced from each other in the circumferential direction of the rotatable shell (2), the second seal (8) being the seal (8) on the outgoing side in the circumferential direction of rotation of the rotatable shell (2) and having a longer extension in the circumferential direction than the first seal (7), the wall of the suction box (4) having an air inlet zone (9) formed by at least one through-hole (10), the air inlet zone (9) being located in the area between the first seal (7) and the second seal (8) such that a suction zone (11) is formed in the area between the seals (7, 8) when the suction box (4) is connected to a source (6) of underpressure, *characterised in that,* with regard to the seals (7, 8), the air inlet zone (9) is asymmetrically placed in the circumferential direction of the roll shell (2) in such a way that it is displaced towards the second seal (8).

2. A suction roll (1) according to claim 1, wherein the suction box (4) has a circular cylindrical cross section.

3. A suction roll (1) according to claim 1, wherein the air inlet zone (9) is formed by a plurality of through-holes (10) in the wall of the suction box (4) that extend in rows in the axial direction of the suction box (4) .

4. A suction roll (1) according to any of the previous claims, wherein the area between the first (7) and the second seal (8) extends over an arc length (β_1) of 40° - 150° and wherein that edge (12) of the air inlet zone (9) which is closest to the first seal (7) is displaced from the first seal (7) by at an arc length (α1) which is 10% - 80 % of the total arc length between the seals (7, 8) while the edge (13) of the air inlet zone (9) which is closest to the second seal (8) is displaced from the second seal by an arc length (α_2) which is no more than 10% of the total arc length (β_1) between the seals (7, 8).

5. A suction roll (1) according to claim 4, wherein the area between the first (7) and the second seal (8) extends over an arc length of 60° - 130° and wherein the edge of the air inlet zone (9) which is closest to the second seal (8) is displaced from the second seal by no more than 5 % of the total arc length between the seals (7, 8), preferably by no more than 3 % of the total arc length between the seals (7, 8).

6. A suction roll (1) according to claim 4 or claim 5, wherein that edge of the air inlet zone (9) that is closest to the first seal (7) is displaced from the first seal by 20 % - 80 % of the total arc length between the seals (7, 8), preferably by 30 % - 70 % of the total arc length between the seals (7, 8).

7. A suction roll (1) according to claim 1, wherein more than 50 % of the total open area of the air inlet zone (9) is placed closer to the second seal (8) than to the first seal (7).

8. A suction roll (1) according to claim 3, wherein the through-holes (10) are shaped as elongated slots that extend mainly in the axial direction of the suction roll (1) and where the through-holes (10) either have rounded corners or are elliptically shaped.

9. A suction roll (1) according to claim 3 or claim 8, wherein the air inlet zone (9) comprises a first and a second parallel row of through-holes (10) extending in the axial direction of the suction roll (1), the first row being parallel with the second row and wherein the through-holes (10) in the first row are offset in the axial direction of the suction roll (1) in relation to the through-holes (10) of the second row.

10. A suction roll (1) according to claim 9, wherein the rotatable roll shell (2) has a diameter in the range of 500 mm – 1800 mm, preferably a diameter in the range of 800 mm – 1600 mm and wherein each through-hole has an extension in the circumferential direction that corresponds to an arc length of 90 mm – 150 mm, preferably 100 mm – 140 mm.

11. A suction roll (1) according to claim 1, wherein the suction box (4) has an exhaust channel (14) for air at an axial end of the suction roll (1) and wherein the exhaust channel (14) comprises a conical part (15) that is tapered towards the axial end of the suction roll (1).

12. A suction roll (1) according to claim 1, wherein conical part of the exit is followed by a circular cylindrical part (16) that leads to an expanding part (17) of the exhaust channel.

13. A suction roll (1) according to claim 1, wherein the second seal (8) has an extension in the circumferential direction that is more than 2 times as long as the extension of the first seal (7) in the circumferential direction and preferably 2 – 4 times as long.

14. A method of operating a suction roll (1) according to any of claims 1 – 13, wherein the inner space of the suction box (4) is connected to a source (5) of underpressure such that the maximum underpressure in the inner space (5) of the suction box (4) will be in the range of 15 MPa – 70 MPa, preferably in the range of 25 MPa – 50 MPa.

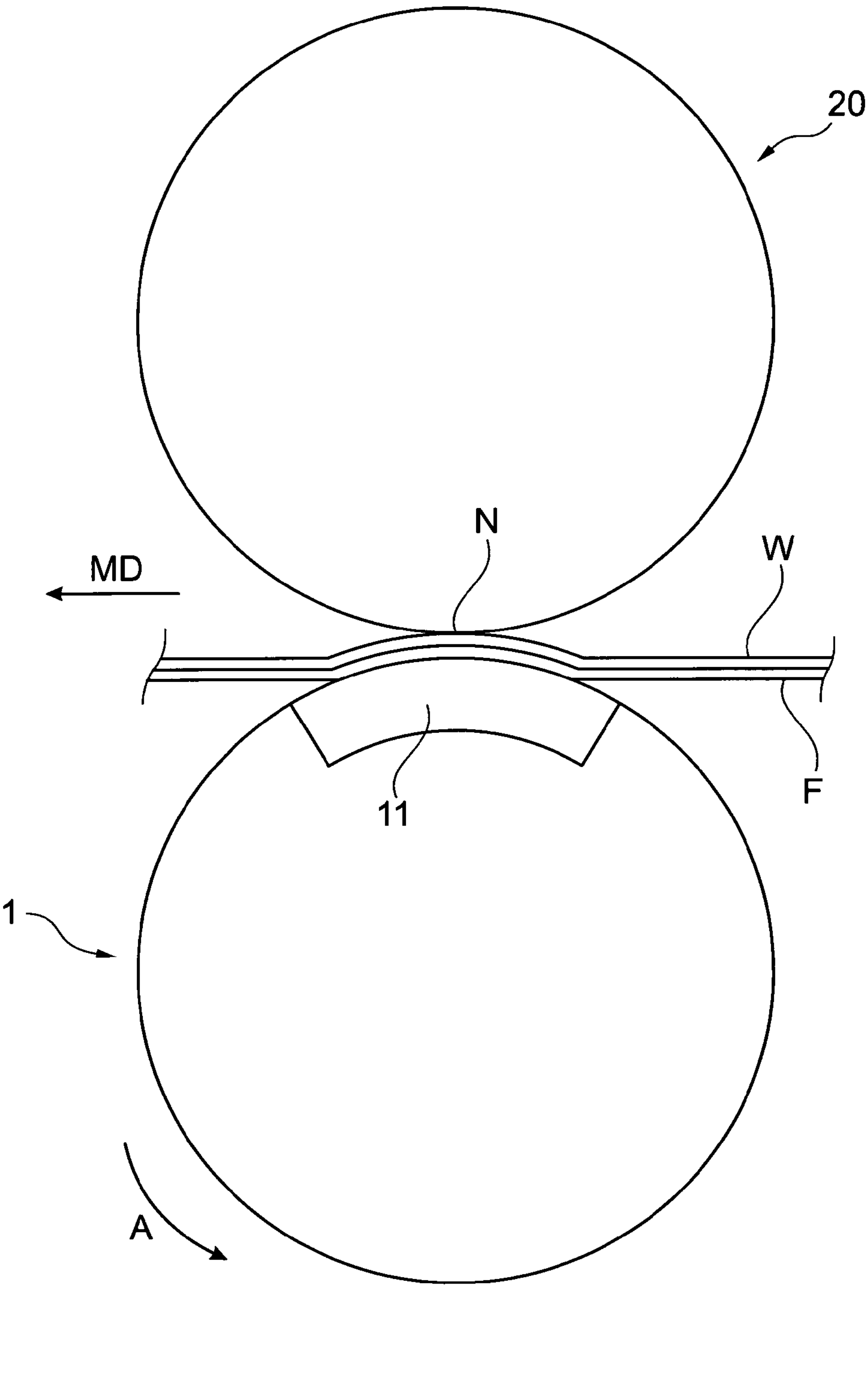

Fig. 1

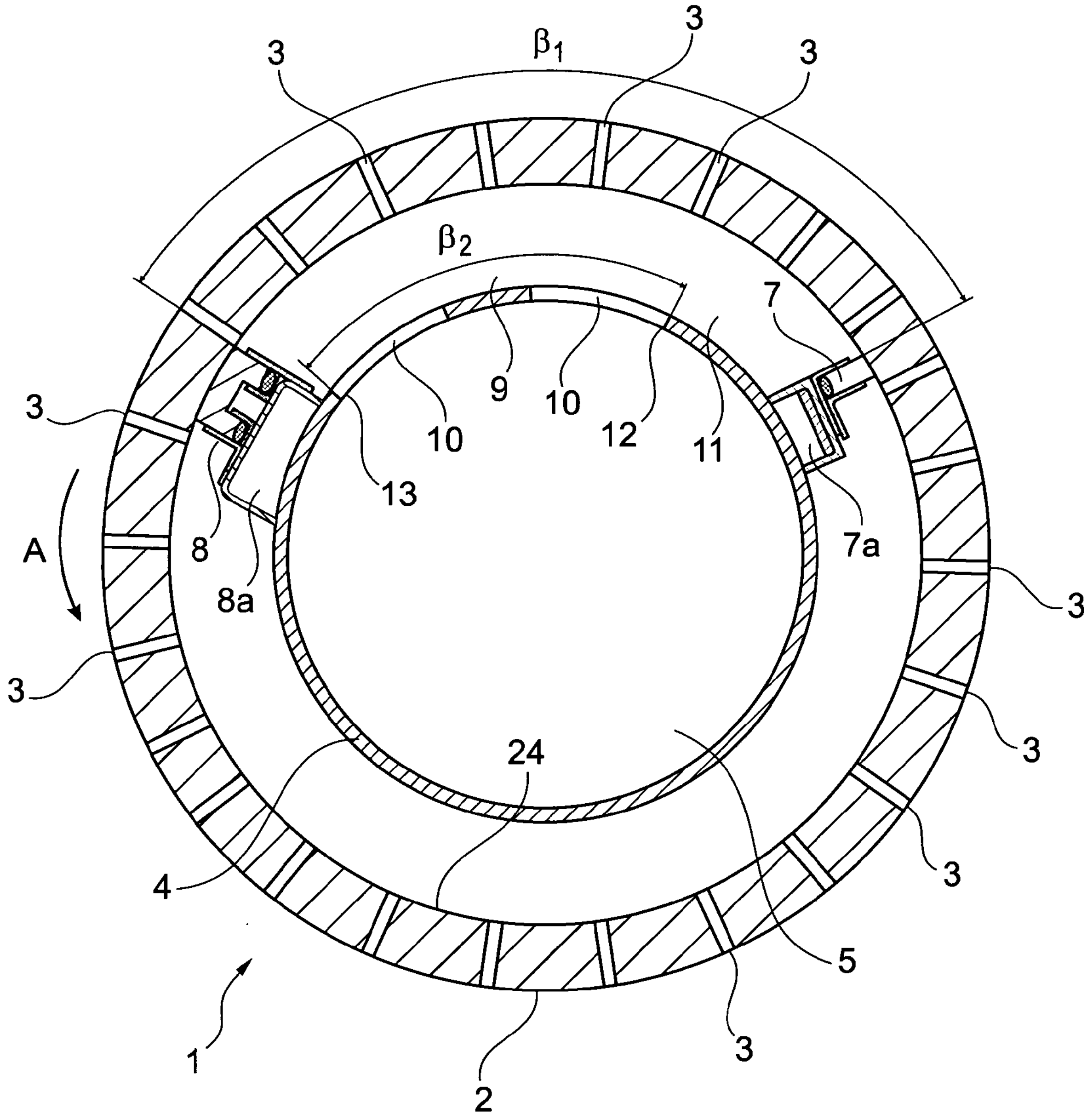

Fig. 2

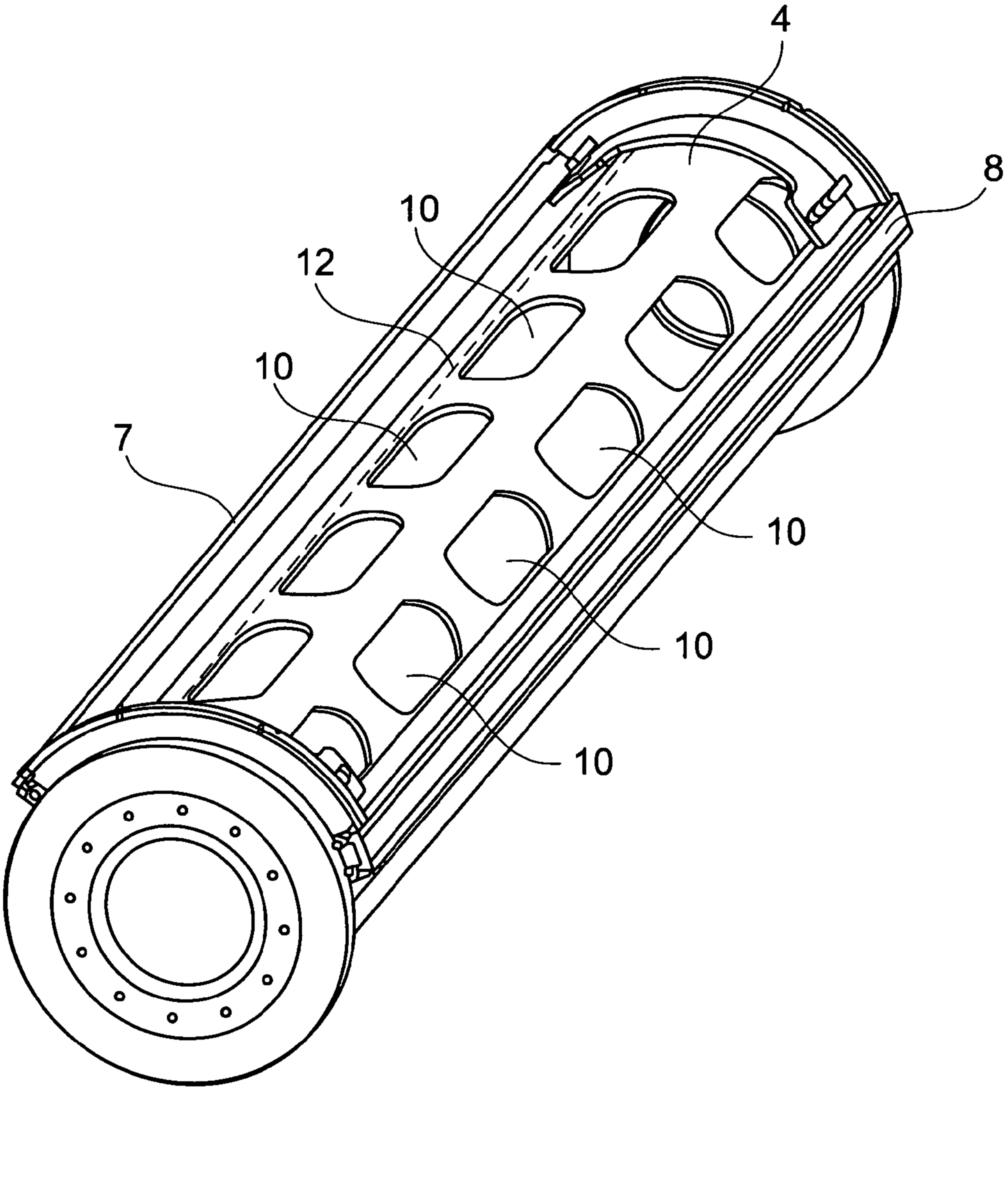

Fig. 3

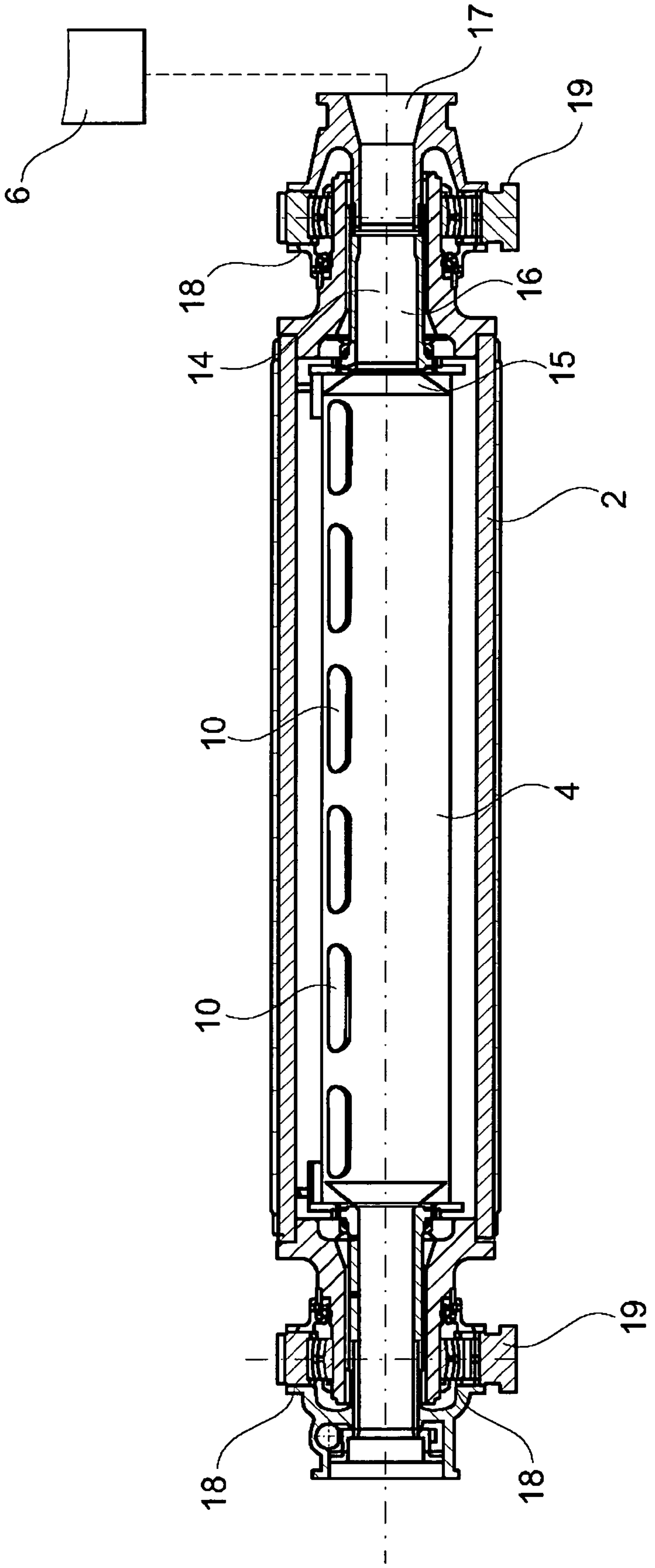

Fig. 4

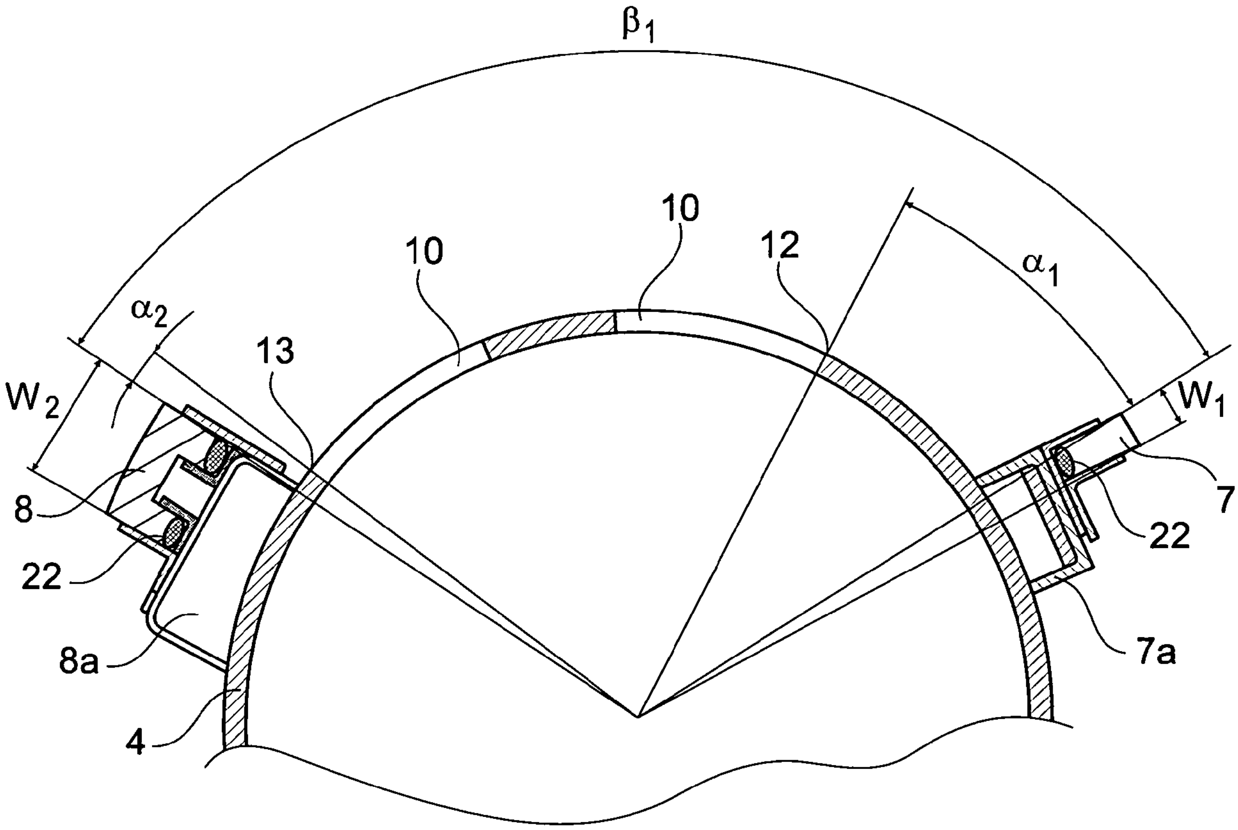

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/056037

A. CLASSIFICATION OF SUBJECT MATTER
INV. D21F3/10
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 practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 36 624 B (BELOIT IRON WORKS) 14 August 1958 (1958-08-14) column 4, line 56 - line 68; figure 3	1,2,4
X	EP 1 783 271 A1 (VOITH PATENT GMBH [DE]) 9 May 2007 (2007-05-09) paragraph [0026] - paragraph [0027]; figure 8	1
A	US 2 772 606 A (KELLY JOSEPH J) 4 December 1956 (1956-12-04) cited in the application the whole document	1,2,4,5, 15,16

☐ 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 document but published on or after the international filing date

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"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	Date of mailing of the international search report
10 June 2011	22/06/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Beckman, Anja

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/056037

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
DE 1036624	B	14-08-1958	NONE		
EP 1783271	A1	09-05-2007	DE 102005052552	A1	03-05-2007
US 2772606	A	04-12-1956	NONE		