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(54) Method and apparatus for drying a fibrous web

(57) There is described a method for controlling curl of a fibrous web in a drying section of a machine for manufacturing the web. The method steps are drying the bottom side of said web by way of contact drying and thereafter drying the top side the web in a press drying step in which the web is pressed against a heated surface and is dried. The pressure on the web in the press drying step is higher than in contact drying. At least one press drying step is the final drying step. A suitable dryer apparatus has a bottom side contact drying arrangement where a permeable surface holds the web in contact with heated drying surfaces. A top side drying arrangement downstream of the bottom side drying arrangement, has an impermeable belt pressing the web against an impermeable support cylinder.

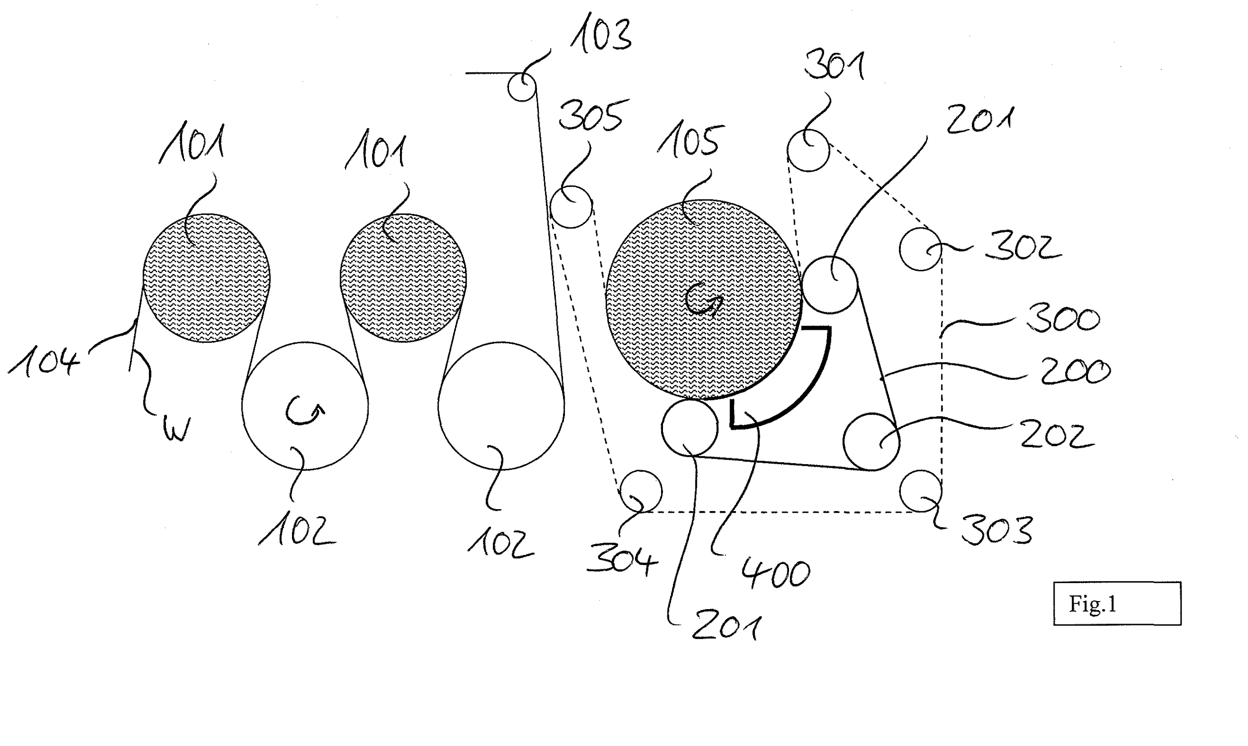

Fig.1

EP 2 722 438 A1

Description

[0001] The invention relates to a method and apparatus involved in drying a fibrous web. The fibrous web can be any type of web made from materials containing fibers, and the web is in particular paper or (card)board.

[0002] One step of manufacture of such a fibrous web is drying the web after forming, pressing or other treatment in the paper or board machine. Drying of the web has a considerable influence on the product properties. One property is, for example, the change of shape during drying, in particular a phenomenon which is known as curling, i.e. a tendency to curl around an axis extending in the length direction of the web so that the edges tend to curl inwardly.

[0003] The curling tendency in either of these directions is considered a quality deficit because it may cause problems in the further processing and later use of the paper or board materials.

[0004] It is known that curling tends to occur towards the side which has been dried last, e.g. when dried with a one-sided drying in a single tier. In order to cope with this problem, the prior art suggests solutions using a double tier with both-sided drying, moisturizing, or impingement dryers. However, these solutions still leave room for improvement of the curl control with regard to space requirements, energy consumption and cost.

[0005] In view of the above, it is the object of the invention to suggest a method and apparatus in which the curl control, when drying a fibrous web is improved with regard to space requirements, energy consumption and cost.

[0006] With regard to the method, the object is solved with a method according to claim 1, and with regard to the apparatus, the object is solved with a dryer apparatus according to claim 7. Advantageous modifications of the invention are depicted in the dependent claims.

[0007] According to the invention, for controlling curl of a fibrous web running through a drying section of a machine for manufacturing and/or treatment of a fibrous web, wherein the web has a top side and a bottom side, the method comprises a step of drying the bottom side of said web by way of contact to a moving lower impermeable surface in a contact zone. Thereafter the top side is dried by way of tension press contact to a moving upper impermeable surface in a tension pressure contact zone in a tension press drying step, wherein the tension pressure on the web in the tension pressure contact zone is higher than the pressure on the web in said contact zone. The tension press drying step is the final drying step.

[0008] The invention is based on the finding that curling occurs toward that surface of the web which dries last, so that the curling tendency can be controlled by controlling the moisture evaporation direction. Because drying of the web is based on heat transfer which occurs in zones where the web is in contact with a heat transmitting surface, the evaporation of the moisture is controlled by way of the conditions in the contact zone and in subsequent uncovered (top side of web is exposed) or unsupported draw (bottom side of the web is exposed). The control of conditions comprises at least one of: control of the surface temperature of surfaces contacting the web in the tension contact zone, pressure and temperature in the tension pressure contact zone, control as to which surface mainly evaporates the moisture and the intensity of evaporation, and moisturizing the web after the tension contact zone in the next supported or unsupported draw.

[0009] By selecting the position of moisture permeable surface(s) and/ or moisture impermeable surface(s) with regard to the respective web side (top or bottom) and by selecting the temperatures thereof, the direction and intensity of moisture release is controlled. Furthermore, by the application of tension pressure in the penultimate drying step or the final drying step or in both drying steps (tension pressure contact zone) heat transfer for moisture removal can be intensified, while the pressure applied to the web has a calendering or flattening effect on the web, to thereby reduce curl tendency. Thus, accurate control of the curling tendency can be obtained.

[0010] It has been found that that the intensified drying effect while improving web quality has the further effect that drying of the web can be carried out during a significantly shorter run of the web, so that the size of the drying section may be considerably reduced.

[0011] Preferably, the method comprises plural steps of alternately drying the bottom side of the web and the top side of the web, wherein at least the penultimate drying step and the final drying step are tension press drying steps. With this arrangement, significant moisture removal accompanied by tension pressing provides efficient water removal while maintaining curl tendency control.

[0012] Preferably, in the tension press drying step, the top side of the web is additionally pressed against the upper impermeable surface by way of a pressing element, wherein the pressing element (for example, a press roll, a stationary press cylinder, etc.) and the upper impermeable surface form a pressing nip in which the pressure on the web in the tension pressure contact zone is locally increased. Using a pressing element, it is possible to control the pressure on the web in a desired pressure profile, that is, the pressure exerted on the web while it is in the tension pressure contact zone is not constant but may follow a desired profile of pressure increase or decrease. Thus, contact pressure and heat transfer can be further intensified. It is noted that this pressure profile is superimposed on the pressure exerted on the web due to its sandwiched position between two surfaces in a tension pressure contact zone. The pressure refers to the force with which the web is pressed against the respective surfaces.

[0013] Preferably, in the tension press drying step, the bottom side of the web is supported on a support surface which is maintained at a lower temperature than the upper impermeable moving surface, so that the moisture to be removed is condensed on the support surface below the bottom side of the web. Advantageously the support surface is a porous surface in the pores of which the condensed moisture is collected. For example, a fabric may constitute said support surface)

[0014] In an advantageous modification, in the final drying step the support surface is maintained at a temperature lower than the temperature of the upper impermeable surface, so that an amount of moisture evaporated from the top side of the web is much larger than the amount of moisture removed from the bottom side of the web, when the web leaves the tension pressure contact zone. It is noted here that in the case that the web is interposed between two impermeable surfaces, the moisture is released from the web immediately when the web leaves the tension pressure contact zone, i.e. when the two impermeable surfaces start to separate, the moisture is allowed to escape from the web.

[0015] With regard to the apparatus, the object of the invention is solved with a dryer apparatus for drying/finishing a fibrous web running through a drying section of a machine for manufacturing and/or treatment of a fibrous web, wherein the web has a top side and a bottom side. The dryer apparatus comprises a bottom side drying arrangement having heated drying surfaces adapted to contact and dry a bottom side of a web passing through said dryer apparatus, and a permeable surface adapted to contact the top side of the web to hold the web in contact with the drying surfaces. Further, a top side drying arrangement is arranged downstream of the bottom side drying arrangement as seen in the moving direction of the web. The top side drying arrangement has a heat conductive impermeable belt forming a heated moving impermeable surface against which the top side of the web is pressed into tension pressure contact by an impermeable support surface. As a true alternative for the top side drying arrangement, the top side drying arrangement has at least one heat conductive cylinder forming a heated moving impermeable surface against which the top side of the web is pressed into tension pressure contact by an impermeable support surface.

[0016] Preferably, the dryer apparatus may comprise a pair of such top side drying arrangements which may be of the same type or of the two different alternative types described above. A bottom side drying arrangement is arranged between said top side drying arrangements as seen in the running direction of the web.

[0017] Preferably, a fabric is interposed between the bottom side of the web and the impermeable support surface. In such an arrangement, if the side of the web which is exposed to the fabric is the cool side (the fabric is arranged between the web and the cool impermeable surface, the moisture evaporated from the web driven by the heat from the hot side is condensed and trapped in the fabric, so that an efficient transport of the moisture away from the web is obtained.

[0018] When the heated moving impermeable surface is formed by a belt as a preferred form, the impermeable support surface is preferably formed by at least one cylinder, and vice versa, i.e. when the heated moving impermeable surface is formed by at least one cylinder as a preferred form, the impermeable support surface is preferably formed by a belt. The belt is preferably a metal belt.

[0019] Preferably, a press roll is arranged in nip contact with the impermeable belt at a belt cylinder to locally load the web in the tension contact zone between the heated moving impermeable surface and the impermeable support surface.

[0020] Preferably, at least the heated moving impermeable surface is smooth so that a smooth surface of the paper is obtained after it has passed through the tension pressure contact zone.

[0021] Preferably at least one steam box or hot fluid box is provided on one or both sides of the belt for heating the belt, when the heated moving impermeable surface is formed from a belt which is preferably formed of metal. The steam box is operated such that condensation occurs on the (belt)surface to be heated, so that a very efficient heat transfer can be obtained allowing the transfer of large amounts of heat into the web to be dried, so that quick and effective drying can be obtained. Also, because the heat transfer is not a bottle neck for the heat flow into the web, the freedom of controlling conditions in the nip contact zone and/or the tension pressure contact zone is increased.

[0022] In preferred forms, the dryer apparatus may have one or more cylinders forming the heated moving impermeable surface, which cylinders are smooth cylinders having a heating device in connection with the cylinder wall. Further preferably, a cooling device is provided in connection with the support surface to cool the support surface.

[0023] In various advantageous modifications the belt may be made from different materials including plastics and composite materials including metal, however, it is presently most preferred that the belt is a metal belt.

[0024] Preferably, the dryer apparatus has a plurality of tension pressure contact zones between the top side of the web and heated moving impermeable surfaces, wherein an open draw or a supported draw which is to be passed by the web, is arranged between the individual tension pressure contact zones.

[0025] Further advantageous forms of carrying out the invention include a method in which in the final drying step, the web is sandwiched between the upper impermeable surface and a support surface which is impermeable, and wherein evaporation of the moisture occurs from the top side of the web, when the web leaves the tension pressure contact zone. The evaporating moisture can be removed by blowing and/or doctoring and/or suction. For this, preferably, a moisture collecting device is arranged at a position where running directions of the heated moving impermeable surface and of the impermeable support surface deviate from each other and expose the web, so that moisture evaporating form the exposed web can be collected. In this connection, the moisture collecting device may comprise at least one of the following elements: a blowing device, a suction box, an air knife, a blow box and a doctor blade.

[0026] In order to improve the runnability of a paper or board machine using the method and apparatus according to the invention, the impermeable belt is coated with a water repellent material avoiding sticking of the web to the belt.

[0027] For an accurate control of the moisture of the web surfaces, a moisturizing device may be provided to for moisturizing the web after a contact zone. In this way, a slight over-drying in the contact zone may be combined with a re-moisturizing of the web surface, so that the surface moisture and the moisture distribution in the web may be controlled arbitrarily and independently.

[0028] The invention will now be described by way of presently preferred embodiments which are shown in the attached drawings. In the drawings

Fig. 1 shows a first embodiment of a dryer apparatus which operates according to the method of the invention;
Fig. 2 shows a modification of the apparatus of Fig. 1;
Fig. 3 shows a second embodiment of a dryer apparatus which operates according to the method of the invention;
Fig. 4 shows a modification of the apparatus of Fig. 3;
Fig. 5 shows another embodiment of a dryer apparatus which operates according to the method of the invention; and
Fig. 6 shows heat flow and moisture flow in different combinations of a web to be dried, a fabric and solid surfaces.

[0029] Before a detailed description of the embodiments of drying apparatuses is given below, the different paths of the moisture and the heat is described with reference to Fig. 6. Throughout Figs. 6a to 6e Reference sign w indicates the web, reference sign f indicates the fabric, reference sign s indicates an impermeable solid surface, reference sign m indicates the moisture flux, reference sign h indicates the heat flux, and reference sign d indicates heating with hot blows.

[0030] In Fig. 6a, the web w is sandwiched or interposed between a solid surface s on top side of the web w and a fabric f arranged below the web w. This situation corresponds to a contact zone wherein the solid surface s may be the surface of a drying cylinder or of a metal belt. The solid surface s is heated and the fabric f is comparatively cool; it may be actively cooled. The term "cool" generally means below 95 °C, thereby enabling condensing; of course, a bit cooler surface gives more condensing and leaves some margin for heating up when it gets some condensation heat.

[0031] Heat h is transported or flows into the web driven by a temperature difference between the solid surface s and the web w. Moisture in the web w will be driven towards the bottom side of the web due to the heat forcing the moisture to evaporate on the bottom side of the web into the fabric f. Because the fabric f is cooler than the evaporating moisture, the condensing moisture m is trapped in the fabric f and can be transported away form the web w by the fabric f.

[0032] Fig. 6b shows a supported draw where the web w rests on the fabric f; i.e. the fabric supports the web from below. In this supported draw e.g. after the tension contact zone, moisture m is released form the top side of the web w due to residual heat in the web w.

[0033] Fig. 6c shows a contact zone similar to Fig. 6a, wherein the difference resides in that the bottom side of the web w rests on the impermeable surface s which supplies heat h from the bottom side of the web w into the web w. Driven by that heat h, moisture m is released from the top side of the web w into a fabric f contacting the top side of the web w. The moisture m condenses in the cooler or cooled fabric f and is trapped in the fabric f. The moisture can then be transported away from the web w by separating the fabric f from the web w.

[0034] Fig. 6d shows an unsupported draw of the web w. As can be seen, moisture m is released from the top side and the bottom side of the web w. The moisture removal from the top side of the web w can be promoted by use of drying gas or air (so-called "blows" or "hot blows" in case drying gas and/or air is preheated) which flows over the top surface of the web w as is indicated by arrow d in Fig. 6d.

[0035] Fig. 6e indicates the situation where the web w is interposed or sandwiched between two impermeable surfaces s which both introduce heat h into the web w. As long as the web w is interposed between the two solid surfaces s, the moisture is trapped in the web w and cannot escape therefrom. As soon as one side of the web w separates from the solid surface s, the moisture is immediately released from the web w, additionally driven by the steam pressure of the evaporating moisture. The proportions of the moisture leaving the web from the top side and from the bottom side can be controlled by way of the temperatures of the heated solid surfaces s. It is noted that the web is in pressure contact with the two solid surfaces s being loaded towards each other.

[0036] It is noted that the solid surfaces may have very different temperatures, so that one of the solid surfaces s is a hot surface in the sense of drying a moist web material, wherein the hot temperature is suitable for promoting the evaporation of the moisture. The term "hot" generally means temperatures over 100 °C for suitably promoting the evaporation of the moisture. The other one of the solid surfaces s is a cooler surface in the sense of drying a moist web material, wherein the cooler temperature is suitable for promoting condensation of the moisture. By suitable selection of the hot and the cool temperature, the moisture distribution in the web can be controlled having an influence on the curl control. Curl control, i.e. suppression of the curl tendency is e.g. achieved if 80-85% of the moisture are released from one side of the web and 15-20% are released from the other side of the web.

[0037] Fig. 1 shows a first embodiment of a dryer apparatus which operates according to the method of the invention. Web w is supported by a drying wire 104 and is passed through a row of drying cylinders 101, wherein the heated drying cylinders are marked with reference signs 101 and are drawn with a wave shaped pattern to indicate that they are heated or hot in the sense described above under reference to Fig. 6. Drying wire 104 with the web w supported thereon is guided from one drying cylinder 101 to the next drying cylinder 101 by reversing rolls 102, which are not heated and which usually contain means (not shown) to support the separation of the web w from the hot drying cylinder surface and to hold the web w on the drying wire 104. In Fig. 1 there are only shown two of the heated drying cylinders 101, but Fig. 1 only shows an end part of a row of drying cylinders 101 which may contain some tens of such cylinders. The drying cylinders 101 are arranged to contact the bottom side of the web w.

[0038] In Fig. 1 the web runs from left to right as can be seen from the rotation direction of the reversing roll 102 indicated with an arrow. The drying wire 104 leaves the surface of the last reversing roll 102 and runs to a wire guide roll 103. The web w rests on the side of the drying wire 104 which faces a fabric 300 arranged in a fabric loop. The fabric loop comprises a fabric 300 and guide rolls 301, 302, 303, and 304. A pick-up roll 305 is arranged inside the fabric loop at a position close to the path of the web w and the drying wire 104. When the web w passes the pick-up point where the fabric 300 and the drying wire 104 are close to each other, the web w is transferred to the fabric 300 by the aid of the pick-up roll 305, so as to continue its run supported by the fabric 300. As can be seen, there is no open or unsupported draw of the web in the apparatus of Fig. 1.

[0039] Outside the fabric loop there is a belt cylinder 105 which is arranged such that the fabric 300 goes partly around it and is guided by the belt cylinder 105. The web is transferred to the fabric 300 on the outside of the fabric loop. When the fabric 300 passes around the belt cylinder 105, the web w is interposed or sandwiched between the fabric 300 and the surface of the belt cylinder 105.

[0040] The belt cylinder 105 is heated as is indicated with a wave shaped pattern. The heating temperature of the belt cylinder is adjustable and is set at least high enough so that sufficient moisture removal by way of evaporation is obtained. Of course the temperature setting of the belt cylinder temperature is dependent on various process conditions and the web characteristics.

[0041] Inside the fabric loop there is a belt loop arranged which belt loop is formed of a belt 200 and belt rolls 201, 202 and 203. The belt 200 is preferably a metal belt which provides an impermeable and heat conducting surface. Other materials may be used as well such as plastic or composite materials which may contain metal. The belt loop is arranged such that the belt 200 is in tension press contact with the fabric 300 and presses the fabric 300 and the web w against the outside surface of the belt cylinder 105 such that the web is pressed against that belt cylinder surface at a part of its circumferential surface. The surface of the belt is smooth.

[0042] Further, Fig. 1 shows a cooling device 400 arranged with the belt 200 to cool the belt 200. In operation, after the meandering path through and along the drying cylinders 102, the web W is transferred to the fabric 300 which carries the web towards the belt cylinder 105. At the belt cylinder 105, the top side of the web w is brought in contact with the heated belt cylinder 105, while it is supported by the fabric 300. On the further path of the web w along with the surface of the belt cylinder 105, the web w and the fabric 300 enter a tension pressure contact zone formed between the belt 200 and the belt cylinder 105. Here pressure is imposed on the web w while the web is heated on its side contacting the belt cylinder side, that is the top side, and the web releases the moisture towards the cooled fabric 300. In the fabric, the moisture condenses and is trapped in the fabric 300 to be taken out from the tension pressure contact zone. The web is picked up from the fabric later to be transferred to further processing of the web, such processes may be for example calendering, coating, winding, slitting, sizing or other web processing steps. The pick-up of the web is not shown in Fig. 1.

[0043] Furthermore, the belt wrap, i.e. the length of the tension pressure contact zone expressed as a wrapping angle may be varied and adjusted by suitable movement of the belt rolls 201, 202 and 203. The belt wrap may have a wrapping angle of 120 to 260 degrees, wherein a preferred angle may lie in the range of 150 to 210 degrees.

[0044] Fig. 2 shows a modification of the embodiment of Fig. 1 which has been described above in detail. The arrangements, devices and operation in the present modification of the dryer apparatus is substantially the same, so that the basic structure will not be described again but it is here focused on the difference between the first embodiment and the present modification. Furthermore, the same reference signs as in Fig. 1 are used for the same or for functionally same elements in the apparatus of Fig. 2, so that the above description of these elements applies to Fig. 2 mutatis mutandis.

[0045] The apparatus in Fig. 2 has been modified by adding a press roll 500 in the area of the tension pressure contact zone, i.e. the area where the belt is in press contact with the fabric 300 to press the web w against the belt cylinder 105. The press roll 500 generates a pressure peak in the tension pressure contact zone, so that the web is subjected to a pressure profile in the tension pressure contact zone. In other words, the pressure on the web in the tension pressure contact zone is not constant. Although it is not shown here, a cooling device similar in function as the cooling device 400 may be added to the belt loop.

[0046] Temperatures, pressures and other parameters like the wrap angle of the belt 200 are adjustable and in substantially the same ranges as has been described before with reference to Fig. 1.

[0047] Fig. 3 shows a second embodiment of a dryer apparatus which operates according to the method of the invention. Similar elements or functionally similar elements as in the first embodiment have the same reference signs in Fig. 3, so that a detailed description thereof may be omitted here. The respective description is included here by way of reference to the above.

[0048] In the left part of Fig. 3 a meandering path of the web w together with a drying wire 104 between and around heated drying cylinders 101 and reversing rolls 102 and guide roll 103 is shown. Where the drying wire 104 approaches a fabric loop with a fabric 300, the web w facing a belt cylinder 107 is picked-up and transferred to the fabric 300. The pick up device is not shown but known devices such as suction box, pick-up roll may be used here to transfer the web w on the surface of the fabric 300. The fabric 300 runs around guide rolls 306, 307 and around a cooled belt cylinder 107 which may be quite similar to belt cylinder 106 of Fig. 1 but which is not heated. Optionally a cooling device (not shown) may be provided to cool belt cylinder 107. The belt cylinder 107 is arranged inside the fabric loop of fabric 300.

[0049] A belt 200 is arranged in the form of a belt loop by cooperating with belt rolls 201, 202, 203. The belt loop is arranged outside the fabric loop of fabric 300 and is arranged to form a tension pressure contact zone between belt 200 and belt cylinder 107 on a part of the circumference of the belt cylinder 107. In this tension pressure contact zone, the web w will be transferred together with the fabric 300, while the belt 200 presses them against the surface of belt cylinder 107. The cylinder surface and the belt surface form an impermeable moving surface.

[0050] The belt is heated by a heating means (not shown) wherein the heating means may comprise steam heating, electric heating including induction heating or combustion heating straight to the belt or through at least one belt roll.

[0051] When the web w passes through the tension pressure contact zone, moisture is driven towards the bottom side of the web w due to the heat flux from the belt 200 to the top side of the web. The evaporated moisture escapes from the web w into the fabric 300 where the moisture condenses due to the cooling of the fabric 300 by way of cooled belt cylinder 107. The condensed moisture is trapped in the fabric and is moved away from the web w, when the web w and the fabric 300 separate.

[0052] It is noted here that similar to the apparatus of Fig. 1 and 2, the pressure imposed on the web and fabric can be adjusted by suitable adjustment of the positions of the belt rolls 201, 202 and 203. Also, as mentioned above, the wrapping angle with which the belt wraps around the belt cylinder 107 is adjustable and should lie in a range of 120 to 260 degrees, preferably between 150 and 210 degrees.

[0053] Also, although not shown, devices and means for further transferring the web w, separating the web w from the belt 200 and the fabric 300 etc. may be of designs/operations known in the art. It is noted that there is no free or unsupported draw of the web in the apparatus of Fig. 3.

[0054] Fig. 4 shows a modification of the apparatus of Fig. 3, wherein all elements are the same as in Fig. 3. Therefore the same reference signs are used for the same elements, so that the above description of these elements applies to Fig. 4 mutatis mutandis and a repetition of the related description is omitted. Here, the only different element will be described.

[0055] The apparatus in Fig. 4 has been modified by adding a press roll 600 in the area of the tension pressure contact zone, i.e. the area where the belt is in press contact with the fabric 300 to press the web w against the belt cylinder 107. The press roll 600 generates a pressure peak in the tension pressure contact zone, so that the web is subjected to a pressure profile in the tension pressure contact zone. In other words, the pressure on the web in the tension pressure contact zone is not constant. Although it is not shown here, a heating device for the belt 200 is added to the belt loop.

[0056] Temperatures, pressures and other parameters like the wrap angle of the belt 200 are adjustable as has been described before with reference to Fig. 3.

[0057] Fig. 5 shows another embodiment of a dryer apparatus which operates according to the method of the invention. Similar elements or functionally similar elements are designated with the same reference signs as in the foregoing drawings Fig. 1 to 4. For the description of the elements having the same reference sign, it is referred to the above description of these elements in order to avoid repetitions. Hereafter, mainly the differences between the apparatus of Fig. 3 and the apparatus shown here will be described.

[0058] In Fig. 5, the drying wire 104 carrying the web w passes a meandering path through heated drying cylinders 101 and reversing rolls 102. By way of a transfer device 109, the web is transferred or handed over to the surface of a cooled belt cylinder 107. Here the web w is in direct contact with the belt cylinder surface; a contact zone is formed. Moving together with the cylinder surface of the cooled belt cylinder 107, the web w moves into a tension pressure contact zone formed in an area in which a heated belt 200 is in tension pressure contact with the web and presses it against the belt cylinder surface. The belt 200 is formed around belt rolls 201, 202, 203, which are adjustable in order to adjust the pressure and/or the wrapping angle of the belt 200 around the belt cylinder 107. Preferred values for the wrapping angle are given in the description to Figs. 1 and 3 above. The belt 200 and the belt cylinder 107 form an impermeable moving surface in the sense of the claims.

[0059] The belt 200 is heated by heating devices 700 which are only schematically shown. These heaters may be steam heaters, electric heaters including induction heaters or combustion heaters.

[0060] After having passed the pressure contact zone between the belt cylinder 107 and the belt 200, the moisture will immediately evaporate from the web, because the moisture could not escape in the pressure contact zone (the web was sandwiched between impermeable surfaces on the top side and the bottom side). The spontaneous evaporation of the moisture supports the release of the web from the impermeable surfaces. The surfaces of the belt 200 and the belt cylinder 107 are smooth. In the presence of moisture heat and pressure, as is the case in the tension pressure contact zone, a pre-calendering effect on the web is obtained, the web surfaces are smooth. A press roll forming a nip with the belt in the tension pressure contact zone similar to the press roll in Fig. 2 and 4 may be provided.

[0061] A pick-up device 803 supports the pick-up of the web w onto fabric 800 which forms a fabric loop around guide rolls 801 and 802.

[0062] It is noted that the description presents the drying in a pressure contact zone at the end of a drying section as the final drying step. However, it is also possible to additionally provide the pressure contact zone also in a previous drying step for drying the top side of a web; for example, such a pressure contact zone using a belt may be provided in connection with the leftmost guide cylinder 102 in Figs. 1 to 5.

Claims

1. A method for controlling curl of a fibrous web running through a drying section of a machine for manufacturing and/or treatment of a fibrous web, wherein the web has a top side and a bottom side,
said method comprising the steps of:

drying the bottom side of said web by way of contact to a moving lower impermeable surface in a contact zone, and
thereafter drying the top side by way of tension press contact to a moving upper impermeable surface in a tension pressure contact zone in a tension press drying step, wherein the pressure on the web in the tension pressure contact zone is higher than the pressure on the web in said contact zone, and wherein said tension press drying step is the final drying step.

2. A method according to claim 1, comprising plural steps of alternately drying the bottom side of the web and the top side of the web, wherein at least the penultimate drying step and the final drying step are tension press drying steps.

3. A method according to claim 1 or 2, wherein in the tension press drying step the top side of the web is pressed against the upper impermeable surface by way of a pressing element, wherein the pressing element and the upper impermeable surface form a tension pressing nip in which the pressure on the web in the tension pressure contact zone is locally increased.

4. A method according to claim 1, 2 or 3, wherein in the tension press drying step, the bottom side of the web is supported on a support surface which is maintained at a lower temperature than the upper impermeable moving surface, so that the moisture to be removed is condensed on the support surface below the bottom side of the web.

5. A method according to claim 4, wherein the support surface is a porous surface in the pores of which the condensed moisture is collected.

6. A method according to claim 5, wherein in the final drying step the support surface is maintained at a temperature lower than the temperature of the upper impermeable surface, so that an amount of moisture evaporated from the top side of the web is much larger than the amount of moisture removed from the bottom side of the web, when the web leaves the tension pressure contact zone.

7. A dryer apparatus for drying/finishing a fibrous web running through a drying section of a machine for manufacturing and/or treatment of a fibrous web, wherein the web has a top side and a bottom side, the apparatus comprising
a bottom side drying arrangement having heated drying surfaces adapted to contact and dry a bottom side of a web passing through said dryer apparatus, and a permeable surface adapted to contact the top side of the web to hold the web in contact with the drying surfaces, and
a top side drying arrangement arranged downstream of the bottom side drying arrangement as seen in the moving direction of the web, said top side drying arrangement having:

a heat conductive impermeable belt forming a heated moving impermeable surface against which the top side of the web is pressed into tension pressure contact by an impermeable support surface, or
at least one heat conductive cylinder forming a heated moving impermeable surface against which the top side of the web is pressed into tension pressure contact by an impermeable support surface.

8. A dryer according to claim 7, comprising a pair of said top side drying arrangements, wherein said bottom side drying arrangement is interposed between said top side drying arrangements as seen in the running direction of the web.

9. A dryer apparatus according to claim 7 or 8, wherein a fabric is interposed between the bottom side of the web and the impermeable support surface.

10. A dryer apparatus according claim 7, 8 or 9, wherein, when the heated moving impermeable surface is formed by a belt, the impermeable support surface is formed by at least one cylinder, and, when the heated moving impermeable surface is formed by at least one cylinder, the impermeable support surface is formed by a belt.

11. A dryer apparatus according to any one of claims 7 to 10, wherein a press roll is arranged in nip contact with the impermeable belt to locally load the web in the tension contact zone between the heated moving impermeable surface and the impermeable support surface.

12. A dryer apparatus according to any one of claims 7 to 11, wherein at least the heated moving impermeable surface is smooth.

13. A dryer apparatus according to any one of claims 7 to 12, wherein at least one steam box or hot fluid box is provided on one or both sides of the belt for heating the belt, when the heated moving impermeable surface is formed from a belt.

14. A dryer apparatus according to any one of claims 7 to 12, wherein the one or more cylinders forming the heated moving impermeable surface are smooth cylinders having a heating device in connection with the cylinder wall.

15. A dryer apparatus according to any one of claims 7 to 14, wherein
a cooling device is provided in connection with the support surface to cool the support surface, and/or
the belt is a metal belt, and/or
the dryer apparatus has a plurality of tension pressure contact zones between the top side of the web and heated moving impermeable surfaces, wherein an open draw or a supported draw which is to be passed by the web, is arranged between the individual tension pressure contact zones.

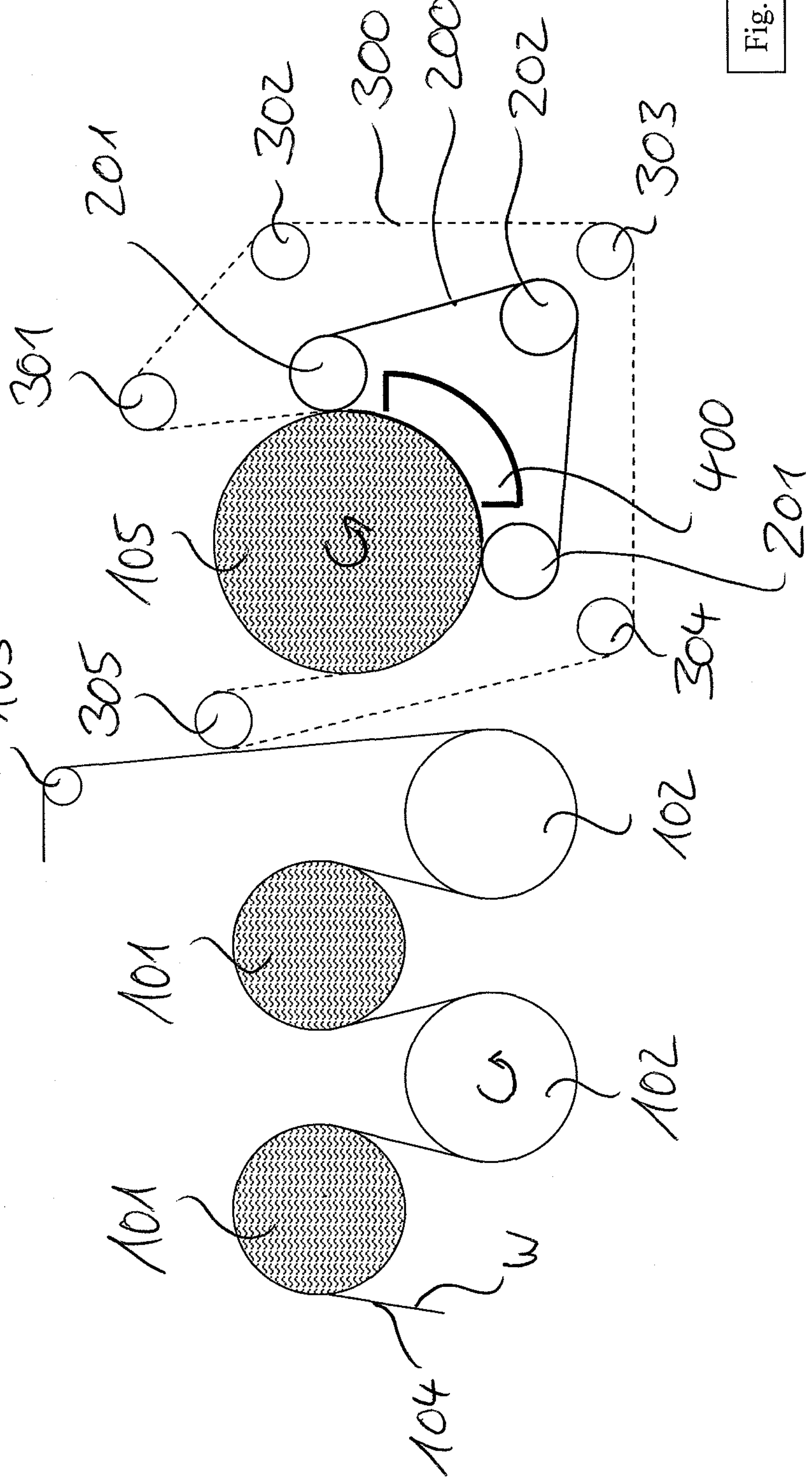

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Fig.1

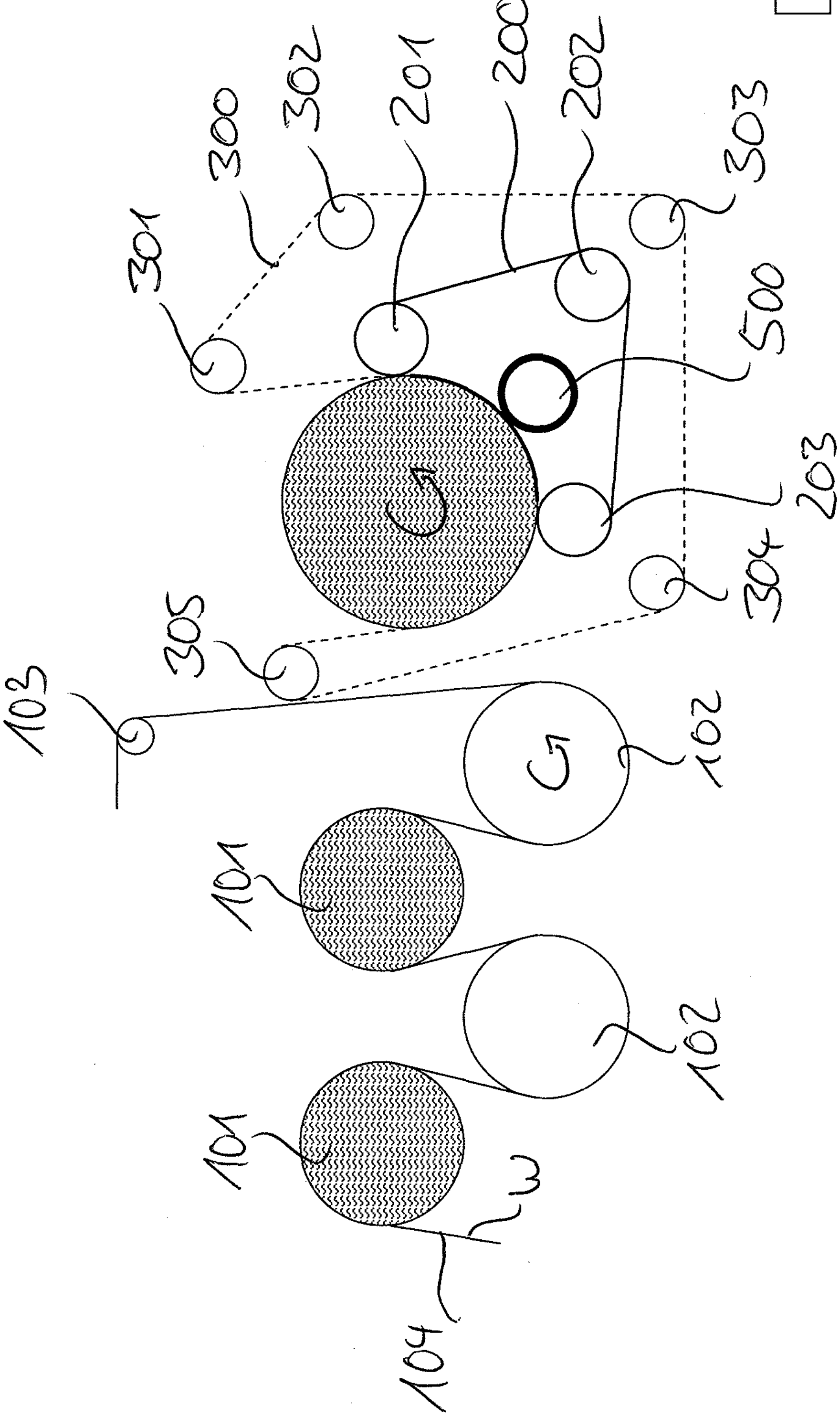
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Fig.2

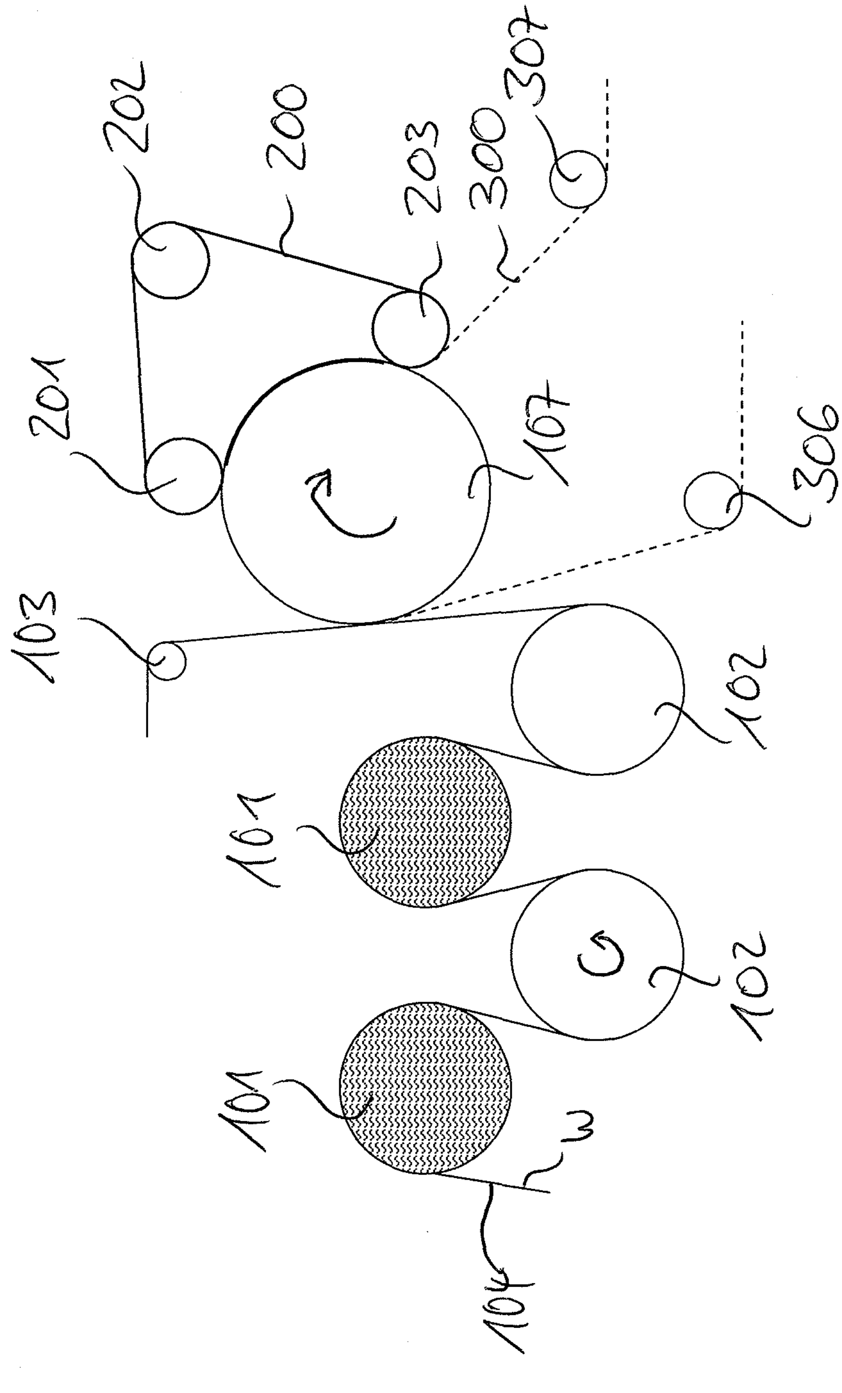

Fig.3

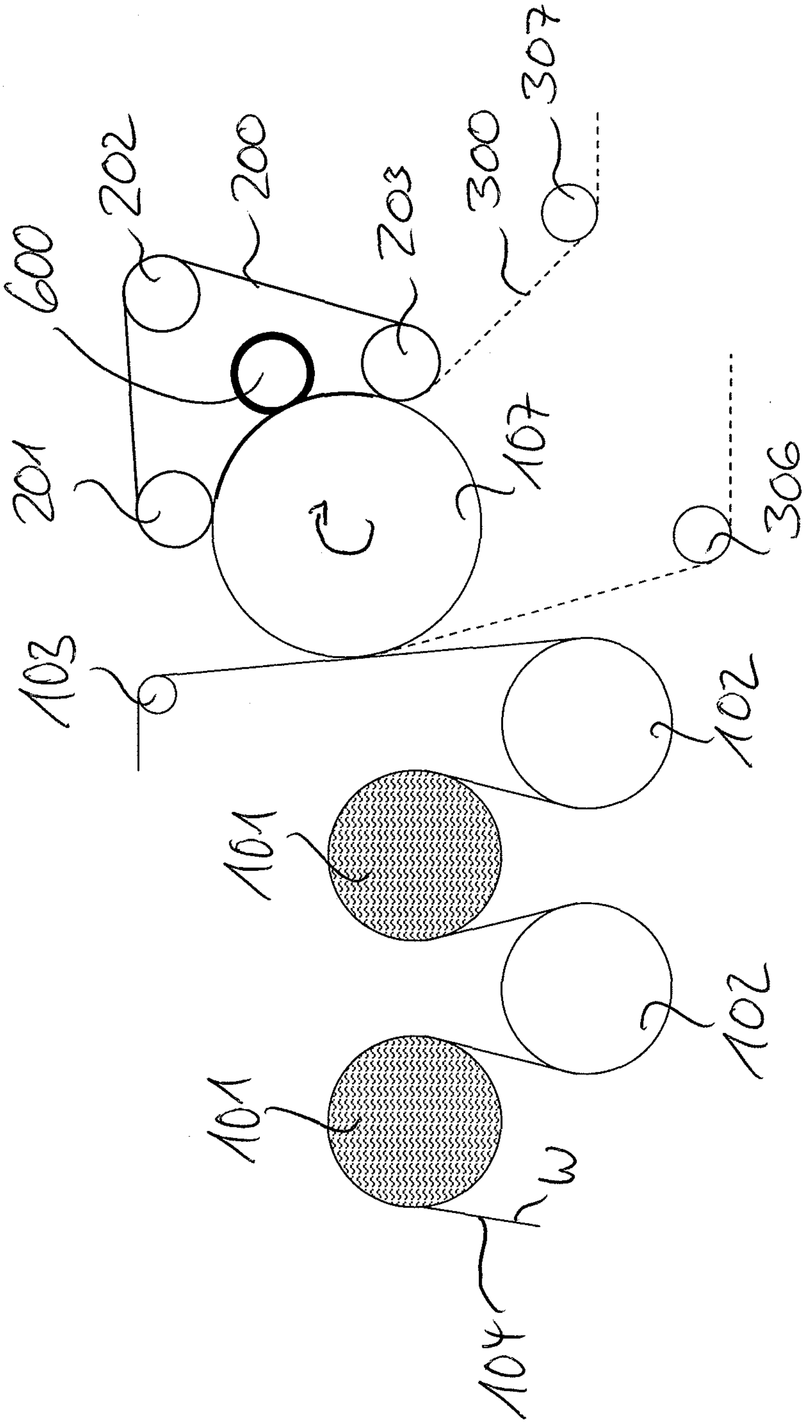

Fig.4

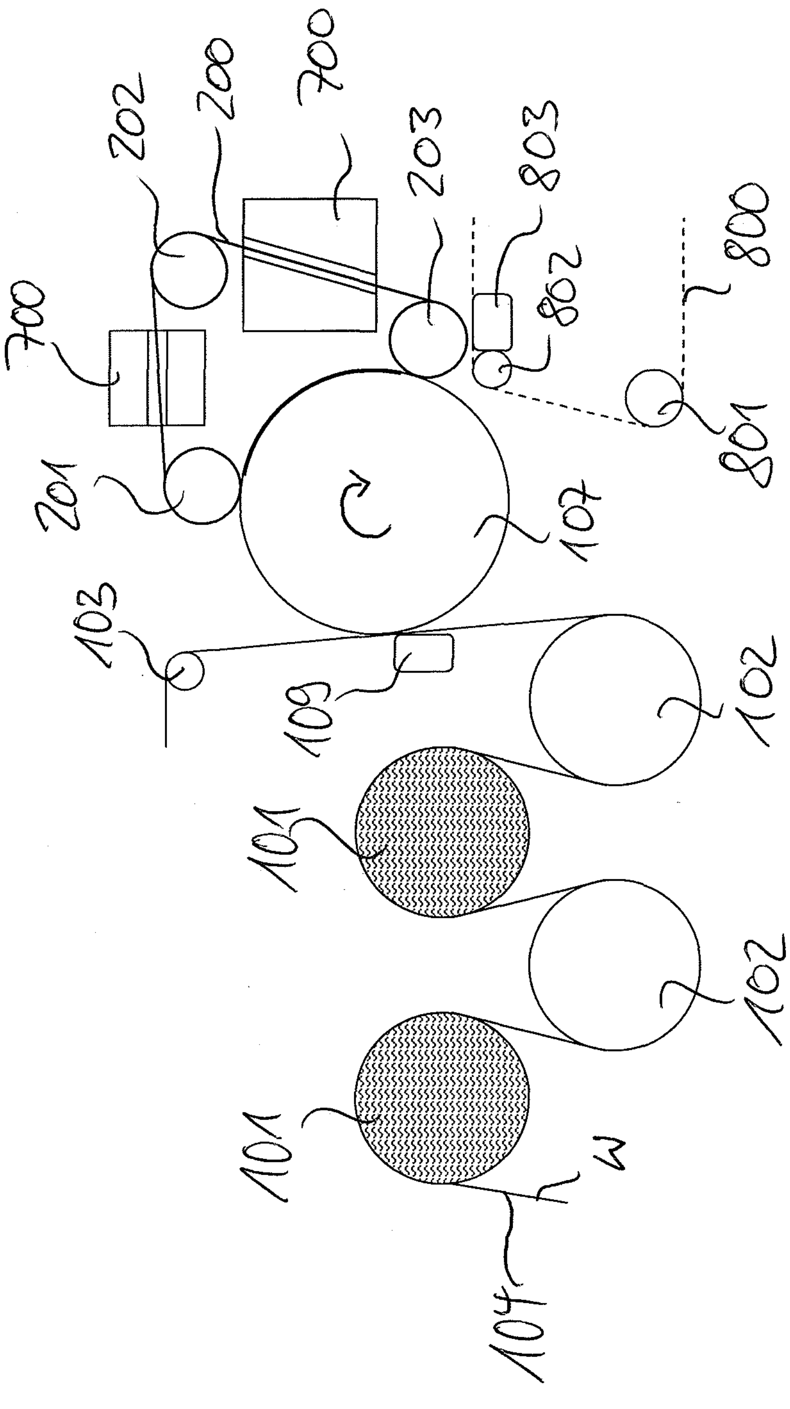
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Fig.5

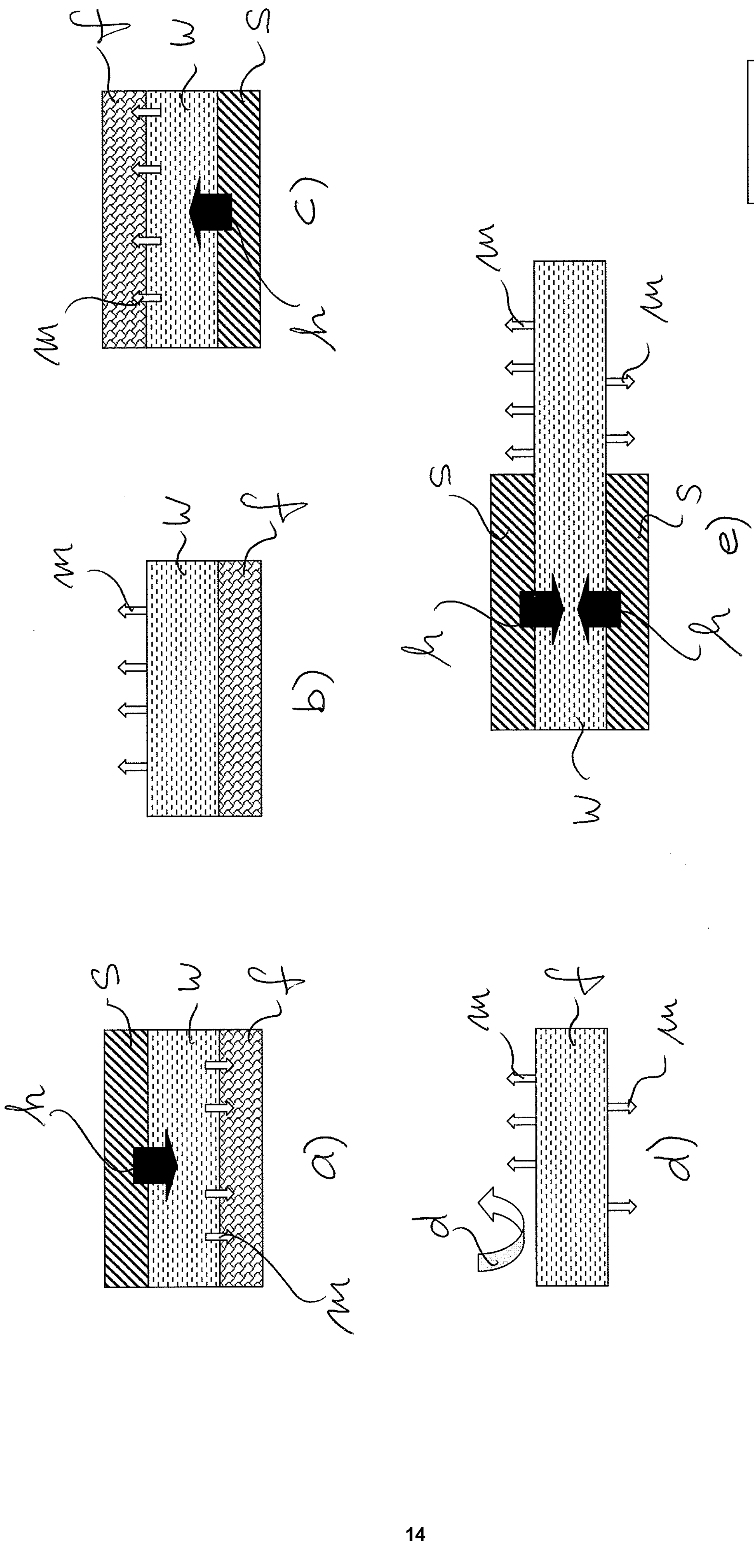

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
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Place of search	Date of completion of the search	Examiner
Munich	6 December 2012	Maisonnier, Claire

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