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(54) Method in the drying of a paper web and a dryer section of a paper machine.

(57) Method and dryer section in contact-drying of a paper web (W). The paper web (W) is dried by means of heated smooth-faced drying cylinders (10, 20A,20B) by using a number of successive so-called normal groups (R_1...R_N) with single-wire draw, in which the drying cylinders (10) are placed in the upper row and the reversing suction cylinders (11) in the lower row. After the press section of the paper machine, the paper web (W) is dried initially in a number of successive groups (R_1...R_N) with single-wire draw by pressing the paper web (W) by means of the drying wire (15) of the cylinder group against the heated faces of the drying cylinders (10) and by, in each group (R_1...R_N) with single-wire draw, passing the paper web (W) on support of the same drying wire (15) from one drying cylinder (10) onto the other drying cylinder over reversing suction cylinders (11) or rolls. By means of the groups (R_1...R_N) with single-wire draw, the paper web (W) is dried to a dry solids content of k_1 = 70...92 %. After the drying steps which were carried out exclusively by means of normal groups (R_1...R_N) with single-wire draw, the paper web (W) is dried immediately further by means of one single group (R_{TW}) with twin-wire draw to its ultimate dry solids content.

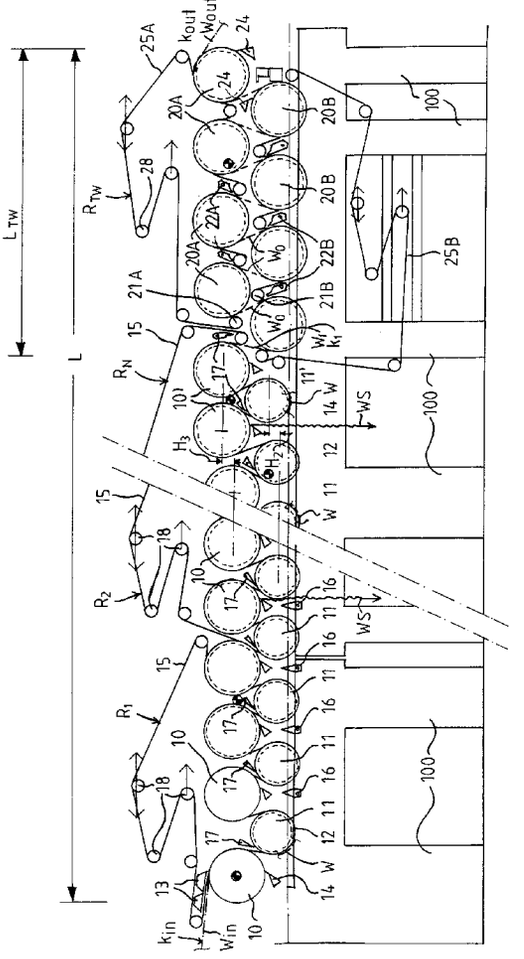


FIG. 1

EP 0 653 515 A2

The invention concerns a method in contact-drying of a paper web, wherein the paper web is dried by means of heated smooth-faced drying cylinders by using a number of successive so-called normal groups with single-wire draw, in which the drying cylinders are placed in the upper row and the reversing suction cylinders or corresponding reversing suction rolls in the lower row, in which method, after the press section of the paper machine, the paper web is dried initially in a number of successive groups with single-wire draw by pressing the paper web by means of the drying wire of the cylinder group against the heated faces of the drying cylinders and by, in each group with single-wire draw, passing the paper web on support of the same drying wire from one drying cylinder onto the next drying cylinder over reversing suction cylinders, and in which method, after the above drying steps, which were carried out exclusively by means of normal groups with single-wire draw, the paper web is dried immediately further by means of one single group with twin-wire draw to its ultimate dry solids content.

Further, the invention concerns a dryer section of a paper machine, whose initial part is composed of a number of successive so-called normal groups with single-wire draw, in which the drying cylinders are placed in the upper row and the reversing suction cylinders or corresponding suction rolls are placed in the lower row, and between which said normal groups the paper web to be dried has closed draws over the group gaps, and which said reversing suction cylinders have been arranged to be subjected to negative pressure, at least at their drying-wire turning sectors, and in which dryer section, after the last group with single-wire draw, one single group with twin-wire draw is provided, in which there are two rows of drying cylinders, one row placed above the other.

In the way known from prior art, in multi-cylinder dryers of paper machines, twin-wire draw and/or single-wire draw is/are employed. In twin-wire draw, the groups of drying cylinders include two wires, which press the web, one from above and the other one from below, against the heated cylinder faces. Between the rows of drying cylinders, which are usually horizontal rows, the web has free and unsupported draws, which are susceptible of fluttering, which may again cause web breaks, in particular since the web is still relatively moist and, therefore, of low strength. This is why, in recent years, increasing use has been made of said single-wire draw, in which each group of drying cylinders has one drying wire only, on whose support the web runs through the whole group so that the drying wire presses the web on the drying cylinders against the heated cylinder faces, whereas, on the reversing cylinders or rolls between the drying cylinders, the web remains at the side of the outside curve. Thus, in single-wire draw, the drying cylinders are placed outside the wire loop and the reversing cylinders or rolls inside said loop.

In prior-art normal groups with single-wire draw, the heated drying cylinders are placed in the upper row and the reversing cylinders in the lower row, which rows are, as a rule, horizontal and parallel to one another. In the applicant's **FI Patent No. 54,627** (equivalent to **US Pat. 4,202,113**) it is suggested that the above normal groups with single-wire draw and so-called inverted groups with single-wire draw be placed one after the other, in which said inverted groups the heated drying cylinders are placed in the lower row and the reversing suction cylinders or rolls in the upper row, the principal objective being to dry the web symmetrically from both of its sides. Also, Messrs. Beloit Corp. have made some suggestions for a dryer section that comprises normal and inverted cylinder groups, in which respect reference is made to the published international patent applications **WO 88/06204** and **WO 88/06205**. In the following, when the terms "normal (drying) group" and "inverted (drying) group" are used, what is meant is expressly the cylinder groups with single-wire draw of the sort mentioned above.

In dryer sections that comprise inverted and normal drying groups, various problems have occurred, for which problems the present invention is supposed to suggest novel efficient solutions. These problems include the large length of the dryer section, which increases the costs of the dryer section and of the machine hall.

Problems have also been encountered in the runnability of the dryer section and in the threading of the web, problems arising from differences in the speeds of different wires, problems in the removal of broke especially in inverted groups, as well as problems related to the control of transverse shrinkage of the web. As a rule, these problems tend to become worse as the running speed of the paper machine becomes higher.

With respect to the prior art involved in and most closely related to the present invention, reference is made to the following patent publications and articles published in journals:

- W. Haessner, "Trocknungstechnik und deren Entwicklung";
  Das Papier 44, 10A, 1990
- "The Valmet Sym-Run Concept", *Paper Asia*, May/Jun 1992
- J. Yli-Kauppila, "Dryer Section for High Speed Paper Machines",
  Proceedings of the Helsinki Symposium of Alternate Methods of Pulp and Paper Drying, Helsinki June 4-7, 1991
- S. Palazzolo, "No-draw drying", *Tappi Journal*, September 1990
- W. Leitenberger, "Die Contirun-Trockenpartie für schnellen, sicheren Bahnlauf",
  Das Papier, Heft 6, 1992

- US Patents Nos. 3,753,298; 3,868,780; 4,602,439; 4,972,608; 4,982,513; 5,022,163; 5,065,529; 5,146,696, and US-5,177,880
- V. Korhonen and A. Kuhasalo, "Ropeless tail threading from press to reel", *World Pulp & Paper Technology* 1993
- H. Lepistö und P. Eskelinen, "Verbesserung der Lauffähighkeit schneller Papiermaschinen mit Hilfe neuer Ventilationseinrichtungen", *Das Papier* 1985, Heft 10A
- Lindberg, Juppi, Eskelinen, "High Speed Dryer Section Developments for Sheet Stability", *78th Annual Meeting, Technical Section CPPA*, 1992.

With respect to the prior art most closely related to the present invention and not public on the date of priority of the present application, reference is made to the International Patent Application No. **WO93/022494** of Messrs. Beloit Corporation, which is equivalent to the **EP Pat. Appl. 93910650.6** and which became public on November 11, 1993, i.e. after the date of priority of the present application.

In the following, the problems and requirements of further development that have occurred in the prior-art dryer sections, for example, according to the patents and papers mentioned above, will be dealt with in more detail. As a background, it should be stated that the highest web speeds of paper machines are currently already of an order of 25 m/s (metres per second), but before long even the speed range of 25...40 m/s will be taken to use. In such a case, a bottle-neck for the runnability of a paper machine will, to an increasing extent, consist of the dryer section, which will, moreover, with the use of the prior-art dryer concepts, become quite long.

In the inverted drying groups mentioned above, in the case of breaks, a problem consists of the removal of broke, for inverted groups are not self-cleaning by the force of gravity. Thus, it is an object of the present invention to provide a dryer section in which no inverted groups are needed at all, but which, yet, meets the other requirements that are imposed.

In prior-art dryer sections in which exclusively groups with single-wire draw are used, in the last wire groups, considerable wear of the drying fabrics has occurred, in particular in the manufacture of fine papers with a high content of fillers. An object of the present invention is also to reduce this problem, which occurs in the drying groups driven by the drying wire because of the considerable thickness of the drying wire. The differences in speed mentioned above, together with a restricted drying shrinkage, have caused web breaks in the last groups when exclusively single-wire draw has been used, which problem is emphasized further if, in the groups with single-wire draw, small-diameter suction rolls proper are used that are provided with an inside suction box. In order to eliminate this problem, in some machines, it has been even necessary to open some group gaps and to lower the level of negative pressure in the suction rolls.

It is an object of the present invention to provide a novel drying method and dryer section in which an extreme end of the dryer section is used that is arranged in such a way that the paper web is given a possibility and time to be relaxed in the free gaps so that any breaks arising from internal strains in the web are eliminated.

It is a further object of the present invention to provide a dryer section whose runnability can be brought to a particularly high level.

Further, it is an object of the invention to provide a dryer section in which so-called ropeless tail threading can be applied favourably over the entire length of the dryer section in the machine direction, which contributes to making the constructions simpler and any standstill times shorter.

In view of achieving the objectives stated above and those that will come out later, the method of the invention is mainly characterized in that by means of said groups with single-wire draw the paper web is dried to a dry solids content of k1 = 70...92 %, that, as said reversing suction cylinders, suction cylinders are used which have no inside suction box, the paper web being held on the drying wires by the intermediate of the perforated mantle and the grooves in the outside face of said cylinders by means of a difference in pressure against the effect of centrifugal forces when the paper web is on the drying wire at the side of the outside curve, and/or that, on the runs between the drying cylinders and reversing cylinders or rolls in said groups with single-wire draw, differences in pressure that disturb the support contact of the paper web are prevented by means of blow boxes or equivalent.

On the other hand, the dryer section in accordance with the invention is mainly characterized in that differences in pressure that disturb the support contact between the drying wire and the paper web on their joint runs from the drying cylinders onto the reversing suction cylinders in the groups with single-wire draw have been reduced or prevented by means of air-blow devices or equivalent, and/or that said reversing suction cylinders are reversing suction cylinders that are provided with a perforated mantle and with outside grooves subjected to a vacuum and which said cylinders have no inside suction box.

According to the invention, in the single group with twin-wire draw placed at the end of the dryer section, it is favourably possible to employ free draws of the paper web between the rows of cylinders, on which free draws the paper web is allowed to be relaxed. Alternatively or additionally, in the single group with twin-wire draw, it is also possible to use fully closed draws between the rows of cylinders, for example closed draws as described in Figs. 3 and 4 in

the applicant's **FI Patent No. 68,279** (equivalent to **US Patent 4,602,439**), or other, corresponding prior-art draw arrangements.

In the dryer section in accordance with the invention, the transverse shrinkage of the web may be increased very little in comparison to a situation in which the web is dried by means of a dryer section exclusively consisting of groups with single-wire draw, but especially when a size press or a coating device is used after the dryer section, in the final product, in this respect, no disadvantageous difference is noticed that is unfavourable to the invention.

In the present invention, by means of a combination of a number of process steps and constructional solutions in themselves known, it has been successfully possible to provide a dryer section that is more advantageous in respect of both its construction and its runnability, the paper produced by means of said dryer section having quality properties that meet even very high requirements, also as regards symmetry and dimensional stability.

In the following, the invention will be described in detail with reference to some exemplifying embodiments of the invention illustrated schematically in the figures in the accompanying drawing, the invention being by no means strictly confined to the details of said embodiments.

Figure 1 is a schematic side view of a dryer section in accordance with the invention that makes use of the method of the invention.

Figure 2 shows a closed draw between a group with single-wire draw and a group with twin-wire draw and an alternative embodiment of a single group with twin-wire draw.

Figure 3 shows such a final end of a dryer section in accordance with the invention in which two cylinder groups are employed that are fitted in inclined planes, in particular in view of reducing the length of the dryer section.

According to Fig. 1, the paper web W_{in} is brought into the dryer section from the press section (not shown) onto the drying wire 15 of the first group R_1 with single-wire draw, to which wire it is fixed by the effect of the negative pressure in the suction boxes 13. The dryer section includes N pieces of groups $R_1,R_2...R_N$ with single-wire draw, between which the web W has a closed draw. In the dryer section in accordance with the invention, the number of the normal groups $R_{1...N}$ is N = 3...9, preferably N = 5...7, and typically N = 6. All the groups $R_1...R_N$ with single-wire draw are so-called normal groups, in which the, e.g., steam-heated smooth-faced drying cylinders 10 are placed in the upper horizontal row and the reversing suction cylinders 11 or equivalent suction rolls are placed in the lower horizontal row. In the last normal group R_N, the last two upper cylinders 10' and the single reversing suction cylinder 11' placed between them are placed at a level by the dimension H_3 higher than in the preceding groups $R_1...R_{N-1}$. The dimension H_3 is typically $H_3 \approx 400$ mm. The frame part 100 of the dryer section is illustrated quite schematically.

Each normal group $R_1...R_N$ has a drying wire 15 of its own, which is guided by guide rolls 18. The drying wires 15 press the web W to be dried on the drying cylinders 10 against their smooth heated face, and on the reversing cylinders 11 the web W remains at the side of the outside curve on the outside face of the wire 15. On the reversing cylinders 11 the web W is kept reliably on support of the wire 15 against the effect of centrifugal forces by the effect of the negative pressure present in the grooved faces 12 of the reversing cylinders 11, whereby transverse shrinkage of the web W is also prevented. The reversing suction cylinders 11 that are used are preferably suction cylinders 11 marketed by the applicant under the **trade mark "VAC-ROLL"™**, which cylinders have no inside suction boxes, which cylinders are provided with a perforated mantle and with outside grooves that are subjected to a vacuum, and in respect with whose constructional details reference is made to the applicant's **FI Patent No. 83,680** (equivalent to **US Pat. No. 5,022,163**). The diameters D_2 of these suction cylinders 11 are substantially larger than the diameters of normal suction rolls that are provided with an inside suction box and that are used in corresponding positions. Hereby, the remarkable advantage is obtained that, on the turning sectors on the reversing cylinders 11, the web W is subjected to lower centrifugal forces, whereby a more reliable transfer is achieved and/or it is possible to use a lower vacuum level in the grooved faces 12 of the reversing cylinders, compared with normal suction rolls.

In a preferred embodiment of the invention, the support contact between the web W and the drying wire 15 is also kept good on the straight runs between the drying cylinders 10 and the reversing cylinders 11, at least on the runs taking place from the drying cylinders 10 to the reversing cylinders 12, by using blow-suction boxes 17, by whose means formation of negative pressures induced by the wire 15 is prevented in the closing wedge-shaped nip spaces between the wire 15 and the cylinder 12 mantle. In respect of the details of the constructions of these blow-suction boxes 17, which are marketed by the applicant under the trade mark "**UNO RUN BLOW BOX**"™, reference is made to the applicant's **FI Patents Nos. 59,637, 65,460, and 80,491** (equivalent to **US Pats. Nos. 4,441,263, 4,515,330, and 4,905,380**. After the introduction of the "UNO RUN BLOW BOX"™, the applicant's competitors have also suggested some blow-box solutions, in whose respect reference is made to the **US Patents 4,502,231 (J.M. Voith GmbH)** and **4,661,198 (Beloit Corp.)**, whose applications in the positions of the blow boxes 17 are also included in the scope of the overall concept of the present invention.

In the groups $R_1...R_N$ with single-wire draw, blow

boxes 16 are also used in the gaps between the reversing cylinders 12, by means of which boxes said intermediate spaces are air-conditioned and evaporation from the web W is promoted. The faces of the drying cylinders 10 are kept clean by the doctors 14.

In the invention, it is a further essential feature and advantage that broke removal by the force of gravity can be applied in the groups $R_1...R_N$ with single-wire draw, which extend over the major part of the overall length L of the dryer section, for the groups $R_1...R_N$ with single-wire draw are open towards the bottom so that the paper web WS that becomes broke can be removed without any particular arrangements onto the broke conveyor (not shown) placed in the basement space of the paper machine.

It is an essential feature of the method of the invention that, in the normal groups $R_{1...N}$, the web W has time to reach a certain, quite high dry solids content of $k_1 \approx 70$ %...92 %, preferably $k_1 \approx 80$ %...85 %, depending on the paper grade. At this dry solids content k_1, the web W is so strong that, for its further drying, it is possible to apply a group with twin-wire draw without a risk of detrimental breaks. Thus, it is an essential feature of the invention that, in the final end of the dryer section, there is expressly just one single group R_{TW} with twin-wire draw. In this single twin-wire group R_{TW}, there are two horizontal rows of contact-drying cylinders 20A and 20B, one row placed above the other, of which cylinders, in connection with the upper cylinders 20A, there is an upper wire 25A, which is guided by wire guide rolls 21A fitted in the gaps between the cylinders 20A and by other guide rolls 28. The web W is pressed into a drying contact against the heated faces of the lower cylinders 20B by means of the lower wire 25B, which is guided by the wire guide rolls 21B fitted in the gaps between the cylinders 20B and by other guide rolls 28.

According to Fig. 1, in the twin-wire group R_{TW}, a draw arrangement marketed by the applicant under the **trade mark "TWIN-RUN"™** is used, in which the guide rolls 21A and 21B are placed so that the drying wires 25A and 25B accompany the web from the drying cylinders 20A and 20B onto the next one so that the free draws W_0 of the web W can be made shorter, as compared with free draws of full length. In this draw arrangement, at the proximity of the wire guide rolls 21A and 21B and at the inlet side of the web W and the drying wire 25A and 25B, air-blow boxes 22A,22B are used. Out of the blow boxes 22A,22B, which are used in the "TWIN-RUN"™ concept and which are fitted in the gaps between the drying cylinders 20A,20B, air jets of suitable direction and blow velocity are applied to the vicinity of the runs of the drying wires 25A,25B placed at their proximity and to the vicinity of the free sectors of the wire guide rolls 21A,21B, by means of which jets the support contact between the drying wires 25A,25B and the web W is promoted, formation of detrimental differences in pressure and fluttering of the web W on the free draws W_0 are prevented. Said blowings can also be applied through the drying wires 25A,25B, whereby it is possible to promote the ventilation of the pocket spaces P formed in the gaps between the drying cylinders 20A,20B. With respect to the further details of the "TWIN-RUN"™ concept and of the blow boxes 22A,22B, reference is made to the applicant's **FI Pat. 80,103** (equiv. to **DE Pat. 3,818,600**).

In connection with the drying cylinders 20A,20B, there are doctors 24. According to Fig. 1, the last two cylinders 10' in the last normal group R_N are placed in the same horizontal plane as the upper cylinders 20A in the single twin-wire group R_{TW}, whereby it is possible to guarantee a transfer of the web W free of problems. According to Fig. 1, the web W is passed from the last cylinder in the last normal group R_N onto the first lower cylinder 20B in the single twin-wire group R_{TW} as an open draw W_1, whose arrangement is similar to the free draws W_0 of the web W in the twin-wire group R_{TW}.

In Fig. 1, the overall horizontal length of the dryer section in the machine direction is $L \approx 70$ m when six normal groups $R_{1...N}$ (N = 6) are used, and the corresponding horizontal length of the single twin-wire group R_{TW} is $L_{TW} \approx 10$ m, when four upper cylinders 20A and four lower cylinders 20B are used in the twin-wire group R_{TW}. In the example of dimensioning given above, the length L_{TW} of the twin-wire group R_{TW} is about 14 % of the overall length. As a rule, the length of the single twin-wire group L_{TW} is about 10...20 %, preferably 12...16 %, of the overall horizontal length L of the dryer section. In a dryer section concept in accordance with this example of dimensioning, in practice, a reduction of about 5 metres is achieved in the overall length L of the dryer section, as compared with a situation in which exclusively groups with single-wire draw are employed, and in this way the costs of the construction investment in the paper machine hall and the other costs indirectly related to same are also reduced considerably.

The number N_1 of the drying cylinders 10 used in each of the normal groups $R_{1...N}$ is in a range of N_1 = 4...8, preferably N_1 = 5...7, and the total number of the drying cylinders 20A and 20B used in the single twin-wire group R_{TW} is N_2 = 4...14, preferably N_2 = 8...10.

In view of prevention of transverse shrinkage of the web W, it is particularly important that, in particular in the dry solids content of k > 65 % of the web W, the web is kept constantly in reliable contact with the drying wires 15. This holding effect is produced on the reversing cylinders 11 by means of the negative pressure present in the grooved mantle 12 of their outer face and on the straight draws between the cylinders 10 and the reversing cylinders 11 by means of the pressure levels arranged by means of blow-suction boxes 17.

Fig. 2 shows an embodiment of the invention in

which a closed draw W_c of the web W is employed between the last normal group R_N and the twin-wire group R_{TW}, which closed draw has been achieved by passing the drying wire 15 and the web W supported on it into contact with the first upper cylinder 20A in the single twin-wire group R_{TW}, to whose smooth face the web W adheres and is transferred, being pressed by the upper wire 25A guided by the guide roll 28a, over the first upper cylinder 20A in the group R_{TW}. In Fig. 2, the guide rolls 21A and 21B placed in the gaps between the drying cylinders 20A and 20B are placed symmetrically in the centre plane passing through the centre axis of the adjacent drying cylinder, in which case the free draws W_0 of the web W passing between the rows of cylinders 20A and 20B are of full length and unshortened, differing from the "TWIN-RUN"™ arrangement shown in Fig. 1. This solution is also included in the scope of the present invention even though it is not in all cases equally advantageous as the shortened free gaps W_0 shown in Fig. 1. A drawback of the free draws W_0 of full length is slightly higher tendency of fluttering of the web W, but, on the other hand, longer free gaps W0 allow more time for evaporation of water and for relaxing of the web tensions in the gaps W_0 between the rows of cylinders 20A and 20B. In Fig. 2, the drying cylinders 10 in the last normal group R_N are placed in a plane slightly lower (dimension H_4) than the upper cylinders 20A in the twin-wire group R_{TW}.

The scope of the invention also includes embodiments in which the free gaps W_0, described above, between the rows of cylinders 20A,20B in the single group R_{TW} with twin-wire draw have been replaced fully or partially by fully closed draw arrangements which are in themselves known in prior art. With respect to these draw arrangements, reference is made to Figs. 3 and 4 in the applicant's **FI Patent No. 68,279** (equivalent to **US Patent 4,602,439**), to **US Patent 3,753,298,** and to the paper mentioned above by **Lindberg, Juppi, Eskelinen, "High Speed Dryer Section Developments for Sheet Stability", *78th Annual Meeting, Technical Section CPPA, 1992.***

In the present invention, it is favourably possible to apply so-called ropeless threading. Ropeless threading can be applied in the normal groups R_1...R_N by means of the drying wires 15 and by means of the reversing suction cylinders 11 as well as on the straight runs of the wires placed in connection with them by means of blow boxes 17 and by means of negative pressure applied to the reversing suction cylinders 11. Substantially similar arrangements can also be used in the single group R_{TW} with twin-wire draw. If necessary, at the doctors 14 and 24, it is also possible to use blow arrangements by whose means the threading is promoted. With respect to these arrangements, reference is made to the applicant's **FI Patent Application No. 904841** (equivalent to **US Pat. Appl. No. 07/766,039**).

As to the dimensioning of the various cylinders and rolls in the dryer section, it should be stated that the diameters D_1 of the drying cylinders 10 in the normal groups R_N are advantageously substantially equal to the diameters D_0 of the cylinders 20A and 20B in the single twin-wire group R_{TW}, i.e. $D_1 \approx D_0$. As a rule, said diameters D_1 and D_0 are chosen as $D_0 \approx D_1 \leqq 2.5$ m, preferably $D_1 \approx D_0 \approx 1.8...2.2$ m. The diameter D_2 of the reversing suction cylinders 11 or of corresponding normal suction rolls is, as a rule, chosen in a range of $D_2 \approx 0.6...1.8$ m. As was stated above, in the invention, preferably reversing suction cylinders 11 are used which have no inside suction box, which are provided with perforated mantles and with outside grooves 12 that are subjected to a vacuum, and the diameter D_2 of said cylinders is chosen in the range of $D_2 \approx 1.0$ ... 1.8 m, preferably $D_2 \approx 1.2$ ... 1.5 m. Fig. 2 also shows the horizontal distance A between the cylinders in a normal group R_N and the corresponding horizontal distance B in the single twin-wire group R_{TW}, which distances are in Fig. 1: A = 2130 mm and B = 2430 mm, when $D_0 = D_1$, in which case, in a normal group 15, the vertical distance between the cylinders 10,11 is H_1 = 1600 mm, and in the twin-wire group R_{TW} the corresponding vertical distance between the cylinders 20A and 20B is H_2 = 2000 mm. The diameter D_3 of the guide rolls 18,28,21a,21b is typically in a range of $D_3 \approx 400...700$ mm, depending on the width of the machine.

A regulation parameter that can be utilized in the invention and by whose means the symmetry of the drying of the opposite sides of the web W can be controlled is the tensions T_N and T_{TW} of the drying wires 15 and 25A,25B. In a preferred embodiment of the invention, T_N is chosen in a range of $T_N \approx 2...4$ kN/m, and T_{TW} is chosen in a range of $T_{TW} \approx 4...8$ kN/m. It is also possible to use an arrangement of tension of the drying wires 15 in which, also in the normal group $R_{1...N}$, the wire tension T_N is increased constantly as the drying makes progress, in accordance with the principles that are described in the applicant's FI Patent No. 83,441.

Moreover, the wire tensions T_{TWA} and T_{TWB} of the lower and upper wire 25A and 25B in the single twin-wire group R_{TW} can also be chosen as different from each other if the symmetry of the drying of the web W should require that. Such an embodiment is particularly advantageous in which the tension T_{TWB} of the wire 25B of the lower cylinders 20B is higher than the tension T_{TWA} of the upper wire 25A. Hereby, the symmetry of drying is promoted by in the single twin-wire group R_{TW} drying the upper side of the web W to a greater extent. The symmetry of drying can also be promoted by in the twin-wire group R_{TW} using different steam pressures and cylinder-face temperatures in the upper cylinders 20A as compared with the lower cylinders 20B. Preferably, in the lower cylinders 20B, a higher steam pressure and cylinder-face tempera-

ture are employed than in the upper cylinders 20A, whereby, together with the difference in tension $T_{TWB} > T_{TWA}$ between the wires 25A and 25B, the symmetry of the drying of the web W is promoted further by, in the single twin-wire group R_{TW} drying the upper face of the wire W to a greater extent than the lower face, whose drying proportion was in the normal groups $R_{1...N}$, owing to the cylinders 10, higher than the drying of the upper face. The above symmetry of drying can be promoted further by choosing the permeabilities of the upper wire 25A and the lower wire 25B different.

When the web W departs from the dryer section at W_{out}, its dry solids content k_{out} is, as a rule, in a range of $k_{out} \approx 92...98$ %, whereas the dry solids content of the web W on its arrival in the dryer section is $k_{in} \approx 40$ % ... 50 %.

Fig. 3 shows such a modification of a dryer section as shown in Fig. 1 in which the last two groups RS_{N-1} and RS_N in the single-wire groups $R_{1...N}$ are particular groups of inclined alignments, in which the first three contact-drying cylinders 10S are placed in a plane T_1 that is inclined downwards in the direction of running of the web W, and the next three corresponding cylinders 10S are placed in an upwards inclined plane T_2. In Fig. 3, the reversing cylinders in the groups RS_{N-1} and RS_N are denoted with the reference 11S and the leading rolls with the reference 18S and the wires with the reference 15S. Said inclined groups are preceded by normal single-wire groups $R_1...R_{N-3}$ similar to those shown in Fig. 1, the web W having closed draws between said normal single-wire groups and the inclined groups RS_{N-1} and RS_N. In stead of the inclined groups RS, it is also possible to use vertical or almost vertical cylinder groups. With respect to said vertical groups, reference is made to the applicant's **FI Patents Nos. 53,333** and **82,097** (equivalent to **US Pats. Nos. 3,868,780 and 4,972,608**) as well as to the **US Patent No. 5,177,880** of Messrs J.M. Voith GmbH. At least the lower parts of the inclined groups RS may extend to below the floor level of the paper machine hall into its basement space.

The scope of the invention also includes embodiments in which the overall length of the dryer section has been made shorter in respect of the groups $R_1...R_N$ with single-wire draw by, in one or several groups $R_1...R_N$, fitting the drying cylinders 10 in two or more horizontal, vertical or inclined planes.

In the following, the patent claims will be given, and the various details of the invention may show variation within the scope of the inventive idea defined in said claims and differ from what has been stated above for the sake of example only.

Claims

1. Method in contact-drying of a paper web (W), wherein the paper web (W) is dried by means of heated smooth-faced drying cylinders (10,20A,20B) by using a number of successive so-called normal groups ($R_1...R_N$) with single-wire draw, in which the drying cylinders (10) are placed in the upper row and the reversing suction cylinders (11) or corresponding reversing suction rolls in the lower row, in which method, after the press section of the paper machine, the paper web (W) is dried initially in a number of successive groups ($R_1...R_N$) with single-wire draw by pressing the paper web (W) by means of the drying wire (15) of the cylinder group against the heated faces of the drying cylinders (10) and by, in each group ($R_1...R_N$) with single-wire draw, passing the paper web (W) on support of the same drying wire (15) from one drying cylinder (10) onto the next drying cylinder over reversing suction cylinders (11), and in which method, after the above drying steps, which were carried out exclusively by means of normal groups ($R_1...R_N$) with single-wire draw, the paper web (W) is dried immediately further by means of one single group (R_{TW}) with twin-wire draw to its ultimate dry solids content, **character- ized** in that, by means of said groups ($R_1...R_N$) with single-wire draw, the paper web (W) is dried to a dry solids content of k_1 = 70...92 %, that, as said reversing suction cylinders (11), suction cylinders are used which have no inside suction box, the paper web (W) being held on the drying wires (15) by the intermediate of the perforated mantle and the grooves (12) in the outside face of said cylinders by means of a difference in pressure against the effect of centrifugal forces when the paper web is on the drying wire (15) at the side of the outside curve, and/or that, on the runs between the drying cylinders (10) and reversing cylinders (11) or rolls in said groups ($R_1...R_N$) with single-wire draw, differences in pressure that disturb the support contact of the paper web (W) are prevented by means of blow boxes (17) or equivalent.

2. Method as claimed in claim 1, **characterized** in that the diameters D_1 of the drying cylinders (10) in the normal groups (R_N) and the diameters D_0 of the cylinders (20A,20B) in the twin-wire group (R_{TW}) are chosen as $D_0 \approx D_1 \leqq 2.5$ m, preferably $D_0 \approx D_1 \approx 1.8...2.2$ m.

3. Method as claimed in claim 1 or 2, **characterized** in that the diameter D_2 of said reversing suction cylinders (11) which have no inside suction box and whose outside faces are provided with grooves (12) that are subjected to a vacuum is chosen in the range of $D_2 \approx 1.0...1.8$ m, and the ratio of diameters D_1/D_2 is chosen in the range of $D_1/D_2 \approx 1.2...4$, preferably in the range $D_1/D_2 \approx 1.2...2$.

4. Method as claimed in any of the claims 1 to 3, **characterized** in that, in the single group (R_{TW}) with twin-wire draw, blow boxes (22A,22B) are employed, which are fitted in the spaces between both the upper and the lower drying cylinders (20A,20B) at the proximity of the wire guide rolls (21A,21B) fitted in said spaces and by means of which boxes the support contact between the drying wires (25A,25B) is promoted, the fluttering of the paper web (W) on the free draws (W_0) is reduced, and/or the ventilation of the closed pocket spaces (P) that remain in the gaps between the drying cylinders (20A,20B) is promoted.

5. Method as claimed in any of the claims 1 to 4, **characterized** in that the symmetry of the drying of the opposite sides of the paper web (W) is promoted by in the last single twin-wire group (R_{TW}) in the dryer section using a wire tension (T_{TW}) that is higher than in the preceding normal groups (T_N).

6. Method as claimed in any of the claims 1 to 5, **characterized** in that the symmetry of the drying of the paper web (W) is promoted by in the last single twin-wire group (R_{TW}) in the dryer section using different wire tensions (T_{TWA} and T_{TWB}) in the upper wire as compared with the lower wire (25A,25B) and/or by using different steam pressures in the upper row of drying cylinders as compared with the lower row (20A,20B) and/or by using different permeabilities in the upper wire as compared with the lower wire (25A,25B), preferably so that, in the group (R_{TW}) with twin-wire draw, the proportion of drying of the upper face of the paper web (W), which takes place on the lower cylinders (20B), is arranged larger than the corresponding proportion of drying taking place on the upper cylinders (20A).

7. Method as claimed in any of the claims 1 to 6, **characterized** in that, by means of said groups (R_1...R_N) with single-wire draw, the paper web (W) is dried to a dry solids content of $k_1 \approx 80$ %...85 %.

8. Method as claimed in any of the claims 1 to 7, **characterized** in that, in the event of breaks, the removal of the paper web (WS) that becomes broke is carried out downwards from the open groups (R_1...R_N) with single-wire draw substantially by the force of gravity onto a broke conveyor or equivalent placed underneath.

9. Method as claimed in any of the claims 1 to 8, **characterized** in that, between the last group (R_N) with single-wire draw and the following single group (R_{TW}) with twin-wire draw, either an open draw (W_1) of the web (Fig. 1) or a closed draw (W_c) of the web is used, which latter draw is preferably arranged so that the drying wire (15) of the last group (R_N) with single-wire draw has a contact sector or a turning sector with the first drying cylinder (20A) in the group (R_{TW}) with twin-wire draw, in which case the paper web (W) is separated from the last-mentioned drying wire (15) and is transferred onto the smooth face of the last-mentioned drying cylinder (20A) (Fig. 2).

10. Method as claimed in any of the claims 1 to 9, **characterized** in that, in the last single group (R_{TW}) with twin-wire draw in the dryer section, free gaps are used which are shorter than a free draw of full length of the paper web (W) and which are produced by means of asymmetric locations of the wire guide rolls (21A and 21B) placed in the gaps between the drying cylinders (20A,20B) (Fig. 1).

11. Method as claimed in any of the claims 1 to 10, **characterized** in that, in the dryer section, so-called ropeless tail threading is applied by, in the threading, guiding the web by means of differences in pressure and by means of blowings.

12. Method as claimed in any of the claims 1 to 11, **characterized** in that, between the rows of drying cylinders (20A,20B) in the single group (R_{TW}) with twin-wire draw, free draws (W_0) of the paper web are used, on which draws the paper web (W) is allowed to relax.

13. Method as claimed in any of the claims 1 to 12, **characterized** in that, between the rows of drying cylinders (20A,20B) in the single group (R_{TW}) with twin-wire draw, closed draws of the paper web (W) are used.

14. Dryer section of a paper machine, whose initial part is composed of a number of successive so-called normal groups (R_1...R_N) with single-wire draw, in which the drying cylinders (10) are placed in the upper row and the reversing suction cylinders (11) are placed in the lower row, and between which said normal groups (R_1...R_N) the paper web (W) to be dried has closed draws over the group gaps, and which said reversing suction cylinders (11) have been arranged to be subjected to negative pressure, at least at their drying-wire (15) turning sectors (12), and in which dryer section, after the last group (R_N) with single-wire draw, one single group (R_{TW}) with twin-wire draw is provided, in which there are two rows of drying cylinders (20A,20B), one row placed above the other, **characterized** in that, differences in pressure that disturb the support contact between the

drying wire (15) and the paper web (W) on their joint runs from the drying cylinders (10) onto the reversing suction cylinders (11) in the groups (R_1...R_N) with single-wire draw have been reduced or prevented by means of air-blow devices (17) or equivalent, and/or that said reversing suction cylinders (11) are reversing suction cylinders (11) that are provided with a perforated mantle and with outside grooves (12) subjected to a vacuum and which said cylinders have no inside suction box.

15. Dryer section as claimed in claim 14, **characterized** in that the diameter D_2 of said reversing suction cylinders (11) which have no inside suction box and whose outside faces are provided with grooves (12) that are subjected to a vacuum has been chosen in the range of $D_2 \approx 1.0...1.8$ m, preferably $D_2 \approx 1.2...1.5$ m, and that the ratio of the diameter D_1 of the drying cylinders (10) in the normal groups (R_N) and the diameter D_2 of the reversing suction cylinders (10) has been chosen in the range of $D_1/D_2 \approx 1.2...4$, preferably in the range $D_1/D_2 \approx 1.2...2$.

16. Dryer section as claimed in claim 14 or 15, **characterized** in that, in the spaces between the drying cylinders (20A,20B) in the single group (R_{TW}) with twin-wire draw, preferably both in the upper row and in the lower row of drying cylinders, air-blow boxes (22A,22B) are provided, by means of which blowings of such directions and velocities can be applied to the drying wires (25A, 25B) running at their proximity and to the free sectors of the opposite wire guide rolls (21A,21B) that the blowings promote the support contact between the drying wires (25A,25B) and the paper web (W), reduce the fluttering of the free draws (W_0) of the paper web (W) and/or promote the ventilation of the closed pocket spaces (P) defined in the gaps between the drying cylinders (20A,20B).

17. Dryer section as claimed in any of the claims 14 to 16, **characterized** in that the paper web (W) has free unsupported draws (W_0) on the runs between the drying cylinders (20A,20B) in said single group (R_{TW}) with twin-wire draw.

18. Dryer section as claimed in any of the claims 14 to 17, **characterized** in that the paper web (W) has closed draws between the rows of drying cylinders (20A,20B) placed one above the other in the single group (R_{TW}) with twin-wire draw.

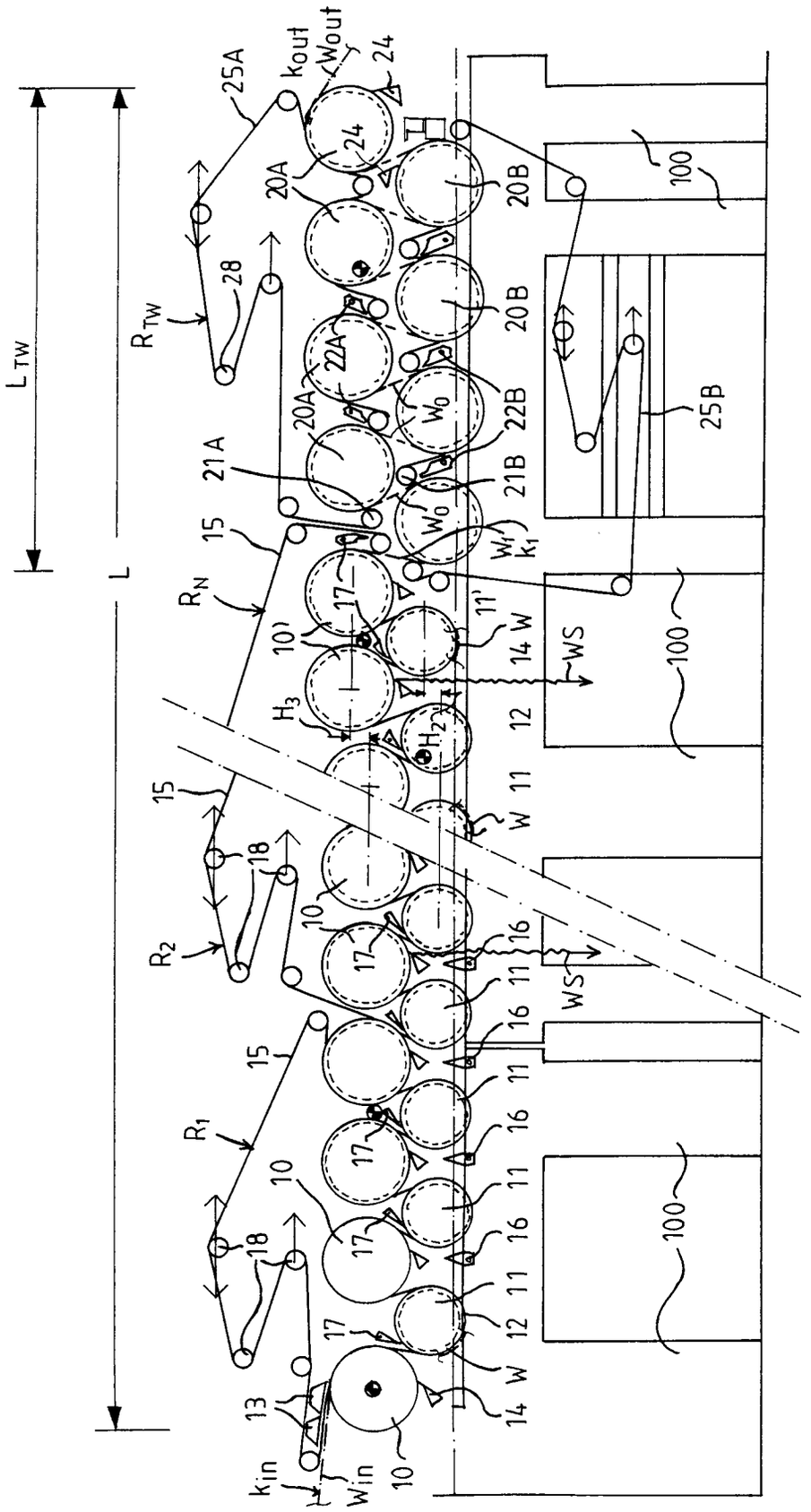
19. Dryer section as claimed in any of the claims 14 to 18, **characterized** in that the horizontal length (L_{TW}) in the machine direction of the last single group (R_{TW}) with twin-wire draw is about 10 %...20 %, preferably about 12 %...16 %, of the overall horizontal length (L) of the dryer section in the machine direction.

20. Dryer section as claimed in any of the claims 14 to 19, **characterized** in that the number of the groups (R_1...R_N) with single-wire draw is N = 3...9, preferably N = 5...7, that the number of the drying cylinders (10) used in the groups (R_1...R_N) with single-wire draw has been chosen in a range of N_1 = 4...8, preferably in a range of N_1 = 5...7, and that the total number of the drying cylinders (20A,20B) used in the single twin-wire group (R_{TW}) has been chosen in a range of N_2 = 4...14, preferably in a range of N_2 = 8...10.

21. Dryer section as claimed in any of the claims 14 to 20, **characterized** in that, in one or several groups (R_1...R_N) with single-wire draw, the drying cylinders (10) have been arranged in two or more horizontal, inclined, or vertical planes so that the overall length of the dryer section can be made shorter.

22. Dryer section as claimed in any of the claims 14 to 21, **characterized** in that one or several of the groups (R_1...R_N) with single-wire draw, preferably of the last groups (RS_{N-1}, RS_N), is/are a group of inclined alignment, in which the first drying cylinders (10S) are placed in a plane (T_1) that is inclined downwards in the direction of running of the paper web (W), and the next drying cylinders (10S) are placed in a corresponding upwards inclined plane (T_2) (Fig. 3).

23. Dryer section as claimed in any of the claims 14 to 22, **characterized** in that the dryer section includes means for producing the differences in pressure and/or the guiding air blowings necessary in so called ropeless tail threading.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21B
W 1
k 1
15
17
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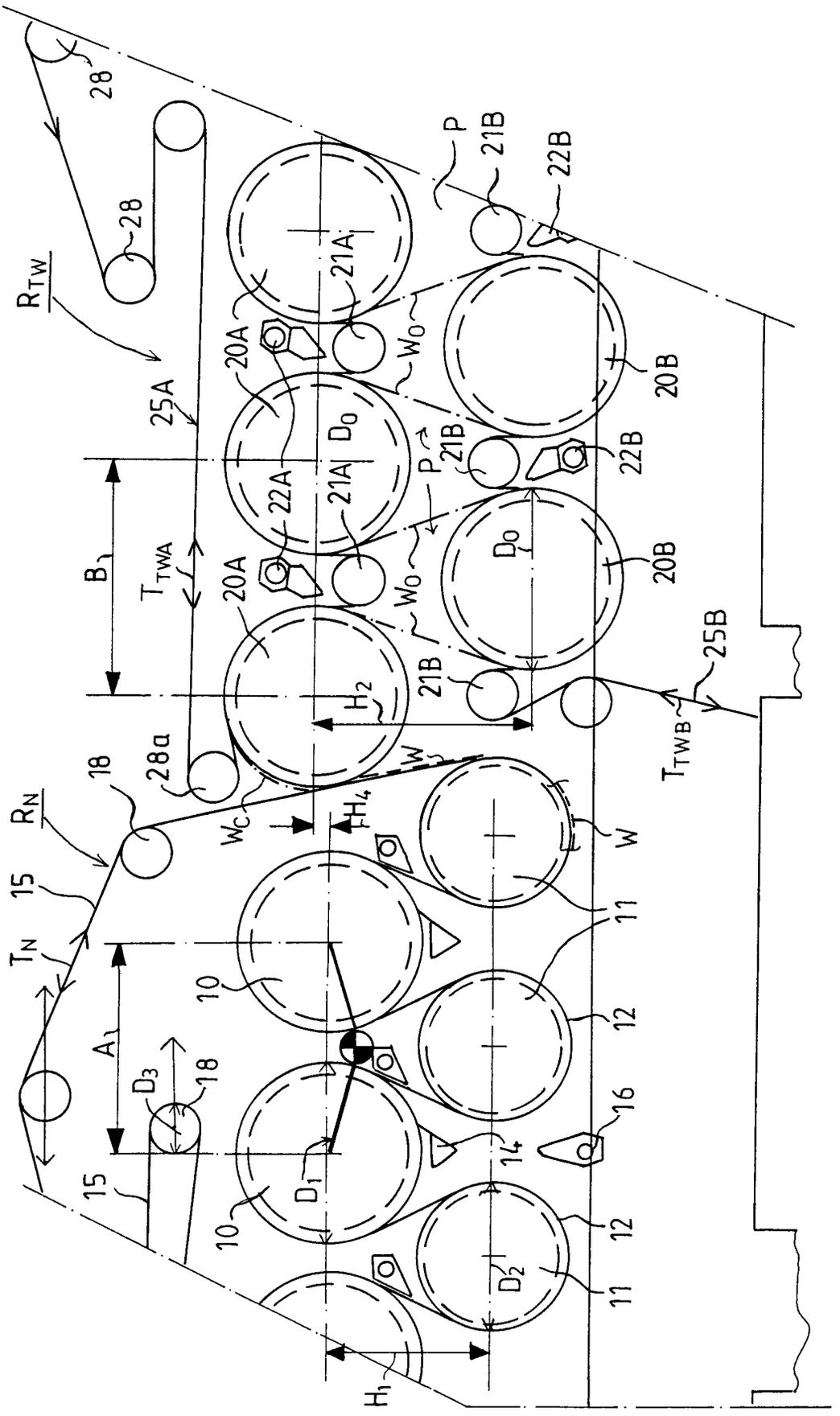
16
18
10
13
k in
W in

FIG. 1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H_2
28a
18
R_N
15
T_N
W_C
H_4
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D_1
D_2
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12
14
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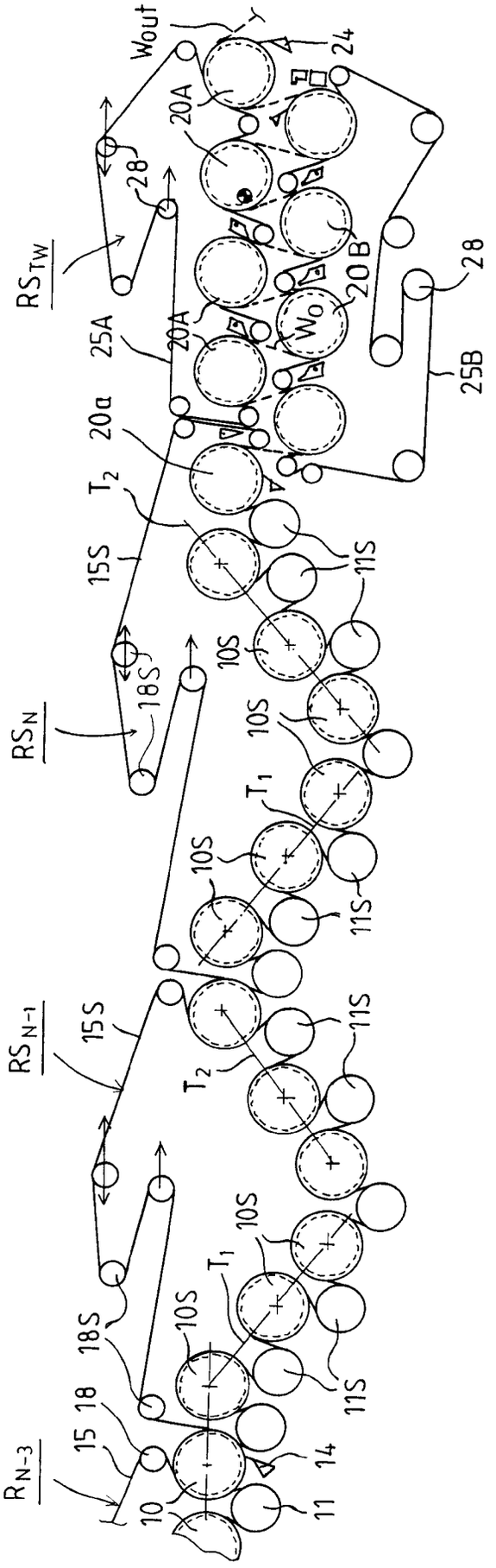
25B

FIG. 2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RSN
10S
T1
10S
11S
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11S
T2
10S
T1
18S
10S
11S
15 18
RN-3
14
10
11

FIG. 3